FRUITS FOR HUMAN USE IN VARIOUS ASPECTS

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Preface

Fruits are among the essential elements of human nutrition. Although the first definition that comes to mind when talking about fruit is "edible products of trees", in fact, fruit is botanically described as "the organ that is formed by the development of the ovary in plants after the fertilization of the flower and carries the seeds". In other words, we call fruit the organ that flowering plants form in different ways from the ovary and that develops with or without seeds. The importance of fruits in human nutrition is mainly due to the large/primary molecules such as carbohydrates, proteins, and fats they contain, the vitamins and inorganic minerals that people must take from outside, and the polyphenols, fatty acids, and organic acids, which are called secondary metabolites that have many important functions although they are small in quantity. Since each type of fruit can be rich in only some of the mentioned components, a varied diet in fruits is very important for a balanced diet. The beginning topics covered in this book are the nutritional values of fruits and the different organs of some species. Recognition and dissemination of new fruit species greatly contribute to the provision of a broader spectrum diet. Some of the studies that have been carried out and can be performed in this context have been included in the book. Again, the effects of fruits and their cultivation on the formation and development of culture in a region were examined. The different uses of fruits and the technologies developed in these areas are presented at the reader's intention. In conclusion, this book will be a resource helping the reader to consider fruit and fruit growing from various perspectives.

Emrah GÜLER

Editor

CHAPTER 1

CHEMICAL COMPOSITION OF ALMOND FRUIT

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1. Introduction

Nuts, macronutrients (fat, protein, carbohydrate), micronutrients (minerals and vitamins), fat-soluble bioactive substances (phospholipids, sterol esters, tocopherols, tocotrienols, phytosterols, phytosterols, terpenoids, sphingolipids and essential fatty acids) (phenolic acids, flavonoids, stilbenes, lignans, tannins or proanthocyanidins, carotenoids, alkaloids, phytates and phytoestrogens) are included in healthy nutrition recommendations (Cesarettin and Fereidoon, 2008). Nuts and by-products (bark, green leaves, stem and leaves) have antioxidant and free radical scavenging activity, anticarcinogenic, antimutagenic and antiproliferative potential due to their rich phytochemical content. Phytochemicals are protective against free radicals. It is protective against some types of cancer, coronary artery disease, stroke, atherosclerosis, osteoporosis, type 2 diabetes, inflammation, endothelial function, death and other neurodegenerative diseases associated with oxidative stress (Cesarettin and Fereidoon, 2008).

Nuts are among the foods with high energy density (Table 1). When nuts are roasted with oil, their total energy content increases. The total energy content increases by 30-40 kcal/100g due to the oil absorption of the nuts during the oil-roasting process (Brufau et al., 2006).

Table 1. Macronutrient content of nuts (g/100g) (Adapted from Dikmen, 2015)

	Raw			Roasted		
	Energy (kcal)	Protein	Fat	Energy (kcal)	Protein	Fat
Almond	579	21.2	49.9	598	20.9	52.5
brazil nuts	659	14.3	67.1	-	-	-
Cashews	553	18.2	43.8	574	15.3	46.4
Hazelnut	628	14.9	60.8	646	15.0	62.4
Macadamia nut	718	7.9	75.8	718	7.8	76.1
Pecans	691	9.2	72.0	710	9.5	74.3
Peanut	567	25.8	49.2	587	24.4	49.6
Pistachios	562	20.3	45.4	567	20.9	44.8
Walnut	654	15.2	65.2	-	-	-

Source: USDA

Nuts are a good source of vegetable protein and are rich in total protein content. Acidic amino acids (aspartic acid and glutamic acid) are nuts' most abundant amino acids (Cesarettin and Fereidoon, 2008). Nuts with a hard shell are very rich in arginine. Although the total protein content of nuts is high, some essential amino acid contents are limited. All nuts are limited to threonine (Brufau et al., 2006). The amount of isoleucine and lysine in the nuts is low. Methionine and cysteine are also low in nuts (mostly almonds). Histidine is high in all nuts (Cesarettin and Fereidoon, 2008). Foods with a high lysine/arginine ratio are associated with an increased risk of developing hypercholesterolemia and atherosclerosis. Nuts have a low lysine/arginine ratio. Because nuts are rich in arginine and poor in lysine, protein-rich foods such as nuts are high in arginine and glycine. These amino acids are suggested to reduce the risk of chronic degenerative disease due to their effect on insulin and glucagon levels (Brufau et al., 2006).

The main component of nuts is the total amount of oil. The amount of fat in these nuts depends on the fatty acid pattern, the soil in which they are grown, and the climate. Most nuts contain phytosterols and sphingolipids (Cesarettin and Fereidoon, 2008). The total fat content of nuts ranges from 46% (cashew, pistachio) to 76% (macadamia). However, the fatty acid composition of nuts is beneficial for health, the saturated fatty acid content is 4-16%, and almost half of the total fat content consists of unsaturated fatty acids (Table 2). Most the nuts are high in monounsaturated fatty acids (oleic acid). Brazil nuts contain monounsaturated fatty acids as well as polyunsaturated fatty acids (linoleic acid), pine nuts have more polyunsaturated fatty acids and less monounsaturated fatty acids, walnuts have more polyunsaturated fatty acids in the form of linoleic acid and α-linolenic acid (C18:3, n-3) (Ros and Mataix, 2006).

Table 2. The fatty acid pattern of nuts (g/100 g) (Adapted from Dikmen, 2015)

	Total fat	Saturated fatty acids	Monounsaturated fatty acids	Polyunsaturated fatty acids	18:2, n-6	18:3, n-3
Almond	49.9	3.8	31.5	12.8	12.3	0.00
Brazil nuts	67.1	16.1	23.9	24.4	23.8	0.02
Cashews	43.8	7.8	23.8	7.8	7.7	0.06
Hazelnut	60.8	4.5	45.7	7.9	7.8	0.09
Macadamia nut	75.8	12.1	58.9	1.5	1.3	0.21
Pecans	49.2	6.8	24.4	15.6	15.5	0.00
Peanut	45.4	5.6	23.8	13.7	13.5	0.26
Pistachios	72.0	6.2	40.8	21.6	20.6	1.00
Walnut	65.2	6.1	8.9	47.2	38.1	9.08

Source: USDA

It is metabolized in the body to linoleic acid, arachidonic acid, and n-6 eicosanoid. α-linolenic acid is metabolized to eicosapentaenoic acid and docosahexaenoic acid, followed by n-3 eicosanoid. n-6 eicosanoids increase platelet aggregation, are vasoconstrictors and are generally pro-inflammatory. eicosanoidsoids inhibit platelet aggregation and are vasodilators and anti-inflammatory. Therefore, the balance of n-6 and n-3 polyunsaturated fatty acids in the diet is an important factor affecting cardiovascular health. The ratio of n-6 fatty acids to n-3 fatty acids should be 4:1. Of all edible plants, walnuts have the highest α-linolenic acid content. The ratio of linoleic acid to α-linolenic acid in walnuts is about 4:1. Consumption of a sufficient amount of walnuts in our daily diet positively affects the production of eicosanoids and provides the balance of n-3/n-6 polyunsaturated fatty acids (Ros and Mataix, 2006).

The carbohydrate content of nuts varies according to their growing status, maturity of the seed, variety and place of cultivation (Cesarettin and Fereidoon, 2008). Nuts with a hard shell are also high in other nutrients. In addition to containing high protein and polyunsaturated fatty acids, it is also a rich source of various micronutrients and fiber (Table 3). Nuts with hard shells contain about 5-10 g/100 g pulp. Almonds (12.2 g/100 g), pistachios (10.3 g/100 g), and hazelnuts (9.7 g/100 g) have the highest pulp content, while cashews (3.3 g/100 g) have the lowest pulp content (USDA). Nuts are rich in minerals such as folic acid, niacin, vitamin E, vitamin B6, copper, magnesium, potassium, zinc, calcium, antioxidants, phytosterols and other phytochemicals (Sabate et al., 2006; Segura et al., 2006).

Table 3. Micronutrient composition of nuts (100 g) (Adapted from Dikmen, 2015)

	E vit (mg)	Folate (μg)	Niacin (mg)	B6 vit (mg)	Ca (mg)	Mg (mg)	Cu (mg)	Zn (mg)	Na (mg)	K (mg)
Almond	25.6	44	3.6	0.14	269	270	1.0	3.1	1	733
brazil nuts	5.6	22	0.3	0.1	160	376	1.7	4.1	3	659
Cashews	0.9	25	1.1	0.4	37	292	2.2	5.8	12	660
Hazelnut	15	113	1.8	0.6	114	163	1.7	2.5	0	680
Macadamia nut	0.5	11	2.5	0.3	85	130	0.7	1.3	5	368
Pecans	8.3	240	12.1	0.35	92	168	1.1	3.3	18	705
Peanut	1.4	22	1.2	0.2	70	121	1.2	4.6	0	410
Pistachios	2.3	51	1.3	1.7	105	121	1.3	2.2	1	1025
Walnut	2.1	31	0.5	0.6	61	201	1.4	3.4	2	523

Source: USDA

The edible part of the almond fruit, one of the hard-shelled fruits, is considered an important food product with high nutritional and medicinal value. The first records of the use of almonds in the field of health were found in ancient Greek, Persian, Chinese and Indian medicine (Albala, 2009). Almond was used as a thickener before the discovery of starch (Albala, 2009) and as a milk substitute (Mori et al., 2011) from the Middle Ages to the 18th century. While almond consumption was 1.452,206 tons in 2000, it reached 4.140,043 tons in 2020 and almost tripled in the last 20 years (FAO, 2022). This increase in almond production is due to its increasing use as a functional food and being a good snack food. Functional component or food is defined as “substances that have positive physiological effects on the human body depending on their composition, in addition to their known nutritional values.” Functional foods are generally classified into three groups: "functional ingredient," "functional ingredient added," and "undesirable compound removed" (Topçuoğlu and Ersan, 2020). Almonds are described as "foods containing functional components" because they contain sufficient amounts of daily nutrients, provide calories, regulate appetite, and prevent and treat especially cardiovascular diseases, obesity and some cancer diseases (Dikmen, 2015). Almonds can be consumed raw or roasted, blanched or unbleached, alone or mixed with other nuts. It can also be made into different forms, incorporated into other products, or used to produce marzipan and nougat (Schirra, 1997). The high lipid content of almond seeds, an important source of calories, increases their high nutritional value. However, high levels of unsaturated fatty acids, especially monounsaturated fatty acids, do not cause cholesterol formation in humans (Sabaté and Hook, 2000).

Figure 1. Chemical composition of the almond kernel (Roncero et al., 2020).

Almonds must be of high quality to both appeal to consumers and meet the needs of the industry (Socias i Company et al., 2008). When industries such as pastry, confectionery and cake are taken into account, the chemical composition of the fruit comes to the fore, as well as the physical properties of almonds (Figure 1). As with other nuts, the first feature that comes to mind when talking about the chemical composition of almonds is oil. In addition to the oil, which is one of the quality criteria of the kernel, the percentage of oleic acid in the lipid fraction of the fruit, the oleic/linoleic acid ratio (O/L) and tocopherol concentration are also the properties sought in the quality criteria of the kernel (Kodad and Socias i Company, 2008; Socias i Company et al., 2008). Cultural practices (Yada et al., 2011), cultivars characteristics (Kodad et al., 2011a; Summo et al., 2018; Roncero et al., 2020), geographical location (Abdallah et al., 1998; Kodad et al., 2011a) and ecological factors (Barbera et al., 1994; Kodad et al., 2011b) are effective on the chemical composition of almonds. This section summarizes the chemical composition of the kernel (the edible part) and information about the factors affecting these variables.

2. Lipid Content and Fatty Acid Profile

Almond, a rich source of lipids, contains mono and polyunsaturated fatty acids (Sabaté and Hook, 2000). Lipid fraction is also an important determinant of flavor, especially after roasting (Socias i Company et al., 2008). The fat fraction in the inner almond consists mainly of storage lipids found as intracellular fat droplets (about 1-3 mm in diameter) in the cotyledonous tissues (Pascual-Albero et al., 1998; Ren et al., 2001). For several months after the fruit set, the oil content of the inner almond is low (< 10% of dry matter) but then increases rapidly until about one month before harvest and then continues to increase gradually (Saura-

Calixto et al., 1984b; Kumar et al., 2000; Egea et al., 2009) or remains constant (Cherif et al., 2009). The high-fat content of almonds is a desirable event for the confectionery industry. Because the high-fat content causes less water absorption by the almond paste (Alessandroni, 1980). On the contrary, almonds with low-fat content are preferred to produce almond milk, a dietetic product (Fasoli et al., 2011). Almond oil content generally depends on genotype, but according to years (Abdallah et al., 1998; Sathe et al., 2008; Kodad et al., 2011a) and growing conditions (Kodad et al., 2010; Kodad et al., 2013). They are reported to show high variability. However, Zhu et al. (2015) reported that moderate irrigation had no detrimental effect on the lipid content of almonds, but severe and extreme deficiencies did affect the lipid content. It has been reported that almond oil is very rich in monounsaturated fatty acids (MUFAs), especially oleic and linoleic acids, and very low in saturated fatty acids, especially palmitic, palmitoleic and stearic (Yada et al., 2011) (Table 4). These five fatty acids make up more than 95% of the total lipid fraction, depending on the variety, and eight minor fatty acids have also been reported (Martín-Carratalá et al., 1998). The degradation of fatty acids to peroxides affects the quality of almonds, resulting in a bitter taste (Harris et al., 1972). Fat oxidation is affected by various factors, such as the percentage of unsaturated fatty acids, light, oxygen, metallic ions, temperature, and enzymes (Gou et al., 2000; Zacheo et al., 2000).

The fatty acid profile is considered the most interesting topic in the oil oxidation process. Kester et al. (1993) suggested that the oleic acid/linoleic acid ratio (O/L) is a good index of resistance to oil rancidity, and higher ratios are preferred. In other nut species, such as hazelnuts, the adopted criterion was the ratio of unsaturated fatty acids/to saturated fatty acids (Bonvehí and Coll, 1993; Peshern et al., 1995). Oleic and linoleic acid contents, important components of fatty acids, vary according to genotype and are affected by climatic (Kodad et al., 2011a; Maestri et al., 2015) and environmental factors (Sathe et al., 2008; Yada et al., 2013).

Table 4. Range of variability of significant almond macronutrients kernels (g/100 g Almond Kernel) (Adapted from Kodad, 2017; Roncero et al., 2020)

Nutrient	Range of Variability (g/100 g)	Origin	References
Oil content			
	40-67	Spain	García-López et al. (1996), García-Pascual et al. (2003), Kodad et al. (2006), Kodad et al. (2011a), Kodad and Socias i Company (2008), López-Ortiz et al. (2008), Romojaro et al. (1988), Sánchez-Bel et al. (2008) and Soler et al. (1989)
	56-61	Greece	Nanos et al. (2002)
	54.75-64.73	France	Kodad et al. (2011a)
	42-66.8	Italy	Kodad et al. (2011a), Barbera et al. (1994), Ruggeri et al. (1998) and Schirra and Agabbio (1989)
	48-63.9	Portugal	Cordeiro et al. (2001) and Egea et al. (2009), Kodad et al. (2011a)
	35-66	USA	Abdallah et al. (1998), Ahrens et al. (2005), Hall et al. (1958), López-Ortiz et al. (2008), Sathe (1992), Sathe et al. (2008) and Venkatachalam and Sathe (2006)
	57-63.9	Ukraine	Kodad et al. (2011a)
	63-66	India	Kodad et al. (2011a)
	48.7-64.5	Morocco	Kodad et al. (2013)
	48-66	Argentina	Kodad et al. (2011a), Maestri et al. (2015)
	20.19-62	Iran	Mehran and Filsoof (1974), Abaspour et al. (2012) and Kiani et al. (2015)
	56.1-59.8	Tunisia	Ayadi et al. (2006)
	48-61	Türkiye	Çelik and Balta (2011) and Askin et al. (2007)
	55-59	Egypt	Nassar et al. (1977)

Protein, total (N × 5.18)		
16.4–22.1	USA	Sathe, 1993
18.5–24.0	California	Yada et al., 2013
20.7–23.3	USA	Ahrens et al., 2005
15.8–25.1	Spain	Esteban, 1985
14.5–29.2	Spain	Kodad et al., 2011a
8.4–24.7	Spain	Font i Forcada et al., 2011
21.0–24.0	Portugal	Barreira et al., 2012
9.6–28.5	France, Italy and Greece	Drogoudi et al., 2013
20.0–32.8	Spain and Morocco	Kodad et al., 2011a
14.1–35.1	Morocco	Kodad et al., 2013
16.7–31.5	Türkiye	Askin et al., 2007
12.7–16.3	Türkiye	Ozcan et al., 2011
20.4–25.8	Türkiye	Simsek et al., 2018
11.52 ± 1.1	Nigeria	Agunbiade, 2006
23.8	India	Chung et al., 2013
20.0	South Africa	Moodley et al., 2007
17.36–23.02	Serbia	Čolić et al., 2020
Carbohydrates, total		
14–21	Portugal	Barreira et al., 2012
23.6–27	USA	Ahrens et al., 2005
28	Nigeria	Akpambang et al., 2008
28.0	South Africa	Moodley et al., 2007
Sugars, soluble		
2.6	Türkiye	Aslantas et al., 2001
1.8-7.9	Spain	Saura-Calixto et al., 1988
1.74–4.31	Greece	Kazantzis et al. (2003) and Nanos et al. (2002)
2.1-7.4	USA	Ahrens et al. (2005), Amrein et al. (2005), Venkatachalam and Sathe (2006)
3.6-12	Italy	Amrein et al. (2005), Barbera et al. (1994) and Ruggeri et al. (1998)
2.5-7.1	Portugal	Cordeiro et al. (2001) and Egea et al. (2009)
Sucrose		
2.5–5.1	California	Yada et al., 2013
1.42–3.62	Greece	Kazantzis et al., 2003
1.15–2.22	Portugal	Barreira et al., 2010

3.67–7.09	Spain	Sánchez-Bel et al., 2008
1.21–3.08	Portugal	Oliveira et al., 2019
Fiber, total dietary		
9.8	California	Mandalari et al., 2008
7.9–16	California	Yada et al., 2013
3.3–8.6	Spain	Kodad, 2006
4.73–6.01	Spain	Sánchez-Bel et al., 2008
11–14	Italy	Ruggeri et al., 1998

Table 5. Fatty acid profile and range of variability of almond kernel oil (Adapted from Kodad, 2017)

Fatty acid	Range of variability (% of total fatty acids)	Origin	References
Linoleic	12-22.5	Argentina	Maestri et al. (2015) and Kodad et al. (2011a)
	15.4-35.1	USA	Abdallah et al. (1998), Sathe et al. (2008) and Kodad et al. (2011a)
	12.6-27	Türkiye	Askin et al. (2007), Karatay et al. (2014) and Çelik and Balta (2011)
	19.2-22.4	Morocco	Kodad et al. (2013)
	11-23	Spain	Prats-Moya et al. (1999), García-López et al. (1996), Soler et al. (1989), Kodad et al. (2011a) and Kodad et al. (2014)
	11.9-24.4	Iran	Kiani et al. (2015) and Mehran and Filsoof (1974)
Oleic	68-77.5	Argentina	Maestri et al. (2015) and Kodad et al. (2011a)
	57.4-77.3	USA	Abdallah et al. (1998), Sathe et al. (2008) and Kodad et al. (2011a)
	64-80.6	Türkiye	Askin et al. (2007), Karatay et al. (2014) and Çelik and Balta (2011)
	68-70.7	Morocco	Kodad et al. (2013)
	65-77	Spain	Prats-Moya et al. (1999), García-López et al. (1996), Soler et al. (1989), Kodad et al. (2011a) and Kodad et al. (2014)
	67.6-80.8	Iran	Kiani et al. (2015) and Mehran and Filsoof (1974)
Palmitic	6.01-7.26	Argentina	Maestri et al. (2015) and Kodad et al. (2011a)
	5.67-7.8	USA	Abdallah et al. (1998), Sathe et al. (2008) and Kodad et al. (2011a)
	4.4-5.3	Türkiye	Askin et al. (2007), Karatay et al. (2014) and Çelik and Balta (2011)
	6.3-7.5	Morocco	Kodad et al. (2013)

	5.4-7.1	Spain	Prats-Moya et al. (1999), García-López et al. (1996), Soler et al. (1989), Kodad et al. (2011a) and Kodad et al. (2014)
	6-8.1	Iran	Kiani et al. (2015) and Mehran and Filsoof (1974)
Stearic	1.06-1.77	Argentina	Maestri et al. (2015) and Kodad et al. (2011a)
	1.1-2.6	USA	Abdallah et al. (1998), Sathe et al. (2008) and Kodad et al. (2011a)
	0.26-1.89	Türkiye	Askin et al. (2007), Karatay et al. (2014) and Çelik and Balta (2011)
	1.9-2	Morocco	Kodad et al. (2013)
	1.54–2.5	Spain	Prats-Moya et al. (1999), García-López et al. (1996), Soler et al. (1989), Kodad et al. (2011a) and Kodad et al. (2014)
	1-1.89	Iran	Kiani et al. (2015) and Mehran and Filsoof (1974)

3. Vitamins

Most of the studies on the vitamin content in almonds are related to antioxidants, which are effective in protecting the oil against oxidation and degradation. The most important of these are tocopherols. Tocopherols are natural monophenols (Reische et al., 1998). The main tocopherol homologues in almonds are α-, γ-, δ- and β-tocopherol. These compounds have a protective effect on biological systems with their hypocholesterolemic, anti-cancer and neuroprotective effects (Sen et al., 2007). In addition, the tocopherol concentration plays an important role in protecting lipids from oxidation, thus prolonging their storage time (García-Pascual et al., 2003).

The most active form of vitamin E is α-Tocopherol and is used in the human body in different ways than other forms (Brigelius-Flohé et al., 2002). The tocopherol concentration in almond oil varies according to the genotype and climatic conditions (Yada et al., 2013; Kodad et al., 2014; Maestri et al., 2015) and the environmental conditions (Kodad et al., 2011b; Yada et al. al., 2013) of the growing region.

As in many plants, the most important factors affecting chemical compounds in almonds are drought and heat stress. Kodad et al. (2006) emphasized a positive relationship between temperatures and tocopherols. Researchers reported higher tocopherol concentrations in almonds harvested at high temperatures. Maestri et al. (2015) also reported a similar relationship between high temperatures and tocopherol. Looking at the relationship between tocopherol and drought, Zhu et al. (2015) reported no significant relationship between tocopherol content and the degree of water deficiency.

Almonds are also a source of B1 (thiamine), B2 (riboflavin), B6 (pyridoxine), and niacin. Vitamin B6 plays an influential role in reducing the homocysteine level in the body, which has a harmful effect at high concentrations (Whitney and Rolfes, 2002). Processing almonds in different ways affect vitamin levels in various ways. Daud et al. (1977) reported that the vitamin B6 content of natural and processed almonds ranged from 0.08 to 0.16 mg/100 g. The same researchers reported that vitamin B6 in almonds decreased by about 12% after boiling and by 25% after roasting.

4. Minerals

Plants, like other living things, need various plant nutrients to survive. Plants absorb the elements they need from the air, water and soil. Some of these elements are the elements that the plant needs to grow and develop, and some are the elements that are beneficial for the growth and development of the plant. Each nutrient element helps different plant functions that enable the plant to grow and develop. Almond is one of the fruits considered important for human health thanks to its mineral elements. The ash content obtained from plant materials is expressed as the inorganic residue left over from burning plant tissue (Yada et al., 2011). As seen from the above, almond mineral contents may vary according to the soil cultivated and specific to varieties (Table 6). Almond is a source of calcium, magnesium and manganese (Yada et al., 2013; Mahmoud and Yasin, 2016). During the growth and maturation of the almond fruit, copper, iron, phosphorus, zinc and potassium accumulate (Schirra et al., 1994). Among these minerals, potassium is approximately four times more abundant than sodium (Mahmoud and Yasin, 2016).

Table 6. Mineral, vitamin and total phenolic contents in almond kernels (Adapted from Grundy et al., 2016; Richardson et al., 2009; Bolling et al., 2011; Yada et al., 2011, USDA)

	Range of Variability (mg/100 g)
Minerals	
Calcium	264–300
Magnesium	230–268
Phosphorus	440–510
Potassium	705–730
Zinc	3.0–4.1
Copper	0.9–1.3
Manganese	1.2–1.8
Vitamins	
Riboflavin	1.0–1.1
Vitamin E (α-tocopherol)	25–27
Total phenolic compounds	260–350

5. Protein and Amino Acids

After the lipid fraction, the second largest chemical component of almond kernels is protein (Gradziel, 2017). The main protein fraction identified in almonds is globulins and albumins, which make up 88-91% of the total protein (Saura-Calixto et al., 1982). The protein content is inversely proportional to the lipid fraction, and the balance in the ratio of these two compounds is important in preparing products such as marzipan (Alessandroni, 1980). The most common amino acids in almond proteins are glutamic acid, aspartic acid and arginine (Socias i Company et al., 2008). Essential amino acids constitute approximately 30% of the protein (Ruggeri et al., 1998). The protein and amino acid content in almonds varies according to the origin of the genotype and the climatic and environmental conditions of the growing region (Saura-Calixto et al., 1988; Kodad, 2006).

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6. Phenols

When the distribution of phenolic compounds in terms of factors affecting health worldwide is examined, it has been observed that the diet supported by vegetables and fruits prolongs the deformation time of the body and organs. However, it has a protective effect on many diseases such as cardiovascular diseases, inflammatory and rheumatic diseases in the bones of the hands and feet, diseases caused by the irregular division of cells, diseases caused by the lungs, and disorders in the eye (Szajdek and Borowska, 2008). Almond kernels are a good source of phenolic compounds (Bolling et al., 2010). Almond phenolics are mainly polyphenolics of the flavonoid type (Wijeratne et al., 2006; Bolling et al., 2010). It has been reported that almonds' total phenol and polyphenol content vary between 60.2-175.1 mg GAE/100 g and 14.6-27.2 mg/100 g, respectively (Kodad, 2006; Milbury et al., 2006; Bolling et al., 2010). Catechin is the main phenolic acid ranging from 11.1-227.2 μg/g, followed by caffeic acid (2.9-32.1 μg/g), epicatechin (2.0–23.5 μg/g) and gallic acid (2.4–6.1 μg/g) (Yıldırım et al. al., 2010).

Augustin and Unnithan (1981) determined that the total phenolic content of almond samples was severely affected during the ripening period. In other words, they concluded that the phenol content is higher in unripe fruits. Because phenolic compounds are used as secondary metabolites for the defense mechanisms of plants, thus, they allow young fruits to complete their developmental stages by protecting them in their maturation and reproductive functions (Maieves et al., 2015). Bolling et al. (2010) reported that flavonoids and total polyphenols depend on variety rather than environmental conditions.

7. Carbohydrates and Fibre

The only forms of carbohydrates found in almond kernels that can be digested, absorbed and metabolized by humans as energy sources are sugars, starch and some sugar alcohols (Gradziel, 2017). Non-starch polysaccharides are indigestible and, therefore cannot be used as an energy source, but they promote physiological effects that are beneficial for human health (Yada et al., 2011).

It has been reported that the soluble sugar content ranges from 1.8 g/100 g (Amrein et al., 2005) to 13 g/100 g (Balta et al., 2009). Most soluble sugars are non-reducing, and sucrose represents more than 90% of the total (Socias i Company et al., 2008). Other sugars include raffinose, glucose, fructose, sorbitol, and inositol (Schirra, 1997; Saura-Calixto et al., 1984a). Some investigators have reported that carbohydrates change during the development of the almond fruit, resulting in a drastic decrease in all sugars two months before harvest (Kazantzis et al., 2003; Egea et al., 2009).

Egea et al. (2009) reported that the main sugar component is sucrose in almonds at harvest, that glucose and fructose contents are insignificant at this stage, and that mannose and arabinose are not detected. Sánchez-Bel et al. (2008), in a study conducted with the cultivar 'Guara,' determined that the sucrose and glucose content of the fruits in the gardens irrigated with drip irrigation were higher than in the orchards that were not irrigated.

In addition to polysaccharides in almonds, there are 10 grams of dietary fiber in 100 grams of almonds (Socias i Company et al., 2008). Saura-Calixto et al. (1988) reported that this fiber positively affects colon health and cholesterol level. Almond fiber consists of cellulose, hemicellulose and lignin (Vidal Valverde et al., 1982).

8. Conclusion

Almonds, used as a by-product in many industries and for fresh consumption, contain many phytochemicals with potential health benefits. It includes a significant amount of quality protein, especially globulins, essential minerals and fiber with low sugar content. It has been reported that varieties, ecological factors, topography, cultural practices, climate and soil characteristics, and pre-harvest and post-harvest factors affect the nutritional content of almonds. However, to clarify the effects of almond phytochemicals on the quality and quantity, more profound studies are needed on drying, blanching, storage, roasting processes and their nutrient content as by-products, factors that cause changes under agricultural and environmental conditions, and especially genetic factors.

Standard methods used today make it difficult to extract and quantify almond phytochemicals. Increasingly, microwave, supercritical fluids and ultrasound-based methods have been used.

There are very few studies on the evaluation of non-lipid compounds derived from almonds. Accordingly, the nutritional composition of the non-lipid fraction of almonds, the by-products remaining after oil extraction, and the source of protein, fiber and mineral substances may be more involved in food applications.

9. References

Abaspour, M., Imani, A., & Hassanlo, T. (2012). Effects of almond genotype and growing location on oil percentage and fatty acid composition of its seeds.

Abdallah, A., Ahumada, M. H., & Gradziel, T. M. (1998). Oil content and fatty acid composition of almond kernels from different genotypes and California production regions. *Journal of the American Society for Horticultural Science*, 123(6), 1029-1033. https://doi.org/10.21273/JASHS.123.6.1029

Agunbiade, S. O., & Olanlokun, J. O. (2006). Evaluation of some nutritional characteristics of Indian almond (Prunus amygdalus) nut. *Pakistan journal of nutrition*. http://dx.doi.org/10.3923/pjn.2006.316.318

Ahrens, S., Venkatachalam, M., Mistry, A. M., Lapsley, K., & Sathe, S. K. (2005). Almond (*Prunus dulcis* L.) protein quality. *Plant Foods for Human Nutrition*, 60(3), 123-128. https://doi.org/10.1007/s11130-005-6840-2

Akpambang, V. O. E., Amoo, I. A., & Izuagie, A. A. (2008). Comparative compositional analysis on two varieties of melon (*Colocynthis citrullus* and *Cucumeropsis edulis*) and a variety of almond (*Prunus amygdalus*). *Research Journal of Agriculture and Biological Sciences*, 4(6), 639-642.

Alasalvar, C., & Shahidi, F. (2008). Tree nuts: Composition, phytochemicals, and health effects: An overview (pp. 15-24). CRC press. eBook.ISBN9780429075025

Albala, K. (2009). Almonds along the Silk Road: The exchange and adaptation of ideas from West to East. *Petits Propos Culinaires*, 88, 19.

Alessandroni, A. (1980). Le mandorle. Panificazione e Pasticceria 8, 67–71.

Amrein, T. M., Lukac, H., Andres, L., Perren, R., Escher, F., & Amadò, R. (2005). Acrylamide in roasted almonds and hazelnuts. *Journal of Agricultural and Food Chemistry*, 53(20), 7819-7825. https://doi.org/10.1021/jf051132k

Askin, M. A., Balta, M. F., Tekintas, F. E., Kazankaya, A., & Balta, F. (2007). Fatty acid composition affected by kernel weight in almond [*Prunus dulcis* (Mill.) DA Webb.] genetic resources. *Journal of food composition and analysis*, 20(1), 7-12. https://doi.org/10.1016/j.jfca.2006.06.005

Aslantas, R., Guleryuz, M., & Turan, M. (2001). Some chemical contents of selected almond (*Prunus amygdalus* Batsch) types. *Cahiers Options Méditerranéennes*, 56, 347-350.

Augustin, A., & Unnithan, V. K. G. (1981). An attempt on maturity of cashew apple. Indian Cashew Journal.

Ayadi, M., Ghrab, M., Gargouri, K., Elloumi, O., Zribi, F., Ben Mimoun, M., Boulares, C. and Guedri, W. (2006). Kernel characteristics of almond cultivars under rainfed conditions. *Acta Horticulturae*, 726, 377. http://dx.doi.org/10.17660/ActaHortic.2006.726.61

Balta, F., Battal, P., Balta, F.M. and Yoruk, H.I. (2009). Free sugar compositions based on kernel taste in almond genotypes Prunus dulcis from Eastern Turkey. *Chemistry of Natural Compounds*, 45(2), 221-224. https://doi.org/10.1007/s10600-009-9296-z

Barbera, G., Di Marco, L., La Mantia, T., & Schirra, M. (1994). Effect of rootstock on productive and qualitative response of two almond varieties. *In I International Congress on Almond*, 373 (pp.129-134). https://doi.org/10.17660/ActaHortic.1994.373.17

Barreira, J. C., Casal, S., Ferreira, I. C., Peres, A. M., Pereira, J. A., & Oliveira, M. B. P. (2012). Supervised chemical pattern recognition in almond (*Prunus dulcis*) Portuguese PDO cultivars: PCA-and LDA-based triennial study. *Journal of agricultural and food chemistry*, 60(38), 9697-9704. https://doi.org/10.1021/jf301402t

Barreira, J., Pereira, J. A., Oliveira, M. B. P. P., & Ferreira, I. C. (2010). Sugars profiles of different chestnut (*Castanea sativa* Mill.) and almond (*Prunus dulcis*) cultivars by HPLC-RI. *Plant Foods for Human Nutrition*, 65(1), 38-43. https://doi.org/10.1007/s11130-009-0147-7

Bolling, B. W., Chen, C. Y. O., McKay, D. L., & Blumberg, J. B. (2011). Tree nut phytochemicals: composition, antioxidant capacity, bioactivity, impact factors. A systematic review of almonds, Brazils, cashews, hazelnuts, macadamias, pecans, pine nuts, pistachios and walnuts. *Nutrition research reviews*, 24(2), 244-275. https://doi.org/10.1017/S095442241100014X

Bolling, B. W., Dolnikowski, G., Blumberg, J. B., & Chen, C. Y. O. (2010). Polyphenol content and antioxidant activity of California almonds depend on cultivar and harvest year. *Food chemistry*, 122(3), 819-825. https://doi.org/10.1016/j.foodchem.2010.03.068

Bonvehí, J. S., & Coll, F. V. (1993). Oil content, stability and fatty acid composition of the main varieties of Catalonian hazelnuts (*Corylus avellana* L.). *Food Chemistry*, 48(3), 237-241. https://doi.org/10.1016/0308-8146(93)90133-Z

Brigelius-Flohé, R., Kelly, F. J., Salonen, J. T., Neuzil, J., Zingg, J. M., & Azzi, A. (2002). The European perspective on vitamin E: current knowledge and future research. *The American journal of clinical nutrition*, 76(4), 703-716. https://doi.org/10.1093/ajcn/76.4.703

Brufau, G., Boatella, J., & Rafecas, M. (2006). Nuts: source of energy and macronutrients. *British Journal of Nutrition*, 96(S2), S24-S28. https://doi.org/10.1017/BJN20061860

Calixto, F. S., Cañellas, J., & de Toda, F. M. (1982). A chemical study of the protein fraction of mediterranean sweet almond varieties (*Prunus amygdalus*). *Zeitschrift für Lebensmittel-Untersuchung und Forschung*, 175(1), 34-37. https://doi.org/10.1007/BF01267829

Çelik, F., & Balta, M. F. (2011). Kernel fatty acid composition of Turkish almond (*Prunus dulcis*) genotypes: a regional comparison. Journal of Food, *Agriculture & Environment*, 9(1), 171-174.

Cherif, A., Belkacemi, K., Kallel, H., Angers, P., Arul, J., & Boukhchina, S. (2009). Phytosterols, unsaturated fatty acid composition and accumulation in the almond kernel during harvesting period: Importance for development regulation. *Comptes Rendus Biologies*, 332(12), 1069-1077. https://doi.org/10.1016/j.crvi.2009.09.012

Chung, K. H., Shin, K. O., Hwang, H. J., & Choi, K. S. (2013). Chemical composition of nuts and seeds sold in Korea. *Nutrition research and practice*, 7(2), 82-88. https://doi.org/10.4162/nrp.2013.7.2.82

Čolić, S., Rakonjac, V., Zec, G., Nikolic, D., & Aksic, M. F. (2012). Morphological and biochemical evaluation of selected almond [*Prunus dulcis* (Mill.) DA

Webb] genotypes in northern Serbia. *Turkish Journal of Agriculture and Forestry*, 36(4), 429-438. https://doi.org/10.3906/tar-1103-50

Cordeiro, V., Oliveira, M., Ventura, J., & Monteiro, A. (2001). Study of some physical characters and nutritive composition of the Portuguese's (local) almond varieties. *Cahiers Options Méditerranéennes*, 56, 333-337. https://om.ciheam.org/om/pdf/c56/01600199.pdf

Daoud, H. N., Miller, M. W., & Luh, B. S. (1977). Effect of commercial processing on vitamin B6 retention in almonds. *Canadian Institute of Food Science and Technology Journal*, 10(4), 244-246. https://doi.org/10.1016/S0315-5463(77)73543-6

Dikmen, D. (2015). Sert Kabuklu Kuruyemişler ve Sağlık Üzerine Etkileri. Beslenme ve Diyet Dergisi, 43(2), 174-182.

Drogoudi, P. D., Pantelidis, G., Bacchetta, L., De Giorgio, D., Duval, H., Metzidakis, I., & Spera, D. (2013). Protein and mineral nutrient contents in kernels from 72 sweet almond cultivars and accessions grown in France, Greece and Italy. *International Journal of Food Sciences and Nutrition*, 64(2), 202-209. https://doi.org/10.3109/09637486.2012.728202

Egea, G., González-Real, M. M., Baille, A., Nortes, P. A., Sánchez-Bel, P., & Domingo, R. (2009). The effects of contrasted deficit irrigation strategies on the fruit growth and kernel quality of mature almond trees. *Agricultural water management*, 96(11), 1605-1614. https://doi.org/10.1016/j.agwat.2009.06.017

Esteban, R. M. (1985). Estudio Comparativo de la Calidad Nutritiva de Variedades de Almendra del SE y NE español. *Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria* (INIA): Madrid, Spain.

Fasoli, E., D'Amato, A., Kravchuk, A. V., Citterio, A., & Righetti, P. G. (2011). In-depth proteomic analysis of non-alcoholic beverages with peptide ligand libraries. I: Almond milk and orgeat syrup. *Journal of proteomics*, 74(7), 1080-1090. https://doi.org/10.1016/j.jprot.2011.03.016

Font i Forcada, C., Kodad, O., Juan, T., Estopañán, G. and Socias i Company, R. (2011). Genetic variability and pollen effect on the transmission of the chemical components of the almond kernel. *Spanish Journal of Agricultural Research* 9, 781–789.

García-López, C., Grané-Teruel, N., Berenguer-Navarro, V., García-García, J. E., & Martín-Carratalá, M. L. (1996). Major fatty acid composition of 19 almond cultivars of different origins. A chemometric approach. *Journal of Agricultural and Food Chemistry*, 44(7), 1751-1755. https://doi.org/10.1021/jf950505m

Garcia-Pascual, P., Mateos, M., Carbonell, V., & Salazar, D. M. (2003). Influence of storage conditions on the quality of shelled and roasted almonds. *Biosystems engineering*, 84(2), 201-209. https://doi.org/10.1016/S1537-5110(02)00262-3

Gou, P., Diaz, I., Guerrero, L., Valero, A., Arnau, J., & Romero, A. (2000). Physico-chemical and sensory property changes in almonds of Desmayo Largueta variety during toasting/Cambios en las propiedades físico-químicas y sensoriales de almendras de la variedad Desmayo Largueta durante el tostado. *Food science and technology international*, 6(1), 1-7. https://doi.org/10.1177/108201320000600101

Gradziel, T. M. (Ed.). (2017). Almonds: botany, production and uses. *Cabi*.

Hall, A. P., Moore, J. G., Gunning, B., & Cook, B. B. (1958). Nutrients in nuts, the nutritive value of fresh and roasted California grown nonpareil almonds. *Journal of Agricultural and Food Chemistry*, 6(5), 377-382. https://doi.org/10.1021/jf60087a008

Harris, N. E., Westcott, D. E., & Henick, A. S. (1972). Rancidity in almonds: shelf life studies. *Journal of Food Science*, 37(6), 824-827. https://doi.org/10.1111/j.1365-2621.1972.tb03679.x

Karatay, H., Sahin, A., Yilmaz, Ö., & Aslan, A. (2014). Major fatty acids composition of 32 almond (*Prunus dulcis* [Mill.] DA Webb) genotypes distributed in East and Southeast of Anatolia. *Turkish Journal of Biochemistry*, 39(3). doi: 10.5505/tjb.2014.55477

Kazantzis, I., Nanos, G.D. and Stavroulakis, G.G. (2003). Effect of harvest time and storage conditions on almond kernel oil and sugar composition. *Journal of Science of Food and Agriculture* 83, 354–359.

Kester, D.E., Cunningham, S. and Kader, A.A. (1993). Almonds. In: Macrae, R., Robinson, R.K. and Sadler, M.J. (eds) Encyclopedia of Food Science, *Food Technology and Nutrition*. Academic Press, London, pp. 121–126.

Kiani, S., Rajabpoor, S., Sorkheh, K., & Ercisli, S. (2015). Evaluation of seed quality and oil parameters in native Iranian almond (*Prunus* L. spp.) species. *Journal of forestry research*, 26(1), 115-122. https://doi.org/10.1007/s11676-014-0009-5

Kodad, O. (2006). Criterios de selección y de evaluación de nuevas obtenciones autocompatibles en un programa de mejora genética del almendro (*Prunus amygdalus* batsch.) (Doctoral dissertation, Universitat de Lleida).

Kodad, O. (2017). 18 Chemical Composition of Almond Nuts. Almonds: botany, production and uses, 428.

Kodad, O., & Socias i Company, R. (2008). Variability of oil content and of major fatty acid composition in almond (*Prunus amygdalus* Batsch) and its relationship with kernel quality. *Journal of agricultural and food chemistry*, 56(11), 4096-4101. https://doi.org/10.1021/jf8001679

Kodad, O., Alonso, J. M., Espiau, M. T., Estopañán, G., & Juan, T. (2011a). Chemometric characterization of almond germplasm: compositional aspects involved in quality and breeding. *Journal of the American Society for Horticultural Science,* 136(4), 273-281. https://doi.org/10.21273/JASHS.136.4.273

Kodad, O., Estopañán, G., Juan, T., & i Company, R. S. (2014). Tocopherol concentration in almond oil from Moroccan seedlings: Geographical origin and post-harvest implications. *Journal of Food Composition and Analysis*, 33(2), 161-165. https://doi.org/10.1016/j.jfca.2013.12.010

Kodad, O., Estopañán, G., Juan, T., & Socias i Company, R. (2013). Protein content and oil composition of almond from Moroccan seedlings: Genetic diversity, oil quality and geographical origin. *Journal of the American Oil Chemists' Society*, 90(2), 243-252. https://doi.org/10.1007/s11746-012-2166-z

Kodad, O., Estopanan, G., Juan, T., Mamouni, A., & Socias i Company, R. (2011b). Tocopherol concentration in almond oil: Genetic variation and environmental effects under warm conditions. *Journal of Agricultural and Food Chemistry*, 59(11), 6137-6141. https://doi.org/10.1021/jf200323c

Kodad, O., Socias i Company, R., Estopañán, G., Juan, T., Molino, F., Mamouni, A., Messaoudi, Z. and Lahlo, M. (2010). Plasticity and stability of major fatty acids in almond cultivars under Mediterranean climate. *Journal of Horticultural Science and Biotechnology* 85, 381–386. https://doi.org/10.1080/14620316.2010.11512684

Kodad, O., Socias i Company, R., Prats, M. S., & López Ortiz, M. C. (2006). Variability in tocopherol concentrations in almond oil and its use as a selection criterion in almond breeding. *The Journal of Horticultural Science and Biotechnology*, 81(3), 501-507. https://doi.org/10.1080/14620316.2006.11512094

Kumar, K., Sharma, S. D., & Goyal, R. K. (2000). Enzymatic changes and oil accumulation during almond kernel development. In XXV International Horticultural Congress, Part 5: Culture Techniques with Special Emphasis on Environmental Implications 515 (pp. 287-296). https://doi.org/10.17660/ActaHortic.2000.515.36

López-Ortiz, C. M., Prats-Moya, S., Sanahuja, A. B., Maestre-Pérez, S. E., Grané-Teruel, N., & Martín-Carratalá, M. L. (2008). Comparative study of tocopherol homologue content in four almond oil cultivars during two consecutive years. *Journal of Food Composition and Analysis*, 21(2), 144-151. https://doi.org/10.1016/j.jfca.2007.09.004

Maestri, D., Martínez, M., Bodoira, R., Rossi, Y., Oviedo, A., Pierantozzi, P., & Torres, M. (2015). Variability in almond oil chemical traits from traditional cultivars and native genetic resources from Argentina. *Food chemistry*, 170, 55-61. https://doi.org/10.1016/j.foodchem.2014.08.073

Mahmoud, K. M., & Yasin, R. T. (2016). Quantitative Analysis of Some Metals in Alomond Kernel in Erbil City. *Int. J. Pharma Sci. Res*, 7, 32-37.

Maieves, H. A., López-Froilán, R., Morales, P., Pérez-Rodríguez, M. L., Ribani, R. H., Cámara, M., & Sánchez-Mata, M. C. (2015). Antioxidant phytochemicals of Hovenia dulcis Thunb. peduncles in different maturity stages. *Journal of functional foods*, 18, 1117-1124. https://doi.org/10.1016/j.jff.2015.01.044

Mandalari, G., Nueno-Palop, C., Bisignano, G., Wickham, M. S. J., & Narbad, A. (2008). Potential prebiotic properties of almond (*Amygdalus communis* L.) seeds. *Applied and environmental microbiology*, 74(14), 4264-4270. https://doi.org/10.1128/AEM.00739-08

Martín Carratalá, M. L., Garcia-Lopez, C., Berenguer-Navarro, V., & Grané-Teruel, N. (1998). New contribution to the chemometric characterization of almond cultivars on the basis of their fatty acid profiles. *Journal of Agricultural and Food Chemistry*, 46(3), 963-967. https://doi.org/10.1021/jf970672h

Mehran, M., & Filsoof, M. (1974). Characteristics of Iranian almond nuts and oils. *Journal of the American Oil Chemists Society*, 51(10), 433-434. https://doi.org/10.1007/BF02635147

Milbury, P. E., Chen, C. Y., Dolnikowski, G. G., & Blumberg, J. B. (2006). Determination of flavonoids and phenolics and their distribution in almonds. *Journal of agricultural and food chemistry*, 54(14), 5027-5033. https://doi.org/10.1021/jf0603937

Moodley, R., Kindness, A., & Jonnalagadda, S. B. (2007). Elemental composition and chemical characteristics of five edible nuts (almond, Brazil, pecan, macadamia and walnut) consumed in Southern Africa. *Journal of Environmental Science and Health*, Part B, 42(5), 585-591. https://doi.org/10.1080/03601230701391591

Nanos, G. D., Kazantzis, I., Kefalas, P., Petrakis, C., & Stavroulakis, G. G. (2002). Irrigation and harvest time affect almond kernel quality and composition. *Scientia Horticulturae*, 96(1-4), 249-256. https://doi.org/10.1016/S0304-4238(02)00078-X

Nassar, A. R., El-Tahawi, B. S., & Sari El-Deen, S. A. (1977). Chromatographic identification of oil and amino acid constitutents in kernels of some almond varieties. *Journal of the American Oil Chemists' Society*, 54(11), 553-556. https://doi.org/10.1007/BF02909081

Oliveira, I., Meyer, A. S., Afonso, S., Aires, A., Goufo, P., Trindade, H., & Gonçalves, B. (2019). Phenolic and fatty acid profiles, α-tocopherol and sucrose contents, and antioxidant capacities of understudied Portuguese almond cultivars. *Journal of food biochemistry*, 43(7), e12887. https://doi.org/10.1111/jfbc.12887

Ozcan, M. M., Endes, Z., & Er, F. (2010). Physical and chemical properties of some seed and kernel oils. *Asian Journal of Chemistry*, 22(8), 6531-6536.

Pascual-Albero, M. J., Pérez-Munuera, I., & Lluch, M. A. (1998). Estructura del cotiledón de la semilla de almendra (*Prunus amygdalus* L.) cruda, remoj ada y tostada/Cotyledon structure of raw, soaked and roasted almond (*Prunus amygdalus* L.). *Food science and technology international*, 4(3), 189-197. https://doi.org/10.1177/108201329800400305

Pershern, A. S., Breene, W. M., & Lulai, E. C. (1995). Analysis of factors influencing lipid oxidation in hazelnuts (*Corylus* spp. 1). *Journal of Food Processing and Preservation*, 19(1), 9-26. https://doi.org/10.1111/j.1745-4549.1995.tb00274.x

Prats-Moya, M. S., Grané-Teruel, N., Berenguer-Navarro, V., & Martín-Carratalá, M. L. (1999). A chemometric study of genotypic variation in triacylglycerol composition among selected almond cultivars. *Journal of the American Oil Chemists' Society*, 76(2), 267-272. https://doi.org/10.1007/s11746-999-0229-6

Reische, D.W., Lillard, D.A. and Eitenmiller, R.R. (1998) Antioxidants. In: Akoh, C.C. and Min, D.B. (eds) Food Lipids. *Chemistry, Nutrition, and Biotechnology*. Marcel Dekker, New York, pp. 423–448. https://doi.org/10.1201/9781315151854

Ren, Y., Waldron, K. W., Pacy, J. F., Brain, A., & Ellis, P. R. (2001). Chemical and histochemical characterisation of cell wall polysaccharides in almond seeds in relation to lipid bioavailability. In Biologically-active phytochemicals in food: analysis, metabolism, bioavailability and function. *Proceedings of the EUROFOODCHEM XI Meeting*, Norwich, UK, 26-28 September 2001 (pp. 448-452). Royal Society of Chemistry.

Richardson, D. P., Astrup, A., Cocaul, A., & Ellis, P. (2009). The nutritional and health benefits of almonds: a healthy food choice. *Food Sci. Technol. Bull. Funct. Foods*, 6, 41-50.

Romojaro, F., Riquelme, F., Gimenez, J. L., & Llorente, S. (1988). Fat content and oil characteristics of some almond varieties. *Fruit Science Reports* (Poland). ISSN : 0137-1479

Roncero, J. M., Álvarez-Ortí, M., Pardo-Giménez, A., Rabadán, A., & Pardo, J. E. (2020). Review about non-lipid components and minor fat-soluble bioactive compounds of almond kernel. *Foods*, 9(11), 1646. https://doi.org/10.3390/foods9111646

Ros, E., & Mataix, J. (2006). Fatty acid composition of nuts–implications for cardiovascular health. *British journal of nutrition*, 96(S2), S29-S35. https://doi.org/10.1017/BJN20061861

Ruggeri, S., Cappelloni, M., Gambelli, L., Nicoli, S., & Carnovale, E. (1998). Chemical composition and nutritive value of nuts grown in Italy. *Italian Journal of Food Science* (Italy). ISSN: 1120-1770

Sabaté, J., & Hook, D. G. (2020). Almonds, walnuts, and serum lipids. Handbook of lipids in human nutrition, 137-144.

Sabaté, J., Ros, E., & Salas-Salvadó, J. (2006). Nuts: nutrition and health outcomes. *British Journal of Nutrition*, 96(S2), S1-S2. https://doi.org/10.1017/BJN20061857

Sánchez-Bel, P., Egea, I., Martínez-Madrid, M. C., Flores, B., & Romojaro, F. (2008). Influence of irrigation and organic/inorganic fertilization on chemical quality of almond (*Prunus amygdalus* cv. Guara). *Journal of Agricultural and Food Chemistry*, 56(21), 10056-10062. https://doi.org/10.1021/jf8012212

Sathe, S. K. (1992). Solubilization, electrophoretic characterization and in vitro digestibility of almond (*Prunus amygdalus*) proteins 1, 2. *Journal of food* *biochemistry*, 16(4), 249-264. https://doi.org/10.1111/j.1745-4514.1992.tb00450.x

Sathe, S. K., Seeram, N. P., Kshirsagar, H. H., Heber, D., & Lapsley, K. A. (2008). Fatty acid composition of California grown almonds. *Journal of food science,* 73(9), C607-C614. https://doi.org/10.1111/j.1750-3841.2008.00936.x

Saura Calixto, F. (1988). La almendra: composición, variedades, desarrollo y maduración (No. 634.55). *Instituto Nacional de Investigaciones Agrarias* (España).

Saura-Calixto, F., Canellas, J., & Garcia-Raso, A. (1984a). Gas chromatographic analysis of sugars and sugar-alcohols in the mesocarp, endocarp, and kernel of almond fruit. *Journal of Agricultural and Food Chemistry*, 32(5), 1018-1020. https://doi.org/10.1021/jf00125a017

Saura-Calixto, F., Soler, L., & Cañellas, J. (1984b). Morphological and compositional changes during development and maturation of the almond (*Prunus amygdalus*). *Agrochimica*, 28(2-3), 175-184.

Schirra, M. (1997). Postharvest technology and utilization of almonds. *Horticultural Reviews*, 20, 267-311. https://doi.org/10.1002/9780470650646.ch4

Schirra, M., & Agabbio, M. (1989). Influence of irrigation on keeping quality of almond kernels. *Journal of food science*, 54(6), 1642-1645. https://doi.org/10.1111/j.1365-2621.1989.tb05178.x

Schirra, M., Mulas, M., Nieddu, G. and Virdis, F. (1994). Mineral content in Texas almonds during fruit growth and ripening. *Acta Horticulturae* 373, 207–214. https://doi.org/10.17660/ActaHortic.1994.373.29

Sen, C. K., Khanna, S., & Roy, S. (2007). Tocotrienols in health and disease: the other half of the natural vitamin E family. *Molecular aspects of medicine*, 28(5-6), 692-728. https://doi.org/10.1016/j.mam.2007.03.001

Simsek, M.; Gulsoy, E.; Yavic, A.; Arikan, B.; Yildirim, Y.; Olmez, N.; Erdogmus, B.; Boguc, F. (2018). Fatty acid, mineral and proximate compositions of various genotypes and commercial cultivars of sweet almond from the same ecological conditions. *Appl. Ecol. Environ. Res*, 16(3), 2957-71. http://dx.doi.org/10.15666/aeer/1603_29572971

Socias, R., Kodad, O., Alonso, J. M., & Gradziel, T. M. (2007). Almond quality: a breeding perspective. *Horticultural reviews*, 34, 197-238. https://doi.org/10.1002/9780470380147.ch3

Soler, L., Canellas, J., & Saura-Calixto, F. (1989). Changes in carbohydrate and protein content and composition of developing almond seeds. *Journal of agricultural and food chemistry*, 37(5), 1400-1404. https://doi.org/10.1021/jf00089a042

Summo, C., Palasciano, M., De Angelis, D., Paradiso, V. M., Caponio, F., & Pasqualone, A. (2018). Evaluation of the chemical and nutritional characteristics of almonds (*Prunus dulcis* (Mill). DA Webb) as influenced by harvest time and cultivar. *Journal of the Science of Food and Agriculture*, 98(15), 5647-5655. https://doi.org/10.1002/jsfa.9110

Szajdek, A., & Borowska, E. J. (2008). Bioactive compounds and health-promoting properties of berry fruits: a review. *Plant foods for human nutrition*, 63(4), 147-156. https://doi.org/10.1007/s11130-008-0097-5

Topçuoplu, E., & Ersan, L. Y. (2020). Fonksiyonel beslenmede bademin önemi. *Bursa Uludağ Üniversitesi Ziraat Fakültesi Dergisi*, 34(2), 427-441.

USDA. National Nutrient Database for Standard Reference Release 27 [cited 2022 Eylül]. Available from: https://data.nal.usda.gov/dataset/usda-national-nutrient-database-standard-reference-legacy-release

Venkatachalam, M., & Sathe, S. K. (2006). Chemical composition of selected edible nut seeds. *Journal of agricultural and food chemistry*, 54(13), 4705-4714. https://doi.org/10.1021/jf0606959

Vidal-Valverde, C., Blanco, I., & Rojas-Hidalgo, E. (1982). Pectic substances in fresh, dried, desiccated, and oleaginous Spanish fruits. *Journal of Agricultural and Food Chemistry*, 30(5), 832-835. https://doi.org/10.1021/jf00113a008

Whitney, E.N. and Rolfes, S.R. (2002). Understanding Nutrition. Wadsworth/Thomson Learning, Belmont, California.

Wijeratne, S. S., Abou-Zaid, M. M., & Shahidi, F. (2006). Antioxidant polyphenols in almond and its coproducts. *Journal of Agricultural and Food Chemistry*, 54(2), 312-318. https://doi.org/10.1021/jf051692j

Yada, S., Huang, G., & Lapsley, K. (2013). Natural variability in the nutrient composition of California-grown almonds. *Journal of food composition and analysis*, 30(2), 80-85. https://doi.org/10.1016/j.jfca.2013.01.008

Yada, S., Lapsley, K., & Huang, G. (2011). A review of composition studies of cultivated almonds: Macronutrients and micronutrients. *Journal of Food Composition and Analysis*, 24(4-5), 469-480. https://doi.org/10.1016/j.jfca.2011.01.007

Yıldırım, H., Onay, A., Süzerer, V., Tilkat, E., Ozden-Tokatli, Y., & Akdemir, H. (2010). Micrografting of almond (*Prunus dulcis* Mill.) cultivars "Ferragnes" and "Ferraduel". *Scientia Horticulturae*, 125(3), 361-367. https://doi.org/10.1016/j.scienta.2010.04.022

Zacheo, G., Cappello, M. S., Gallo, A., Santino, A., & Cappello, A. R. (2000). Changes associated with post-harvest ageing in almond seeds. *LWT-Food Science and Technology*, 33(6), 415-423. https://doi.org/10.1006/fstl.2000.0679

Zhu, Y., Taylor, C., Sommer, K., Wilkinson, K., & Wirthensohn, M. (2015). Influence of deficit irrigation strategies on fatty acid and tocopherol concentration of almond (*Prunus dulcis*). *Food Chemistry*, 173, 821-826. https://doi.org/10.1016/j.foodchem.2014.10.108

CHAPTER 2

GRAPE LEAF IS AN EXCELLENT NUTRITIVE

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1. Introduction

Grapevine (*Vitis vinifera* L.) is a native crop of Mediterranean and Central Asia, cultivated since ancient times and used for various purposes. Grape's byproducts, such as raisins, wine, and particularly leaves, are widely exploited as traditional nutraceuticals. Stuffed grape leaves are one of the most popular dishes in Mediterranean food. Fresh leaves in conventional cooking are mainly eaten with meat, rice, and vegetables, a dish commonly known as dolma, a Turkish name for crammed vegetables (Heine, 2018). The cuisines have synonyms in Turkey and Greece as "dolma" and "dolmadakia", generally eaten with lemon at ambient temperatures (El et al., 1997).

Even though fresh leaves are preferable for consumption, grape leaves are generally preserved by canning due to quickly decreasing quality or decay in the post-harvest period. Grape leaves are harvested in a narrow period of the spring season when shoots are still young. Almost every grape variety in *Vitis vinifera* is used for leaf harvest in Turkey. We also know that the leaves of Isabella, a variety in *Vitis labrusca*, are commonly harvested to use in dolma in the Black Sea region.

Grapes contain diverse primary and secondary metabolites such as sugars, vitamins, polyphenols, and stilbenes (Anđelković et al., 2015; Aguilar, et al., 2016; Lima et al., 2016). Most secondary metabolites are already used in the food supplement industry and cosmetics. Studies addressing the biochemical diversity of grapevine are primarily focused on berries or wines that are of high interest commercially (Maia et al., 2019). However, grape leaves are valuable sources of such substances and shouldn't be overlooked. The leaves are rich sources of wide-spectrum polyphenolics and antioxidants utilized in traditional medicine for disorders like inflammation, diarrhea, and diabetes-induced hepatic complications (Nassiri-Asl and Hosseinzadeh, 2009; Lacerda et al., 2016).

2. Grape Primary Metabolites

Primary metabolites are the substances normally involve in yearly cycle of the grapevine during growth, development, or reproduction processes. Fresh grape leaves have an average of 8.1 g carbohydrates, 5.0 g dietary fiber, 6.0 g protein, 2.9 g total sugar, 34.2 g moisture, and 43.3 kcal energy in a portion of 100 g (Figure 1). Grape leaves contain fair amounts of carbohydrates and are a square food. Grape leaves possess relatively low calories compared to high sugar by-products such as raisins. The high level of carbohydrates the leaves contain does not mean a high glycemic index. Besides a low glycemic index, the leaves are a rich source of fiber that lower glucose levels in the blood. The elevated fiber ratio also helps digestion, thus better nutrient absorption.

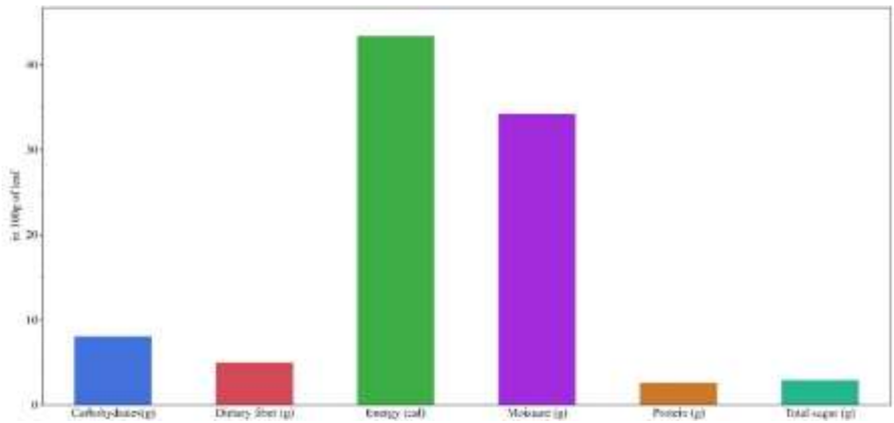

Figure 1. Some primary metabolites of fresh grape leaves (Rana et al., 2022).

3. Minerals and Vitamins in Grape Leaves

Vitamins are on of the main nutritional value exist in grape leaves. The amount of Mg, Zn, Cu, and Ca intake affects the severity of hidden hunger, a term used for describing insufficient citamin/mineral intake altought enough calories are taken (Torres et al., 2018). The hidden hunger is among the prior problems in developing countries (White and Broadley, 2009). Grape leaves are superior in terms of calsium (170.0 mg/g), potassium (126.7 mg/100g), and magnessium (43.3 mg/100g) minerals. Mineral content in leaves varies according to leaf parts, and the K and Mg contents of the petioles are reported to be higher than the leaf blades (Esetlili et al., 2020). Moreover, mineral contents in the petiole and leaf balde was reported to be highly correlated (Tepecik et al., 2013). Therefore, petioles of grape leaves are also significant nutracauticals. The leaves also rich in Vitamin A, E, and K (Figure 2). The grape leaf contains plenty of ascorbic acids (vitamin C), vitamin A, vitamin D, vitamin B1, and B2. Due to its high nutrient content (Eriş and Şeniz 1997), grape leaves can be dried and turned into a spice. Thus, maximum benefit can be obtained from grape leaves in terms of nutritional content (Alibaş, 2012).

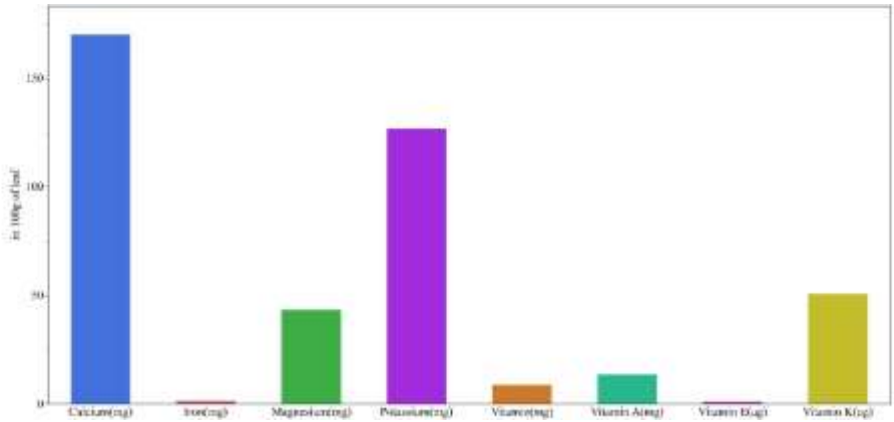

Figure 2. Some prominent vitamins and minerals exist in grape leaves.

4. Fatty Acid Profile of Grape Leaves

Most lipid molecules can be found in the membranes of plant cells and together they represent 5–10% of the dry weight of vegetative plant cells (Masuero et al., 2021). A 100 g portion of grape leaves contain 2.12 g total fat, 1.06 g polyunsaturated fat, 0.08 g monounsaturated fat (Ünver et al., 2007). Major fatty acids in grape leaves are C 18:1 oleic acid, C 14:0 myristic acid, C 18:0 stearic acid, C 18:2 ω6 linoleic acid, C 16:0 palmitic acid, and C 18:3 ω3 linolenic acid (Akin and Citil, 2012). Major saturated fatty acid in the leaves is reported to be myristic acid possessing almost 1/3 of total saturated acids (Demir and Otludil, 1997). Linoleic acid is one of the other prominent fatty acids abundantly exist in grape leaves (Della Corte et al., 2015). Polyunsaturated fatty acids are major components in fish oil and egg yolks, and their status is associated with several diseases like obesity, cardiovascular and immune functions, insulin action, neuronal development, and neuropsychiatric disorders such as depression and suicide risk (Zárate et al., 2017). Polyunsaturated fatty acids regulate lipid metabolism and possess anti-inflammatory and anticancer effects (Wang et al., 2014). Long-chain polyunsaturated fatty acids are considered cell membrane's structural components besides their function in intracellular signaling and metabolic pathways involved in the pathogenesis of vasoproliferative and retinal neurodegenerative disorders (SanGiovanni and Chew, 2005). When mentioned benefits of fatty acids evaluated, grape leaves stand out as a great nutrient containing more than 1% polyunsaturated fatty acids.

5. Polyphenol Status of Grape Leaves

Polyphenols and their effects on health attract more attention and are the subject of more research (Cvejić et al., 2022). Considering that they can prevent many cardiovascular and non-infectious diseases, the biological activities of polyphenols attract more and more attention every day (Scalbert et al., 2005). Many researchers have shown that grape leaves have high flavonoid content (Hmamouchi et al., 1996; Dresch et al., 2014; Harb et al., 2015; Handoussa et al., 2017). Among the flavonoids, especially quercetin derivatives have a high concentration (Goufo et al., 2020). Flavonoids are known to be beneficial to health by regulating cell signaling pathways and have antioxidant effects (Gupta et al., 2022). Quercetin was reported to exhibit successful results in treating cardiovascular disease, cancer, and neurodegenerative diseases (Ay et al., 2021). This compound has also been proven good against allergic reactions (Rakel and Minichiello, 2022). In addition, many other beneficial effects of quercetin are mentioned extensively in the research (Shebeko et al., 2018).

Correlation analysis to reveal the relationships between leaf phenolics disclosed some remarkable relationships and how these relationships changed in genotypes with different fruit colors. While mostly positive and strong relationships were determined between the polyphenols in the leaves of the red-fruited genotypes, the relationships between the phenolics in the green/yellow-fruited genotypes were weaker, and the number of negative relationships was higher. One of the exciting results was the association of ellagic acid with flavonoids. While this component exhibited relatively strong negative correlations with flavonoids in cultivars with red fruit, it formed relatively strong positive correlations with flavonoids in genotypes with green/yellow fruit. Gallic acid, on the other hand, had insignificant correlations with other polyphenols found in the leaves of red-fruited cultivars. In contrast, it was found to be strongly positively correlated with epicatechin in the leaves of /green/yellow fruited genotypes. For other relationships between leaf polyphenols, please review Figure 3.

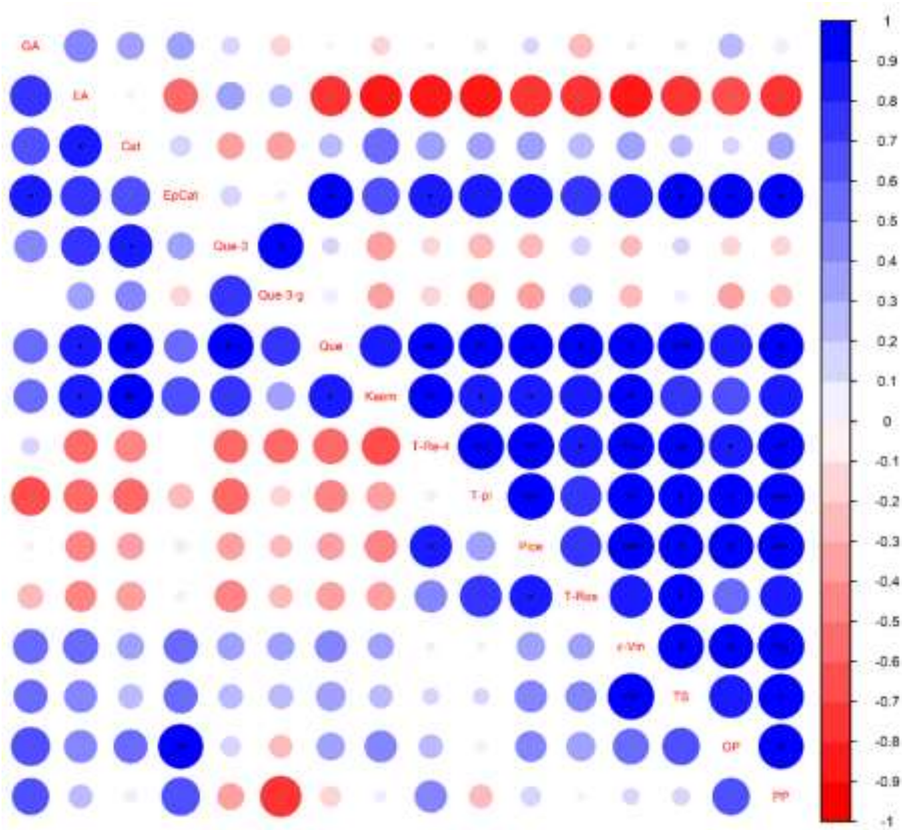

Figure 3. Correlations among some prominent polyphenols in leaves of red (upper triangle) and white (lower triangle) grape varieties. Correlation analyzes were performed in the "corrplot" package of R software by normalizing the data obtained from several studies.

6.Nutracautical Improvement

Plants are the major source of natural bioactive chemicals, which are employed in the pharmaceutical, dairy, and cosmetic sectors (Yılmaz et al., 2021a). However, the availability of plant-based compounds is limited by insufficient natural sources and technical difficulties in cultivation (Yılmaz et al., 2021b). Moreover, nutraceutical quantity is not always sufficient for chemical extract purposes. Biochemical substances and plant growth can be enhanced by microbial inoculants

(Yılmaz et al., 2022). Some studies demonstrated the additive effects of fertilizers on leaf nutraceuticals (Yağmur et al., 2005; Bekişli et al., 2016). Moreover, plant growth regulators/hormones can also contribute to leaf nutrients and quality (Kara and Akın, 2011).

7.Conclusions

Grape leaves are excellent sources of primary and secondary nutraceuticals. Grape leaves are a high-energy food and a high fiber source, which helps digestion and provides excellent benefits to the daily diet. Especially the high flavonoid content of the leaves is significant in increasing the resistance against epidemiological diseases that are increasing day by day and in reducing the risk of many other diseases. In addition, the fact that the leaves are rich in minerals makes them an excellent source of nutrients in terms of balanced nutrition in the diet. It should be ensured that leaf cultivation becomes more widespread by choosing varieties with high-quality leaves. It will be possible to obtain a better quality and good product using appropriate cultivation techniques and technology.

References

Aguilar, T., Loyola, C., de Bruijn, J., Bustamante, L., Vergara, C., von Baer, D., ... & Serra, I. (2016). Effect of thermomaceration and enzymatic maceration on phenolic compounds of grape must enriched by grape pomace, vine leaves and canes. *European food research and technology*, *242*(7), 1149-1158.

Akin, A., & Citil, O. B. (2012). Effects on fatty acid compositions of Müsküle grape leaves (Vitis vinifera L.) of different harvest times. *Asian Journal of Chemistry*, *24*(5), 2271-2273.

Alibaş, İ. (2012). Asma yaprağının (Vitis vinifera L.) mikrodalga enerjisiyle kurutulması ve bazı kalite parametrelerinin belirlenmesi.

Anđelković, M., Radovanović, B., Anđelković, A. M., & Radovanović, V. (2015). Phenolic compounds and bioactivity of healthy and infected grapevine leaf extracts from red varieties Merlot and Vranac (Vitis vinifera L.). *Plant foods for human nutrition*, *70*(3), 317-323.

Ay, M., Charli, A., Jin, H., Anantharam, V., Kanthasamy, A., & Kanthasamy, A. G. (2021). Quercetin. In *Nutraceuticals* (pp. 749-755). Academic Press.

Bekişli, M., Gürsöz, S., & Adıgüzel, A. (2016). Farklı Zamanlarda ve Dozlarda Uygulanan Nanoteknolojik Yaprak Gübresinin Merlot (Vitis vinifera L.) Üzüm Çeşidinin Verim ve Bazı Kalite Özelliklerine Etkisi. *Harran Tarım ve Gıda Bilimleri Dergisi*, *20*(1), 46-61.

Cvejić, J., Krstonošić, M. A., Mikulić, M., & Miljić, U. (2022). Polyphenols. In *Nutraceutical and functional food components* (pp. 243-312). Academic Press.

Della Corte, A., Chitarrini, G., Di Gangi, I. M., Masuero, D., Soini, E., Mattivi, F., & Vrhovsek, U. (2015). A rapid LC–MS/MS method for quantitative profiling of fatty acids, sterols, glycerolipids, glycerophospholipids and sphingolipids in grapes. *Talanta*, *140*, 52-61.

Demir, R., & Otludil, B. (1997). Investigation of the saturated and unsaturated fatty acids in the internodes and leaves of Vitis vinifera L.(Mazruma). *Biochemical archives*, *13*(4), 223-228.

Doğan, A., & Uyak, C., (2020). A Different Approach for Grape Leaf Color. *Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi*, *37*(1), 44-52.

Dresch, R. R., Dresch, M. K., Guerreiro, A. F., Biegelmeyer, R., Holzschuh, M. H., Rambo, D. F., & Henriques, A. T. (2014). Phenolic compounds from the leaves of Vitis labrusca and Vitis vinifera L. as a source of waste byproducts: Development and validation of LC method and antichemotactic activity. *Food analytical methods*, *7*(3), 527-539.

EL, S. N., Kavas, A., & Karakaya, S. (1997). Nutrient composition of stuffed vine leaves: a Mediterranean dietary. *Journal of food quality*, *20*(4), 337-341.

Eriş, A., & Şeniz, V. (1997). Bahçe Bitkileri. *Uludağ Üniversitesi Ziraat Fakültesi Ders Notları*, (28).

Esetlili, B. Ç., Merken, Ö., Güler, A., Pekcan, T., Karabat, S., Akay, Ü. N. A. L., ... & Eryüce, N. (2020). Cabernet Sauvignon Şaraplık Üzüm Çeşidinde Farklı Potasyumlu Gübre Uygulamalarının Yaprak Besin Element İçerikleri Üzerine Etkileri. *Ege Üniversitesi Ziraat Fakültesi Dergisi*, 9-16.

Goufo, P., Singh, R. K., & Cortez, I. (2020). A reference list of phenolic compounds (including stilbenes) in grapevine (Vitis vinifera L.) roots, woods, canes, stems, and leaves. *Antioxidants, 9*(5), 398.

Gupta, P., Kour, J., Bakshi, M., & Kalsi, R. (2022). Flavonoids. In *Nutraceuticals and Health Care* (pp. 105-113). Academic Press.

Handoussa, H., Hanafi, R., El-Khatib, A., Linscheid, M., Mahran, L., & Ayoub, N. (2017). Computer-assisted HPLC method development using DryLab for determination of major phenolic components in Corchorus olitorius and Vitis vinifera by using HPLC-PDA-ESI-TOF-MSn. *Res. Rev. J. Bot. Sci*, *6*, 9-16.

Harb, J., Alseekh, S., Tohge, T., & Fernie, A. R. (2015). Profiling of primary metabolites and flavonols in leaves of two table grape varieties collected from semiarid and temperate regions. *Phytochemistry*, *117*, 444-455.

Harb, J., Alseekh, S., Tohge, T., & Fernie, A. R. (2015). Profiling of primary metabolites and flavonols in leaves of two table grape varieties collected from semiarid and temperate regions. *Phytochemistry*, *117*, 444-455.

Hmamouchi, M., Es-Safi, N., Lahrichi, M., Fruchier, A., & Essassi, E. M. (1996). Flavones and flavonols in leaves of some Moroccan Vitis vinifera cultivars. *American Journal of Enology and Viticulture*, *47*(2), 186-192.

Kara, Z., & Akın, A. (2011). Müşküle Sofralık Üzüm Çeşidinde Gibberellik Asit (GA) Uygulamalarının Salamuralık Asma Yaprağı Üretimi ve Yaprakta Ham Sellüloz İçeriğine Etkileri. *Selcuk Journal of Agriculture and Food Sciences*, *25*(2), 42-45.

Lacerda, D. S., Costa, P. C., Funchal, C., Dani, C., & Gomez, R. (2016). Benefits of vine leaf on different biological systems. *Grape Wine Biotechnol*, *19*, 125-143.

Lima, A., Bento, A., Baraldi, I., & Malheiro, R. (2016). Selection of grapevine leaf varieties for culinary process based on phytochemical composition and antioxidant properties. *Food chemistry*, *212*, 291-295.

Maia, M., Ferreira, A. E., Laureano, G., Marques, A. P., Torres, V. M., Silva, A. B., ... & Silva, M. S. (2019). Vitis vinifera 'Pinot noir'leaves as a source of bioactive nutraceutical compounds. *Food & function*, *10*(7), 3822-3827.

Masuero, D., Škrab, D., Chitarrini, G., Garcia-Aloy, M., Franceschi, P., Sivilotti, P., ... & Vrhovsek, U. (2021). Grape Lipidomics: An Extensive Profiling thorough UHPLC-MS/MS Method. *Metabolites*, *11*(12), 827.

Nassiri-Asl, M., & Hosseinzadeh, H. (2009). Review of the pharmacological effects of Vitis vinifera (Grape) and its bioactive compounds. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *23*(9), 1197-1204.

Rakel, D., & Minichiello, V. (Eds.). (2022). *Integrative Medicine, E-Book*. Elsevier health sciences.

Rana, A., Kaur, J., Sharma, K., Singh, J., & Bhadariya, V. (2022). A comprehensive review on the nutritional value and health benefits of grape leaves.

SanGiovanni, J. P., & Chew, E. Y. (2005). The role of omega-3 long-chain polyunsaturated fatty acids in health and disease of the retina. *Progress in retinal and eye research*, *24*(1), 87-138.

Scalbert, A., Johnson, I. T., & Saltmarsh, M. (2005). Polyphenols: antioxidants and beyond. *The American journal of clinical nutrition*, *81*(1), 215S-217S.

Shebeko, S. K., Zupanets, I. A., Popov, O. S., Tarasenko, O. O., & Shalamay, A. S. (2018). Effects of quercetin and its combinations on health. In *Polyphenols: Mechanisms of Action in Human Health and Disease* (pp. 373-394). Academic Press.

Tepecik, M., Barlas, N. T., İrget, M. E., Ateş, F., & Ateş, B. (2013). Sultani Çekirdeksiz Üzüm Çeşidinde Bazı Kalite Özellikleri İle Yapraktaki Makro Besin Elementi İçeriğinin Belirlenmesi. *Selcuk Journal of Agriculture and Food Sciences*, *27*.

Torres, N., Antolín, M. C., Garmendia, I., & Goicoechea, N. (2018). Nutritional properties of Tempranillo grapevine leaves are affected by clonal diversity, mycorrhizal symbiosis and air temperature regime. *Plant Physiology and Biochemistry*, *130*, 542-554.

Ünver, A., Özcan, M., Arslan, D., & Akin, A. (2007). The lactic acid fermentation of three different grape leaves grown in Turkey. *Journal of food processing and preservation*, *31*(1), 73-82.

Wang, W., Zhu, J., Lyu, F., Panigrahy, D., Ferrara, K. W., Hammock, B., & Zhang, G. (2014). ω-3 polyunsaturated fatty acids-derived lipid metabolites on angiogenesis, inflammation and cancer. *Prostaglandins & other lipid mediators*, *113*, 13-20.

White, P. J., & Broadley, M. R. (2009). Biofortification of crops with seven mineral elements often lacking in human diets–iron, zinc, copper, calcium, magnesium, selenium and iodine. *New Phytologist*, *182*(1), 49-84.

Yağmur, B., Aydın, Ş., & Çoban, H. (2005). Bağda yapraktan demir (Fe) uygulamalarının yaprak besin element içeriklerine etkisi. *Ege Üniversitesi Ziraat Fakültesi Dergisi*, *42*(3), 135-145.

Yılmaz, A., Güler, E., Soydemir, H. E., Demirel, S., Mollahaliloğlu, S., Çiftçi, V., & Karadeniz, T. (2021a). Miracle Plant: Black Chokeberry (Aronia melanocarpa). MAS Journal of Applied Sciences, 6(1), 83-94.

Yılmaz, A., Soysal, S., Emiralioğlu, O., Yılmaz, H., Soydemir, H. E. ve Çiftçi, V. (2021b) Sürdürülebilir Tarımda Anıza Ekimin Önemi. M.F. Baran, K. Bellitürk ve A. Çelik (Ed) Türkiye'de Sürdürülebilir Tarım Uygulamaları: Zorluklar ve Potansiyeller (221-230. ss.). Adıyaman; Turkey: İKSAD.

Yılmaz, A., Yılmaz, H., Soydemir, H. E., & Çiftçi, V. Soya (Glycine max L.)'da PGPR ve AMF Uygulamalarının Verim Özellikleri ve Protein İçeriğine Etkisi. *Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi*, *8*(1), 108-118.

Zárate, R., el Jaber-Vazdekis, N., Tejera, N., Pérez, J. A., & Rodríguez, C. (2017). Significance of long chain polyunsaturated fatty acids in human health. *Clinical and translational medicine*, *6*(1), 1-19.

CHAPTER 3

COLORS AND ANTIOXIDANT VITAMINS IN FRUITS

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1. Introduction

One of the basic needs of human beings is nutrition. Today, with rapid population growth and urbanization, agricultural areas and therefore production amounts are decreasing (Soydemir and Yılmaz, 2022). Increasing the amount of production and protecting the existing agricultural areas are important in terms of meeting the nutritional needs of people (Özcan, 2018; Durmuş et al., 2018; Yılmaz et al., 2022). Fruits are valuable foods in terms of nutrition and health protection of people with their dietary fiber, minerals, vitamins, and phytochemicals, as well as being effective on appetite with their appearances and attractive colors (Yılmaz et al., 2021). Epidemiological studies recommend the consumption of fruits and vegetables to protect against many diseases, from cancer to obesity, skin and eye health, lung and bone diseases. The fact that fruits and vegetables protect people's health is due to the presence of vitamins A, C, and E, fibers, and secondary metabolites (Lara et al., 2020).

Nowadays, with the Covid-19 pandemic, it has been understood once again that the prevention of many diseases, especially the protection of the immune system, is through regular consumption of vegetables and fruits. Therefore, fruits and vegetables are increasingly included in diet and nutrition programs (Barrett and Lloyd, 2012).

Cancer, stress, insomnia, and some chronic diseases, which are among the most important diseases of our age, are triggered by unhealthy and irregular nutrition. Especially vitamin A deficiency negatively affects healthy development of the body and resistance to infections (Ötleş and Atlı, 1997). It is important for people to supplement their meals with antioxidant-rich foods in order to protect their health (Çevik and Pirinççi, 2017; Okçu and Keleş, 2009; Güleşci and Aygül, 2016).

Fruits are used in many areas other than nutrition. Fruit skin color is an indicator of maturity and quality in the fruit market (Figure 1). In addition, fruits attract the attention of consumers in the market with their attractive colors (Ranganath, 2022). Fruit trees are also considered ornamental plants with their alluring colors in park and garden arrangements, and landscape areas. It is possible to use fruits in many areas and they create their own language with their unique colors and contents and provide us with information.

Fruits are one of the important sources of vitamins and they contain different amounts of vitamins according to the species (Karadeniz, 2004). Vitamins A, C, and E, carotenoids, and phenolic compounds are known as the most common antioxidants found in plants (Çağlar and Demirci, 2017).

These antioxidant vitamins, carotenoids, and phenolic compounds are present in different amounts in fruits. In recent years, fruits are among the indispensable in nutrition programs as they are effective in protecting against diseases caused by free radicals. This is due to the fact that color of fruits are rich in antioxidants. The relationship between colors and foods are important, as consumers prefer red, blue, or purple-colored foods that are rich in antioxidants (Cömert et.al., 2020). It is necessary to take 3000 ORAC / day vitamins and minerals in daily nutrition (Özcan, 2018). This amount that should be taken can be met from fruits, which are the source of healing with their colors and contents (Karadeniz, 2004). In this section, information about the colors of fruits and antioxidant vitamins has been tried to be summarized. This section is based on compiled using reference data from TürKomp, the Turkish Food Composition Database (TürKomp, 2020), the USDA National Nutrient Database (USDA, 2020), and various researchers.

Figure 1. Some fleshy fruits.

2. Carotenoid Content in Color of Fruits

Pigments are various groups of natural chemical compounds synthesized in plants. There are four main groups of pigments: chlorophylls, carotenoids, flavonoids, and betalains (Solovchenko et al., 2019; Ranganath, 2022). Carotenoids and anthocyanins are the main pigments responsible for fruit colours (Ranganath, 2022). Karatoneids, which are yellow, orange, and red pigments (Miura et. al., 1998; Maoka, 2020), are distinguished by the nutrient richness of various foods

(Rocha and Reed, 2014) and are synthesized by plants (Karakurt and Aslantaş, 2008; Chapman, 2012). Anthocyanins are responsible for the colors red, blue and purple (Ranganath, 2022).

Carotenoids function as photoprotection, antioxidants, color attractants, and precursors of plant hormones in the non-photosynthetic organs of plants (Maoka, 2020). Color formation in plants varies according to the level of influence of nutrients, environmental factors, and pigments that affect coloration, as well as genetic factors (Karakurt and Aslantaş, 2008). They also provide additional nutrients in the form of dietary antioxidants (McGhie and Ainge, 2002). In nutrition, carotenoids are important in terms of conversion to vitamins (Granado et. al., 2003). The carotenoid with the highest vitamin A activity is the beta-carotenoid (Aktaş, 2021).

Beta-carotene and beta critoxanthin are carotenoids that provide orange color, lutein and zeaxanthin yellow color and lycopene red color (Yanmaz et al., 2015). Carotenoids cannot be synthesized by humans but must be obtained through food or supplements (Zimmer et al., 2022).

Fruits have rich beta-carotene content according to their color groups. While hazelnuts, walnuts, and pistachios, which are among the fruits in the brown color group, do not contain beta-carotene, chestnut contains 288 µg of beta-carotene. In the red-colored fruit group, beta-carotene contents are 145 µg in cornelian cherry, 141 µg in cherry and 127 µg in gilaburu fruit. In yellow fruit groups, this value is 160 µg in bananas.

Among the fruits in the orange color group, loquat fruit has the highest beta carotene content with 2110 µg, and this ratio contains the highest ratio in all fruit species. In the blue-purple color group, blackberry has the highest beta carotenoid content with 172 µg (Table 1). The higher the beta-carotene content is in the fruit, the higher the orange color intensity of the fruit will be (Chapman, 2012). Karataş and Çöteli (2016) reported that the richest fruit in terms of beta-carotene was blackberry with 71.14 µg/g fresh weight, and the poorest fruit was red grape with 5.91 µg/g fresh weight. Kazaz et al. (2009) reported the beta-carotene content of rosehip fruit as 3.25 µg/g.

Lycopene is an important type of carotenoid that gives the red color (Bramley, 2000). The lycopene content of fruits with red color is higher than other colored fruits. Unlike beta carotenoids, lycopene does not show provitamin A activity (Karataş and Çöteli, 2016; Ötleş and Atlı, 1997). Gilaburu, which is in the red-colored fruit group, contains 113 µg, raspberry 60 µg, cherry 7 µg, and strawberry 26 µg lycopene. While persimmon in the orange color group contains 107 µg and grapefruit contains 1209 µg lycopene, blackberry in the blue-purple fruit group contains 9 µg/100g lycopene (Table 1.). Karataş and Çöteli (2016), in a study conducted on fruit species, reported that the lycopene content was the highest in blackberries (52.19 mg/g), and the lowest in figs (0.40 mg/g). In a study conducted on rosehip, it was reported that the lycopene content was 12.90 – 35.18 mg/100g (Böhm et al., 2003). There may be differences in the amount of carotenoids between fruit colors and types. These differences may be caused by cultivar, genotype, climatic factors, growing conditions, and maturity stages.

Lutein is one of the carotenoids of the dietary origin of fruits and vegetables. Like beta-carotene, it does not have the activity of vitamin A in humans. Use of lutein visual system can be effective in improving. The sources of lutein, which are generally accepted as good food sources, are green vegetables such as dark spinach, broccoli, and lettuce (Granado et al., 2003). Fruits contain a significant amount of lutein. While the lutein content of chestnut, which is one of the fruits in the brown color group, is 135 µg, other fruits in the same group do not have lutein content. The lutein content of some fruits in the yellow color group is between 8-27 µg, while the fruit types in the red color group are between 3-85 µg. In orange fruits, lutein is between 14 µg (orange) - 44 µg (Persimmon), and in blue-purple fruits 64 µg (blueberry) and 125 µg (blackberry). Avocado, which is one of the green fruits, contains 46µg of lutein, while this value is 300 µg in kiwi. Kiwi is the richest fruit in terms of lutein content among all fruit species (Table 1). Perry et al. (2009) reported that they contain 15 µg of lutein in red apples, 53 µg in green grapes, 24 µg in red grapes, 171 µg in kiwis, 79 µg in green olives, and 11 µg in peaches in their study on xanthophyll contents. The contents of carotenoids may differ from each other in various sources and studies conducted by researchers. This shows that fruits can vary according to the ripening and harvesting times, the conditions of the country where they are grown, and the methods used (Perry et al., 2009; Granado et al., 2003).

Since fruits and vegetables have rich sources of carotenoids, they can reduce the risks of some cancer diseases and eye diseases (Eggersdorfer and Wyss, 2018). It can be said that beta-carotene, which is one of the important antioxidants in the daily diet of people, promotes the prevention of diseases (Maiani et al., 2009). It has been reported that beta carotene reduces the risks of lung and stomach cancer, regulates the immune system, has an anti-cancer effect (Ndayishimiye and Chun, 2017), and can prevent free radical-induced damage to DNA and molecules with its antioxidant activity (Krinsky and Johnson, 2005). Brain-cognitive functions and fertility of beta-carotene and lutein; maternal-infant nutrition of lutein, heart health of lycopene, anti-cancer and skin diseases; beta-carotene is known to prevent the treatment of immune, fertility, brain, and functional disorders (Eggersdorfer and Wyss, 2018).

3.Vitamin A Profile in Color of Fruits

Vitamins provided by various foods are used in the energy of cells. In the absence of vitamins, protein, fat, and sugars are blocked. Vitamins are divided into two groups; fat-soluble and water-soluble (Karadeniz, 2004). Vitamins A, D, E (tocopherol) and K are fat-soluble vitamins while Thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid, folic acid, B12, biotin, and C (Ascorbic acid) are water-soluble vitamins (Gabriela-Roxana and Oliviu-Mihnea, 2019). Fruits are the most important sources of vitamins (Karadeniz, 2004), they contain different amounts of vitamins according to species and ecological factors (Gabriela-Roxana and Oliviu-Mihnea, 2019).

Vitamin A regulates various metabolic and physiological activities necessary for the body (Chapman, 2012).Since carotenoids are a source of vitamin A (Zhou et al., 2007), they are used in a healthy diet (Burri et al., 2011; Poiroux-Gonord et al., 2010). Acting as an antioxidant, vitamin A strengthens immune function and takes a role in maintaining vision, growth, and integrity of epithelial and mucous tissue (Huang et al., 2018).

Among the fruit species, the Vitamin A content of loquat fruit is quite high (176 RE/100g). Carotenoids contribute to the orange color of the skin of loquat fruit, and especially red-fruit fleshed loquat varieties are a valuable source of provitamins (Zhou et al., 2007). It is seen that the vitamin A values of red-colored fruits such as cornelian cherry (12 RE/100 g), cherry laurel, and strawberry fruits are slightly higher compared to other fruits in the same group. Among the fruits with brown skin color, only chestnut (24 RE) contains vitamin A. Blackberry and grape contain 14 RE of vitamin A. The amount of vitamin A in kiwi, which is a green fruit, is 11 RE (Table 1).

Table 1. Vitamin A and carotene contents in color of fruits (100g).

Colors	Fruits	Vitamin A (RE)	Beta-carotene (µg)	Lycopene (µg)	Leucine (mg)	Lutein (µg)
Brown	Hazelnut				695	
	Walnut				967	
	Chestnut	24	288			135
	Almond				1316	
	Pistachio				972	
Red	Cornelian cherry	12	145			55
	Cherry laurel	12	19			29
	Gilaburu	2	127	113		45
	Raspberry	11	105	60		85
	Cherry	9	141	7		18
	Strawberry	12	90	26		18
	Pomegranate	7	30			3
Yellow	Banana	13	160			12
	Quince	8	91			10
	Pear	10	116	0		27
	Lemon	4	43			10
	Pineapple	7	81			8
Orange	Persimmon	21	248	107		44
	Orange	5	48			14
	Mandarin	17	200			38
	Peach	16	196			30
	Nectarine	12	143			23
	Grapefruit	65	781	1209		15
	Loquat	176	2110			22
	Apricot	67	809			20
Blue-Purple	Blueberries	8	100			64
	Fig	11	134			84

	Backberry	14	172	9	125
	Grape	14	166		76
Green	Kiwi	11			300
	Avocado	5	61		46

Source: TürKomp, 2022.

4. Vitamin C Profile in Color of Fruits

Plants contain different organic compounds in human nutrition, one of which is vitamin C (Dalkılıç, 2020). Ascorbic acid functions as an antioxidant (Santos and Silva, 2008) and is found naturally in many fruits (El-Ishaq and Obirinakem,2015; Naidu, 2003). It is used both as a vitamin supplement and as a food supplement (El-Ishaq and Obirinakem, 2015). Sensitive to air, light, and heat, vitamin C is used for long-term storage of foods and excessive processing can easily destroy it (Naidu, 2003). Vitamin C deficiency causes scurvy (Santos and Silva, 2008). Vitamin C found in fruits strengthens the immune system and has a role in the production of collagen, the breakdown of some amino acids, and carbohydrate and iron metabolism (Gabriela-Roxana and Oliviu-Mihnea, 2019). Fruits are sources of vitamin C (Martin et al., 2002).

Strawberry is the red-colored fruit with the highest vitamin C among fruit types at 75.5 mg. Cornelian cherry, which is in the same group, is a good source of vitamin C with 66.2 mg. The green kiwi has high amount of vitamin C content of 60.1 mg. Orange and mandarin in the orange group contain 45.3 mg and 42.4 mg of vitamin C, respectively. Pineapple is the fruit with the highest vitamin C content, with 59.3 mg in yellow fruits. It is known that the content of vitamin C in blue-purple colored fruits is considerably less compared to the fruits in the other color group (Table 2). In general, nuts are not good sources of vitamins A and C (Alasalvar and Bolling, 2015). Orsavová et al. (2019), gooseberry and currant are important sources of vitamin C, and red gooseberry varieties have higher vitamin C content than green ones. Orsavová et al. (2019) reported that the amount of ascorbic acid may differ depending on the light intensity, time of day, plant tissue age, and cell division.

5. Vitamin E Profile in Color of Fruits

Vitamin E is an important phenol antioxidant that is fat-soluble and abundant in most nuts (Alasalvar et al., 2003; Alasalvar and Bolling, 2015). Vitamin E includes α-,β-,γ-,δ-tocopherol and corresponding α-,β-,γ-,δ-tocotrienols. Vitamin E is a light yellow-amber colored, odorless oil that is sensitive to air and light, and darkens by oxidation. The most abundant vitamin E is α-tocopherol. Seeds, fruits, and green leafy vegetables are the best sources of vitamin E (Niki and Abe, 2019).

Nuts are known for their health-promoting aspects, especially for their role in reducing the risk of cardiovascular diseases, with their favorable lipid profile and low glycemic structure (Alasalvar and Bolling, 2015). Vitamin E has a vital role in the fight against various diseases such as atherosclerosis, oxidative stress, cancer, and cataracts. In addition, vitamin E can be effective against asthma, allergies and diabetes (Rizvi et al., 2014).

Nuts have rich vitamin E content. Almonds contain 24.79 α-TE while hazelnuts have 23.65 α-TE vitamin E. According to the data of TürKomp (2022), there is no vitamin E content in colored fruits. Almonds have the highest data in terms of riboflavin and niacin, pistachios in terms of thiamine and B6, and hazelnuts in terms of folate (Table 2).

There are limited sources of vitamin E content in colored fruits. Mukhtar et al. (2019) reported that the vitamin E content of persimmon is between 0.63-1.34 μg/g. Orsavová et al. (2019) reported that the vitamin E content in green gooseberry was between 0.43-6.11 $mg.kg^{-1}$, in red varieties 4.11-12.85 $mg.kg^{-1}$, in black currant varieties it was between 3.71-10.87 $mg.kg^{-1}$. The same authors also found vitamin E in gooseberry and blackcurrant seed oil and stated that blackcurrant seed oil contains higher amounts of vitamin E than gooseberry seed oil. In both oils, the predominant fraction was formed by γ-tocopherol. Also, oil composition and tocopherol fractions differed between cultivars.

Table 2. Vitamin Content in Color of Fruits (B6, C, E, Niacin, Thiamine, Folate, Riboflavin).

Colors	Fruits	Riboflavin (mg)	Niacin (mg)	Tiamine (mg)	Vitamin E (α-TE)	Folate (µg)	Vitamin B6 (mg)	Vitamin C (mg)
Brown	Hazelnut	0.136	1.792	0.605	23.65	98	0.515	
	Walnut	0.138	1.201	0.317	1.19	64	0.549	
	Chestnut	0.045	1.19	0.02	0,41		0.263	37.4
	Almond	0.804	3.533	0.204	24.79		0.141	
	Pistachio	0.227	1.406	0.662	1.48		1.613	
Red	Cornelian	0.021	0.347	0.01			0.043	66.2
	Gileboru	0.013	0.305	0.007			0.056	46
	Cherry	0.028	0.277	0			0.066	2.3
	Raspberry	0.031	0.467	0.09			0.032	20.6
	Cherry	0.024	0.382	0.008			0.033	6.6
	Strawberry	0.022	0.298	0.013		25	0.036	75.5
	Pomegranate	0.023	0.283	0.024			0.055	7
Yellow	Banana	0.028	0.803	0.021			0.349	8.6
	Quince	0.017	0.215	0.014		4	0.049	15.2
	Pear	0.014	0.319	0.011			0.019	4.8
	Lemon	0.027	0.333	0.033		14	0.052	24.3
	Pineapple	0.02	0.231	0.041			0.125	59.3
Orange	Persimmon	0.005	0.363	0.016			0.035	8.9
	Orange	0.029	0.291	0.026			0.099	45.3
	Mandarin	0.022	0.195	0.02			0.086	42.4
	Loquat	0.025	0.273	0.011			0.048	4.2
	Apricot	0.031	0.504	0.026			0.063	8.5
Blue-Purple	Blueberries	0.025	0.321	0.009			0.077	21.9
	Fig	0.038	0.335	0.036		8	0.174	2.1
	Blackberry	0.024	0.4	0.09		2	0.04	13.3
Green	Kiwi	0.025	0.346	0.009		32	0.096	60.1
	Avocado	0.128	1.12	0.059			0.211	8.5

Source: TürKomp, 2022.

6. Content of Phenolic Compound, Anthocyanin and Antioxidant in Color of Fruits

Phenolic compounds contribute to the sensory properties of fruits and vegetables such as color and taste. (Karabulut and Yemiş, 2019; Balasundram et al., 2006). Due to their antioxidant properties, phenolic compounds have many health benefits (Balasundram et al., 2006). The main dietary phenolic compounds are phenolic acids, flavonoids, and tannins (Balasundram et al., 2006). The most important plant in phenolic group is flovonides (Söylemezoğlu, 2003). Knowing the contents of phenolic compounds (Balasundram et al., 2006), which are abundant in fruits and vegetables, is important in terms of improving people's nutrition and health (Sun et al., 2002).

Anthocyanins are water-soluble natural pigments that impart a pink to purple color to fruits, vegetables, flowers, and other plants. The color of fruits is an important quality characteristic of anthocyanin accumulation (Lara et al., 2020). Anthocyanins attract attention with their antioxidant properties as well as giving fruits and vegetables their attractive color (Ersus and Yurdagel, 2006; Koca et al., 2006; Karakurt and Arslantaş, 2008). Chokeberry is a fruit rich in anthocyanins with both fruit and juice content (Yılmaz et al., 2021). These rates are 240mg/100g and 1562.2mg/100g DW, respectively. Among the red fruits, strawberries contain 60-80 g per 100 g of FW anthocyanins (Table 3).

Chokeberry contains 2080 mg and blueberry 525 mg of phenolic compounds. There are 120-315 mg phenolic compounds in red-colored cranberry fruit, 126 mg in raspberry, 182 mg in red grape and 225 mg in strawberry. Yellow colored fruits have the least phenolic content. Of the fruits in this color group, pineapple has 40.4 mg, banana 56.1 mg and lemon 66.3 mg phenolic content. Phenolic contents in brown colored fruits are 47-418 mg in almonds, 137-274 mg in chestnuts, 291-835 mg in hazelnuts and 1558-1625 mg in walnuts (Table 3).

Table 3. Phenolic and anthocyanin content of some fruits.

Colors	**Fruits**	**Phenolic compounds**	**Anthocyanin**	**References**
Blue-Purple	Chokeberry	2080 mg/100g fruits	240 mg/100g meyve (frozen)	Olas, (2018).
	Chokeberry Juice	4772.2 mg/l	1562.2 mg/100 g dw	Olas, (2018).
	Blueberries	525 mg/100g fruits		Olas, (2018).
Red	Cranberry	120-315 mg/100g		Olas, (2018).
	Raspberry	126 mg/100g fruits		Olas, (2018).
	Strawberry	225 mg/100g fruits	60-80 g per 100 g FW	Olas, (2018).
	Red grapes	182 mg/100g		Sun et. al., (2002).
Yellow	Banana	56.1 mg/100g		Sun et. al., (2002).
	Lemon	66.3 mg/100g		Sun et. al., (2002).
	Pineapple	40.4 mg/100g		Sun et. al., (2002).
Brown	Almond	47-418 mg /100 g		Alasalvar, and Bolling, (2015).
	Chesnut	137-274 mg /100 g		Alasalvar, and Bolling, (2015).
	Hazelnut	291-835 mg /100 g		Alasalvar, and Bolling, (2015).
	Walnut	1558-1625 mg /100 g		Alasalvar, and Bolling, (2015).

Antioxidants are substances found naturally in fruits and vegetables that can delay or prevent oxidation (Özcan, 2018). There is a direct relationship between total phenolic and total antioxidant activity in phytochemical extracts of fruit species. In other words, high phenolic content in fruits may indicate high total antioxidant activity (Sun et al. 2002). The total phenolic and flavonoid contents of fruits are determinant in terms of antioxidant properties, rather than their unique colors. All dark-colored fruits in different fruit classes have higher phenolic content than light-colored fruits (Özden and Özden, 2014).

The pigments of fruits and vegetables are associated with their antioxidant content. Fruits with high antioxidant capacity such as black grapes, blueberries, red apples, currants, strawberries, sour cherries and cranberries have high anthocyanin and total phenol content. The low antioxidant capacity of purple fruits such as figs and plums may be due to the difference in the antioxidant capacity of the fruit's flesh/skin ratio. Orange and yellow fruits and vegetables rich in ascorbic acid have higher antioxidant capacity than those rich in chlorophyll and carotenoids (Cömert et al., 2020). In terms of antioxidant capacity, fruits and fruit juices are similar. Chokeberry is the food with the highest antioxidant capacity in both its fruit and juice (Table 4) (Kulling and Rawel, 2008; USDA, 2020).

Table 4. Antioxidant potential of some fruit juices.

	Juice TEAC (µmol/m)
Chokeberry	65-70
Blueberry	13.3-17.1
Cranberry	6.7-14.8
Pomegranate	41.6
Orange	3.4-4.8

Source: Kulling and Rawel, (2008).

7. Oxygen Radical Absorbance Capacity (ORAC) in Color of Fruits

The Oxygen Radical Absorbance Index is a world-class method for measuring the antioxidant capacity of foods (Esfehani et al., 2022). In this method, the ability of herbal chemicals and other chemicals to resist free oxygen radicals is tested (Pehluvan and Güleryüz, 2004). ORAC value is associated with antioxidant level (Özcan, 2018).

Fruits and nuts are good food sources for antioxidant-rich diets (Haytowitz and Bhagwat, 2010). The fruit with the highest ORAC value is chokeberry fruit in the blue-purple colored group with 16062 µmol TE/100 g. This is followed by walnut in the brown colored group with 13057 µmol TE/100 g, and hazelnut with 9645 µmol TE/100 g. The highest ORAC values belong to these 3 fruits. Moreover, the fruits in the red group have high ORAC values. Cranberry in the red group has the highest ORAC value in its group with 9090 µmol TE/100 g. Yellow and orange fruits have lower ORAC values than those in other colored fruit groups (Table 5). Pelvan et al. (2008) stated that the ORAC value in plump hazelnuts was 3454 µmol TE/100 g. Wang et al. who determined the ORAC value (2015) reported that there is 3423.44 µmol

TE/100 g in walnuts. In pistachio, Yuan et al. (2022) found that 5484.56 µmol TE/100 g. Alasalvar et al. (2005) determined the ORAC capacity as 7996 µmol TE/100 g in cherry laurel. Kraujalytė et al. (2013), determined the ORAC capacity in Gileboru to be 260.38 µmol TE/100 g. Atala et al. (2009) determined the ORAC capacity as 7370 µmol TE/100 g in blueberry, 8650 µmol TE/100 g in blackberry, and 2870 µmol TE/100 g in raspberry. ORAC capacities detected by different researchers in similar fruits may vary. ORAC values in fruits indicate the antioxidant value. The higher the ORAC values are, the higher the antioxidant levels will be (Esfehani et al., 2022).

Table 5. Total-ORAC (µmol TE/100 g) Values of Some Fruits.

Brown	**Fruits**	**Total-ORAC**	**References**
	Hazelnut	9645	USDA, (2022).
	Walnut	13057	USDA, (2022).
	Almond	4454	USDA, (2022).
	Pistachio	7675	USDA, (2022).
Red	Cranberry	9090	USDA, (2022).
	Raspberry	5065	USDA, (2022).
	Cherry	3747	USDA, (2022).
	Strawberry	4302	USDA, (2022).
	Pomegranate	4479	USDA, (2022).
	Gojiberry	3290	USDA, (2022).
	Gileboru	260.38	Kraujalytė et al. (2013).
	Cherry laurel	7996	Alasalvar ve ark. (2005).
Yellow	Banana	795	USDA, (2022).
	Lemon	1346	USDA, (2022).
Orange	Orange	1819	USDA, (2022).
	Mandarin	1627	USDA, (2022).
	Apricot	1110	USDA, (2022).
Blue-Purple	Blueberries	4669	USDA, (2022).
	Fig	3393	USDA, (2022).
	Blackberry	5905	USDA, (2022).
	Chokeberry	16062	USDA, (2022).
Green	Avocado	1922	USDA, (2022).

8. Conclusion

Colors can give us information about many subjects, from people's mental states, lifestyles, cultures, customs, and traditions. Colors show themselves in nature as well as in human life. In the plant kingdom, it is possible to see different colors in the leaves, flowers, and fruits of each plant. Fruits has created color language in the plant kingdom with their unique colors of fruits.

Colorful fruits are antioxidant-rich foods that are beneficial for visual, sensory, and physical health. In recent years, consumers prefer red, blue, or purple fruits and vegetables due to being healthy and beneficial for antioxidant compounds in their structure (Cömert et.al., 2020). Cömert et al., (2020) stated in their study that anthocyanin-rich magenta, blue, and red colored fruits and vegetables potentially contribute more than 20% of the required daily antioxidant intake and are in the category of high antioxidant foods. According to the antioxidant and ORAC values of the fruits; white color means immunity, yellow color means beauty, green color means cleaning of toxins, orange color means cancer prevention, purple color means long life span and lastly red color means heart health (Özcan, 2018).

In this review, data from various sources on antioxidant vitamins, phenolic compounds, and ORAC capacities of fruit species were brought together. In fruits, brown color can mean vitamin E, red and green color can represent vitamin C, blue-purple color can mean ORAC richness, orange color can mean beta-carotene and vitamin A. These data are only examples as they do not contain definitive results. Each researcher sometimes obtained different results even in the exact fruits. It is an undeniable fact that fruits are sources of healing and colors give information.

9. References

Aktaş, İ. (2021). Beta Karoten, Antioksidan İçeren Besinler, 1. Cilt, 4. Bölüm, Publishing House, ISBN: 978-625-7562-81-2, (Editör: Doç.Dr. Sedat Bilgiç).

Alasalvar, C., & Bolling, B. W. (2015). Review of nut phytochemicals, fat-soluble bioactives, antioxidant components and health effects. *British Journal of Nutrition*, *113*(S2), S68-S78.

Alasalvar, C., Al-Farsi, M., & Shahidi, F. (2005). Compositional characteristics and antioxidant components of cherry laurel varieties and pekmez. *Journal of food science*, *70*(1), S47-S52.

Alasalvar, C., Shahidi, F., Liyanapathirana, C. M., & Ohshima, T. (2003). Turkish tombul hazelnut (*Corylus avellana* L.). 1. Compositional characteristics. *Journal of Agricultural and Food Chemistry*, *51*(13), 3790-3796.

Atala, E., Vásquez, L., Speisky, H., Lissi, E., & López-Alarcón, C. (2009). Ascorbic acid contribution to ORAC values in berry extracts: An evaluation by the ORAC-pyrogallol red methodology. *Food Chemistry*, *113*(1), 331-335.

Balasundram, N., Sundram, K., & Samman, S. (2006). Phenolic compounds in plants and agri-industrial by-products: Antioxidant activity, occurrence, and potential uses. *Food chemistry*, *99*(1), 191-203.

Barrett, D. M., & Lloyd, B. (2012). Advanced preservation methods and nutrient retention in fruits and vegetables. *Journal of the Science of Food and Agriculture*, *92*(1), 7-22.

Böhm, V., Fröhlich, K., & Bitsch, R. (2003). Rosehip—a “new” source of lycopene? *Molecular Aspects of Medicine*, *24*(6), 385-389.

Bramley, P. M. (2000). Is lycopene beneficial to human health? *Phytochemistry*, *54*(3), 233-236.

Burri, B. J., Chang, J. S., & Neidlinger, T. R. (2011). β-Cryptoxanthin-and α-carotene-rich foods have greater apparent bioavailability than β-carotene-rich foods in

Western diets. *British journal of nutrition*, *105*(2), 212-219. doi:10.1017/S0007114510003260.

Çağlar, M., & Demirci, M. (2017). Üzümsü meyvelerde bulunan fenolik bileşikler ve beslenmedeki önemi. *Avrupa Bilim ve Teknoloji Dergisi*, *7*(11), 18-26.

Çevik, B. A., & Pirinçci, E. (2017). Beslenme ve Kanser. *Firat Tip Dergisi*, *22*(1).

Chapman, M. S. (2012). Vitamin a: history, current uses, and controversies. In *Seminars in cutaneous medicine and surgery* (Vol. 31, No. 1, pp. 11-16). WB Saunders. 10.1016/j.sder.2011.11.009.

Cömert, E. D., Mogol, B. A., & Gökmen, V. (2020). Relationship between color and antioxidant capacity of fruits and vegetables. *Current Research in Food Science*, *2*, 1-10.

Dalkılıç, Z. Vitamin C Kaynağı Olarak Subtropik ve Tropik İklim Meyve Türleri. *Uluslararası Anadolu Ziraat Mühendisliği Bilimleri Dergisi*, *2*(4), 19-29.

Durmuş, M., Yetgin, Ö., Abed, M. M., Haji, E. K., & Akcay, K. (2018). Domates bitkisi, besin içeriği ve sağlık açısından değerlendirmesi. *International Journal of Life Sciences and Biotechnology*, *1*(2), 59-74.

Eggersdorfer, M., & Wyss, A. (2018). Carotenoids in human nutrition and health. *Archives of biochemistry and biophysics*, *652*, 18-26.

El-Ishaq, A., & Obirinakem, S. (2015). Effect of temperature and storage on vitamin C content in fruits juice. *International journal of Chemical and Biomolecular science*, *1*(2), 17-21.

Ersus, S., & Yurdagel, Ü. (2006). Meyve ve sebzelerde bulunan antosiyaninlerin kimyasal yapısı ve stabilitesini etkileyen faktörler.78-86.

Esfehani, M., Eidi, F., & Movahedi, A. (2022). Comparison of food intake groups, dietary oxygen radical absorbance capacity (ORAC), and their relationship with atherogenic indices of plasma in patients with metabolic syndrome and healthy individuals. 10.30495/FH.2022.66679.1104.

Gabriela-Roxana, P. & Oliviu-Mihnea, G. (2019). The Vitamin Content of Fruits. *'Constantin Brancusi' Targu-Jiu*, Engineering Series, No. 4 /2019.

Granado, F., Olmedilla, B., & Blanco, I. (2003). Nutritional and clinical relevance of lutein in human health. *British Journal of Nutrition*, *90*(3), 487-502.

Güleşci, N., & Aygül, İ. (2016). Beslenmede yer alan antioksidan ve fenolik madde içerikli çerezler. *Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi*, *5*(1), 109-129.

Haytowitz D, Bhagwat S. (2010). USDA Database for the oxygen radical absorbance capacity (ORAC) of selected foods, release 2. U.S. Department of Agriculture (USDA). 2010;10-48.

Huang, Z., Liu, Y., Qi, G., Brand, D., & Zheng, S. G. (2018). Role of vitamin A in the immune system. *Journal of clinical medicine*, *7*(9), 258.

Karabulut, G., & Yemiş, O. (2019). Fenolik bileşiklerin bağlı formları ve biyoyararlılığı. *Akademik Gıda*, *17*(4), 526-537.

Karadeniz, T. (2004). Şifalı Meyveler (Meyvelerle Beslenme ve Tedavi Şekilleri), ISBN: 975288867-4.

Karadeniz, T. (2021). Miracle Plant: Black Chokeberry (*Aronia melanocarpa*). *MAS Journal of Applied Sciences*, *6*(1), 83-94.

Karakurt, H., & Aslantaş, R. (2008). Bitki renk maddelerinin (pigmentler) oluşum ve değişim fizyolojisi. *alatarım*, *7*(2), 34-41.

Karataş, F. & Çöteli, E. (2016). Kırmızı ve koyu kırmızı bazı meyvelerdeki a, e vitamini, beta karoten ve likopen miktarlarının araştırılması. *Gümüşhane Üniversitesi Fen Bilimleri Dergisi*, *6*(2), 61-66, https://doi.org/10.17714/gufbed.2016.06.007.

Kazaz, S., Baydar, H., & Erbaş, S. (2009). Variations in chemical compositions of *Rosa damascena* Mill. and *Rosa canina* L. fruits. *Czech Journal of Food Sciences*, *27*(3), 178-184.

Koca, İ., Karadeniz, B., & Tural, S. (2006). Antosiyaninlerin antioksidan aktivitesi. *Türkiye*, *9*, 24-26.

Kraujalytė, V., Venskutonis, P. R., Pukalskas, A., Česonienė, L., & Daubaras, R. (2013). Antioxidant properties and polyphenolic compositions of fruits from different European cranberrybush (*Viburnum opulus* L.) genotypes. *Food chemistry*, *141*(4), 3695-3702.

Krinsky, N. I., & Johnson, E. J. (2005). Carotenoid actions and their relation to health and disease. *Molecular aspects of medicine*, *26*(6), 459-516.

Kulling, S. E., & Rawel, H. M. (2008). Chokeberry (*Aronia melanocarpa*)–A review on the characteristic components and potential health effects. *Planta medica*, *74*(13), 1625-1634. DOI: 10.1055/s-0028-1088306.

Lara, M. V., Bonghi, C., Famiani, F., Vizzotto, G., Walker, R. P., & Drincovich, M. F. (2020). Stone fruit as biofactories of phytochemicals with potential roles in human nutrition and health. *Frontiers in Plant Science*, *11*, 562252. https://doi.org/10.3389/fpls.2020.562252.

Maiani, G., Periago Castón, M. J., Catasta, G., Toti, E., Cambrodón, I. G., Bysted, A., ... & Schlemmer, U. (2009). Carotenoids: actual knowledge on food sources, intakes, stability and bioavailability and their protective role in humans. *Molecular nutrition & food research*, *53*(S2), S194-S218.

Maoka, T. (2020). Carotenoids as natural functional pigments. *Journal of natural medicines*, *74*(1), 1-16.

Martin, A., Cherubini, A., Andres-Lacueva, C., Paniagua, M., & Joseph, J. (2002). Effects of fruits and vegetables on levels of vitamins E and C in the brain and their association with cognitive performance. *The journal of nutrition, health & aging*, *6*(6), 392-404.

McGhie, T. K., & Ainge, G. D. (2002). Color in fruit of the genus Actinidia: carotenoid and chlorophyll compositions. *Journal of Agricultural and Food Chemistry*, *50*(1), 117-121.

Miura, Y., Kondo, K., Saito, T., Shimada, H., Fraser, P. D., & Misawa, N. (1998). Production of the carotenoids lycopene, β-carotene, and astaxanthin in the food yeast Candida utilis. *Applied and environmental microbiology*, *64*(4), 1226-1229.

Mukhtar, Z. G., Ibrahim, M. S., Ibrahim, Y. İ., &, Karataş, F. (2019) Amounts Of Vitamın A, Vitamın E, Vitamin C, B-Carotene, Lycopene, Ghrelin, Glutathione, And Mda In Fruits Of *Diospyros Kaki* L. *Gıda*, *44*(4), 585-592.

Naidu, K. A. (2003). Vitamin C in human health and disease is still a mystery? An overview. *Nutrition journal*, *2*(1), 1-10.

Ndayishimiye, J., & Chun, B. S. (2017). Optimization of carotenoids and antioxidant activity of oils obtained from a co-extraction of citrus (Yuzu ichandrin) by-products using supercritical carbon dioxide. *Biomass and Bioenergy*, *106*, 1-7.

Niki, E., & Abe, K. (2019). Vitamin E: Structure, properties and functions. pp. 1-11 DOI: 10.1039/9781788016216-00001.

Okcu, Z. & Keleş, F. (2009). Kalp-damar hastalıkları ve antioksidanlar. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, *40*(1), 153-160.

Olas, B., (2018). Berry phenolic antioxidants–implications for human health? *Frontiers in pharmacology*, *9*, 78. https://doi.org/10.3389/fphar. 2018.00078.

Orsavová, J., Hlaváčová, I., Mlček, J., Snopek, L., & Mišurcová, L. (2019). Contribution of phenolic compounds, ascorbic acid and vitamin E to antioxidant activity of currant (*Ribes* L.) and gooseberry (*Ribes uva-crispa* L.) fruits. *Food chemistry, 284*, 323-333.

Ötleş, S., & Atlı, Y. (1997). Karotenoidlerin İnsan Sağliği Açisindan Önemi. *Pamukkale üniversitesi mühendislik bilimleri dergisi*, *3*(1), 249-254.

Özcan, M. (2018). Renklerin Tüketimde ve Sağlıkta Önemi. Black Sea Journal of Agriculture, 1(3), 83-88.

Özden, M., & Özden, A. N. (2014). Farklı renkteki meyvelerin toplam antosiyanin, toplam fenolik kapsamlarıyla toplam antioksidan kapasitelerinin karşılaştırılması. *Gıda Teknolojileri Elektronik Dergisi*, *9*(2), 1-12.

Pehluvan, M., & Güleryüz, M. (2004). Ahududu ve böğürtlenlerin insan sağlığı açısından önemi. *Bahçe*, *33*(1).

Pelvan, E., Olgun, E. Ö., Karadağ, A., & Alasalvar, C. (2018). Phenolic profiles and antioxidant activity of Turkish Tombul hazelnut samples (natural, roasted, and roasted hazelnut skin). *Food chemistry*, *244*, 102-108.

Perry, A., Rasmussen, H., & Johnson, E. J. (2009). Xanthophyll (lutein, zeaxanthin) content in fruits, vegetables and corn and egg products. *Journal of food Composition and Analysis*, *22*(1), 9-15.

Poiroux-Gonord, F., Bidel, L. P., Fanciullino, A. L., Gautier, H., Lauri-Lopez, F., & Urban, L. (2010). Health benefits of vitamins and secondary metabolites of fruits and vegetables and prospects to increase their concentrations by agronomic approaches. *Journal of Agricultural and Food Chemistry*, *58*(23), 12065-12082.

Ranganath, K. G. (2022). Pigments That Colour Our Fruits: An Overview. *Erwerbs-Obstbau*, 1-13.

Rizvi, S., Raza, S. T., Ahmed, F., Ahmad, A., Abbas, S., & Mahdi, F. (2014). The role of vitamin E in human health and some diseases. *Sultan Qaboos University Medical Journal*, *14*(2), e157.

Rocha, D. S., & Reed, E. (2014). Pigmentos naturais em alimentos e sua importância para a saúde. *Revista EVS-Revista de Ciências Ambientais e Saúde*, *41*(1), 76-85.

Santos, P. H. S., & Silva, M. A. (2008). Retention of vitamin C in drying processes of fruits and vegetables—A review. *Drying Technology*, *26*(12), 1421-1437.

Solovchenko, A., Yahia, E. M., & Chen, C. (2019). Pigments. In *Postharvest physiology and biochemistry of fruits and vegetables* (pp. 225-252). Woodhead publishing.

Soydemir, H. E., & Yılmaz, A. (2022) Bitki doku kültüründe antibiyotik kullanımı. A. Yılmaz ve S. Soysal (Ed). Modern Tarım Uygulamaları (279-289 ss.). Adıyaman; Turkey: İKSAD.

Söylemezoğlu, G. (2003). Üzümde fenolik bileşikler. *Gıda*, *28*(3).

Sun, J., Chu, Y. F., Wu, X., & Liu, R. H. (2002). Antioxidant and antiproliferative activities of common fruits. *Journal of agricultural and food chemistry*, *50*(25), 7449-7454.

TürKomp (2022). Tarım ve Orman Bakanlığı, Ulusal Gıda Kompozisyon Veri Tabanı, versiyon 1.0, www.turkomp.gov.tr sitesinden alınmıştır (Erişim tarihi: Eylül 2022).

USDA (2020). USDA Database for the Oxygen Radical Absorbance Capacity (ORAC) of Selected Foods, Release 2, http://www.orac-info-portal.de/download/ORAC_R2.pdf, (Erişim tarihi: 11 Eylül 2020).

Wang, X., Zhao, M., Su, G., Cai, M., Zhou, C., Huang, J., & Lin, L. (2015). The antioxidant activities and the xanthine oxidase inhibition effects of walnut (*Juglans regia* L.) fruit, stem and leaf. *International Journal of Food Science & Technology*, *50*(1), 233-239.

Yanmaz, R., Akan, S., Salman, A. (2015). Türkiye'den Toplanan Kestane Kabağı (*Cucurbita Maxima* Duchesne) Genotiplerinde Meyve Et Rengi ile karotenoid Miktarı Arasındaki İlişkinin Belirlenmesi. Bahçe Özel Sayı, Cilt: Cilt II-Sebzecilik- Bağcılık- Süs Bitkileri, VII. Bahçe Bitkileri Kongresi Bildirileri, 55-60.

Yılmaz, A., Güler, E., Soydemir, H. E., Demirel, S., Mollahaliloğlu, S., Çiftçi, V., & Karadeniz, T. (2021). Miracle Plant: Black Chokeberry (*Aronia melanocarpa*). *MAS Journal of Applied Sciences*, *6*(1), 83-94.

Yılmaz, A., Yılmaz, H., Soydemir, H. E., & Çiftçi, V. (2022) Soya (*Glycine max* L.)'da PGPR ve AMF Uygulamalarının Verim Özellikleri ve Protein İçeriğine Etkisi. *Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi*, *8*(1), 108-118.

Yuan, W., Zheng, B., Li, T., & Liu, R. H. (2022). Quantification of Phytochemicals, Cellular Antioxidant Activities and Antiproliferative Activities of Raw and Roasted American Pistachios (*Pistacia vera* L.). *Nutrients*, *14*(15), 3002.

Zhou, C. H., Xu, C. J., Sun, C. D., Li, X., & Chen, K. S. (2007). Carotenoids in white- and red-fleshed loquat fruits. *J. of Agricultural and Food Chemistry*, *55*(19), 7822-7830.

Zimmer, T. B. R., Mendonça, C. R. B., & Zambiazi, R. C. (2022). Methods of protection and application of carotenoids in foods-A bibliographic review. *Food Bioscience*, 101829. https://doi.org/10.1016/j.fbio.2022.101829.

CHAPTER 4

ROSEHIP AND USAGE AREAS

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1.The History of Rose Hips

Fruits have an important place in human life. From past to present, fruits have been used in various rituals due to belief, as well as being used in the field of nutrition and health due to the important vitamins, minerals and secondary metabolites they contain. People have attributed sanctity to some types of fruit in history. One of the fruits considered sacred in different civilizations is rose hips. Rosehip, which is called "Food of the Gods" in Greek Mythology, is colloquially referred to by names such as wild rose, dog rose, dog rose, navel rose, mad rose, rose nose, rose apple, chilean, and dog rose. In the years before Christ, it symbolized innocence in Mediterranean culture and in some cultures it was grown in front of houses to protect from evil spirits and the evil eye. Rosehip, which occupies an important place in Turkish mythology, has also been the subject of folk literature, folk songs have been sung and poems have been sung in its name (Ergun, 2012; Unalan, 2021).

Plants have been widely used in the medical world in history as well as today. Known as the famous physicians of the past, Hippocrates, İbni Sina and Lokman Hekim have achieved successful results from treatments with herbs. While rosehip was used against wounds and inflamed boils during the Hippocratic period, Ibn Sina used rosehip fruit against bloody hemorrhoids and diarrhea, and in pomade prepared from its leaves for redness and itching. Egyptians used rosehip fruit in scurvy disease, Romans used rosehip flowers in stomachache in ancient times. Rosehip was used in the Middle Ages against diarrhea, bladder and gallstones, tapeworm, snakebite, kidney and diabetes, bleeding gums, spitting blood (Onal and Oruc, 2012; Yildiz, 2005; Sar, 2011; Ozdemir and Tor, 2021). In addition, rose hips were used in the treatment of dog bites in the 18th and 19th centuries, while its roots were used for rabies. For this reason, it is thought that it was named dog or dog rose (Howard, 1987). It was discovered by the governments of England, Norway and Sweden during the World War II that rose hips, which were cultivated by the Romans, were rich in vitamin C content (Yildiz, 2005). The importance of rosehip fruit has been known since ancient times, and due to its rich nutritional content, it has been used as an important raw material in the food and pharmaceutical industry from history to the present.

2. Rosehip Systematics and Plant Characteristics

2.1 Rosehip systematics and distribution

Rosehip is the most common member of the *Rosaceae* family, which has around 100 species in the world. Chromosome numbers vary between 2n=14-2n=42 depending on the species. Its homeland is the continent of Asia and the most diversity is in West Asia. (User, 1967: Ercisli, 2005; Ozcelik et al., 2012; Aslan, 2012; De Riek et al., 2013). Rosehip naturally spreads in a wide region at an altitude of 2500-600 m, which includes Asia, the Middle East, Northwest Africa, Europe and North America (Nilsson, 1997; Ilisulu 1992). Especially, Turkey has a rich rosehip potential due to its geographical location. To date, 35 different rosehip species have been described (Altun et al. 2021). The systematics of the rosehip plant is shown in Table 1.

Table 1. The systematics of the rosehip plant

Kingdom	*Plantae*
Section	*Magnoliophyta*
Class	*Magnoliopsida*
Order	*Rosales*
Family	*Rosaceae*
Subfamily	*Rosaoideae*
Genus	*Rosa*
Type	*Rosa canina* L.

2.2 Plant characteristics

Rosehip has a bush form, dense and multi-stemmed, upright and drooping plant structure. It sheds its leaves in winter and can grow up to about 2 meters. Although most species are spiny, spineless genotypes are also found. Rosehip is a perennial herb. It is estimated that the rosehip tree in the garden of a church in Germany is at least 300 years old (Erenberk, 1991).

Although the leaves of the rosehip plant vary according to the genotypes, they are elliptical-oval, with about 3-11 leaflets, compound, smooth or serrated edges, bluish green.

Rosehip flowers are hermaphrodite. Petals are yellow, pink, white, cream or light red. The flowers, which are collected in the form of umbrellas or in a single cluster, have 5 sepals and petals varying in number from 5 to 7. Although the sepals are permanent in some species, they are usually shed when fruit is formed. Sepals are green in color, round or elliptical in shape. The flowering time of rose hips is 5-7.

months and the flowering period is usually 15-25 days (Kutbay and Kilinc, 1996).

Figure 1. General view of the rosehip plant in nature.

Rosehip is botanically berry, pomologically among pome fruits. At the same time, rosehip fruit is a false fruit because it occurs as a result of fleshing of the flower table. Fruit color is green before ripening, after ripening it varies from orange, yellow and brick to bright red. The fruit surface is shiny, glabrous or hairy, its shape varies from elliptical to flattened round shape. The edible part of the fruit is the fleshy part in a thin layer between the peel and the core. The inner part is hairy or glabrous, the species contains a large number of nuclei. However, seedless genotypes are also encountered. The seeds are small, hard-shelled and there is a germination problem due to the abscisic acid it contains.

Figure 2. The fruits of the rosehip plant.

Rosehip plant has fringe, hairy root and tap root structure that can go down to about 4 meters deep.

3. Rosehip Cultivation

The main goal of fruit growers is to grow fruit in the quality and yield desired by the buyers. In this direction, in order to grow a fruit, it is necessary to know the fertilization biology, reproduction, maintenance, climate and soil requirements, harvest and storage conditions, important diseases and pests and control. Like every fruit, rosehip has its own cultivation technique. Rosehip fruit is a gift from nature to us. Although it usually grows spontaneously in nature, it is important to establish closed gardens in order to ensure standardization and increase yield and quality.

The majority of rosehip species are self-pollinating (Nybom, 2004). The fruit set rate is about 82% in *R. canina* and about 85% in *R. rubiginosa*. Some species, such as *R. pandulina*, are self-infertile. Yield per unit area in cultivation depends on the fruit size of the rosehip species, as well as the formation of abundant flowers and the formation of fruit from the flower that is formed. The rosehip plant reaches economic efficiency in 3-4 years and full efficiency in 5-6 years.

3.1 Propagation methods

Propagation of rosehip plant can be done by generative and vegetative methods.

3.1.1 Generative propagation method

Individuals formed by generative (seed) propagation may show similar or completely different characteristics to the characteristics of the mother and father due to the genetic expansion. Seed propagation in fruit growing is done for breeding studies due to genetic and phenotypic variations besides individuals obtained with seeds are used as rootstocks in grafting because they are resistant to ecological conditions.

A high rate of germination occurs in the seeds taken during the period when the rosehip fruits turn dark orange or light red. Due to the abscisic acid contained in the seed and its hard and impermeable shell, there are some difficulties in reproduction. It is stated that rosehip seeds can germinate in a very long time, such as 8-18 months (Urgenc, 1992). Unless they undergo some pre-treatment, they germinate at very low rates or they cannot germinate. Before planting rosehip seeds, when processes such as soaking, folding, hormone applications, acid etching, cracking are performed together (abrasion + folding, hot folding + cold folding + abrasion, etc.), dormancy disappears and the germination rate of the seed increases (Kaska, 1970; Gunes, 2013; Altun et al., 2021).

3.1.2 Vegetative propagation methods

Cultivation of species with the same characteristics is possible by vegetative propagation. Vegetative propagation is a form of reproduction by using any part of the plant (branch, bottom shoot, arm, eye, tuber, etc.) to create new individuals with the same genetic structure as the plant. This type of reproduction can be grouped under 6 headings: propagation by grafting, propagation by cuttings, propagation by tissue culture, propagation by root (bottom) shoot, propagation by stem, tuber, rhizome, propagation by using apomictic seeds and propagation by immersion.

Rosehip can be propagated by grafting, cutting, bottom shoots and tissue culture.

Propagation by grafting is done by combining two different plant parts and fusing them to obtain a new plant. In rosehip species, ‘T’ budding and chip grafting can be done, stagnant and shoot bud grafting depending on the time of vaccination (Gunes, 2013). However, because the rosehip plant is thorny and it is easier to propagate with cuttings and bottom shoots, it is not a preferred propagation method.

Propagation with cuttings is a form of propagation by rooting the rootless vegetative parts taken from the plant whose vegetative organ can be rooted and forming a new individual. Rooting rosehip cuttings depends on the species. While some species are very difficult to root, some species may be easier to root. Rooting success is affected by genetic factors as well as factors such as time of cutting, age, type, nutrition and disease status of the plant. IBA, IAA and NAA, which are in the auxin group, are used to increase rooting success in rose hips (Gunes, 2013). The most preferred plant growth regulator for rooting is IBA. Rosehip propagation by cuttings, one-year-old, 6-9 mm diameter, 15-20 cm long shoots are cut in late autumn or early winter and kept in moist sand and wrapped in moist paper in bunches and stored in the refrigerator until spring. Cuttings removed from the refrigerator in the spring are taken into the rooting medium. With the softwood cuttings lasting in the same year, reproduction can be made by cutting the cuttings during the period when the shoots are partially hardened.

Rosehip can be propagated by bottom shoots. In the spring, new shoots emerge from the eyes in the root and root collar of the rosehip plant. These shoots are kept in the soil until early spring next year and are expected to take root. In the first months of spring, it is rooted and used as a sapling.

Propagation by layering in rosehip plant is done by rooting the one-year flexible shoots dip in the soil. In order to accelerate root formation, it is recommended to make a scratch under the part placed in the soil.

Propagation by tissue culture is a form of reproduction in which new plants are obtained from parts taken from plant parts, in a sterile environment, in artificial media, which have the capacity to form a complete plant. Propagation with tissue culture in rosehip can be done by various methods such as embryo shoot tip, callus, meristem, armpit, anther culture (Gunes, 2013).

The formation of seeds without fertilization in plants is called apomictic seed, and the seed formed is called apomictic seed. The plant consisting of apomictic seeds and the mother plant have the same genetic characteristics. Vegetative propagation can be done with apomictic seeds. Apomictic seeds can be produced from rose hip species such as *R. canina* and *R. rubiginosa* (Mazzolariet al., 2017).

3.2 Climate and soil requirements

Rosehip is a plant species that can adapt to extreme climatic conditions and spread over a wide area. It grows naturally at an altitude of 2500 m in Turkey, Pakistan and Afghanistan, between 1500-3000 m in Iran, and up to 2900 meters in Iraq. This plant, which has a high need for cooling, blooms in May, June and July, depending on the species and altitude. Since it begins to bloom in the last months of spring, the flowers are not damaged by the cold. High quality fruit can be obtained in regions with an altitude of 600 m and higher, where sufficient rainfall is received during the vegetation period and sunbathing is good. As you go to higher altitudes, the quality of the rosehip fruit and the amount of vitamin C it contains increase.

Rosehip can be easily grown in many different soil structures because its adaptability is very strong. It is drought resistant as it has a deep root structure. The best growth is observed in loose soils rich in nutrients, adequately ventilated.

3.3 Orchard establishment

In the rosehip orchard establishment, the pollination characteristics of the planted species should be known in order to have a high fruit set rate and the species to be planted should be selected accordingly. The planting distance should be decided by considering the condition of the land to be planted, the development status of the habitus in the species to be planted, and the transition distance of the agricultural machinery. In the pits opened for planting, the seedlings are placed in such a way that the root collar or grafting site remains on the soil during the planting period and the pits are closed with soil. The planting period of saplings varies according to the regions. In regions with very harsh winters, seedlings are planted in spring, while in more temperate regions, planting is done in autumn. Planting in the fall allows the plant to enter the next vegetation period in an adapted way.

3.4 Yardwork

Although the rosehip plant does not require meticulous care, providing optimum conditions increases yield and fruit quality. For this reason, it is important to carry out operations such as irrigation, fertilization, pruning and tillage.

Since the roots of the rosehip plant reach deep, it is drought resistant. However, in the first few years when the seedlings are newly planted, it is useful to irrigate 4-5 times every 25 days, depending on the condition of the soil, during the dry vegetation period.

Fertilization should be done at appropriate times according to the results of soil analysis. With the right fertilization, yield and quality increase significantly.

Pruning in rosehip plants is done thinning offshoots in ocak-shaped plants, cleaning the bottom shoots overflowing from the ocak. In addition, in rosehip seedlings grown as a single stem grafted on *R. multiflora*, it is done in order to control the plant and to give the desired shape when offshoots occur from the graft site. In pruning, in some species such as *R. canina*, considering the fruit formation on 2-year-old offshoot, old offshoot that overlap each other, block the light, make harvesting difficult, should be cut over the bud facing the outer part.

Soil cultivation in rosehip orchards is done 2-3 times a year by hoeing the rows during the seedling development periods and plowing with a plow at a depth of 15-20 cm according to the climatic conditions of the region where the orchardis located. Tillage ensures that the garden is cleaned of weeds, the soil is ventilated, the snow and rain water are used appropriately, the overwinter insects are eliminated, and the fertilizer mixes into the soil effectively.

3.5 Harvest

Rosehip harvest is done when the fruits get the color specific to their species and when they reach the technological maturity period when they have the highest vitamin C content. Although the technological maturity time varies according to the species, there are also differences within the species in species such as *Rosa canina*. Harvesting is done between August and November, depending on the climate and location of the region, according to the ripening status of the fruit and the way it is evaluated. Harvesting fruits on time is important in terms of fruit quality and nutritional content. In the early harvest, yield loss occurs because the fruits cannot reach sufficient size. Since the rosehip fruit is not mature enough, it lacks important quality criteria such as color and taste. At the same time, since the fruits will be more difficult to break from the offshoot, it will be difficult to harvest. In the late harvest, fruit drop and physiological disorders are observed as well as the vitamin C content of the fruits decreases and the storage life is shortened.

Figure 3. Rosehip harvest in nature.

By drying, rosehip can be kept intact for up to 1 year in an airtight sealed glass jar in a dim, cool and dry place (Baytop, 1983).

3.6 Important diseases and pests

Rosehip species, which are quite resistant to diseases and pests, have diseases and pests that they are exposed to due to adverse environmental conditions such as sudden changes in air temperatures, long-term moistness of the air and soil, lack of nutrients, etc. Some of the diseases and pests encountered in Turkiye are leaf spot, black spot, rust and powdery mildew diseases, and pests such as fruit borer, sprout borer, bark lice (*Aulacaspis rosea*, *Lapidosaphes ulmi* and *Quadraspidiotus pemiciosus*), and spider mites.

4. Nutritional Content of Rosehip

The importance of nutrition in terms of human health has become even more striking with the coronavirus epidemic that started in 2019, and interest in fruits with high vitamin C content and rich in other phytochemical compounds and food products obtained from these fruits has increased.

Rosehip is richer than most fruit types in terms of nutritional content because it contains high amounts of vitamin C, vitamins A, B1, B2, E and K, minerals such as phosphorus, calcium, magnesium sodium, potassium, and important phenolic compounds. It is one of the richest fruits in the world, especially in terms of vitamin C, which the human body cannot produce and must be taken daily.

There are phytochemicals in the rosehip plant that show antioxidant properties, which have an important role in human health (Güler et al., 2021).

Studies have shown that rosehip fruits contain matairesinol, secoisolariciresinol and quercetin flavonoid with phytoestrogen effects, and ketone aldehyde and acidic substances in fruit essential oil (Karakaya, 1999; Valsta et al., 2003). It is also stated that it contains carotenoids such as rubixanthin, lutein, zeaxanthin, β-cryptoxanthin, as well as lycopene and β-carotene, which are powerful antioxidants. It has been determined that the amount of lycopene in rosehip fruits is higher than in tomatoes (Orhan et al., 2013).

Rosehip leaves contain flavanol substances called hyperoside, quercitrin and isocercitrin. It is stated that rosehip flowers contain substances such as cyanidin-3,5-diglucoside in anthocyanidin structure in small amounts as well as chemferol and quercetin glycosides, and their pollen contains volatile compounds (Tarnoveanu, 1995; Mikanagi et al., 2000; Orhan et al., 2013).

In seeds, eriodicthiol, taxifolin, catechin, epicatechin, quercetin, chemferol-3-O-(6''-O-E-p-coumaroyl)-β-D-glucopyranoside and -3-O-(6''-O-Z-p-coumaroyl)-β-D-glucopyranoside, quercitrin, apigenin, floridzin and methyl gallate, and the obtained seed oils are stated contain stearic, oleic, palmitic, linoleic and linolenic acids (Szenthmihalyi et al., 2002; Orhan et al., 2013).

In terms of vitamin C, while ripe rosehip fruits contain only L-ascorbic acid, green unripe fruits contain both ascorbic acid and dehydroascorbic acid (Kurucu and Kesikoglu, 1990).

In addition, rosehip has been determined that it contains elements such as silver, aluminum, manganese, arsenic, boron, barium, calcium, magnesium, phosphorus, zinc, cobalt, chromium, copper, iron, potassium, lithium, sodium, nickel, lead, strontium, thallium, gallium and vanadium (Ozcan et al., 2008).

5. Rosehip Usage Areas

The rosehip plant, which grows naturally in a wide area in the world, its leaves, fruit, roots and the plant itself are used for various purposes.

5.1 Usage in food industry

As mentioned in the previous section, rosehip is an important fruit type in terms of food technology with its high nutritional content. It is used as a raw material in the food industry in many countries such as

Germany, Finland, Switzerland and Turkey. In these countries, it is used in the production of fruit jelly, jam, marmalade, baby food, pulp, fruit juice, nectar and tea bags. It is also used to enrich the nutritional value of fruit and vegetable juices with low vitamin C levels.

Rosehip fruit is also used as an additive in the pastry and confectionery industry due to its nutritional content, color and unique flavor. It is used to obtain different flavors in cakes, desserts and cakes. In the feed industry, it is used as an additive to increase the nutritional value of animal feed (Baytop, 1983; Yamankaradeniz, 1983a).

5.2 Usage in pharmaceutical industry

Rosehip plant has been used for many years among people for the treatment of many diseases. It is believed that rosehip tea will be beneficial when used in regulating blood pressure, lowering bad cholesterol, diuretic in respiratory tract infections, cold and flu.

In Anatolia, rosehip fruits are used as a folk medicine, for ulcers and similar stomach ailments, for diabetes, hemorrhoids, kidney ailments, abdominal pains, colds and rheumatism. Its leaves and flowers are used in the treatment of bronchitis, and its roots are used in diseases such as colds, hemorrhoids, abdominal pains and rheumatism.

Rosehip is used as a raw material in the manufacture of medicines because it is rich in tannin, pectin and essential oils. There are immunomodulatory, antimicrobial, antioxidant, antiproliferative, antiulcer, antidiabetic, and drug activity studies against kidney stones on the plant. Today, the plant has clinical use with preparations such as

Litozin®, Hyben Vital®, especially in cases of rheumatoid arthritis (Orhan et al., 2013).

5.3 Landscape usage

Rosehip is a valuable plant that can be used as an ornamental plant in landscape design works with its bright red, yellow, pink, white and cream-colored flowers, and fruits of various colors from orange, tile to bright red that ripen in autumn.

Rosehip plant is used in gardens, parks and green space arrangements due to its solitary plant. Due to its strong and deep root structure, it is used for economic evaluation of the land in areas with erosion risk and in sloping, stony, arid and calcareous areas. It is used in highways and railways, in afforestation of central medians, in directing traffic, and in creating a visual effect on roadsides. At the same time, the rosehip plant is used in afforestation and nature restoration works in clearings in the forest. Due to its thorny structure in the garden and field edges, it is used as a live fence as well as a snowstorm and wind screen (Yamankaradeniz, 1983b). In addition, rosehip species such as *Rosa canina* L. 'Inermis' are used as rootstocks in rose cultivation due to their drought resistance.

5.4 Other usage areas

Rosehip is among the fruits widely used in the cosmetic industry, thanks to its vitamin C content and carotene. In countries such as Russia and Poland, rosehip is used in the cosmetics industry because its seeds contain high levels of unsaturated fatty acids. Rosehip fruits and flowers are used to make cologne, perfume, soap, shampoo, cream, and rosehip oil is used as a cosmetic product.

The flowers and roots of the rosehip plant are used as dyestuffs in the textile industry (Turkben et al., 1996). It is also used in the leather manufacturing industry (Kocan, 2010).

Rosehip spirit, tincture and rosehip extract are also produced from the rosehip plant to be used for various purposes.

Rosehip is also important for wildlife. In autumn and winter months, animals use rosehip bushes as a shelter, as well as keeping fruit on the plant for a long time, providing a food source for wild animals. In addition, rosehip fruit is an important food source for birds living in parks and gardens during the winter months.

6. Future Potential of Rosehip

Due to climate change, the negative effects of which we have felt more and more in recent years, it is becoming more and more important to grow plants that are resistant to heat and drought. In addition, world food security is in danger due to the rapid increase in the world population, the decrease in agricultural areas and the danger of extinction of usable water resources.

Plants with high nutritional and economic value and resistant to drought and heat are important in order to meet the increasing food demand in the world, to repair the nature destroyed due to drought and forest fires caused by global warming and to maximum use of these areas.

Today, people are oriented towards naturalness, traditional medicine, herbal products and organic agriculture. Therefore, the demand for medicinal and aromatic plants such as rosehip has increased. A balanced and standardized production is needed to meet the increasing demand. Rosehip plant is very suitable for organic agriculture because of its easy control of diseases and pests. Due to its high adaptability and regular production every year, the amount of production required by the market can be met from the gardens established by using less input.

Today, the production of rosehip plant is made by collecting from nature in some countries, especially in Turkiye. This type of production does not meet the market need and importation becomes mandatory. For these reasons, the establishment rosehip orchards has come to the fore in recent years. As a result of recent studies in Turkiye, Arı Fidan and Gazi Osman Pasa University Faculty of Agriculture have registered 2 rosehip varieties (Yildiz and Gercekcioglu). Registration and production of medicinal and aromatic plants will provide a great advantage to meet the required seed demands. At the same time, since it is harvested in the autumn period when agricultural activities decrease, it gives the producers the opportunity to make use of their free time. For these reasons, the value of rose hips will be better understood day by day. In the future, it will be inevitable to develop new varieties suitable for different uses and increase the production amount and market value.

7. References

Altun, B., Boyacı, S., Kazankaya, A., (2021). The Effect of Different Stratification Media and Temperature Applications on Seed Germination and Seedling Growing in Rosehip (*Rosa canina* L.) *Yuzuncu Yil University Journal of Agricultural Sciences*, 31(2), 330-336.

Anonymous (2022). Rosehip Feasibility Report And İnvestor Guide. Chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.tarimorman.gov.tr/SGB/TARYAT/Belgeler/Projeler/KUSBURNU_FIZIBILITE_RAPORU_VE_YATIRIMCI_REHBERI(1).pdf access date:08.09.2022

Anonymous (2022). Rosehip Growıng https://samsun.bel.tr/uploads/files/brosur76.pdf access date:08.09.2022

Aslan, S. (2012). Rosa, in: Guner, A., Aslan, S., Ekim, T., Vural, M. & Babac, M.T. (edlr.), List of Plants of Turkey (Veinous plants), *Nezahat Gokyigit Botanical Garden and Flora Research Association Publication*, İstanbul.

Ayaz, M. (2018). The effect of roseship (*Rosa canina* L.) on some values in human. Doctoral dissertation, İnstitute of Science Harran University

Baytop, T., (1983). Pharmacognosy. Istanbul University Press, Istanbul, 408s.

De Riek, J., De Cock, K., Smulders, M. J., and Nybom, H. (2013). AFLP-based population structure analysis as a means to validate the complex taxonomy of dogroses (*Rosa* section *Caninae*). Molecular Phylogenetics and Evolution, 67(3), 547-559.

Demir N, Acar J, Sarıoğlu K, Mutlu M. (2001). The use of commercial pectinase in fruit juice industry. Part 3: Immobilized pectinase for mash treatment. *J Food Eng*, 47: 275-280.

Ercisli, S. (2005). Rose (*Rosa spp.)* germplasm resources of Turkey. Genetic Resources and Crop Evolution, 52(6), 787-795.

Erenberk, H. (1991). Rose growing. *TubitakBilim ve Teknik Dergisi* 265: 42-43.

Ergun P., (2012). Tree culture in Turkish Culture. Ankara: Ataturk Cultural Center Presidency Publications.

Gercekcioglu, R., Bilgener, S., Soylu, A. (Ed.) (2014). General Fruiting (Principles of Fruit Growing), (4rd Edition). NOBEL Publications, Ankara

Gunes M. (2013). Rosehip. Berries Fruits. Tomurcukbag Ltd. Sti Education Publications No: 1, Kalecik/Ankara, p. 423-457

Güler, E., Bak, T., Karadeniz, T. & Muradoğlu, F. (2021). Relationships of Fruit Characteristics of Rosehips (Rosa canina L.) Grown in Bolu City Center. Journal of the Institute of Science and Technology, 11 (2), 831-838.

Howard, M. (1987). Traditional folk remedies: a comprehensive herbal. Century.

Ilisulu, K., (1992). Medicinal and spice plants. Publication of Ankara University Agricultural Faculty, Number: 1256, Ankara

Karakaya, S., & EL, S. N. (1999). Quercetin, luteolin, apigenin and kaempferol contents of some foods. Food Chemistry, 66(3), 289-292.

Kaska, N. (1970). Investigations on the amount of abscisic acid in zerdali and Kutahya sour cherry seeds and the changes in these amounts during folding. Ankara University Faculty of Agriculture Publications, 431.

Kochan, N. (2010). Evaluatıon Of Dog Rose (*Rosa canına* L.) Plants On Landscape Plannıng And Desıgn Works. *Harran Journal of Agricultural and Food Sciences*, 14(4), 33-37.

Kurucu, S. and Keskinoglu, C. (1990). Composition and Biological Activity of *Rosa* (Rose) Species Fruits. *FABAD Journal of Pharmaceutical Sciences* 15: 121–131.

Kutbay H. G. and Kılınc M. (1996). Taxonomic properties of rose hip species are grown in Turkey. Rose hip symposium, Gumushane, pp. 75–83.

Mazzolari, Ana Clara; Marrero, Hugo J.; Vázquez, Diego P. (2017). Potential contribution to the invasion process of different reproductive strategies of two invasive roses. *Biological Invasions*, 19(2), 615–623.

Medveckienė, B., Kulaitienė, J., Vaitkevičienė, N., Levickienė, D., and Bunevičienė, K. (2022). Effect of Harvesting in Different Ripening Stages on the Content of the Mineral Elements of Rosehip (*Rosa spp*.) Fruit Flesh. *Horticulturae*, 8(6), 467.

Mikanagi, Y., Saito, N., Yokoi, M., & Tatsuzawa, F. (2000). Anthocyanins in flowers of genus *Rosa*, sections Cinnamomeae (= *Rosa*), Chinenses, Gallicanae and some modern garden roses. *Biochemical Systematics and Ecology*, 28(9), 887-902.

Nilsson O. (1997). Rosa. In: Davis P. H. (ed.), Flora of Turkey and the East Aegean Islands. Vol. 4., Edinburgh University Press, Edinburgh, pp. 106–128.

Nybom, H., Werlemark, G., Esselink, D. G., and Vosman, B. (2004). Sexual preferences linked to rose taxonomy and cytology. In I International Rose Hip Conference 690 (pp. 21-28).

Onal, A. and Oruc, S. (2012). Investigation of dyeing properties of cotton and woolen fabrics with extract obtained from rosehip (*Rosa canina*) fruits. *Gaziosmanpasa Journal of Scientific Research*, (1), 21-26.

Orhan, D. D., Hartevioglu, A. (2013). Chemical composition and biological activities of rosehip plant. Spatula DD, 3(1), 23-30.

Ozbek H., Guclu S. and Tozlu G. (1996). The Arthropoda species are feeding on *Rosa spp.* in Erzurum, Erzincan, Bayburt and Artvin provinces. Rose hip Symposium, Gumushane, pp. 219–230.

Ozcan, MM, Unver A, Ucar T, Arslan D. (2008). Mineral content of some herbs and herbal teas by infusion and decoction. *Food Chem*. 106: 1120-7.

Ozcelik, H., Ozgokce, F., Unal, M., Korkmaz, M. (2012). The Diversity Centers and Ecological Characteristics of *Rosa* L. (*Rosaceae*) Taxa in Turkiye. *International Research Journal of Plant Science*, 3(10): 230-237.

Ozdemir, F. and Tor, A. N. (2021). Cankırı Region Distributed *Rosa Canina* Inermis (Rose X Dumalis Bechst.) Investigation Of The Morphological Characterıstıcs And Fruıt. *Turkish Journal of Forest Science*, 5(2), 418-432

Sar, S. (2011). The Analysis of the Use of Certain Berries from the Perspective of Pharmacy and History of Medicine. *Mersin University School of Medicine Lokman Hekim Journal of History of Medicine and Folk Medicine*. 1(2), 1-6.

Szentmihályi, K., Vinkler, P., Lakatos, B., Illés, V., & Then, M. (2002). Rose hip (*Rosa canina* L.) oil obtained from waste hip seeds by different extraction methods. *Bioresource technology*, 82(2), 195-201.

Tarnoveanu, D. S., Rapior, S., Gargadennec, A., & Andary, C. (1995). Flavonoid glycosides from the leaves of Rosa canina. Fitoterapia (Milano), 66(4), 381-382.

Turkben, C., Copur, U., Tamer, E., & Senel, Y. (1999). A research on the determination of some characteristics of rosehip fruits naturally grown in Bursa region. *Turkey III. Horticultural Congress*, 14(17), 809-814.

Turkyılmaz M, Yemifl O, Ozkan M. (2012). Clarification and pasteurisation effects on monomeric anthocyanins and percent polymeric colour of black carrot (*Daucus carota* L.) juice. *Food Chem*, 134: 1052-1058.

Unalan, O. (2021). Rosehip in Turkish Culture. *ODU Journal of Social Sciences Research*. 11 (3), 745-762.

Urgenc, S. (1992)., Tree and ornamental plants nursery and cultivation techniques, Istanbul University Faculty of Forestry Publication, Istanbul, 716s,

User, E. T. (1967). A research on the vitamin C status of rose hips grown in Central and Northern Anatolia in our country, and folk traditions related to it. *Turkish Journal of Hygiene and Experimental Biology*, 27(1), 39-60.

Valsta, L. M., Kilkkinen, A., Mazur, W., Nurmi, T., Lampi, A. M., Ovaskainen, M. L., and Pietinen, P. (2003). Phyto-oestrogen database of foods and average intake in Finland. *British Journal of Nutrition*, 89(S1), S31-S38.

Yamankaradeniz, R. (1983a). Physical and chemical properties of rose hip (*Rosa sp.*) at different maturation stages. Gıda, 8(4), 151-156.

Yamankaradeniz, R. (1983b). Rosehip (*Rosa sp.*) evaluation possibilities. Food, 8(4).

Yildiz, O. (2005). The application of some processes over the roseship' fruit Doctoral dissertation, Master's thesis İnonu Univ. FBE, Malatya.

CHAPTER 5

CRAMP BARK (*Viburnum opulus* L.) AND ITS SIGNIFICANCE AS NATIVE PLANT OF ANATOLIA REGION, TÜRKİYE

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Introduction

The Latin name Viburnum opulus L., English name Cramp Bark or Wind qelder rose, as the motherland of Gilebor, whose family is Caprifoliaceae, is shown in Europe, Northwest Africa, Turkestan (Davis, 1972) and Canada (Richard and Pierre, 1992). This kind of fruit is among the fruits found in Anatolia. The Gilebor plant is the natural sprawl of Europe, Northwest Africa, Turkestan (Davis, 1977) and Canada (Richard and Pierre, 1992).

It is understood that fruits are a valuable fruit due to vitamins, minerals, antioxidants, and other bioactive substances (Rop et al., 2010; Kim et al., 2003; Andreeva et al., 2004; Cam et al., 2007; Velioglu et al., 2006; Altun. et al. 2008) and the selection of natural populations in Russia (Nekrotova et al., 1987).

While plants contain important vitamins such as C, E, A, they also provide natural compounds with antioxidant properties. Studies have shown that antioxidant activity substances play important roles in the prevention of many diseases such as cataract, cancer, cardiovascular diseases, neurological disorders caused by oxidative stress (Frei, 1994; Riemersma, 1994; Mackerras, 1995; Halliwell, 1996; Schwartz, 1996).

In Canada, cultivation studies are still continuing (Richard & Pierre, 1992). Late flowering and white flowering varieties are common in Europe. Fruits that ripen towards the autumn can remain in the tree even in winter. Today, in Europe, Aureum, Compactum, Manum, Notcutt, Roseum is cultivated in a variety of varieties (Anonymous, 2009).

Cultivated in the Netherlands and England. In Norway and Sweden, she has been in bakery products for many years. In the US, it is used successfully in medicine in the treatment of many diseases such as nerve diseases, fatigue, cramp relievers, epilepsy, tetanus, rheumatism diseases. In North America, it is reported that gilebor plant is chosen as one of the best species among the 38 species in rural landscaping (Nekrotova et al. 1987). In the SO2 sensitivity test of 72 species, gilebor plant is determined as the most resistant species and it is recommended to use this plant in highly polluted areas such as industrial zone and highways (Mapeza, 1986), and this type works well in both landscape arrangements and rural afforestation (Öztürk and Özçelik, 1991; Baytop, 1984; Davis, 1972; Kara et al. 1995) increases the interest in gileboraya.

Our country grows in Western, Central, North and Eastern Anatolia Regions. In the Middle Anatolia region, especially the fruit of the gilebor plant, which is a traditional drink in the Kayseri region, is extracted. cramp bark plant is mentioned in different names in our country. Snowball, also known as gilebor in the region of Kayseri, gilabada, gildar, giligili, girabolu, girebolu gileburu, gilebolu, gilaburu, gilaboru; cramp bark in the Konya region; It is known as gili gili (Altan et al., 2004) in Tunceli and Black Sea Region. This plant is also known as Crambark, Guelder Rose and European Cranberrybush (Ekici and Velioglu, 2003).

Plant and Fruit Properties

Approximately 30 to 40 of the spherical fruits with a thin crustacean, single-core, non-abdominal cleft form a cluster. Fruits that are watered as they mature have a weak, drooping, umbrella appearance. The fruit juice yield of these fruits is approximately 43.5% (Ekici and Velioglu, 2003).

Gilebor mostly adapted to the continental climate, which is hot and dry in summers and cold in winter. As a plant, it is mostly shrub-shaped, sometimes gaining a small tree appearance (Fig. 1a, b, c). The leaves are opposite, the next with the cross, the edges are notched, 3-5 lobed structure. The leaves are green in spring and take a clear red color in autumn. It has an umbrella shape and a bulk flower structure. Gilebor is a shrub that opens white flowers in May-June. Fruits are greenish in color and take a dark red color to maturity and there is a heart shaped seed inside. Fruits are generally spherical, with a thin shell (Fig. 2a, b, c, d). 30-40 of the fruits come together to form a cluster (Koca, 2009; Karadeniz et al., 2003).

It is mostly spread on trench sides, wetlands and grown as ornamental plants in parks and gardens. It is resistant to winter temperatures up to -25 ° C. Their bodies are very branched and lint-free. Foliage is usually three-piece, mutual and handle. The ripe fruit is red and spherical (Figure 1). Gilebor berries are green in color, yellow to green, and red when ripened, red, spherical, thin-shelled, heart-shaped, flower-shaped umbrellas, inflorescence 5-10 cm in diameter, each in the case of flowers, 75.25 pieces of fruit is composed of average (Karadeniz, 2004; Gundogar, 2013).

This species is cultivated as a fence plant, commonly in a natural way or at the edges of the garden and is replicated with steel. In the Kayseri region, cramp bark fruits are harvested by producers and purchased by local wholesalers, either in brine or placed in canisters in fountain waters and sold in the domestic market.

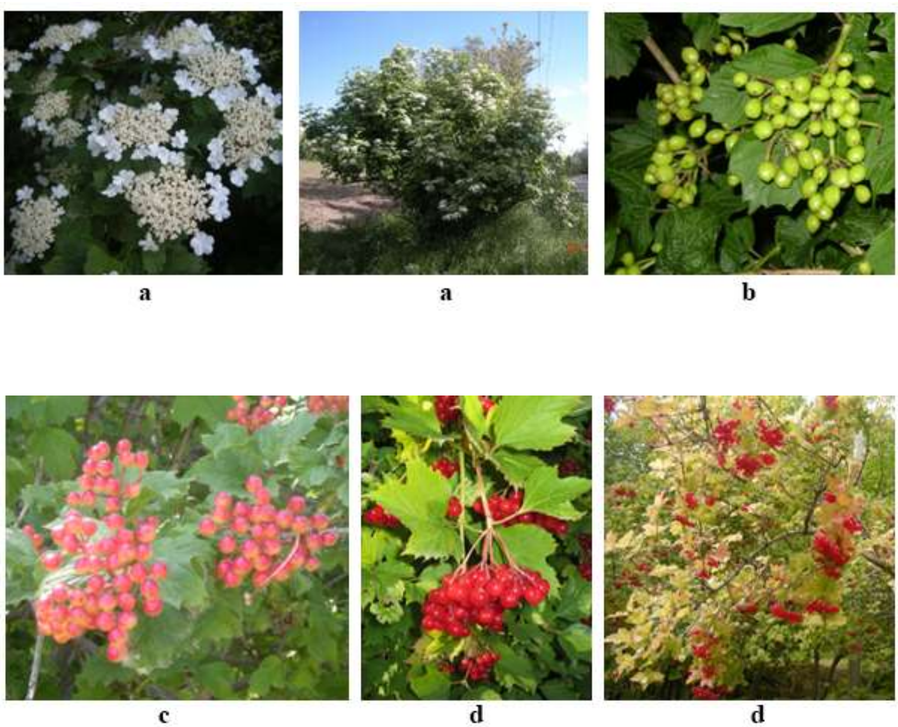

Figure 1. Appearance of cramp bark fruits at different periods a: flowering, b: after fruit attitude, b: color transformation in fruits, d: ripe fruits, e: harvested fruits, f: cramp bark fruits offered for sale, g: consumption

Biochemical Properties and Uses

In the shells of cramp bark fruits are resin, valerian acid, sugars, tannins, and organic acids. Usage obtained by squeezing ripe fruits is used as a beverage. Its fruits contain vitamins, minerals, and other bioactive substances.

It is understood that fruits are a valuable fruit because of the vitamins, minerals and other bioactive substances contained in them and the varieties have been revealed in Russia by selection studies made from natural populations (Nekrotova et al., 1987). In a study, raspberries (*Rubus ideaus cv.* Heritage,), cramp bark (*Viburnum spp*.), Elderberry (Sambucus spp.) Rosehip (*Rosa canina var. canina* L.) in terms of antioxidant capacity of the fruits of the grapes have been compared to the highest antioxidant capacity cramp bark has been seen to have fruit (Elmastaş and Gerçekçioğlu, 2006).

This plant, which was called “Gül Ebru” during the Seljuks and Ottomans, was called by this name because of its beautiful appearance during the flowering period. Cramp bark is known in different regions of our country with the names known Gilaburu”, “Gilaboru”, “Gilebolu”, “Geleboru”, “Girabolu”, Gilabu”, “Gildar”, “Giraboğlu”, “Giligili” and “Gülabba” (Ekinci et al. 2003; Aksoy et al. 2004; Özer and Kalyoncu, 2007; Hızlısoy, 2009).

In Canada, cultivation studies are continuing (Richard & Pierre, 1992). Late flowering and white flowering varieties are common in Europe.

Fruits that ripen towards the autumn can remain in the tree even in winter. Today, in Europe, Aureum, Compactum, Manum, Notcutt, Roseum is cultivated in a variety of varieties (Anonymous, 2009). Cultivated in the Netherlands and England. In Norway and Sweden, she has been in bakery products for many years. In North America, it is reported that cramp bark is chosen as one of the best species among the 38 species in rural landscaping (Nekrotova et al. 1987).

Dried peel is used as a tincture to ease tea or painful menstrual cramps. This plant is often used as a uterine sedative in the treatment of women's diseases such as spasm, cramping and muscle relaxant, prevention of postpartum disorders, low and internal bleeding (Anonymous, 2016).

In the SO_2 sensitivity test of 72 species, cramp bark is determined as the most resistant species and it is recommended to use this plant in highly polluted areas such as industrial zone and highways (Mapeza, 1986), and this type works well in both landscape arrangements and rural afforestation (Öztürk and Özçelik, 1991; Baytop, 1984; Davis, 1972; Kara et al.1995) increases the interest in gileboroya.

It is considered as a precious ornamental plant in parks and gardens with its white flowers such as showy balls, bright red berries and autumn rotating leaves (Öztürk and Özçelik, 1991; Baytop, 1984; Davis, 1972). In Norway and Sweden, she joined the bakery products and is used in Canada to make jelly-like dessert.

Medicine, Folk Medicine, and Other Uses

In the composition of cramp bark fruit, 19.86% crude cellulose, 7.81% water soluble dry matter, 6.71% crude protein, 5.83% reducing sugar, 560 mg / kg ascorbic acid, 2473.8 mg / kg potassium and 402.62 mg / kg sodium are reported. It is also known as a fruit rich in antioxidants.

Fruit shells include sugars, tannins, organic acids, resins, valerian acids. Due to the minerals, vitamins and bioactive substances it contains, studies are carried out abroad. It is reported that this fruit improves blood pressure and is beneficial against cramps and migraine. It has also been reported that fruit juice is used in the treatment of kidney, liver, bile and ulcer diseases and it can be used as a diuretic (Baytop, 1967; Karadeniz et al., 2003). Likewise, cramp bark fruit has been reported to be used in asthma, epilepsy, high blood pressure, heart disease, rheumatism, nervous disorders and some skin problems (Sönmez et al. 2008).

In the US, it is used successfully in medicine in the treatment of many diseases such as nerve diseases, fatigue, cramp relievers, epilepsy, tetanus and rheumatism diseases in the bark of plant known as Cramp Bark (Anonymous, 2009).

Known as a kidney doctor among the people, gilaburun has a reducing effect on kidney stones. Although its fruits are used in the ink industry, it is rich in linoleic and oleic fatty acids, organic acids, inorganic substances and ketone compounds, which are especially concentrated in fruit seeds (Yang et al. 2011).

Its leaves and bark are rich in vitamin K (Aksoy et al. 2004). Studies have found that it has an effect on increasing coagulation and reducing blood loss (Yürüker, 1993).

In our country, cramp bark cultivation is limited, fruits are eaten as berries and nuts are considered as syrup. Fruits are known to be effective in the treatment of ulcers, diuretic and coughing (Gerçekçioğlu and Yavaş, 1999).

Flowers and body shell constipated, diuretic, stomach pains and kidney stones, reducing the effect shows. In addition, pickles are made of fruits.

Cramp bark is a sedative, sleep-giving, diuretic and laxative effective. For the above benefits, 30 g body shell and leaf should be boiled in 1 lt water or 3 cups per day by composting the fruits.

Cramp bark corrects tension, relieves muscle congestion and spasm, is beneficial to muscle cramps, ovarian, uterine and muscle problems, and migraine. Child abstinence removes the painful cramps that occur in the uterus and menstruation and is healing in bile and liver diseases. It also reduces blood loss due to menopause, especially during bleeding periods, in the prevention of excessive blood loss, playing a astringent role in the vessels. Helps to calm the convulsive state in children. Cramp bark relieves the cardiovascular system in hypertension and removes constipation due to blood pressure. To be applied externally, muscle cramps or relieves tension, is beneficial on migraine. Fruits are used in the treatment of kidney, liver, bile, ulcer diseases, are used as a good diuretic and cough suppressant in folk medicine (Karadeniz, 2004; Gerçekçioğlu and Yavaş, 1999; Öztürk and Özçelik, 1991).

When scientific studies conducted in the world in recent years are examined, cramp bark fruit juice provides a reduction in some tumoral formations due to its antioxidant properties, it also relaxes the skeletal and muscular system, regulates the vascular width, relaxes the vascular system in patients with high blood pressure, calms the heart, strengthens the heart, treats constipation and urinary problems. It has been reported to be effective (Yao et al. 2004; Yang et al. 2011; Kraujulyte et al. 2013; Karaçelik et al. 2015).

It is thought that the fermented products of Viburnum opulus L. can be recommended as a natural preservative for people with suspected or high potential for urinary tract infections as an alternative to antifungal drugs (Yıldız and Ekici, 2019).

In the Şebinkarahisar region (Giresun) cramp bark can be stored in the fountain water for 5-6 months without disturbing its freshness or consumed as pickles. In addition, mixed with plain or other fruits are made by compote or syrup (Karadeniz et al., 2003).

Biochemical properties of edible portion of 100 g:

TSSC 14.37%, pH 3.9, acidity 1.57%, invert sugar 5.83%, water 86.68%, crude protein 6.71%, ash 2.64%, crude cellulose 19.86%, crude oil 6.47%, ascorbic acid (mg / kg) 560, Ca 6.04 mg, Mg 6.08 mg, Fe 0.342 mg, Cu 0.086 mg, Zn 0.50 mg, Na 40.26 mg, K 247.38 mg (Karadeniz, 2004; Bolat and Ozcan, 1995; Gundogar, 2013).

As a result, the benefits of cramp bark in terms of vitamins and minerals in human nutrition, the benefits obtained by using it in folk medicine as well as in the landscaping arrangements of flowers, fruits, and leaves because of the valuable in terms of decorative, more important research is seen on the fruit is a kind of fruit. When this type of fruit is cultivated, we believe that our country's fruitfulness will undoubtedly contribute positively.

References

Aksoy, A., A. Güvensan, E. Akçiçek, M. Oztürk, (2004). Etnoecology of Viburnum opulus L. International Symposium on Medicinal Plants: Linkages Beyond National Boundaries, 7-9 September 2004, Islamabad, Pakistan, 65-70.

Altan, A., S. Kuş, K. Kaya, 2004. Gilaboru (*Viburnum opulus* L.) Suyunun Reolojik Davranışının Belirlenmesi. Geleneksel Gıdalar Sempozyumu, 23-24 Eylül, Van, 381-385.

Altun, M. L., G. S. Cıtıroğlu, B.S. Yılmaz, T. Çoban. (2008). Antioxidant Properties Of Viburnum Opulus And Viburnum Lantana Growing In Turkey. International Journal Of Food Sciences And Nutrition, 59(3): 175-180

Andreeva, T. I., E. N. Komarova, M. S. Yusubov, E. I. Korotkova. (2004). Antıoxıdant Actıvıty Of Cranberry Tree (*Vıburnum Opulus L*.) Bark Extrac. *Pharmaceutical Chemistry Journal Vol. 38, No. 10:26-28.*

Anonim, 2009. http://www.library.utoronto.ca

Anonim, 2015.www.bunyankaymakamlik.gov.tr

Anonim, 2016. http://www.luminescents.co.uk).

Baytop, A. (1984). Türkiye'de Bitkilerle Tedavi (Geçmişte ve Bugün). İstanbul Üniversitesi Eczacılık Fak. Yayınları, No: 40, İstanbul.

Bolat, S., M. Özcan. (1995). Gilaburu (*Vibirnum opulus* L.) Meyvesinin Morfolojik, Fenolojik ve Pomolojik Özellikleri ile Kimyasal Bileşimi. Türkiye II. Ulusal Bahçe Bitkileri Kongresi, Ç.Ü. Ziraat Fakültesi Yayınları, Cilt 1: 772-775, Adana.

Cam, M., Y. Hisil, A. Kuscu. (2007). Organıc Acıd, Phenolıc Content, And Antıoxıdant Capacıty Of Fruıt Flesh And Seed Of *Viburnum Opulus Chemistry Of Natural Compounds, Vol. 43, No. 4: 460-461.*

Davis, P.H. (1972). Flora of Turkey and East Aegean Island. Vol 4. Edinburg Üniv. Press. P.543-544.

Ekici, L., S. Velioğlu. (2003). Gilaburu ve Sağlık. www.cinetarim.com.tr/dergi/arşiv 46/ arastirma02.htm

Elmastaş, M., R. Gerçekçioğlu. (2006). Bazı Üzümsü Meyve Türlerinin Antioksidan Aktiviteleri. II. Ulusal Üzümsü Meyveler Sempozyumu Sayfa: 295-298.

Frei, B. (1994). Natural Antioxidants in Human Health and Disease. Academic Press, San Diego.

Gerçekçioğlu, R., M.A. Yavaş. (1999). Gelebor'un (*Viburnum opulus* L.) Yeşil ve Odun Çelikleri İle Çoğaltılması Üzerine Bir Araştırma. Türkiye III.Ulusal Bahçe Bitkileri Kongresi, 14-17 Eylül, Sayfa:838-842, Ankara.

Gündoğar, R. (2013). Kayseri Yöresinde Yetişen Gilebor (*Viburnum opulus* L.) Genotiplerinin Belirlenmesi. Ordu Üniversitesi Fen Bilimleri Enstitüsü, Doktora Tezi. (Basılmamış).

Halliwell, B. (1996). Antioxidants in human health and disease. Ann. Rev. Nutr. 16, 33±50.

Hizlisoy, H. (2009). Çeşitli Mikroorganizmalar Üzerine Gilaburunun Antimikrobiyal Etkisinin İncelenmesi, Yüksek Lisans Tezi, Erciyes Üniversitesi Sağlık Bilimleri Enstitüsü, Kayseri,1-37.

Kara, Z., Y. Fidan, R. Gerçekçioğlu. (1995). Tokat Yöresinde Tabii Olarak Yetişen Gilebor (*V.opulus* L.)'un Fenolojik ve Pomolojik Özellikleri Üzerinde Bir Araştırma. Türkiye II. Ulusal Bahçe Bitkileri Kongresi. Cilt I, Sayfa:767-771.

Karaçelik, A.A., M. Küçük, Z. İskefiyeli, S. Aydemir, S. De Smet, B. Miserez, P. Sandra. (2015). Antioxidant components of Viburnum opulus L. Determined by on-line HPLC- V-ABTS radical scaving and LCUV-ESI-MS methods. Food chemistary, 175:106-114.

Karadeniz, T. (2004). Şifalı Meyveler (Meyvelerle Beslenme ve Tedavi Şekilleri). (Yardımcı Ders Kitabı). Burcan Ofset. Matbaacılık Sanayii. 208 s.

Karadeniz, T., T. Şişman, S. M. Şen. (2003). Şebinkarahisar'da Yetiştirilen Bir Gilebor (*Viburnum opulus* L.) Tipinde Morfolojik ve Pomolojik Özellikler. Ulusal Kivi ve Üzümsü Meyveler Sempozyumu 23-25 Ekim, Sayfa: 481-484.

Kım, Mı-Y, K. Iwaı, A. Onodera, H. Matsue. (2003). Identification And Antiradical Properties Of Anthocyanins İnfruits Of *Viburnum Dilatatum* Thunb. *J. Agric. Food Chem., 51,* 6173-6177.

Koca, S. (2009). Kayseri ilinde Gilaboru Bitkisi (*Viburnum opulus* L.) Üzerinde Bulunan Arthropoda Türlerinin Belirlenmesi. Yüksek Lisans Tezi, Selçuk Ün. Fen Bilimleri Enst. Konya.

Kraujalyte, V., P. R. Venskutonis, S. Pukalska, L. Cesonine. (2013). Antioxidant properties and polyphenolic compositions of fruits from different European cranberry bush (*Viburnum opulus* L.) genotypes. Food Chemistry, 141:3695–3702.

Mackerras, D. (1995). Antioxidants and health. Fruits and vegetables or supplements? Food Australia 47S, 3-23.

Mazepa, V.G. (1986). Sensitivity of Tree and Shrub Species to Different Concentration of SO_2. Lesovodsvo-i-Agrolesomelioratsiya 72, 33-37.

Nekratova, N.A, N.F. Keratova, V.M. Vershinin. (1987). Sources of Medicinal and Fod Plants in Some Southern and Central Region of The Tomsk Area. Rastitel'niye-Resursy, 23(2):178-189.

Özer, E, İ. H. Kalyoncu. (2007). Gilaburu (*Viburnum opulus* L.)'nun Yeşil Çelikle Çoğaltma İmkanlarının Araştırılması. Selçuk. Ün. Zir. Fak. Dergisi: 21 (43): 46-52.

Öztürk, M., H. Özçelik. (1991). Doğu Anadolu'nun Faydalı Bitkileri. Siirt İlinin Kültür ve Araştırma Vakfı yayınları, Ankara.

Richard, G., T. S. Pierre. (1992). The Development of Native Fruit Species as Horticultural Crops in Saskatchewan. HortScience 27(8):866,947.

Riemersma, R. A. (1994). Epidemiology and the role of antioxidants preventing coronary heart disease: a brief overview. Proc. Nutr. Soc. 53, 59-65.

Rop, O. V. Reznicek, M. Valsikova, T. Jurikova, J. Mlcek, D. Kramarova. (2010). Antioxidant Properties Of European Cranberrybush Fruit (*Viburnum Opulus* Var. *Edule*). *Molecules 15*, 4467-4477

Schwartz, J. L. (1996). The dual roles of nutrients as antioxidants and prooxidants: their effects on tumor cell growth. J. Nutr. 126S, 1221-1227.

Sönmez, N., H. H. A., Alizadeh, R. Öztürk, A. A. Acar. (2008). Some Physical Properties of Gilaburu Seed. Tarım Bilimleri Dergisi: 13 (3): 308-311.

Velioglu, Y. S., L. Ekic, E.S. Poyrazoglu. (2006). Phenolic Composition Of European Cranberrybush (*Viburnum Opulus* L.) Berries And Astringency Removal Of İts Commercial Juice. International Journal Of Food Science And Technology, 41, 1011–1015

Yang, B., M. Ahotupa, P. Määttä, H. Kallio. (2011). Composition and antioxidative activities of supercritical CO_2-extracted oils from seeds and soft parts of northern berries. Food Research International, 44, 2009–2017.

Yao, L. H., Y. M. Jiang, J. Shi, F. A. Tomas-Barberan, N. Datta, R. Singanusong, 2004. Flavonoids in Food and their health benefits. Plants Foods for Human nutrition, 59:113- 122.

Yıldız, R., H. Ekici. (2019). Gilaburu (*Viburnum opulus* L.)'Nun Farmakolojik Açıdan Değerlendirilmesi. Veteriner Farmakoloji ve Toksikoloji Derneği Bülteni Bulletin of Veterinary Pharmacology and Toxicology Association ISSN: 1309-4769, 10(1): 16-23.

Yürüker, A. (1993). Viburnum orientale Pallas üzerinde fitokimyasal çalışmalar, Doktora Tezi, Hacettepe Üniversitesi Sağlık Bilimleri Enstitüsü, Ankara.

CHAPTER 6

GRAPE IN ANOTOLIAN CULTURE

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1. Introduction

The grape was cultivated and started to be used by humans more than 6000 years ago. The culture of viticulture and winemaking began in the northeastern part of Anatolia thousands of years ago and spread to the whole world (Sağlam and Çalkan Sağlam, 2018; Atak, 2021).

Vine (*Vitis vinifera* L.) is a plant adapted various climatic and soil conditions. Viticulture is made between 20°-50° north and 20°-40° south latitudes in the world (Ergül et al., 2017; Karakuş, 2020) Because of its easy adaptation to the ecology, the vine plant is known to be grown over a wide area in the world (Balı et al., 2021).

Grape is one of the most widespread cultivated plants in the world and Turkey, as it is not very selective in climate and soil and has alternative evaluation possibilities. Grape is one of the most produced fruits in the world. Approximately 78 million tons of grapes are produced every year in the world. Grapevine is cultivated in almost every region except the tropical close to the equator. Also, there is no significant vineyard area in the parts of Africa other than the northern and southern ends (Atak, 2021).

Viticulture is an important agricultural sector for both the world and Türkiye. 77.8 million tons of fresh grapes are produced in a total of 7.5 million hectares of vineyards in the northern and southern hemispheres (Anonymous, 2019). The fresh grapes produced are evaluated by different sectors based on viticulture. Today, approximately 32% of the total fresh grape production is used in the table grape industry for fresh consumption. Moreover, in the last twenty years, with the changing world conditions, significant developments have occurred in the viticulture-based industry. While there was an average of 11.8 million tons of table grape production in the world in 1991-1995, the latest statistical data show that the amount reached 28.0 million tons. The main reason for the increasing table grape production in the 21st century is the consumption demand. The consumption of table grapes in the world has increased rapidly since 1991, reaching 28 million tons from 11.7 million tons (Anonymous, 2020)

The history of the vine or grape goes back millions of years. Although there are very different opinions about the homeland of the vine. The Caucasus, the south of the Caspian Sea, and the North-East Anatolia regions are shown as the homeland due to the richness of wild vine forms. However, as a result of the geological and archaeological researches carried out in the 20th century it was determined that even 60 million years ago, the vine was grown in many parts of the world. Press residue grape seeds dating back to 10,000 years ago were found in Anatolia. This shows that making wine from grapes is as old as human history and that the culture of viticulture started in Anatolia during these years. The history of viticulture is intertwined with Anatolian civilizations.

Many archaeological finds from the Hittites who came to Anatolia in 2000 BC and established a great civilization of 600 years describing the importance of viticulture have reached the present day. In addition, the presence of figures of grapes and wine in the rock paintings, the inclusion of special provisions in the Hittite laws for the protection of vineyards and the product, the mention of raisins in the Boğazköy texts are other documents that carry the importance of Anatolian viticulture in terms of social and economic aspects.

Archaeological findings reveal that grape and wine were of great importance during the Hittites period in Anatolia, viticulture developed greatly between 1800 and 1550 BC, and grapes and wine were presented as offerings to the gods in religious ceremonies and social life. The Hittites also applied agricultural laws in accordance with today's understanding to protect their assets such as vineyards and gardens (Oraman, 1965; Akşit, 1981).

2. The Importance of Grape in Anatolia

Türkiye has an important place among the countries engaged in viticulture in the world (Ergönül and Öztürk, 2015). Due to its location, the ecology of Türkiye is suitable for viticulture. Therefore, different grape varieties can be grown in most regions of the country (Karabat et al., 2009).

The vine (*Vitis vinifera* L. *subsp. sativa*), which is cultivated all over the world, was formed from wild vine (*Vitis vinifera* L. *subsp. silvestris* Gmel.) by natural or artificial hybridization and selection lasting thousands of years (Oraman, 1972; This, et al., 2006). There are approximately 10,000 grape varieties in the world (Alleweldt, 1997). It is among the important gene centers of the cultivated vine of Turkey *Vitis vinifera* L. *sativa* and wild vine (*Vitis vinifera spp silvestris*)

(Arroyo-Garcia, et al., 2006). Turkey is located in the center of the geography where the gene centers of the vine intersect and where it was first cultivated. Accordingly, there are more than 1200 grape varieties in Turkey (Ergül and Ağaoğlu, 2001; Ergül et al., 2002; Uzun and Bayır, 2008).

Although the first thing that comes to mind when it comes to the history of viticulture and winemaking in Anatolia is the Hittite civilization that came to Anatolia since 1900 BC, the Hittites learned viticulture from people living in Anatolia before. The Assyrians, an important civilization of Mesopotamia and Anatolia, were very advanced in trade as well as winemaking. The Assyrians carried the dried grapes and wine from one place to another and traded them. As a matter of fact, the grape fossils dating back to 1300 BC and tools and equipment related to winemaking in the excavations in Diyarbakır show that the grape civilization goes back much further (Anlı, 2006).

One of the most important evidences of the use of a product in a region is the findings obtained from the archaeological excavations. In particular, the remains of objects that are used or consumed intensively are indispensable from archaeological excavations. Anatolia is a geography where grapes are consumed and cultivated for thousands of years. The presence of figures and reliefs related to grapes in historical artifacts unearthed from archaeological excavations in different regions of Türkiye are the most important indicators pointing to the widespread viticulture culture in that region (figure 1).

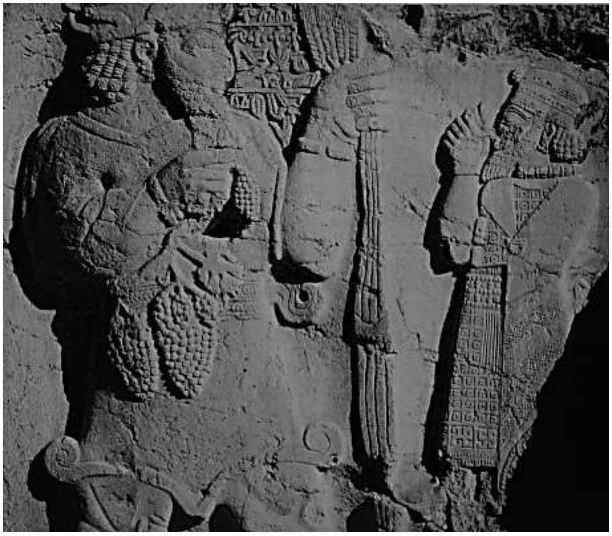

Figure 1. Rock embosses from king warpalava, pre-hittite, (BC 1200-742), Konya, Ereğli, Aydınkent (Dvriz).

In fact, important artifacts from prehistoric times related to viticulture were found in archaeological studies carried out in every region in Türkiye. In the archaeological searches carried out in Çanakkale Hisarlık region, grape seed fossils dating back 3000-4000 years have been found. The lamp of 1750 BC, which is in Konya Karahöyük and carries many bunches of grapes side by side, is the proof of the high value placed on grapes in Anatolia (Akşit, 1981).

The history of the vine in Anatolia begins with the civilizations in Anatolia. Although the history of wine is older, the beginning of wine culture was with the Hittite civilization. BC Hittites exhibited in the Museum of Anatolian Civilizations. The solid gold wine jug and pedestal wine glass dating from 3000 BC from the Hittites on display at the Museum of Anatolian Civilizations is the oldest wine container found (figure 2) (Deliorman et al., 2011).

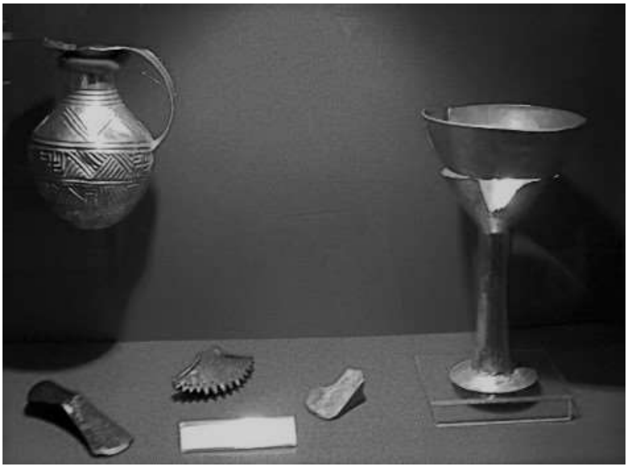

Figure 2. A wine cup and a decanter wine made of solid gold- Museum of Anatolian Civilizations-Hittites (3000 BC).

Local gods are depicted on votive steles left over from the Roman Period in the Phrygia Region in Anatolia (200-300 AD), which the people made to present satisfaction to the gods and convey their wishes (figure 3). Zeus Ampelikos and Zeus Ampeleitos, who protect the vineyards, are among them. Various organs were used for health, tools and equipment used in agriculture for abundance, oxen, shepherds, and the vine were used to symbolize fertility (Anlı, 2006).

Figure 3. Grapevine, grape and Dionysos portrayal on a soil container.

According to archaeological findings, grapes were produced after 6000 BC for consumption of fresh or dried fruit and for use in wine making. The age of the seeds found in bulk as the squeezing residue as a result of making alcoholic beverages, determined by using the radio carbon technique, shows that the wine was known and produced 10,000 years ago (Ağaoğlu, 1999).

Egyptian hieroglyphs from around 2400 BC depict grape growing and winemaking. The therapeutic value of wine has also been known for a long time. Hippocrates, Plinus, Galen used wine in the treatment of many diseases. Different parts of the plant were used by the people for different purposes. Ancient Egyptians, Hippocrates, Theophrast, Dioscorides, Plinus and Galen described the medicinal properties of the vine plants and its products (Bombardelli and Morazzoni, 1995).

Figure 4. Diana, goddess.

It has been proven by scientists that Anatolian civilizations influenced Greek civilization. The source of the Dionysian belief in Greek civilization is probably the god that also we see on the Dvriz relief, holding a bunch of grapes in his hand (figure 4). The beliefs that passed from the Hittites to the Lydians later passed to Crete and from there to the Greek civilization. In Greece, Dionysus, son of Zeus, was considered the protector of natural crops, later the protector of vineyards and the inventor of wine. It has been accepted by ancient historians that Dionysus and his vintage entertainments came to Greece from Anatolia. The Romans, on the other hand, adapted Dionysus to their own culture as Bacchus. Over time, Bacchus transformed from the god of wine to a divine savior. Christianity spread in Anatolia immediately embraced the Bacchus society and its symbols. The hanging figure is frequently used because Jesus depicts himself as hanging and his blood as wine. Thus, wine has become an inseparable sacred part of Christian culture and rites (Akurgal, 1997).

Many coins from the Archaic, Classical and Hellenistic Periods (fig. 5) was used grape and vine leaves. On the obverse side of the coins, there is a god consecrated as the symbol of the city where the money was minted, a figure in mythology or a local product showing natural wealth, while on the reverse side there is an atribus symbolizing the god. For example, coins with Dionysus on the obverse have grape clusters, vine leaves or kantharos on the reverse. Karia, Tenedos and Soloi coins can be given as examples of grape figured coins (Tekin, 1997).

Figure 5. Grape bunch on a coin.

The importance of vines and grapes in Anatolian culture is also evident in many historical ruins. Diyarbakir Ulu Mosque, that the oldest mosque in Anatolia, was built in 639 by Muslim Arabs by converting the Martoma Church in the center of the city into a mosque. The vine leaves and bunches of grapes used in the decoration of the mosque are striking (Figure 6) (Anlı, 2006).

Figure 6. Vine leaves and grapes on a mosque wall dating from the Ottoman period.

Vine and grape figures were also frequently used on fountain monuments and tombstones during different civilizations (Figure 7). In addition, vine and grape figures have become one of the indispensable patterns of stonework in exterior decorations (Mutlu, 1997).

Figure 7. Grape and human figure on grave ornamentation.

There are also many documents showing that viticulture was practiced in many regions in Anatolia. For example; The Menua (Semiramis, Samram) irrigation canal and the vineyard around it, which remained from the Urartians (900-600 BC) in Van, are widely described in old documents (Anlı, 2006).

During the Seljuk and Ottoman periods, vines and grapes were frequently used in the wall tiles of mosques and palaces. This is the most important evidence that the value attached to the vine by the Muslim Seljuks and Ottomans continued similarly to other societies. Today, some of these tiles have been smuggled abroad and are exhibited in various museums.

Viticulture has declined in all countries under Arab domination, in North Africa, Sicily, and Spain. Because the sultans, who preferred water and cool shadows with Semitic frugality rather than the cult of scorching liquor, did not allow viticulture for wine production. There were even conservatives who did not want to tolerate grapes at that time. The Umayyad Sultan's of Andalusia, Hakem 2, said, "He almost uprooted the vine in Spain and allowed only one-third of the vineyards. Because Islamic rules allow to consumption grapes as grapes, in the form of raisins, fruit pulp, sherbet and grape honey." With the first sea voyages of the Greeks to the west, the coasts of Italy were also introduced to this evil drink (Hehn, 1998).

Babylon Hanging Gardens, one of the seven wonders of the world, is located on the coast of the Euphrates and was discovered by the famous German archaeologist Robert Koldewey during excavations that began in 1898. It is understood from the excavation that Babylon was the most magnificent city of Mesopotamia. The three structures unearthed in Koldewey's excavation were enough to turn the world's eyes on Babylon. The ruins of the hanging gardens, the Tower of Babel and a very majestic street. Koldewey, who researched ancient inscriptions and clay tablets during his excavations, succeeded in unearthing the Babylon's Hanging Garden, which is called the Hanging Gardens of Queen Semiramis in ancient sources. Thus, it was revealed that Hanging Gardens of Babylon were built by Queen Semiramis, who ruled Babylon after the death of the Assyrian king Ninos (Gürkan, 2014; Akşit, 1981)

In the history of Anatolian civilizations, vineyards and wine have always played an important role in the livelihood of the people and in trade. Throughout history, grapes obtained in Anatolia were mostly consumed as dry and fresh, while some of them were evaluated as molasses, bulama, fruit pulp, Turkish delight and köfter.

Grapes and grape products are not only important in terms of nutritional content; It is also of great importance because of its extremely positive effects on human health. In recent years, intensive studies have been carried out to determine the effects of these products in this direction (Aras, 2006).

When we compare today's viticulture with the it's in the ancient period, it is seen that the grape culture was also affected in the development of history, degenerated in the countries where it was born, on the other hand, it reached the last stage of its development in the regions that acquired this culture much later (Mutlu, 1997).

3. Grapes and Mythology

Mythologies are made up of legends. In mythology, there are many legends told about vines and grapes. The most commonly told legend is briefly as follows;

The ship that Noah had boarded with various animals to protect all of them from the flood had run aground. Some of the animals on the ship dispersed in search of food. When one of them a goat, returned to the ship, was making strange movements and bumping into other animals when there was no reason. Noah followed the goat the next day for knowing what goat would do. Finally, he saw that the goat was eating the fruit of the vine, an ivy plant entwined in the trees, and then the goat was cheerful and drunk. Noah, who discovered grape juice, that is wine, thanks to the goat, was cheerful and enjoying himself whenever he drank wine. This did not please the devil, he blew with his scorching breath and dried the vines, and then he regretted it. The only way to make the vines green again was to shed the blood of seven animals at the bottom of the vine. The blood of lions, tigers, dogs, bears, roosters, magpies and foxes was sheded on the soil of the dried vine saplings. After this, a year later, the vines turned green and yielded again. Drunk people would display the behavior of the animal that suited their temperament. In other words, they would be as strong and brave as a lion, as fierce as a tiger, as strong as a bear, as belligerent as a dog, as loud as a rooster, as cunning as a fox, and as talkative as a magpie (Hehn, 1998).

It is believed that this pattern of behavior continues even today. Because of this understanding, it continues to be avoided especially from drunkards who are belligerent like a dog, loud as a rooster, and chatty like a magpie.

In the mythological period, the importance given to vine, grape and wine is quite high. It was believed that the gods played a major role in the fertility of grapes and wine. It is even known that in some regions, the grapes were even sacrificed to the gods in order to be fertile.

In Italy, people have believed that, the vineyards were protected by the god Jupiter. In order for the vineyards to yield good products, a feast was held for Jupiter twice a year. The first feast was held when the vine was in bloom, and the second when the first crop of the year was tasted. On this festival, the priest sacrificed a female sheep to the chief god, and then a bunch of water was squeezed and presented to the god (Hehn, 1998).

It is possible to come across many legends describing the importance of the vine from the mythological period. Some of these explain how valuable the vine is as a plant, the grape as a valuable fruit, and the wine as a valuable drink. On the other hand, the number of works that have been put forward to explain how the vine and grape emerged is too great to be underestimated.

King Oineus' father's name was Phytios, meaning "plant". The dog of Oretheus, king of Aitolia, gave birth to a wood. Thinking that this miracle has a meaning, Oretheus bury the piece of wood in the ground. After a while, a vine emerges from the place where he was buried, which produces wonderful grapes. Seeing this, Oretheus names his son Phytios. It is a coincidence that Oineus, the son of Phytios, also became the king after whom wine was named (Hehn, 1998).

Legends about grapes and wine are not limited to these. The findings obtained from the excavations point to many more legends. Wine is one of the holiest of Christianity, one of the monotheistic religions.

Clement of Alexandria describes Jesus as “the great bunch of grapes, crushed for our sake Logos”. When Jesus realizes that he is going to die, he gathers his twelve apostles, after blessing the bread and wine, divides them among his disciples, telling them that the bread is his body and the wine is his blood. Jesus tells his disciples that in the reign of God, he will not drink the fruit of this vineyard again until he has tasted it fresh. After that day, Jesus was arrested and crucified. The soldiers mocked Jesus by handing him sour wine. However, Jesus never tasted the product of that vineyard (Hehn, 1998).

4. The Place and Importance of Grapes in Turkish Folk Culture

Grapes in Turkish culture and mythology; It is a symbol of beauty, fertility, blood, life, love and health. In almost all types of folk literature, grapes are found with various characteristics. Grape; Apart from the genres based on narrative such as epics, fairy tales, folk tales and legends, there are proverbs, riddles, poems, lullabies, folk songs, etc. has also been the subject.

The importance given to grapes in Turkish culture is quite high. Giving a bunch of grapes for each advice shows both the value given to the advice and the importance given to the grape. The fact that the grape is a fertile fruit is also one of the issues mentioned.

The word grape, which appears with different values and benefits at every stage of our lives, carries different functions in our fairy tales. In the fairy tale “Grape Seller”, the function of the grape is protection. A man who makes a living by traveling around villages and selling grapes takes advice from a villager he meets on the road for every bunch he gives. Thus, he avoids the mistakes he will make. Giving grapes in exchange for information is a feature that needs attention. Here, it is seen that the source of health and curative properties of grapes are considered equal to people who gain value with their knowledge (Şenocak, 2008).

As an example of a legend in Turkish culture; Sultan II. Murad is informed that a person named Hamza Baba cultivated 5-10 square meters of land in someone else's land, and that despite the small size of the land, he obtained a lot of crops. The months are February or March. On the orders of Sultan Murad, the zaptiyes came to the land to investigate the matter and found Hamza Baba planting a vineyard. Hamza Baba tells them that when they are going to catch him, they cannot go to the sultan empty-handed and to wait for a while. Seeing that the sticks planted a few minutes ago yield grapes right after, the zaptiyes believe in the miracle of Hamza Baba (Aras, 2006).

The nutritional value and health importance of grapes has been known by Turks for thousands of years. There are even tales describing the importance of grapes for health.

The blood and life-giving properties of grapes, especially black grapes, are also mentioned in fairy tales. In the tale called "The Giant with Kara Hasan", the giant gives Kara Hasan to his wife and tells him to feed her with black grapes for forty days so that they can eat the victim. The tale mentions the blood-forming and fattening properties of grapes (Aras, 2006).

The word grape also appears in proverbs and idioms that have the feature of giving advice from the past to the present. While sometimes saying “Grapes have stem, pears have stalks” and young girls while expressing young girls who find fault with everyone and cannot marry, the phrase “üzüm üzüm üzülmek” expresses a lot of sadness and pain (Doğan, 1992).

Sometimes, the phrase "extracting molasses from grape seeds" is meant to describe talented and knowledgeable people. With the phrase "stemless grapes" (Aksoy, 1991), it is used to mean a spouse who does not have close relatives and deprivation of the concepts of excess and abundance is expressed.

Apart from these, grape has been accepted as a sacred fruit pointing to abundance, fertility and productivity since mythological times in the geographies where viticulture is developed, especially in the Aegean, Mediterranean, Middle East and Anatolian civilizations; It has taken important place as a powerful symbol in mystical and religious systems and literary traditions. For example; In Mevlana's language, the words "grape, raisins, clusters, bunches of grapes, grapes, grape shoots, grape leaves, vines, vine branches, grape leaves, grape juice, grape wine, wine, vineyard, viticulture" are frequently encountered (Akarpınar, 2005).

Besides the grape, which is the fruit of the vine, other parts of the plant also take place in the descriptions and expressions of great literary masters.

So much so that even Mevlana used it in his works in her depictions of the shoot, which is the organs of the vine, and “koruk”, which is the name given to unripe fruits of grape.

Grape Shoot; In Mevlana's eyes, Mesnevi is a grape shoot. Just as the grape shoot lengthens by being tied and pulled under the sun, the friendship, closeness and conversations between Çelebi and Mevlâna reinforced and matured Mevlâna's thoughts, created the Mesnevi, and provided the emergence of wise words, each of which tasted ripe grapes.

Koruk; In the language of Rumi, unripe grape, grape and wine represent the states of knowing, finding and being, respectively. Koruk is a symbol of rawness, grapes are symbols of being master, and wine is a symbol of being maturity (Aksoy, 1991).

On the other hand, grape has taken its place in many idioms and proverbs. Grape has always been a symbol of high value, maturity, mastering. “Being a grape”; to know oneself, to grasp its essence, to reach the truth. The "dervish that turning into grape" discovered the secret of existence and found God not in matter but in meaning. To be a grape is to taste absence and never return to substance (Aksoy, 1991).

It has been used in descriptions and descriptions in wine as in grapes. Especially in the expression of love and god love, wine is often used. While wine finds a wide place especially in mystical works, what is mentioned here is actually love in the god love sense. However, it is very important to use wine, even in a different sense, in the depiction of god love.

Although the wine shows that the grape is matured, the wine is still raw. The original, taste, smell and food of the fruit show its effect in wine. Raw grape juice matures over the years. Even if the grape does not appear in the wine, the original is the grape. Just as the grape dissolves in wine, the lover burns down in the fire of god love; passes from existence to non-existence. Grapes and Wine; The concept of "to be or not to be", which can only be explained by concrete-abstract transitivity, is one of the mainstays of Sufism. Mevlâna makes use of the grape and wine pairing in this regard: “The soul sees wine from grapes and what exists out of nothing”. According to him, those who experience the transitivity of being or not are “looking at grapes and seeing wine, looking at nothing and seeing what exists” (Aksoy, 1991).

5. Final Evaluation

Grape, whose cultivation started in prehistoric times, is an indispensable product for human beings. The importance given to grapes, not only in terms of human health and nutrition, but also in people's beliefs and symbols in their living spaces, was once again brought to the agenda with examples. So much so that concepts such as grape, wine and vineyard, which are loaded with the meanings of love and fertility, are encountered in historical works from ancient times to the present day. In addition, the importance given to grapes and wine in mythological works belonging to both Turkish and other societies is clearly seen in the sources.

What needs to be done today is to ensure that these works are passed on to future generations without being lost or damaged. It is necessary to carry out studies so that the works (tale, mania, riddle, proverb…) that have an important share in Turkish folk culture and in which the words related to grapes are not forgotten and lost. However, symbols such as grapes, vineyards, wine, grape leaves, which were given such importance in the past, should also be included in today's works.

Not only the mystical meaning of the grape, but also the currant of the grape should be protected. For example; from a historical point of view, the current situation of our viticulture culture, which dates back to very old years, unfortunately does not show a very pleasant situation in terms of protecting our local varieties. The reason for this is that we did not take care of the varieties that we cultivated in our villages in the past, and we watched them disappear. The best example of this is the Sultani Çekirdeksiz variety, which has an important share in the production and export of grapes in our country. In the world markets of Sultani Çekirdeksiz, which is the important variety of our country; The fact that it is known as "Thompson Seedless" is due to our inability to protect this variety. We can briefly explain this situation as follows;

When we look at the history of Thompson Seedless, a person named Thompson, who worked in Turkey in the 1800s, took seedless grape shoots from the vineyards in Izmir's Urla district, first to Crete and then to America. The Sultani Çekirdeksiz grape variety, which was taken to America, was patented in 1900 under the name "Thompson Seedless" due to the great interest in the United States. It is included in the scientific records that the US embassy officer Thompson brought the Sultani Çekirdeksiz (Sultanina) grape from Anatolia to the USA (Winkler et al., 1974). Sultani Seedless is still known as Thompson Seedless whole world, although its homeland is Anatolian lands. This shows us that we do not protect our values enough in grapes like many of our other values.

It can be seen that throughout history, grape has always been a factor that significantly affects the way of life. Therefore, we must protect and take care of the grape and its elements, which are a part of our culture.

6. References

Ağaoğlu, S., 1999 *Bilimsel ve Uygulamalı Bağcılık (Cilt I, Asma Biyolojisi)*, Rekmay Ltd.,Ankara , s.1.

Akarpınar R.B., 2005. Mevlâna Celâleddin Rûmî'nin Mesnevi ve Rubâiyyat'ında "Meyve" ve "Üzüm" Sembolleri. Bilig-Kış ; 32: 145-164

Akşit, İ., 1981. Hititler. Türkiye'nin Tarih Hazineleri Orta Anadolu Uygarlığı, Sandoz yayınları:2, 160 s

Aksoy, Ö.A., 1991, Atasözleri ve Deyimler Sözlüğü I-II, İstanbul.

Akurgal, E., 1997 *Anadolu Kültür Uygarlıkları*, s. 187.

Alleweldt, G., and Pasingham, J.V., 1988. Progress in Grapevine Breeding. Theor. Appl. Genet. 75:669-673

Anlı R. E, 2006. Bağlar Güzeli: Üzüm ve Üzüm Kültürü Yapı Kredi Yayınları İstanbul, 1. Basım, 238 sayfa

Anonymous, 2019. FAOSTAT. (2019). Statistics Division of Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00153 Rome, İtaly.

Anonymous, 2020. T.C Tarım ve Orman Bakanlığı. Üzüm Değerlendirme Raporu [Erişim: 21.11.2021, file:///C:/Users/user/Desktop/ara%C5%9Ft%C4%B1rmalar/12.pdf]

Aras Ö., 2006 Üzüm Ve Üzüm Ürünlerinin Toplam Karbonhidrat, Protein, Mineral Madde Ve Fenolik Bileşik İçeriklerinin Belirlenmesi, Yüksek Lisans Tezi, Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Bahçe Bitkileri Anabilim Dalı, Isparta.

Arroyo-Garcia, R., Ruiz-Garcia, L., Bolling, L., 2006. Multiple origins of cultivated grapevine (Vitis vinifera L. ssp. sativa) based on chloroplast DNA polymorphisms. Mol. Ecol. 15: 3707–3714.

Atak A., 2021. Dünya ve Türkiye Bağcılığı. In , Bağcılık (Üzüm Yetiştiriciliği) p:8-17 ISBN: 978-625-439-165-1, Balı, E. A., Dardeniz, A., Baytekin, G., Şahin, E., and Türkmen, O. S., 2020. Bazı Üzüm Çeşitlerinin Doku Kültürü Yöntemiyle Mikroçoğaltımı Üzerine Bir Araştırma. Cilt 1 Sayı 2, 30-35

Bombardelli, E., Morazzoni, P., 1995. "*Vitis vinifera* L." *Fitoterapia*, Sayı 66 (4), 1995, s. 291-317.

Deliorman D., Orhan N., Ergun F., 2011. Anadolu Medeniyetlerinde Asma (Vitis vinifera L.), Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Tarih Bölümü Tarih Araştırmaları Dergisi, Cilt 30, Sayı:50. s. .69-80

Doğan, A., 1992, Açıklamaları ve Örnekleriyle Deyimler Sözlüğü, Ankara.

Ergönül, O., and Öztürk, L., 2015. Bazı Asma (Vitis Vinifera L.) Çeşit Ve Anaç Klonlarının Termoterapi Ve Meristem Kültürü İle Virüslerden Arındırılması. Trakya University Journal of Natural Sciences, 16(2): 57-61, 2015 ISSN 2147–0294

Ergül, A., Ağaoğlu, Y., 2001. Ülkemizde asma fidanı üretiminde kullanılan bazı Amerikan asma anaçlarının moleküler benzerlik analizi. Tarım Bilimleri Dergisi7: 141-143.

Ergül, A., Aydemir, B.Ç., and Özmen, C.Y., 2017. Asma Biyoteknolojisi Alanında Gelişmeler. TÜRKTOB Dergisi 2017 Sayı: 24 Sayfa: 12-14

Ergül, A., Marasalı, B. and Ağaoğlu, Y.S., 2002. Molecular discrimination and identification of some Turkish grape cultivars (Vitis vinifera L.) by RAPD markers. Vitis, 41: 159 – 160

Gürkan, H., 2014. Asma Bitkisinin Tarih Boyunca Önemi ve Günümüzde Kullanımı, Erciyes Üniv. Eczacılık Fak. Bitirme Ödevi. 106 s.

Hehn V., 1998. Zeytin, Üzüm Ve İncir, Aça N. (Edt), Dost Kitabevi, Ankara: 112 sf.

Karabat, S., Yüksel, İ., Ünal, A., İnan, M.S., Yağcı, A., Ateş, F., and Yıldız, S., 2009. Farklı Terbiye Sistemlerinde Yetiştirilen Sultani Çekirdeksiz Üzüm Çeşidinin Sofralık Kalitesini Arttırmaya Yönelik Uygulamalar. Türkiye 7. Bağcılık Ve Teknolojileri Sempozyumu Bildiriler Kitabı, Cilt 2; 105-110

Karakuş, C., 2020. Malatya yöresi üzüm çeşitlerinden Köhnü ve Banazkara'nın In vitro çoğaltımı (Master's thesis, MTÖ Üniversitesi). 56s.

Mutlu, B., 1997. *Batı Sanatında Biçimlenme ve Doğu Akdeniz*, İstanbul Güzel Sanatlar Akademisi Yayınları, İstanbul 1977, s. 89

Oraman, M, N., 1972, Bağcılık Tekniği II, Ankara Üniversitesi Ziraat Fakültesi, Bahçe Yayınları: 470, Ders Kitabı No: 162, 402 s

Oraman, M.N., 1965. Arkeolojik Buluntuların Işığı altında Türkiye Bağcılığının Tarihçesi Üzerinde Araştırmalar-I. Ankara Ün. Ziraatak. Yıllığı 15(2): 96-108 s

Sağlam, H., and Çalkan Sağlam, Ö., 2018. Türkiye Bağcılığına Tarihsel Bir Bakış; Asma Genetik Kaynaklarının Önemi. Selcuk Journal of Agriculture and Food Sciences, 32(3), 601-606.

Şenocak, E., 2008. Türk halk kültüründe ve mitolojik bağlamda üzümün yeri, International Periodical For the Languages, Literature and History of Turkish or Turkic Volume 3/5 Fall

Tekin, O., 1997. Antik Nümizmatik ve Anadolu (Arkaik ve Klasik Cağlar), Kanaat Matbaası, İstanbul 1997, s. 113.

This, P., Lacombe, T., Thomas, M.R., 2006. Historical origins and genetic diversity of wine grapes. Trends in Genetics, 22: 511-519.

Uzun, H. and Bayır, A., 2008. Viticulture in Turkey. Bulletin UASVM, Horticulture 65(1): 334-337.

Winkler A.J., Cook J.A., Kliewer W.M., Lider L.A., 1974. General Viticulture. 633p, Univ. of California. Pres, Berkeley.

CHAPTER 7

USE OF SOME FRUITS AND BY-PRODUCTS IN ANIMAL NUTRITION

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Introduction

Feed expenses constitute an important part of the costs in livestock, such as approximately 70%. The nutrition of animals such as cattle, sheep and goats, which are characterized as ruminants, is largely based on roughage. In our country, there are inadequacies in the production of quality roughage due to the use of meadow pasture areas for other purposes and the mistakes made in breeding practices in the roughage produced. For this reason, the most important issue to be considered in the development of our livestock is to meet the need for quality and cheap roughage. Insufficient and expensive roughage sources have led feed producers and animal breeders to find new and alternative feed sources that are not suitable for human consumption and to conduct research on this subject. In this context, vegetable and fruit mixtures (remaining as waste) can be used as alternative feed in markets and markets. The amount of such by-products consisting of vegetable and fruit mixtures is estimated to be 7-10 million tons. Vegetables and fruits are mainly produced as human food. However, in places and times when production is abundant or prices are not at a reasonable level, vegetable and fruit mixture residues are obtained as an alternative feed source in market-market or vegetable and fruit sales or production areas (İpçak et al., 2011). Fruits have a great importance in terms of nutrition, especially due to their vitamin content and pharmacological properties. However, there is a competition between humans and poultry that consume feeds such as corn, wheat and barley, which are also heavily consumed by humans in terms of nutrition. Considering the increasing food need in parallel with the rapid population growth, it is also important to research alternative feed raw materials and carry out studies in order to meet the nutritional needs of poultry.

Animals not only benefit themselves by consuming fruits, but also contribute to fruit production by using them in weed control in orchards. When animal production is considered especially in terms of organic agriculture, it should be considered together with plant production. Biological control practices should be considered instead of chemical control in weed control in organic agricultural production. In this context, farm animals such as sheep and geese can also be used in weed control. Geese are creatures that have been used in the control of weeds in China for centuries, and their first use in the modern sense was in cotton cultivation areas. Later, it became a method used and recommended in many cultivated plants, especially in the United States, and it was used especially in the control of narrow-leaved and some broad-leaved weeds. In cotton, corn, strawberry, fruit nurseries, orchards, vineyards, tobacco and some watery habitats, geese successfully provide adequate weed control. Although it varies according to the culture plant, applications are made with a maximum of four geese per decare, and the type called White China goose constitutes the most successful group. Controlled grazing with small cattle is another biological control application. In the USA, the controlled grazing of the weed named *Taeniatherum caput-medusae* (L.) Nevski was successful with sheep, but a large number of animals were needed in a short period of time. (Uygur and Uygur, 2010). However, weed control in hazelnuts can be achieved by free range chicken, especially in hazelnut orchards.

In the light of all this information, in this review, information on feed sources such as fruit pulp used in ruminant feeding, silage obtained from fruits, fruit products used in poultry feeding and their effects on animals will be tried to be given.

Fruit P and Use in Animal Nutrition

After obtaining products such as fruit juice, jam and marmalade from fruits, the remaining pulp, consisting of peel, pulp and seed, is used in animal nutrition. Especially apple and pear pulp are better than other pulps in terms of protein and energy, and dried pulp is at the level of medium quality hay. Pear pulp is particularly rich in cellulose. (Erdinç et al., 1987). Although these pulps are used fresh, dried and made with silage, it is recommended to be evaluated by drying or silage because of their high water content and perishability. Yalçınkaya et al. (2012), in a study they have done, they compared silage made from apple, apricot and peach pulp in terms of quality. The silage of apricot pulp made by adding straw + urea has the highest lactic acid level; peach (47.73 g/kg DM) pulp silage was found to be the lowest (13.91 g/kg DM). On the other hand, acetic acid and propionic acid levels decreased significantly in straw and urea added silages. Although there is a general opinion that lactic acid levels should be high in silages; There are also studies reporting that silages with high lactic acid levels adversely affect microbial protein synthesis in the rumen, so the lactic acid level in silages should be reduced. In the study, lactic acid levels of fruit pulp silages were found to be close to the lactic acid levels of silages of plants such as corn and sorghum, which are mostly used in animal nutrition. The point to be considered in the use of these pulps is the risk of pesticide residues in the pulp obtained from fruits with pesticide residues. For this reason, pesticides should not be applied for a certain period of time before harvest. The most commonly used pulps for this purpose in animal nutrition are apple pulp, pear pulp and citrus pulp. In addition, the pulp of fruits such as pomegranate, blackberry, raspberry, plum, cherry, bitter almond can be used. In addition, there are substances that have a cyanide effect in the seeds of the pulp of fruits such as plum, apricot and peach. Therefore, their use is not recommended. (Ergün et al., 2013). Although fruit pulp is mostly used in the nutrition of ruminant animals, evaluations are made for its use on poultry as well. As mentioned above, poultry are in competition with humans in terms of nutrition and alternative feed materials that are not suitable for human consumption are needed to prevent this competition. They reported that when various fruit waste mixtures such as apple, mango, carrot, citrus, avocado, melon and tomato were added to the rations of broiler chickens, it reduced feed utilization and abdominal fat ratio. It has been reported that fruit peels with high natural antioxidant content have a positive effect on growth, microbial and immunological parameters when used as a feed additive in the diet of broiler chickens (Şengül et al., 2019).

Apple pomace contains phenolic and polyphenolic compounds with antioxidant properties such as catechin, epicatesin, caffeic acid, flavonol, philoridzin, quercetin. It is reported that more than 50% of the cellulose in apple pomace plays an important role in regulating intestinal motility and lowering plasma lipid concentration due to possible water-soluble pectin, and dried apple pomace contains an average of 100-180 mg/g peçtin (Günal and Bakırcı, 2006). It consists of apple pulp, skin, pulp and core. It can be used as a silage additive, especially in the silage of carbohydrate-poor feeds. Bağuç and Aksu (2021), reported that the addition of 5 and 10% apple added to wet sugar beet pulp improves the quality of wet sugar beet pulp silage and that apples can be added to wet sugar beet pulp as a water-soluble carbohydrate source. It contains an average of 22-26% dry matter and in dry matter 5% Crude protein (HP), 3% Crude fat (HY), 20% Crude fiber (HS), 4% Crude ash (HK) and 2300 kcal/kg Metabolized energy (ME) included. It is insufficient in protein but rich in nitrogen-free essence. It contains an average of 15% sugar and is very tasty and has a constipating effect. Therefore, it should be used with laxative feeds. By making fresh or silage, 8-10 kg per day can be given to horses and 1 kg to sheep and goats. Although 1 kg is given to cattle, it is not suitable for use in poultry due to its high cellulose content and high water content (Ergün et al., 2013). It is stated that the addition of apple pulp to the rations of beef cattle has positive effects when the balance of calcium and phosphorus in the ration is provided. (Erdinç et al., 1987). However, it is thought that it would be beneficial to conduct studies on its usability in poultry. Kılıç and Ayhan (2002) revealed that up to 15% apple pulp can be used in quail rations as a result of their research. In a study, it was reported that the addition of 5 and 10% apple peel to broiler chickens under heat stress increased HDL cholesterol and lowered LDL cholesterol. (Yeniçeri et al., 2022).

Orange and lemon pulp mostly consists of peels. It is rich in crude protein, crude oil and crude cellulose-poor nitrogen-free core material. Orange and lemon peels contain pectin, which cannot be used due to the lack of enzymes to digest them, especially in poultry. If these pulps will not be given immediately, they should be dried or silaged. Since they are poor in protein, urea can be added while making silage. Fresh pulp contains an average of 13-18% dry matter and this dry matter contains 6% HP, 6% HK, 3% HY, 14%HS and 25% sugar. The degree of digestibility is quite high. ME level is 1600 kcal/kg in poultry and 2900 kcal/kg in ruminants. Good results have been obtained when used with dairy and beef cows and given with good quality alfalfa hay and concentrated feed mixes. Dry pulp can be added to cattle mixed feeds up to 10% and poultry feeds up to 5%. Ruminant animals have been seen in recent years as the main responsible for global warming. Especially ruminant animals emit methane gas with their feces, which has a greenhouse gas effect. In a study examining the effect of citrus silages on methane release, the lowest methane gas content was obtained from the unpeeled grapefruit, and the highest methane gas content was obtained from the rind Washington. Since citrus silages such as alfalfa and corn have a lower methane gas production capacity compared to their methane gas content (16-18%), it can be considered as a low-capacity, less harmful silage type in terms of greenhouse gas effect emitted into the atmosphere and in terms of methane gas production capacity. It has been stated that citrus silages without rind are more advantageous than citrus silages with rind (Başar and Atalay, 2020). It also has positive effects on egg yolk. (Ergün et al., 2013). It has been reported that the addition of citrus peel to broiler diets reduces total cholesterol and triglyceride levels. In some studies, it has been reported that citrus peel can be used at the level of 5% in layer rations without adversely affecting performance. (Şengül et al., 2018). In a 6-week study examining the effects of adding orange peel (0, 2.5, 5, 7.5, 10%) to broiler diets on growth characteristics and blood oxidant levels, the values obtained in terms of slaughter weight and feed consumption were lower in the treatment groups compared to the control group. found. There were no significant differences between the groups in terms of feed efficiency level. The blood antioxidant level increased depending on the ratio of orange peel in the diet and was measured in the group containing the highest 10% orange peel. (Şengül et al., 2018).

Pomegranate has gained great importance in fruit juice production especially in recent years. Pomegranate pulp, seed and oil show antimicrobial and antioxidant properties thanks to the polyphenolic compounds they contain. In a study, pomegranate peel extract containing 13% ellagic acid showed a bacteriostatic effect against the gram-positive anaerobic bacteria *Propionibacterium acnese* and gram-positive facultative anaerobic bacteria *Staphylococcus aureus* and *Stahpylococcus epidermidis*. *Listeria monocytogenes, Staphylococcus aureus, Escharicia. coli* and *Yersinia enterocolitica,* pomegranate peel extract at a concentration of 0.01% showed a good antimicrobial effect against *Staphylococcus aureus* and *Bacillus cereus*, while a high concentration of 0.1% of this extract was effective in the development of *Pseudomonas, Escharicia. coli* and *Staphylococcus. typhimurium*, hydrolyzed or condensed tannins, the most important phenolic compound found in pomegranate extract, showed strong antifungal activity against *Candida albicans*. (Korkmaz, 2014). Approximately 48% of the total weight of the pomegranate consists of the peel and 52% of the fruit, which is the edible part. The edible part consists of 78% pomegranate juice and 22% seeds (Sarıca, 2011). Various researchers have reported that pomegranate peel has antioxidant, antimicrobial, anticancer properties, has a positive effect on the immune system and is used in the treatment of various diseases. (Şengül et al., 2018). Adding pomegranate extract in the amount of 0, 5 or 10 g daily to the ration of Holstein calves; A study was conducted to examine the effects on performance, health, digestion of nutrients and immune parameters and according to the results of this study; While the addition of pomegranate extract did not affect the feed consumption and live weight gain of the calves at the first 30 days of age, it was determined that the dry matter consumption and live weight gain of the calves decreased after 30 days of age in proportion to the increase in the amount of added pomegranate extract. In addition, it has been reported that adding pomegranate extract to the ration does not affect dry matter, organic matter and starch digestibility, but decreases the digestibility of crude protein and crude oil and increases the plasma total immunoglobulin level. (Sarıca, 2011). It is stated that the tannins in the pomegranate pulp or peel form a complex with proteins, inhibit the development of cellulotic bacteria and reduce the digestion of cellulose, however, grains below 4% increase the benefit of feed protein by increasing the amount of by-pass protein for ruminants (Sarıca, 2011). They reported that the addition of 6% and 12% pomegranate pulp to the ration did not significantly affect the dry matter consumption and live weight gain of goats, but the milk yield decreased with the increase in the level of pomegranate pulp added to the ration. In addition, it is stated that the addition of 6% and 12% pomegranate pulp to the ration increases the milk fat level by 8% and 15%, respectively, but the amount of milk fat and milk protein level are not affected. In addition, they found that blood glucose, cholesterol, urea, triglyceride and lipoprotein levels were not affected. The researchers stated that pomegranate pulp can be used as an alternative energy source in goat rations, that the tannins in the pomegranate pulp or peel form a complex with proteins and prevent the development of cellulolytic bacteria, therefore, the digestion of cellulose decreases, but the tannin level below 4% increases the by-pass protein ratio and increases the utilization of feed protein. (Korkmaz, 2013). It has been reported that condensed tannins or proanthocyanidins, which are polyphenols contained in pomegranate seeds, pulp and peel, increase cholesterol transport and bile acid excretion, thereby reducing intestinal cholesterol absorption (Şengül et al., 2018). In an 11-week study investigating the effects of adding pomegranate peel powder (1-1.5%) and a synthetic antioxidant (125 g/t) to quail rations on some yield characteristics, physiological and immunological parameters, the highest group in terms of live weight was 1.5%. While the group containing pomegranate peel was the highest in terms of feed consumption and feed conversion rate, the control group was the highest. While the differences between the experimental groups in terms of egg external quality characteristics were insignificant, the internal quality characteristics of yolk diameter and blood cholesterol level were found to be lower in the treatment groups compared to the control group. (Şengül et al., 2018). In a study investigating the effect of adding 0.5% and 1% pomegranate pulp to broiler rations, there was no difference in daily live weight gain between the groups during the 35-day feeding period, but between the control group and the group containing 0.5% pomegranate pulp in terms of daily feed consumption. no difference occurred. The treatment groups were found to be better than the control group in terms of feed efficiency. (Şengül et al., 2018). In a study investigating the effect of adding 0.5%, 1%, 1.5% and 2% pomegranate pulp to broiler rations, it was reported that pomegranate pulp significantly increased the protein, iron, sodium and magnesium levels of breast and thigh meat and lowered cholesterol levels. (Şengül ve ark., 2018). In a study investigating the effect of pomegranate pulp and pomegranate pulp extract on breast meat quality and antioxidant status in broiler chickens, it was reported that long chain fatty acids and omega 3 fatty acids in breast meat increased with the addition of 0.2-0.3 g/kg pomegranate pulp extract (Saleh et al., 2018).

Apart from these, fruit residues obtained as a by-product in the alcohol industry are also used as a feed source. Especially the pulp and yeast obtained as a by-product during wine production from grapes are used in animal nutrition. Grape pulp is crushed and squeezed together with grape litter and stems while making wine, or it can be squeezed by separating the litter. In this way, a product called grape pomace is obtained. Grape pomace is highly digestible and consists of 60% pulp and 40% seeds. It contains on average 12% HP, 26% HS, 4% HY, 10% HK and 1300 kcal/kg ME. It can be given to cattle as 10kg/day as wet and 2 kg/day in dried form (Ergün et al., 2013). The moisture content of grape pulp is 70%. One ton of pulp is 249 kg. grape stem, 225 kg. grape seeds and 425 kg. consists of grape skin. Dry pulp consists of 40% kernel and 60% non-kernel part. After separating the non-core part, the core is dried and cleaned. Its oil is extracted with hexane and 85% grape seed oil can be obtained (Duyum, 2011). Dried grape pomace is a medium quality energy source for ruminants. It can be used instead of dried grass. Dry form can be preferred for lamb feeding. It increases feed efficiency and growth performance and reduces feed cost.

Meals obtained from fruits and their use in animal nutrition

Meal is the name given to the protein-rich product that remains after the oil is removed from the oilseeds. Meals are generally used to meet the protein needs of animals. The digestibility and biological value of the protein are high. It is rich in phosphorus and low in calcium. In our country, soybean meal, sunflower meal, cottonseed meal, flaxseed meal, rapeseed meal, poppy meal, sesame meal and peanut meal are used extensively in animal nutrition, and the meal obtained from fruits such as hazelnut and olive is used in animal nutrition.

As it is known, hazelnut is a garden product in which we rank first in the world in terms of production in our country. The meal obtained from hazelnut oil is rich in protein, poor in cellulose and highly digestible. While it contains approximately 35-45% crude protein, &6-8 HY, 8-9% HS, it contains 2200 kcal/kg of metabolized energy. It can be used up to 5% for broiler rations, 10% for laying hens, up to 20% for quails and ruminants (Ergün et al., 2013). In particular, soybean meal, which is the main feed raw material of broiler rations, is mostly imported, and imported soybean meal contains a large amount of GMOs. For this reason, hazelnut meal can be evaluated as a feed raw material that can be an alternative to soybean meal. As a matter of fact, in a study, it was reported that hazelnut meal protein can be substituted for 80% of the protein obtained from soybean meal in the rearing period rations of Japanese quails (Kırımızıgül and Çufadar, 2019). Şehu et al. (1996) reported that hazelnut pulp can be used up to 20% in quail rations. Baytok et al. (1999) reported that hazelnut meal can be used instead of 50% of soybean meal in laying hen compound feeds. Although hazelnut pulp is poor in terms of lysine (0.99%) and methionine (0.15%) amino acids, it has been determined that it has a rich structure in arginine (4.53%), leucine

(2.77%) and isoleucine (2.82%) amino acids. In a study, it was stated that the use of hazelnut pulp up to 10% in broiler rations would not have a negative effect on economically important performance parameters (Gençoğlu et al., 2011).

The olive pulp that remains after the oil is extracted from olives in olive oil production facilities is also called pomace. According to the procedure applied while extracting the oil, the moisture and oil content of the pomace obtained varies. According to the processes they undergo, olive pomace is classified as raw olive pomace, de-oiled pomace, partially seeded pomace and olive pulp (Gemalmaz ve Bilal,2016). It has a core and a shell in its structure. It contains approximately 75-80% KM, 5-10% HP, 8-15% HY, 35-50% HS and is a low nutritional product with 950-1090 kcal/kg ME content. Up to 10% can be added to the mixed feed of dairy cows and livestock (Ergün et al., 2013). The amount of nutrients that olive pulp contains according to the processing method is presented in Table 1.

Table 1. Nutrient content of olive pomace according to processing method

Olive pomace variety	Dry Matter, %	Crude Protein, %	Crude Fat %	Crude Ash,%	Crude Fiber,%
Raw	75-80	5-10	8-16	3-5	35-50
Degreased	85-90	8-10	4-6	7-10	35-40
Core remowed	80-95	9-12	15-30	6-7	20-30

Source: Duru and Kaya, 2015

Apart from the pulp of the olive, its leaves and black water can also be used for animal feeding. Olive leaves and olive black juice are rich in phenolic compounds with versatile biological effects, especially antimicrobial and antioxidant. Olive leaves are exposed during pruning of olive trees, olive picking and cleaning-blending before olive oil extraction. The amount of olive leaves obtained is between 12-30 kg/tree, depending on the age of the tree and the type of pruning. In some regions where olive cultivation is common, olive leaves are used for feeding livestock or the leaves collected with olive branches are used as combustible. Although it is reported that olive leaves and olive black juice contain more than 30 phenolic compounds, these compounds are generally grouped as phenolic acids, phenolic alcohols, flavonoids, secoiridoids and lignans. Depending on the process used during the olive oil processing, 1-2%, 53% and 45% of the polyphenol compounds in the fruit pulp pass into oil, black water and pomace, respectively. The antibacterial, antiviral and antifungal effects of the phenolic components in the olive leaf and olive black juice have been demonstrated by in vitro studies. Compounds with antimicrobial activity have been reported by many researchers as hydroxytyrosol, oleuropein, 4-hydroxybenzoic acid, vanillic acid and p-coumaric acid. As a matter of fact, hydroxytyrosol is effective against gram positive and gram negative bacteria that cause respiratory and intestinal infections; Studies have shown that phenolic compounds in olive leaf extract have antimicrobial effects against many microorganisms such as *Escherichia coli, Staphylococcus aureus*, *Klebsiella pneumonia*, *Bacillus cereus,* *Salmonella typhi* and *Vibrio parahaemolyticu.* He investigated the effects of commercial olive leaf extract (Lext) against laryngotracheitis infection, one of the respiratory diseases that seriously affect the poultry industry in Egypt, and it was reported that olive leaf extract can be used as a potential antimicrobial agent as a result of the findings. (Malayoğlu and Aktaş, 2011).

Use of fruit extracts and aromatic oils in animal nutrition

After the prohibition of antibiotics used as growth factors in animal nutrition in our country and in the European Union since 2006, the search for feed additives that can be an alternative to antibiotics still continues. For this purpose, enzymes, probiotics and prebiotics, organic acids and plant essential oils and extracts are used. These plants are especially preferred because of their antimicrobial, antioxidant and antifungal effects. In addition to medicinal and aromatic plants such as thyme, fennel, sage, as plant essential oils or extracts, there are studies where extracts and essential oils are used in fruits such as rosehip, carob, jujube, walnut, citrus, pomegranate and coconut.

As a result of the study examining the effects of orange peel oil and sex ratio on egg production and egg characteristics in layer quails, it was reported that the addition of 200ppm orange peel oil to the ration significantly improved egg quality (Erişir et al., 2015). The essential oil and flavonoids are concentrated in the pigment glands in the colored (flavedo) part of the orange peel and make up about 0.2-0.5% of the whole fruit. The main component of the essence of peel is

Limonene, which makes up about 95%. D-Limonene (1-methyl-4-(1-methylethenyl) cyclohexane), a cyclic monoterpene in lemon flavor, is the main component of citrus peel essential oils such as orange, lemon, tangerine, grapefruit (Erişir et al., 2015).

In a study examining the effect of pomegranate peel extract as an antimicrobial growth factor on the small intestine microbiota in broiler rations, it was stated that it could be used as an alternative to antibiotics. (Hamady et al., 2015).

Carob fruit is a prominent fruit in human nutrition due to its high antioxidant and fiber content. The chemical composition of carob, which consists of 90% fruit flesh and 10% seeds by weight, varies depending on the type of plant, the region where it is grown and the harvest time (Battle and Tous, 1997). It was determined that carob contains 52-62% total sugar and this total sugar is 34-35% sucrose, 7.8-9.6% glucose, 10.1-12.2.2% fructose. The K, Ca, P and Mg values of carob are 843-1215, respectively; 251-361; It varies between 85-681 and 63-326 mg/kg. In addition, the fiber content of the carob fruit, which contains 3944.7 mg/kg of total phenolic substance, is 258.3 g/kg. In addition, 100 g of carob contains 4.2 g crude protein (HP), 0.69 g fat. It has been reported that carob fiber is rich in both quantity and various phenolic antioxidant substances, and its inclusion in the diet may have chemotherapeutic properties. In the production of carob molasses in Turkey, the remaining part of the extraction, namely the carob pulp, can be used for animal feeding in its moist and dried form (Demirbaş and Çetinkaya, 2020). In addition, carob flakes can be used as silage additives (Ateş and Atalay, 2022). Due to the low HP content of carob fruits, it is reported that supplementing with additional protein sources is necessary to achieve the expected performance if they are included in the ration (Kurt and Öztürk, 2018).

Rosehip is a fruit rich in vitamin C. It is reported to contain ascorbic acid between 417.3-3062 mg/100 g. (Yıldız et al., 2020). The importance of rosehip fruit in terms of health is due to its rich vitamins and minerals, as well as its content of bioflavonoids and carotenoids (lycopene, zeta-carotene, beta-carotene, xanthophyll, neoxanthine and lutein). Due to the phenolic compounds it contains, its antioxidant potential is quite high. It has been reported that rosehip has an antioxidant effect by reducing carcass weight and TBARS value in meat. (Criste et al., 2017). By-products obtained from rose hips can be used in animal nutrition. The leftover products after processing rosehip into juice, jam, marmalade and tea emerge as a good source of feed raw materials. The seeds obtained as a result of the processing of rose hips are very rich in energy and metabolic problems are not observed as a result of the use of grains. Rosehip seed constitutes approximately 20-44% of the fruit, and contains approximately 94% dry matter, 9% crude protein, 8% crude oil, 44% crude fiber and 1800kcal/kg energy. It has been proven to have cholesterol and triglyceride lowering effects. As a result of a study examining the performance, egg quality characteristics, egg yolk lipid profile and serum parameters of 15% rosehip seed addition to layer hens, it was reported that rosehip seed had positive effects especially on egg quality characteristics, increased shell durability and decreased the rate of broken eggs (Kaya et al., 2019). Yıldız et al. (2020) investigated the effect of rosehip fruit added to the rations of layer hens under cold stress at different levels on egg production and characteristics, live weight change and feed efficiency. It was determined that the color scale value of rosehip fruit additive improved compared to the control group, and the addition of rosehip fruit to the rations of laying hens caused a numerical improvement in the color and redness of egg yolk. It has been suggested that rosehip fruit at the level of 15 g/kg can be added to the rations since the weekly egg number, egg production and total egg weight, egg yolk and redness values, which are egg laying performance values, are numerically higher than all other groups. (Yıldız et al., 2020).

The use of grape seed oil and pomegranate seed oil in broiler rations has shown that both grape and pomegranate seed oil have positive effects on the fatty acid profile of poultry meat, improve meat quality and can be defined as functional food. It is also stated that it can provide people with better quality food without changing their food consumption habits. The addition of 2% grape seed oil to the diet significantly increased the ratio of omega-6 fatty acids and omega 6:omega 3 ratio. Pomegranate seed oil containing punicic acid, on the other hand, contributed to its conversion to rumenic acid, which supports the health of broilers and enriches meat quality. These additives have also been reported to have cholesterol-lowering effects (Banaszkiewicz et al., 2018). As a result of a study examining the effects of adding grape seed, olive leaf and pomegranate peel extracts added as natural antimicrobials to broiler rations, oleuropein in olive leaf and proanthocyanidin in pomegranate peel extract, especially in rations based on corn-soybean pulp, increased the growth performance of broilers, serum lipid concentration and ileum microflora. It has been stated that it has a positive effect on its content and can be used as natural antimicrobials instead of probiotics in broiler rations (Sarıca and Ürkmez, 2016).

Other feedstuffs obtained from fruits and used in animal nutrition

Apart from the main alternative feed raw materials mentioned above and used in animal nutrition, fruit residues such as walnuts, coconuts, pumpkin seeds, banana peels can also be evaluated as alternatives.

Walnuts are a valuable source of protein and energy for poultry and especially for the feed industry. However, since it is a feed raw material that is not easy to mix homogeneously with the feed due to its high oil content, research has been carried out on its use in the feed industry after the oil is removed. In a study conducted in turkeys, it was reported that degreased walnut kernel (walnut pulp) together with soybean meal or corn can be used up to 10% after 21 days. Walnut inside parrot etc. It can be used in the feed of cage birds and poultry. It has been reported that cashew nut, which is a similar raw material, can be used up to 250 mg/kg in the nutrition of meat-type quails. In addition, walnut orchards are considered as a good poultry manure application area for the poultry industry. It is stated that more profit can be obtained if the substances such as kali and leaves, which are found in walnut by-products and are thought to cause decreases in performance when used in animal nutrition, are used after certain processes in order to increase their nutritional values (Eratalar et al., 2017).

In addition to walnuts, it is stated that pecan can be used as a feed additive in animal nutrition. The shell released in the production of pecan nut (*Carya illinoinensis*) is accepted as an organic waste material. It is noteworthy that the pecan nut shell has high fiber content, antioxidant and antimicrobial properties. In line with this information; It is reported that pecan nut shell can be used as a prebiotic in animal nutrition as a feed additive that supports the immune system and stops the development of some pathogens. (Kor et al., 2018).

The pulp obtained from the extraction of coconut oil is an important feed raw material. Although it contains moderate protein such as 15-25%, it is more suitable for use in ruminant feeds rather than poultry feeds due to its high cellulose content (11-16%) and insufficient lysine and methionine. The chemical composition of coconut pulp varies according to the method of production. Crude protein is 22% and crude oil is 4.5% in the pulp obtained by extraction method; The values in the pulp obtained by the expeller method were reported as 20% and 9.0%, respectively (Ayaşan, 2016). Although it can be added to the feed of poultry at a rate of 5-10%, its use in young animals is not recommended.

One of the feed raw materials that can be an alternative for ruminants is pumpkin seed. A significant amount of waste material is obtained from zucchini (*Cucurbita pepo*), after the seeds are separated (the skin and fruit flesh, the inner fluid and the small seeds make up 95% of the whole zucchini). Pumpkin pulp contains 12.5% dry matter content, 11.3% crude protein, 1.4% crude oil, 19.7% crude fiber, 17.6% raw ash, 3870.2 cal/kg energy and is widely used in the nutrition of ruminant animals (Yılmaz et al., 2016). However, zucchini residues with seeds can also be used by making silage. It is reported that the silage of pumpkin waste can be used in animal feeding and the ethanol formed during ensiling can be used in different areas. (Pirinç et al., 2020). In addition, it has been determined that watermelon juice, watermelon puree and watermelon pulp that can be used in animal nutrition can be produced from unmarketed watermelons belonging to the cucurbit family. (Terlemez and Çerçi, 2019).

The leaves of the guava fruit, which is a tropical plant, contain significant amounts of essential oil components. Due to this feature, it can be used as an antimicrobial and antioxidant. It has been reported that it has antioxidant properties due to its high content of gallic acid (Morsy et al., 2019).

A study aimed to determine the effectiveness of adding red guava fruit pulp (vitamin C and lycopene) as a natural source of antioxidants on the production capacity of broiler chickens compared to synthetic vitamin C. The treatments were based on basal ration without red guava flour (T0), basal ration 1.7% red guava fruit meal (T1), basal ration 3.4% red guava fruit meal (T2), basal ration 5.1% red guava fruit meal (T3) and synthetic C. It consists of vitamin (T4) and basal ration. Experimental ration given for four weeks. The results showed that the treatments did not affect muscle protein mass, calcium mass and bone production. Carcass weight in T2 group was higher than that of T4, but it was not different from other treatments. As a result, it has been reported that the inclusion of red guava fruit pulp in the diet at a rate of 3.4% can act as a source of vitamin C and natural antioxidant and increase the production capacity of broiler chickens. (Bikrishima et al., 2014).

Jujube fruit used in human nutrition is also the subject of nutrition studies. Kilinc et al. (2020) investigated the effects of jujube leaf extract on small intestine microflora and some blood parameters in laying hens. The extracts were added to the rations at 45, 90 and 135 mg/kg. The jejunum part of the small intestine (the part where absorption takes place) of jujube leaves did not affect the number of coliform bacteria, but affected the number of lactobacilli. As a result, it was stated that it can be added to the rations at the level of 90 and 135 mg/kg.

One of the feed raw material sources that can be used in animal nutrition, especially in the feeding of ruminant animals, is banana peels. Banana peel is a particularly important source of carbohydrates. Although it contains 13% crude fiber, it contains approximately 8% crude protein in 12% dry matter. However, due to the tannin found in the banana peel, it shows anti-nutritional properties, so processes to remove tannin may be required. NDF, ADF, cellulose, hemicellulose and lignin content can be reduced by steaming, applying ammonia or making silage. By fermenting with *Rhyzopus oligosporus*, the crude protein content can be increased approximately 3 times (Astuti, 2014).

Use of animals in weed control

In the information given so far, it has been explained how animals can benefit from fruits as nutrients. However, plants can also benefit from animals. This becomes even more important in organic farming. Especially in the biological control of weeds, animals such as geese, sheep and chickens can be used. Weeds, which are an important part of the ecosystem, have been a problem since the beginning of agriculture. Researchers have developed and applied the methods we call cultural, mechanical, physical, chemical, biological and integrated to get rid of weeds. Following the development of agricultural chemicals, the use of herbicides increased rapidly, resulting in undesirable side effects such as herbicide resistance and residue problems. Biological control is an important alternative method against intensive pesticide consumption and is one of the most important tools of sustainable agriculture systems such as organic agriculture. It is called biological control of weeds to reduce the populations of weeds so that they cannot harm us by using creatures such as insects, pathogens (fungi, bacteria, etc.), nematodes, sheep, geese, fish, and snails that feed on weeds and that we call natural enemies. Geese, on the other hand, are creatures that have been used in the control of weeds in China for centuries, and their first use in the modern sense was in cotton cultivation areas. Later, it became a method used and recommended in many cultivated plants, especially in the United States, and it was used especially in the control of narrow-leaved and some broad-leaved weeds. In cotton, corn, strawberry, fruit nurseries, orchards, vineyards, tobacco and some watery habitats, geese successfully provide adequate weed control. Although it varies according to the culture plant, applications are made with a maximum of four geese per decare and the type called White Chinese goose is the most successful group (Uygur and Uygur, 2010). Geese can be used at any age to control weeds without damaging some growing sprouts. Young geese at 6 weeks show the best performance in terms of weed removal. Geese; They clean the weeds of corn, cotton, sugarcane and strawberry fields and nurseries, orchards and vineyards very well. However, it is not known why geese do not eat some sprouts. Geese should be removed from strawberry orchards when the fruits begin to ripen. Six or 8 geese can easily carry out the weed removal job in a 1-acre strawberry garden. The geese used in weed cleaning should be given plenty of water and shade. Dense trees, type A skeletons or small shelters can be used as canopy. Also, very little food should be given to the geese in the evening. The main point in weeding is to starve the geese. At the end of the weed season, geese are usually taken from the field and placed in barns for lubrication until they weigh 4.5-5.5 kg more for 3 to 4 weeks. If geese are bred in a narrow space, they can cause vegetation to disappear and stones to appear in their area in a short time (Tilki, 1999).

Conclusion

The world population is increasing rapidly. It is expected that there will be problems in food production to meet the needs of the increasing population in the near future. In particular, the necessity of turning to alternative feed raw materials that are not suitable for human consumption arises in ruminant animals that have difficulties in reaching the feed source due to global warming and shrinkage of meadow and pasture areas, and in the feeding of poultry that are in competition with humans. For this purpose, it is thought that researching new alternative feed raw materials apart from the alternative raw materials some of which is given above and accelerating the studies to reveal their effects on animals will contribute to the prevention of future problems. However, an issue that has been on the agenda lately is that the effect of ruminant animals on global warming is being talked about a lot. For example, the Netherlands banned the advertising of meat or products on the grounds that cattle cause global warming. For this reason, it should be taken into account that it is important to search for feed raw materials that will have a minimum effect on global warming by reducing methane gas emission in the search for alternatives.

References

Astuti, T. (2014). The Result of Biotechnology by Local Microorganisms to Banana Peel on Rumen Fluid Characteristics as Ruminant Feed. *Journal of Advanced Agricultural Technologies* 1(1): 28-31.

Ateş, H., Atalay, A.İ. (2020). Yemlik Keçiboynuzu Kırığının Mısır Silajında Katkı Maddesi Olarak Kullanımı. *Journal of Agriculture* 5 (1): 1-9.

Ayaşan, T. (2016). Kanatlı ve ruminant hayvan beslemede Hindistan cevizi kullanımı. *Türk Tarım-Gıda Bilim ve Teknoloji Dergisi* 4 (2): 61-65.

Bağuç, Y., Aksu, T. (2021). Elma (Malus pumila) katkısının yaş şeker pancarı posası silajı kalitesine etkisi. *Atatürk Üniversitesi Veteriner Bilimleri Dergisi* 16 (1): 49-56.

Banaszkiewicz, T., Biatek, A., Tokarz, A., Kaszperuk, K. (2018). Effect of dietary grape and pomegranate seed oil on the post-slaughter value and physicochemical properties of muscles of broiler chickens. *Acta Sci. Pol. Technol. Aliment.* 17(3) : 199–209.

Başar, Y., Atalay, A.İ. (2020). Turunçgil Posalarının Ruminant Beslemede Alternatif Yem Kaynağı Olarak Kullanımı ve Metan Üretim Kapasiteleri. Iğdır Üniversitesi Fen Blimleri Enstitüsü Dergisi 10 (2): 1449-1445. DOI: 10.21597/jist.725292.

Battle T, Tous J 1997. Carob Tree (Ceratonia siliqua L.) Promoting the conservation and use of underutilized and neglected crops 17, International Plant Genetic Resources Institute, Via Delle Sette Chiese, 142, 00145 Rome, Italy, 91.

Baytok, E., Yörük, M.A., Muruz, H., Aksu, T., Gül, M. (1999). Yumurta tavuğu karma yemlerinde soya küspesi yerine fındık küspesi kullanılmasının yumurta verimi ve kalitesine etkisi. *Van Yüzüncüyıl Üniversitesi Veteriner Fakültesi Dergisi* 10 (1-2): 92-97.

Bikrishima, S.H.L., Mahfudz, L.D., Suthama, N. (2014). Production Capacity of Broiler Chickens Fed Red Guava Fruit Meal as Source of Natural Antioxidant**.** *JITP* 3 (2): 69-75.

Bıldırcınlarda (Coturnix coturnix japonica) Yumurta Verimi ve Yumurta Özellikleri Üzerine Etkisi. *F.Ü.Sağ.Bil.Vet.Derg.* 29 (1): 23 – 30.

Criste, R.D., Panaite, T.D., Tabuc, C., Saracila, M., Şoica, C., Olteanu, M. (2017). Effect of oregano and rosehip supplemention broiler (14-35 days) performance, carcass and internal organs development and gut health. *AgroLife Scientific Journal* 6 (1): 75-83.

Demirbaş, H., Çetinkaya, N. (2020). Keçiboynuzu posasının kimyasal kompozisyonu, İn vitro sindirilebilirliği, fenolik bileşikler ve antioksidan aktivitesinin belirlenmesi. Manas Journal of Agriculture Veterinary and Life Sciences 10(2): 103-109.

Duru, A., Kaya, Ş. (2015). Zeytin posası silajının hayvan beslemede kullanım olanakları. *Mustafa Kemal Üniversitesi Ziraat Fakültesi Dergisi* 20 (1): 64-71.

Duyum S. (2011). *Şarap sanayi yan ürünlerinin besin madde içerikleri ve in vitro parçalanabilirliklerinin belirlenmesi* (Yüksek Lisans Tezi) Kırıkkale Üniversitesi Sağlık Bilimleri Enstitüsü, Kırıkkale.

Eratalar, S.A., Okur, N., Yaman, A., Karadeniz, T. (2017). Bıldırcın yemlerinde iç ceviz, ceviz yaş kabuğu ve yaprağı kullanımının yumurta kabuk ve yumurta sarısı rengine etkileri. bahçe 46 (özel sayı 2: ııı. ulusal ceviz sempozyumu): 71–76.

Erdinç, H., Çamaş, H., Yaman, K., Oğan, M., Antaplı, M., Yavuz, H.M. (1987). Sığır beslemesinde elma posası kullanma olanaklarının araştırılması. *Uludağ Üniversitesi Veteriner Fakültesi Dergisi* 3 (5): 73-80.

Ergün, A., Tuncer, Ş.D., Çolpan, İ., Yalçın, S., Yıldız, G., Küçükersan, M.K., Küçükersan, S., Şehu, A., Saçaklı, P. (2013). Yemler Yem Hijyeni ve Teknolojisi. ISBN: 975-97808-3-8, Genişletilmiş 5. Baskı, ANKARA.

Erişir, Z., Şimşek, Ü.G., Çiftçi, M., Yıldız, N., Dalkılıç, B. (2015). Portakal Kabuğu Yağı ve Cinsiyet Oranının Yumurtacı

Gemalmaz, E., Bilal, T. (2016). Alternatif kaba yem kaynakları. *Lalahan Hayvancılık Araştırma Enstitüsü Dergisi* 56 (2): 63-69.

Gençoğlu, H., Deniz, G., Orman, A., Türkmen, İ.İ. (2011). Broiler rasyonlarında fındık küspesinin kullanılma olanaklarının araştırılması. *Uludag University Journal Faculty Veterinary Medicine* 30 (1): 29-34.

Günal, M., Bakırcı, A.S. (2006). Kurutulmus Elma ve Domates Posalarının Anaç Bıldırcın Rasyonlarında Kullanılma Olanakları. *Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi* 1(2):28-37.

Hamady, G.A.A., Abdel-Moneim, M.A., El-Chaghaby, G.A., Abd-El-Gany, Z.M., Hassanin, M.S. (2015). Effect of Pomegranate peel extract as natural growth promoter on the productive performance and intestinal microbiota of broiler chickens. *African Journal of Agricultural Science and Technology (AJAST)* 3 (12): 514-519.

İpçak, H.H., Selek, H.B., Kurtuluş, D., Koç, F., Özdüven, M.L. (2011). Pazar Atığı Sebze ve Meyvelerden Yapılan Silajlarda Fermantasyon Özellikleri ve Aerobik Stabilite Üzerine Etkileri. *VII.Ulusal Zootekni Öğrenci Kongresi Bildiriler Kitabı* P: 121-126. 20-22 Mayıs 2011, AYDIN.

Kaya, H., Kaya, A., Esenbuğa, N., Macit, M. (2019). The Effect of Rosehip Seed Supplementation into Laying Hens Diets on Performance, Egg Quality Traits, Yolk Lipid Profile and Serum Parameters. *Alinteri Journal of Agriculture Sciences* 34 (1): 84-87.

Kılıç, Ö.O., Ayhan, V. (2002). Kurutulmuş Domates ve Elma Posalarının Bıldırcın Rasyonlarında Kullanım Olanakları. *Hayvansal Üretim* 43(2): 35-43.

Kılınç, G., Sezener, M.G., Gülhan, T. (2020). Yumurtacı tavuklarda hünnap (Ziziyphus jujuba Mill.) yaprak ekstraktının ince bağırsak mikroflorası ve bazı kan parametreleri üzerine etkileri. *Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi* 6 (1): 91-99.

Kırmızıgül, A., Çufadar, Y. (2019). Japon bıldırcınlarında rasyona fındık küspesi ilavesinin büyüme performansı ve karkas özelliklerine etkisi. *Bahri Dağdaş Hayvancılık Araştırma Dergisi* 8 (1): 28-35.

Kor, D., Karadaş, F., Karageçili, M.R. (2018). Organik Bir Materyal Olarak Pikan Cevizi (Carya illinoinensis) Kabuğu Alternatif Bir Yem Katkı Maddesi

Olabilir Mi? *Yüzüncüyıl Üniversitesi Tarım Bilimleri Dergisi* 28 (1): 135-143.

Korkmaz F. (2014). *Raf ömrü dolan bazı gıdaların ruminant beslemede alternatif yem kaynağı olarak kullanım olanklarının araştırılması* (Yüksek Lisans Tezi) Namık Kemal Üniversitesi Fen Bilimleri Enstitüsü, Tekirdağ.

Kurt, Ö., Öztürk, D. (2018). Bazı baklagil ağaç meyvelerinin besleme değerinin belirlenmesi. *Black Sea Journal of Agriculture* 1(3): 60-65.

Malayoğlu, H.B., Aktaş, B. (2011). Zeytinyağı işleme yan ürünlerinden zeytin yaprağı ile zeytin karasuyunun antimikrobiyal ve antioksidan etkileri. *Hayvansal Üretim* 52 (1): 49-58.

Morsy, M.A., Younan, G.E., El-Gabry, H.E. (2019). Effect of dietary guava (psidium guajava) leaf extract supplementation on productive performance, blood parameters and carcass traits of growing rabbits. *Egyptian Journal Nutrition and Feeds* 22 (2) Special Issue: 183-192.

Pirinç, A., Özbilgin, A., Kahraman, O., Polat, E.S. (2020). Determination of nutritional values of seedling pumpkin residues silage. *Turkish Journal of Agriculture- Food Science and Technology* 8(3): 768-772.

Saleh, H., Golian, A., Kermanshahi, H., Mirakzehi, M.T. (2018). Antioxidant status and thigh meat quality of broiler chickens fed diet supplemented with a-tocopherolacetate, pomegranate pomace and pomegranate pomace extract. *Italian Journal of Animal Science* 17 (2): 386–395.

Sarıca, Ş. (2011). Nar Suyu Yan Ürünlerinin Hayvan Beslemede Kullanım Olanakları. GOÜ Ziraat Fakültesi Dergisi 28 (2): 97-101.

Sarıca, Ş., Ürkmez, D. (2016). The use of grape seed-, olive leaf- and pomegranate peel-extracts as alternative natural antimicrobial feed additives in broiler diets. *European. Poultry Science* 80. ISSN 1612-9199, © Verlag Eugen Ulmer, Stuttgart. DOI: 10.1399/eps.2016.121.

Şehu, A., Yalçın, S., Kaya, İ. (1996). Bıldırcın rasyonlarına katılan fındık küspesinin büyüme ve karkas randımanı üzerine etkisi. *Ankara Üniversitesi Veteriner Fakültesi Dergisi* 43: 163-168.

Şengül, A.Y., Şengül, Ö., Daş, A. (2019). The possibilities of using fruit waste in nutrition of poultry. *Turkish Journal of Agriculture-Food Science and Technology* 7 (5): 724-730.

Terlemez, F., Çerçi, İ.H. (2019). Pazarlama Dışı Olan Karpuzlardan (Citrullus lanatus) Hayvan Beslemede Kullanılabilecek Yan Ürünlerin Elde Edilmesi, Depolanması, Bazı Besin Madde ve Mikrobiyolojik Özelliklerinin Belirlenmesi. *Türk Tarım ve Doğa Bilimleri Dergisi* 6(4): 835–844.

Tilki, M. (1999). Yabani otları temizleme. http://www.agaclar.net/forum/yabanci-otlarla-mucadele/9464.htm. (Erişim tarihi: 12.09.2022).

Uygur, S., Uygur, F. N. (2010). Yabancı otların biyolojik mücadelesi. *Türkiye Biyololik Mücadele Dergisi* 1 (1): 79-95.

Yalçınkaya, M.F., Baytaok, E., Yörük, M.A. (2012). Değişik Meyve Posası Silajlarının Bazı Fiziksel ve Kimyasal Özellikleri. *Erciyes Üniversitesi Veteriner Fakültesi Dergisi* 9 (2): 95-106.

Yeniçeri, M., Filik, A.G., Filik, G. (2020). The Effect of Some Selected Fruit Wastes for Poultry Feed on Growth Performance of Broilers. *Palandöken Journal of Animal Science, Technology and Economics,* 1(1): 33-41.

Yıldız, S., Tekeli, A., Demirel, M., Aldemir, R., Yörük, İ.H., Belhan, S., Koşal, V. (2020). The effect of dietary supplemental levels of roseship fruit on egg yield and characteristics and live weight change and feed conversion ratio of cold stressed laying hen diet. *Van Veterinary Journal* 31 (2): 67-73.

Yılmaz, H.Ş., Kökten, K., Kaplan, M., Uçar, R. (2016). Çerezlik Kabak (Cucurbita pepo L.) Atıklarının Hayvan Beslemede Kullanım Olanaklarının Araştırılması. *Türk Tarım ve Doğa Bilimleri Dergisi* 3(1): 79–82.

CHAPTER 8

USAGE OF SOME FRUIT SPECIES IN ORNAMENTAL PLANTS

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1. Importance and Usage Areas of Ornamental Plants

As a result of urbanization, concretization and the rapid increase in technology, the interest in green and flowers is increasing day by day. Due to people's longing and love for flowers, green and nature during the Covid-19 epidemic, the place and importance of ornamental plants in our lives has been understood once again. In addition, magnetic waves, harmful gases, solid and liquid wastes released by constantly developing and increasing mobile phones, network connections, satellites, airplanes, electronic devices, artificial intelligence technologies, missiles, bombs etc. products cause great problems on humans and the environment. For this reason, outdoor plants are frequently used in places such as parks, gardens, recreation areas, roadsides etc. in order to provide people with more comfortable and peaceful environments and to beautify the environment.

Undoubtedly, one of the basic conditions for cities to be a healthy place depends on the sufficient level of plant species and number in the green areas in the cities. Ornamental plants play a significant role in arranging urban areas, improving city structure, designing spaces that positively affect human health, beautifying indoor and outdoor spaces, and supporting mental health (Celik, 2019; Karatas and Kilic, 2017; Uludag and Erturk, 2012).

The color, odor and visual effects of plants increase the feeling of peace and appreciation in people and trigger peace and tranquility. Seasons also have psychological effects on people. The plant species that are the harbingers of spring show that spring has come by enabling them to have a more effective visuality than other species by blooming before leafing or with their first leaves. Thus, it enables people to realize the seasonal change in the best way (Caglar Yilmaz et al., 2013).

Ornamental plants: It is known as important plants that appeal to emotions more on special days such as joyful, sad and painful days. Ornamental plants were frequently used in the treatment of mental patients in the past, especially in the Ottoman period, in palaces, parks, home gardens and cemeteries (Baktir, 2013). Today, it finds a wide range of uses such as landscaping, parks and gardens, roadsides, rock gardens, sports facilities, recreation and picnic areas, indoors, garland, arrangement and bouquet making. It provides raw materials to the food, jam, cosmetics, pharmaceutical and detergent industries in the field of health, in the fight against diseases and pests. Ornamental plants are also used as fuel, pesticide, timber, canopy, honey production, pasture, erosion inhibitor, fertilizer and windbreak. In addition, ornamental plants constitute the most important plant group in the fight against green development and climate change due to their features such as cleaning the soil, water and air, improving ecology and restoring the deteriorated natural balance.

2. Classification of Ornamental Plants

Ornamental plants are plants that come to the forefront with their shapes and forms such as stems, branches, leaves, flowers, fruits and scents etc., with their aesthetic features as alive or dried. As a matter of fact, all plants can be used as ornamental plants. Ornamental plants can be grouped under 5 main groups according to their intended use. (1) Cut ornamental plants, (2) Indoor ornamental plants, (3) Outdoor ornamental plants, (4) Geophytes and (5) Aquatic ornamental plants (Arslan, 2022).

2.1 Cut ornamental plants

They are ornamental plants used in bouquets, baskets, wreaths and arrangements, in funerals, cemeteries, election squares etc. in places, mixed or alone as fresh, dried, bleached or dyed. Cut flowers (carnation, lily, cut rose, gerbera etc.) and cut greens (*Nephrolepis spp*., *Gypsophila paniculata* L., *Ruscus spp*., etc.) are included in this group. Arbutus (*Arbutus unedo* L.), myrtle (*Myrtus communis* L.) are among the fruit species used as cut flowers and greens.

2.2 Indoor ornamental plants

They are ornamental plants grown as annual or perennial bush, shrubs and herbaceous plants in various pots and containers for their flowers, leaves, stems, fruits etc. for parts, as well as in many areas such as homes, balconies, rooms, living rooms and offices, which are live or dry ornamental plants used in celebrations, visits and congratulations. For example, ornamental plants such as *Pelargonium spp*., violet, rubber tree (*Ficus elastica* Roxb. Ex Hornem), hall ivy, cacti, *Sedum spp*., can be counted in this group. Kumquat, olive and ornamental pomegranate are among the fruit species used as indoor plants.

2.3 Outdoor ornamental plants

They are live or dry ornamental plants that are naturally found or used in the planning and decoration of outdoor spaces in parks, gardens, rocks, roadsides, medians, picnic areas and similar places. Broad and coniferous trees, shrubs and bush, annual or perennial seasonal plants, grasses and ground covers, some plants used as wrappers and climbers are included in this group. Arbutus, myrtle, kumquat, olive, avocado, hazelnut, walnut, pomegranate and guelder rose are fruit species used as outdoor plants.

2.4 Geophytes

They are plants that dry out after completing their vital activities with their above-ground organs such as leaves, flowers and stems and continue their lives with underground structures such as onions, corms, cormels, tubers and rhizomes. Bulbous, rhizome and tuberous plants, which are mostly found naturally, are in this group. Geophytes can be used both as a cut ornamental plant and as an ornamental plant indoors and outdoors.

2.5 Aquatic ornamental plants

They are ornamental plants that grow in or on the shore or in water-saturated areas such as sea, stream, lake, pond, dam, aquarium and pool. Plants such as water lily, water chestnut (*Trapa natans* L.), *Typha* L., bulrush (*Scirpoides holoschoenus* L. Sojak), eelgrass (*Zostera marina* L.), algae etc., can be given as examples of aquatic ornamental plants.

3. Types of Fruits With Ornamental Plant Feature

Plant design is one of the important stages of landscape design in outdoor areas. The choice of plant species used is as important as the plant design, as well as the aesthetic and functional features it adds to the design. In addition, the ecological demands and adaptations of plants also affect plant selection and use. Therefore, functional and aesthetic features limit the plant species that can be used in plant design, and the variety of species that can be used is limited when ecological demands are taken into account (Atabeyoglu and Bilge, 2019). It is seen that many fruit species, which stand out with their flowers, branches, stems, leaves, fruits, branching shape, seeds, scents, shapes and forms, are both used and have a high potential for use in covering and beautifying outdoor spaces with green cover. In addition, many fruit species have the potential to be used both indoors and in the floriculture sector as a cut ornamental plant.

3.1 Olive (*Olea spp.*)

Olives, which is an evergreen plant, is widely preferred as an outdoor ornamental plant in the form of trees, shrubs and bush in parks, gardens, medians, roadsides and pavements. Leaves, stems, green and black fruits come to the fore as ornamental plant evaluation criteria. The olive plant, which has dark green and silvery leaves, has been widely used as an ornamental plant, especially outdoors, from past to present. The olive tree, which is the symbol of abundance, abundance, well-being and peace, is an important ornamental plant as a softening, emphasizing, limiting, complementary, supportive, shade and landscape plant, which is always preferred outdoors in the landscape because it lives for many years and remains green in all seasons. Since it can be grown in regions dominated by Mediterranean and subtropical climates and is a plant species resistant to heat and drought, it emerges as a potential ornamental plant in the fight against climate change in the future. Olives, which can be considered as an edible ornamental plant, draws attention with its aesthetic and functional properties. As a macro bonsai plant, it is used both as an indoor and outdoor ornamental plant, especially because its trunk stands out. The olive branch's usability as cut greens in bouquets and wreaths is also quite high, and it also has a special importance geographically, historically and religiously. It is seen that olive branches and leaves are made by girls and brides in the form of a ring on their heads and used as a crown or flower filler. Among the reasons for preference as an ornamental plant, we can say that it hosts birds in urban and rural areas and makes a positive contribution to the ecosystem in which it is located. However, due to the fact that it is an edible ornamental plant, care should be taken in its use as an ornamental plant, since the fruits of olive trees, which are used especially on the side of the main roads, are likely to be contaminated with heavy metals, which are harmful chemicals.

3.2 Hazelnut (*Corylus spp.*)

Hazelnut species with high commercial value are used as a valuable ornamental plant that adds aesthetic and functional features to urban and rural green spaces due to its features such as buds, flowers, branches, branching shape and leaf color. *Corylus maxima* 'Purpurea', *Corylus maxima* 'Atropurpurea', *Corylus colurna* 'Obelisk', *Corylus colurna* 'Terra Red', *Corylus heterophylla*, *Corylus fargesii*, *Corylus avellana* 'Aurea', *Corylus avellana* 'Obelisk', *Corylus avellana* 'Atropuryl', *Corylus avellana* 'Aurea', *Corylus avellana* 'Atropuryl', *Corylus avellana* 'Atropuryl', *Corylus avellana* 'Contorta', *Corylus avellana* 'Contorta Red Majestic', *Corylus avellana* 'Purple Umbrella', *Corylus avellana* 'Red Dragon', *Corylus avellana* 'Pendula' and *Corylus avellana* 'Fusco Rubra' are species and varieties with ornamental plant value (Atabeyoglu and Bilge, 2019). The majority of these species are used as single or multi-stemmed border, shade and erosion plants in the form of shrubs, trees and bush on the roadsides. Most importantly, it is a valuable ornamental plant for outdoors due to its functional and aesthetic properties due to its leaves with red, purple, green, yellow green and burgundy colors and tones. It is an important outdoor ornamental plant as it adds a different form and beauty to the environment every season, as it sheds its leaves, and provides rest, peace and a magnificent view. Hazelnut, which is a perennial plant, is suitable for use as a softening, emphasizing, limiting, complementary, supportive, shade and landscape plant, which is always preferred outdoors. It has a high potential to be used in the fight against climate change in the coming years due to its large growing area in regions with mild climate and its resistance to frost, wind and cold.

3.3 Avocado (*Persea americana* Mill.)

Avocado, an evergreen, perennial, subtropical plant species, is a suitable plant for outdoor decorations due to its dark green glossy leaves. Leaves and fruits come to the fore as ornamental plant evaluation criteria. It is a plant species with a high potential to be used as a single-trunk tree and shrub as a border, privacy, noise preventer and shade plant. It has aesthetic and functional properties for landscape design in regions with Mediterranean and subtropical climates. It can be used as an edible ornamental plant in holiday villages, gardens, around villas, sites and residences, along roadsides, sidewalks and medians. Its dark green glossy leaves are very suitable for making wreaths as cut greens. In addition, it is considered as a fruit species that contributes a lot to the urban ecosystem in terms of hosting birds in urban areas against the negative environment in winter.

3.4 Citrus (*Citrus* spp., *Fortunella* spp., *Poncirus trifoliata* (L) Raf)

All other citrus species, with the exception of *Citrus trifoliata* (*syn*. *Poncirus trifoliata* L.), are perennial, evergreen plants. For this reason, it is widely preferred as an indoor and outdoor ornamental plant in the form of trees and shrubs in parks, gardens, houses, balconies, medians, pavements and roadsides. As ornamental plant evaluation criteria, mostly fruits, leaves, thorns, flowers and scents come to the fore. It contains an important group of ornamental plants suitable for use both indoors and outdoors as softening, emphasizing, limiting, complementary, supportive, air cleaner, shade and landscape plants. It can be grown widely in regions with Mediterranean and subtropical climates. Its purple and white flowers and citrus fruits from yellow to orange and red add a functional and aesthetic appearance to their environment as ornamental plants. Among the reasons for preference as an ornamental plant, we can say that it hosts birds in urban and rural areas and makes a positive contribution to the ecosystem in which it is located. Citrus, which have commercial value due to being an edible ornamental plant, are suitable for use as ornamental plants in rural and urban areas. Honkong wild kumquat (*F. hindsii var. chintou* Swing.), oval kumquat (*F. margarita* (Lour.) Swing.), round kumquat (*F. japonica* (Thunb.) Swing.), Malaysian kumquat *(F. polyandra* (Ridl.) Tan.), *F. crassifolia* Swing., *F. obovata hort. ex* Tan., cedrate (*C. medica* L.), lemon (*C. limon* L.), Mexican key lime (*C. aurantifolia* (Chrism) Swing), bitter orange (*C. aurantium* L.), orange (*C. sinensis* Osb), mandarin (*C. reticulata* Blanco), pomelo (*C. Grandis* (L) Osb), grapefruit (*C. paradisi* Macf), Indian wild orange (*C. indica* Tan), takibana (*C. tachibana* Tan) are species and varieties with ornamental plant value (Yasuda et al., 2016; Onelge et al., 2017; Ozcan, 2020). Citrus fruits, thanks to their long stay on the plant and their beautiful appearance, have soothing, lively and peaceful properties in rural and urban areas and indoors. Bitter orange and kumquats are mostly used as ornamental plants. The spiny types of citrus fruits, which do not have much resistance to cold and thirst, are also suitable for use as border plants.

3.5 Walnut (*Juglans* spp.)

Since walnut trees are flamboyant plants, they are grown as ornamental plants in residences, villas and home gardens and benefit from both their shade and fruit. Since the walnut plant grows with a free crown, it has a beautiful and magnificent habitus (Sen, 2009). Since walnut is a deciduous plant, it can have a different feature and aesthetic appearance in every season. Walnut trees are an important ornamental plant for shade and landscape purposes as an outdoor plant in the landscape, as they are the symbol of nobility and splendor, live for many years and shed light on history. It is widely preferred as an outdoor ornamental plant in the form of trees and shrubs in parks, gardens, holiday villages, medians, sidewalks and roadsides. As ornamental plant evaluation criteria, mostly leaves, trunk and branches come to the fore. It can be grown widely in regions with mild climate, cold and subtropical climates. Walnut, which has a high commercial value due to being an edible ornamental plant, is suitable for use as an ornamental plant in rural and urban areas.

3.6 Apple (*Malus* spp.)

Apple is an important fruit species that has a wide growing area in the world and has many species and varieties. Apple species, which are basically considered ornamental plants such as ornamental apple or flower apple, have cherry-sized fruits and are deciduous, in the form of small trees, shrubs or bush, are used as ornamental plants in the landscape because of early blooming in spring. Many small-fruited apple species such as *Malus sylvestris* Mill., *Malus trilobata*, *Malus floribunda* and *Malus baccata* (Aslan, 2020) are used as ornamental plants. Therefore, apple species, which are perennial plants, are highly preferred as indoor and outdoor ornamental plants in the form of trees, shrubs or bush in parks, gardens, houses, balconies, medians, pavements and roadsides. As ornamental plant evaluation criteria, flowers that bloom in many different colors from white to pink, fruits of different colors from yellow to red, leaves and scents come to the fore. At the same time, they add a functional and aesthetic appearance to their environment as ornamental plants due to their leaves that can be of different colors in autumn. The fruits of many of the small-fruited species used as ornamental plants cannot be eaten because they are bitter. It contains an important group of ornamental plants suitable for use both indoors and outdoors as softening, emphasizing, limiting, complementary, supportive, air-purifying, noise-preventing, shade and landscape plants. It can be grown widely in regions with mild climate, cold and subtropical climates. Since it is a source of pollen and nectar in beekeeping, it has positive contributions to the ecosystem, especially outdoors. In addition, the cultivated apple (*Malus domestica*) species are highly ornamental and suitable for use in terms of being edible and creating a different visual feast in rural and urban areas every season as an ornamental plant.

3.7 Plum and Cherry (*Prunus* spp.)

Most of the plum and cherry species are widely grown as fruit or ornamental plants. It has functional, aesthetic and decorative features in the form of perennial, deciduous, shrub, tree and bush. They have an accentuating feature because they bloom in red, white and pink colors before leafing out in early spring. Plum and cherry species, which are basically considered ornamental plants such as ornamental plum or ornamental cherry, are used as ornamental plants in the landscape due to early blooming in spring. *Prunus cerasifera* 'Atropurpurea’, *Prunus cerasifera* 'Pissardii Nigra’, *Prunus cerasifera var. Pissardii*, *Prunus divaricata*, *Prunus* 'Accolade', *Prunus serrulata* 'Kanzan', *Prunus serrulata* 'Shidare Sakura' are plum and cherry species and varieties with ornamental plant value (Aslan, 2020). They are highly preferred as a perennial outdoor ornamental plant in the form of trees, shrubs or bush in parks, gardens, medians, pavements and roadsides. Different colored flowers, leaves, fruits and thorns in some species come to the fore as ornamental plant evaluation criteria. Due to their leaves of different colors in autumn, they add a functional and aesthetic appearance to their environments as ornamental plants. They include an important group of ornamental plants suitable for outdoor use as softening, emphasizing, limiting, complementary, supportive, air-purifying, noise-reducing, shade and landscape plants. It can be grown widely in regions with mild climate, cold and subtropical climates. Since it is a source of pollen and nectar in beekeeping, it has positive contributions to the ecosystem, especially outdoors. In addition, cultivated plum and cherry species are highly ornamental and suitable for use in terms of being edible and creating a different visual feast in rural and urban areas as ornamental plants in every season.

3.8 Pomegranate (*Punica granatum* L.)

Pomegranate is used as an outdoor ornamental plant in the form of trees, shrubs and bush in parks, gardens, holiday villages, medians, sidewalks and roadsides. Pomegranate, which is a perennial and deciduous fruit, is used as a pot and bonsai plant in offices, living rooms and balconies. Flowers, leaves and fruits come to the fore as ornamental plant evaluation criteria. It grows widely in regions with hot and subtropical climates and is drought resistant. Pomegranate, which has commercial value as it is an edible ornamental plant, is suitable for use as an ornamental plant in rural and urban areas. Since pomegranate is considered to be the fruit of paradise, it has a religious significance in its preference as an ornamental plant. Pomegranate is an important ornamental plant species that can be used both indoors and outdoors as a softening, emphasizing, limiting, complementary, supportive, air cleaner and landscape plant. *Punica granatum* ‘Flore Pleno’, *Punica granatum* ‘Nochi Shibari’, *Punica granatum* ‘Legrellei’, *Punica granatum* ‘Lutea Plena’, *Punica granatum* ‘Rubra Plena’, *Punica granatum* ‘Nana’ are important pomegranate species and varieties used as ornamental plants. These ornamental pomegranates, which are dwarfed and have small fruits, which are basically considered as ornamental plants, provide a functional and aesthetic appearance to the environments in which they are used. In addition, the orange flowers, seasonally colored leaves, green and red fruits of pomegranate varieties such as 'Hicaz' can be used as edible outdoor ornamental plants in both rural and urban areas. Due to these features, the potential of the pomegranate in terms of functional and aesthetic appearance is quite high.

3.9 Fig (*Ficus carica* L.)

Fig is a perennial deciduous subtropical fruit species. It is a plant with a high potential as an outdoor ornamental plant in the form of trees, shrubs and bush in parks, gardens, medians, pavements and roadsides. As ornamental plant evaluation criteria, its leaves and stems come to the fore, but its green, yellow and black fruits also contribute to functionality and aesthetics. Since the fig tree lives for many years and is a religiously meaningful fruit, it is suitable for use as a softening, complementary, supportive, shade and landscape plant as an outdoor ornamental plant in the landscape. It is a potential ornamental plant in the fight against climate change in the future, as it can be grown in regions with Mediterranean and subtropical climates and is a plant species resistant to heat and drought. In addition, the use of fig leaves as cut greens in wreaths is quite high. It is a fruit with high usage value as an edible ornamental plant both commercially and for food in urban and rural areas.

3.10 Mulberry (*Morus* spp.)

Since mulberry trees are perennial and showy plants, they are grown as ornamental plants in urban areas such as parks, residences, villas and home gardens and benefit from both their shade and fruit. The mulberry plant has a large, beautiful and decorative crown structure as it grows in a free crown and drooping form. Since mulberry is a deciduous plant, it can have a different feature and aesthetic appearance in every season. It is used as an important coolness and shade plant outdoors. It is often preferred as an outdoor ornamental plant in the form of trees and shrubs in parks, gardens, holiday villages, medians, sidewalks and roadsides. As ornamental plant evaluation criteria, mostly leaves, trunk and drooping branches come to the fore. It can be grown widely in regions with mild climate, cold and hot climates. Mulberry, which has commercial value due to being an edible ornamental plant, is suitable for use in rural and urban areas for this purpose. However, it should not be used on roads, school gardens, parking lots and in places where it is frequently stepped on such as pavements, as it will cause pollution as a result of spilling the fruit. In such areas, more fruitless species and varieties may be preferred. Mulberry is a potential ornamental plant in the future in the fight against climate change due to its wide growing area and its resistance to heat, drought, frost, wind and cold.

3.11 Loquat (*Eriobotrya japonica* Lindl.)

Loquat, an evergreen, perennial subtropical fruit species, is a suitable plant for outdoor decorations due to its dark green leaves. Leaves and fruits come to the fore as ornamental plant evaluation criteria. It is a plant with a high potential to be used as a border and privacy plant, as a single-trunk tree and shrub, as a noise suppressor and as a shade plant. It stands as an aesthetic and functional plant species for landscape design in regions with Mediterranean and subtropical climates. It can be used as an edible outdoor ornamental plant in holiday villages, gardens, villas, sites, around houses and residences, roadsides, pavements and medians. In addition, its dark green broad leaves are very suitable for making wreaths and arrangements as cut greens. It is a type of fruit that contributes a lot to the ecosystem in terms of hosting birds in urban and rural areas, especially for the winter months.

3.12 Cherry laurel (*Laurocerasus officinalis* Roem.)

Cherry laurel is an evergreen, perennial fruit with dark green glossy leaves and red cluster shaped fruits with a high potential for outdoor decoration. Leaves, flowers and fruits come to the fore as ornamental plant evaluation criteria. It is suitable to be used as a border, hedge and privacy plant in groups or in the form of single-stemmed trees, shrubs and bush, noise suppressor, air purifier, accent plant, shade and landscape plant. It stands as a plant species that can be evaluated as aesthetic, functional and decorative in the landscape design of regions with mild climates. It is an important fruit species that can be used as an edible ornamental plant in holiday villages, gardens, around villas, sites and residences, on roadsides, pavements and medians. Its dark green glossy leaves are very suitable for making wreaths and arrangements as cut greens. In addition, it is a fruit species that contributes a lot to the urban ecosystem in terms of hosting birds in urban and rural areas, especially for the winter months.

3.13 Strawberry tree (*Arbutus unedo* L.)

Strawberry tree is preferred as an outdoor ornamental plant with its aesthetic and functional properties. Evergreen, perennial, shrub and tree-shaped arbutus has an important outdoor ornamental plant potential in landscape design with its leaf, flower, fruit and stem characteristics. Therefore, its use in urban green areas is becoming increasingly important (Guler et al., 2017). Its fresh shoots are also used as cut greens in bouquets, arrangements and wreaths. Strawberry tree is suitable for use as an edible outdoor ornamental plant in the form of shrubs and trees in parks, gardens, holiday villages, medians and roadsides due to its green, yellow, red fruits and bright green leaves and beautiful flowers. It can be used outdoors as a softening, accentuating, complementary, supportive, air-purifying, border, hedge, shade and landscape plant. In addition, it is a type of fruit that contributes to the urban ecosystem a lot because it hosts birds in urban and rural areas, especially in winter.

3.14 Carob (*Ceratonia siliqua* L.)

Carob is a perennial, splendid, wide and free-crown, and is preferred as an outdoor ornamental plant considering its aesthetic and functional characteristics. Carob, which grows in the form of evergreens, shrubs, trees and bush, and is among the natural species of the Mediterranean Region, has an important outdoor ornamental plant potential in landscape design with its leaf, fruit, flower and stem characteristics. In this respect, it is important in the use of rural and urban green spaces. Its fresh shoots are also used as cut greens in bouquets, arrangements, and wreaths. Due to its bright green leaves, it is suitable for use as an edible outdoor ornamental plant in the form of shrubs, trees and bush in parks, gardens, holiday villages, medians, and roadsides. It can be used outdoors as a softening, accentuating, complementary, supportive, air-purifying, border, hedge, shade, and landscape plant. Carob, which has a high tolerance to drought and heat, emerges as a potential ornamental plant in the fight against climate change in the coming years. In addition, it is a fruit species that contributes a lot to the urban ecosystem in terms of hosting birds in urban and rural areas, especially for the winter months.

3.15 Date palm (*Phoenix spp.*)

The date palm, which grows extensively in tropical and subtropical regions in general, is an important drought-tolerant palm species (Yildiz and Sohrabi, 2019). Date palm trees are frequently planted in touristic coastal areas in Türkiye and are used for both shade and ornamental purposes. *P. acaulis, P. canariensis, P. dactylifera, P. pusilla, P. reclinata, P. robelenii, P. rupicola, P. sylvestris, P. andamanensis, P. atlantica, P. caespitosa, P. loureiroi,* and *P. Paludosa* palm species are suitable for cultivation as ornamental plants in Türkiye (Hazir and Buyukozturk, 2013). Date trees are preferred in outdoor decorations considering their decorative, aesthetic and functional properties. Evergreen, perennial, date palm, which develops in the form of trees and shrubs, has an important indoor and outdoor ornamental plant potential in landscape design with its leaf, fruit, flower, and stem characteristics. Therefore, it is important in the use of rural and urban green spaces. However, since the leaf tips and bottoms are thorny, attention should be paid to its use indoors and outdoors. It has the potential to be evaluated as an edible outdoor ornamental plant in parks, gardens, holiday villages, beaches, medians, and roadsides. It can be used indoors and outdoors as a softening, accentuating, complementary, supportive, air-purifying, border, hedge, shade and landscape plant. Date palm, which has a high tolerance to drought and heat, emerges as a potential ornamental plant in the fight against climate change in the coming years.

3.16 Cranberry bush (*Viburnum opulus* L.)

Cranberry bush is often used as an outdoor ornamental plant in the form of a bush in parks, gardens, holiday villages, medians, and roadsides, due to both its fruits and leaves and its flamboyant flowers. As an ornamental plant evaluation criterion, it comes to the forefront with its flowers blooming in yellowish white tones, colorful fruits and leaves in green and red tones. The leaves, which turn to red tones in the autumn months, add a functional and aesthetic appearance to the environments they are used. Cranberry bush is an important ornamental plant suitable for emollient, emphasizing, complementary, supportive, air purifying, border, hedge and landscape plant. Cranberry bush can be grown in the form of a perennial bush, green leaves and deciduous, widely in regions where both hot and cold climates are dominant. Species and varieties that are frequently used as outdoor ornamental plants are sycamore-leaved viburnum (*Viburnum opulus* 'Sterile'), European dogwood bush (*Viburnum opulus* 'Roseum').

Figure 1. A) Cherry Laurel, B) Ornamental Apple, C) Kumkuat, D) Date Palm, E) Pomegranate, F) Mulberry

Figure 1 (continues). G) Olive, H) Carob, I) Bitter Orange, J) Ornamental Plum, K) Avocado, M) Fig, N) Orange

4. Conclusion

The use of fruit species as edible ornamental plants in rural and urban areas should be increased. Nowadays, it is seen that especially inedible ornamental plants are frequently used in the greening of urban areas. However, almost all parts of fruit species such as flowers, leaves, seeds, fruit characteristics and fragrances can be used for ornamental purposes. It is obvious that people living in urban areas, especially children, learn about fruit types and varieties only through limited opportunities such as books or digital media. Therefore, the use of fruit species and varieties in urban areas will ensure that fruits are learned by touching and feeling for educational purposes and that they are not forgotten. In addition, as an alternative to the desire to see more ornamental plants of different species and varieties, fruit types and varieties should be included in landscape planning studies. Fruit species used for ornamental purposes also have positive contributions to climate, noise and visual pollution, soil and air pollution and wildlife. The presence of fruit species in terms of edible ornamental plants in the greening of urban areas will benefit many living things living in urban. Due to the leaves, flowers, seeds, stems and scents that can change according to the season, fruit types will have a decorative, functional and aesthetic appearance. In addition, fruit species used as edible ornamental plants will contribute as a source of food for homeless and low-income individuals. It will increase biological diversity by creating an ecosystem and living space for the living things in urban.

5. References

Akkemik, U., Eminagaoglu., O. (2014). *Prunus* L. (Plums). Trees and Bushs of Türkiye. 369-373

Anonymous (2013). Mulberry Cultivation. Horticulture. *T. C. Ministry of National Education*. Ankara

Anonymous (2014). *Punica granatum* Cultivation. Horticulture. *T. C. Ministry of National Education*. Ankara

Arslan, M. (2022). A Research on The Ornamental Plant Propertıes, Domestıcatıon Possıbılıtıes, and Molecular Characterızatıon of *Sılene Compacta* Fıscher. (PHD Thesıs). Bolu Abant Izzet Baysal Unıversıty, Instıtute of Graduate Studıes, Bolu

Aslan, H. (2020). Determination of Fruit Species Used in Open Green Areas in The City of Ankara and Their Use As Ornamental Plants in Landscape Architecture. *Journal of Agricultural Faculty of Bursa Uludag University*. 34(Special Ed.), 99-114. e-ISSN 2651-4044

Atabeyoglu, O., Bilge, G. (2019). Use of *Corylus spp* in landscape design. *Academic Journal of Agriculture.* 8(Special Ed.), 145-156. ISSN: 2147-6403 e-ISSN: 2618-5881 DOI: http://dx.doi.org/10.29278/azd.638966

Aykun Dikmen, B., Yilmaz, H. (2021). The Use of Fruit Trees in Urban Open Green Areas of Erzurum. *Atatürk University Journal of Agricultural Faculty*. 53 (3), 262-272. ISSN: 1300-9036, E-ISSN: 2651-5016, doi: 10.17097/ataunizfd.880508

Bayram, S., Tepe, S. (2008). The Effect of Low and High Temperatures on Some Avocado Varieties Growing in Antalya Conditions. *Mediterranean Agricultural Sciences*. 21(1), 97–104

Bozkurt, S. E. (2021). Determining the Possibilities of Using Some Woody and Shrub Species Naturally Grown in Sivas in Landscape Architecture. *Eurasian Journal of Forest Science*. 9(3), 79-91. DOI: 10.3195/ejejfs.969214

Cetinay, S., Guler, S., Cosgun, S., Sahin, M., Gungoroglu, C. (2013). Comparing of Wild and Grafted Carob Trees (*Ceratonia siliqua* L.) in terms of Fruit and

Seed Characteristics. *Suleyman Demirel University Journal of Natural and Applied Science*. 17(1), 64-69

Dalkılıc, Z., Yersel, B., Ünal, M., Özer, S., Yavas, S. (2019). Effect of Organic Liquid Fertilizer on Rooting of Hardwood Cuttings in Fig (Bursa Siyahı), Pendula Mulberry, Red Mulberry, Walnut (Kaplan-86). *IJAAES International Journal of Anatolia Agricultural Engineering.* (Special Ed. 1), 60-66. ISSN: 2667-7571

Fat, A., Beyhan, N., Balik, H. İ. (2022). Determination of Pollen Quality Levels in Cherry Laurel (*Laurocerasus officinalis* Roemer). *International Journal of Agriculture and Wildlife Science*. 8(2), 166-178, doi: 10.24180/ijaws.1062418

Gercekcioglu, R., Bilgener, S., Soylu, A. (Ed.) (2014). General Fruiting (Principles of Fruit Growing), (4rd Edition). NOBEL Publications, Ankara

Gokalp, D. D., Yazgan, M. E. (2013). Rural Landscape Planning in Agro-Tourism and Agri-Tourism. *KMU Journal of Social and Economic Research*. 15 (24), 25-29, ISSN: 1309-9132

Guler, S., Bozdogan, E., Burgut, A. (2017). Alternative Fruit Trees in The Landscape Design: *Arbutus unedo* L. *Journal of Atatürk Central Horticultural Research İnstitute*. 46(Special Ed. 1), 215-222. Garden ISSN:1300-8943

Gulgun, B., Yazici, K. (2017). The Visual Feast of Nature: Wild Fruits II. *Journal of TURKTOB*

Guneroglu, N., Pektas, S. (2022). The Importance of Woody Plant Taxons with Edible Fruit Feature in Landscape Architecture: KTU Kanuni Campus example. *Turkish Journal of Forestry*. 23(1), 79-89. DOI: 10.18182/tjf.100955

Hazir, A., Buyukozturk, H. D. (2013). *Phoenix* spp. and other ornamental palms in Turkey. The threat from red palm weevil and red palm scale insects. *Emirates Journal of Food and Agriculture.* 25 (11), 843-853. doi: 10.9755/ejfa.v25i11.16500

Karadeniz, T., Arslan, M. (2019). Determination of the density of fruit and forest trees grown/growed in Hazelnut orchards. *2nd International Agricultural Congress*. 21-24 November, Ankara.

Karadeniz, T., Kırca, L., Senyurt, M., Bak, T. (2020). Determination and Evaluation of Wild Hazelnut Genotypes in Tirebolu Harkköy Region. *IJAAES International Journal of Anatolia Agricultural Engineering.* (1), 13-23. ISSN: 2667-7571

Karut, K., Kazak, C. (2005). A new pest of Date palm trees (*Phoenyx dactylifera* L.): *Rynchophorus ferrugineus* (Olivier, 1790) (*Coleoptera: Curculionidae*) in Mediterranean region of Turkey. Turkish *Journal of* Entomology. 29 (4): 295-300. ISSN:1010-6960

Olcay, N., Demir, M. K. (2019). Nutritional Composition and Functional Properties of Kumquat (*Fortunella spp*.). *Journal of the Institute of Science and Technology*. 9(4), 2124-2132. ISSN: 2146-0574, eISSN: 2536-4618, DOI: 10.21597/jist.508131

Olgun, R., Yilmaz, T., Turk, S. (2018). Investigation of User Preferences on The Use of Edible Plants on Planting Designs of Public Parks, A Case of Konyaaltı, Antalya. *Turkish Journal of Landscape Research*. 1(1), 42-48

Onelge, N., Arikan, G., Bozan, O. (2017). Investigatıon of *Citrus exocortis viroid* (CEVd) in Ornamental *Citrus* Plants. *Cukurova Journal of Agriculture and Food Sciences*. 32(1), 43-46

Ozcalik, M., Eskisarili, S. (2019). Color Phenomenon in Landscape Architecture. *The International Journal of Uyghur Studies*. 14, 60-74

Ozcan, M. (2020). Citrus and Tea Growing Lecture Note. Ondokuz Mayis University, Faculty of Agriculture, Department of Horizontal Plants, Samsun

Ozcan, M. (2020). Pomegranate Cultivation, Subtropic Fruis Lecture Note. Ondokuz Mayis University, Faculty of Agriculture, Department of Horizontal Plants, Samsun

Ozturk, F., Acar, A. (2019). A Taxonomic Study on Landscape Plants Used in Denizli. *BEU Journal of Science*. 8 (4), 1209-1217

Ozturk, F., Erkan, C., Olcucu, C., Cirig, N., Ozok, N., Ogun, E. (2017). Assessment of Landscaping Plants in Respect of Beekeeping in Van Province. *Yuzuncu Yil University Journal of Agricultural Sciences*. 27(4), 601-607. doi: 10.29133/yyutbd.316240

Sen, S. M. (2009). Walnut Cultivation, Nutritional Value, Folklore (3rd Edition). UCM Publications/1, Agricultural Publications/1, Ankara

Sevik, H., Ozturk, S., Cetin, M. (2016). Harmful Effects of Plants Used In Landscape Application (Kastamonu Sample). *Duzce University Journal of Science and Technology*. 4, 486-492

Taskin, O., Asik B. B., İzli. N. (2019). Mineral Content of Leaves, Stalks and Fruits of European Cranberrybush Plant (*Viburnum opulus* L.). *Journal of Agriculture and Nature*. 22(2): 178-182, DOI:10.18016/ksutarimdoga.vi.484362

Tasligil, N. (2011). Geographical Distribution and Economical Features of Carob Tree (*Ceratonia siliqua* L.). *ODU Journal of Social Sciences Research.* 2(3), 252-266. ISSN: 1309-9302

Yasuda, K., Yahata, M., Kunitake, H. (2016). Phylogeny and Classification of Kumquats (*Fortunella spp*.) Inferred from CMA Karyotype Composition. *The Horticulture Journal*. 85 (2), 115–121. doi: 10.2503/hortj.MI-078

Yener, S. H. (1994). *Morphological and Anatomical Studies on Olive Trees Grown in Different Regions of Turkey* (Ph.D. Thesis). Marmara University, Institute of Science and Technology, İstanbul

Yildiz, N., Sohrabi, M. (2020). Climate and Soil Requirements of Date Palm (*Phoenix dactylifera* L.). *International Journal of Engineering, Design and Technology*. 1(2), 64-70.

Zarifikhosroshahi, M., Kafkas, E. (2018). Determination of Bioactive, Biochemical and Nutrient Contents of Cranberry Bush (*Viburnum opulus* L.) Fruits. *Journal of The Faculty of Engineering*. 35-5, 41-51

CHAPTER 9

SOME IMPORTANT FRUIT ENZYMES

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Enzymes are one of the most important biomolecules for livings. All living things such as humans, animals, plants, protista, fungi, bacteria, archea etc. perform their vital activities by enzymes.

Enzymes are known and identified as “biocatalyst” because they regulate metabolic reaction in organisms. All metabolic reactions can take place in the presence of an enzyme or enzyme group. Protein synthesis, photosynthesis, lipid synthesis, protein degradation, lipid degradation, carbohydrate degradation, gen regulation, DNA repair, transcription, replication, apoptosis (programmed cell death), adding or eliminating anyone of functional biochemical group to/from biomolecules etc. all reactions are under the control of enzymes.

Looking at the structure of living things, they consist of **"organic molecules"** such as carbohydrates, proteins, fats, nucleic acids, and vitamins, and **"inorganic molecules"** such as water and minerals.

Enzymes are special biomolecules composed of protein and they provide the continuity of living structure by accelerating biochemical reactions that take a very long time to occur under normal conditions. In biological structures, it is not possible for reactions to take place without enzymes. However, there is a very tight specificity between biochemical reactions and the enzyme or enzyme group that will bring about that reaction. Not every enzyme catalyzes every reaction, and not every reaction can be accomplished by every enzyme. Therefore, according to classical logic, there must be as many enzymes as necessary biochemical reactions for a living thing to exist. In other words, a living organism growth depending on the number and variety of enzymes it contains.

Plants produce location-specific and even tissue- and cell-specific enzymes to develop their anatomical structures such as roots, stems, leaves, flowers, and fruits. The formation and development of fruits is also managed and directed by many enzymes. Therefore, when considering "fruit enzymes", enzymes that are in different anatomical structures of the plant and that enable the formation of fruits may also come to mind. However, in this section priority will be given to enzymes, which are mainly found in the structure of fruits itself and transferred to humans as food and to animals as feed.

Fruit enzymes by functions

1. Respiratory Enzymes

Plants provide the necessary energy to survive by breaking down organic matter by burning. This event, which meets the energy need, is called **"respiration"**. Enzymes involved in respiration are also known as **"respiratory enzymes"**. Considering all living things, respiration can occur in two different metabolic pathways: "aerobic respiration" and "anaerobic respiration (fermentation)", depending on the type of final electron acceptor.

Plant respiratory enzymes are extremely important for providing the necessary energy for plant growth and development and for the formation of structures such as roots, stems, leaves, branches and fruits in sufficient quality. In this section, some of these enzymes will be discussed in terms of their structure and functions.

Starch phosphorylase (EC 2.4.1.1)

Starch phosphorylase (EC 2.4.1.1) is the general name of the plant α-glucan phosphorylase (Figure 1). It is belonging to glycosyltransferase family and very important enzyme of carbohydrate metabolism in plant. During the phosphorolytic degradation of starch, this enzyme catalyzes the conversion 1-4-glucosidic bonds of glucan polymers into glucose-1-phosphate (Glc-1-P) reversibly in the presence of orthophosphate (Pi). While this enzyme plays a role in the glucose supply required to meet the energy needs in fruits, it also provides the control of carbohydrate stores such as starch.

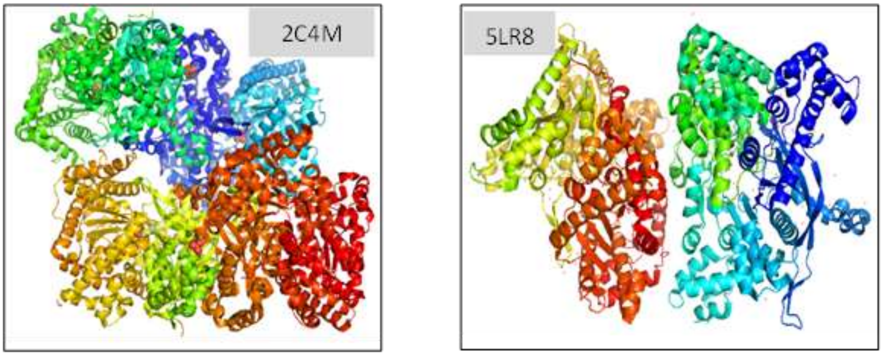

Figure 1. Structure of Starch Phosphorylase. Pymol 3D Cartoon Views of A) 2C4M (*Corynebacterium Callunae*) and B) 5LR8 (*Hordeum Vulgare* Subsp. *Vulgare*)

Phosphoglucomutase (EC 5.4.2.2)

Phosphoglucomutase is one of the important enzymes that reversibly catalyzes the conversion of Glucose-1-phosphate molecules, which are formed because of the breakdown of starch polymers in fruits, to

Glucose-6-phosphate (Figure 2). The serine amino acid plays a role in the phosphoglucomutase activity. It is known that the hydroxyl group of the serine amino acid is used in many enzyme activities.

Studies have shown that Phosphoglucomutase activity declined in the early fruit formation period, while it reached to the highest level in the ripe fruit period in some fruits.

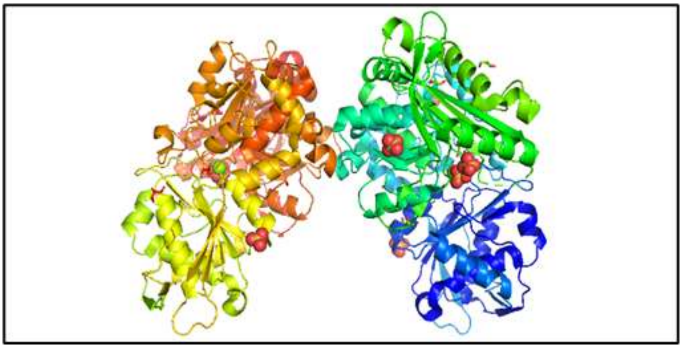

Figure 1. Crystal Structure of Phosphoglucomutase Belonging to Human (PDB ID: 5EPC)

Phosphoglucoisomerase (PGI) / phosphohexose isomerase (PHI) (EC 5.3.1.9)

Phosphoglyco isomerase catalyzes reversibly the isomerization between glucose-6-phospate and fructose-6-phosphate reversibly in fruit cells (Figure 3). This enzyme is important for fruit ripening. Mg^{+2} and Mn^{+2} act as cofactors in the enzyme activity. Phosphoglyco isomerase has some isoenzymes. For example, Fruits have different isoenzymes. For example, there are two isoenzymes in bananas with the same molecular weight but different heat stability and isoelectric points.

It has been reported that increases and decreases in Phosphoglyco isomerase activity and related gene expression are observed depending on the climacteric period. Due to this increase and decrease in phosphoglyco isomerase activity, starch and sucrose formation are controlled, while biochemical changes such as taste, odour, color and tissue structure occur in fruit ripening.

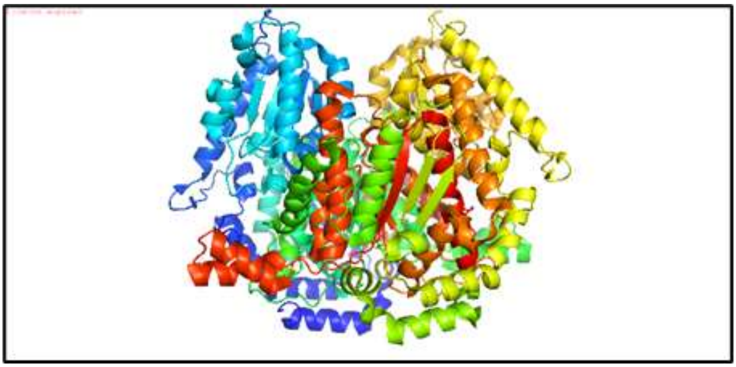

Figure 2. The Crystal Structure of Phosphoglucose Isomerase From Rabbit Muscle (PDB ID :1N8T)

Glyceraldehyde 3-phosphate dehydrogenase (EC 1.2.1.12)

GAPDH catalyzes the transformation of glyceraldehyde 3-phosphate to glycerate-1, 3-biphosphate. NADPH is formed in the continuation of this reaction (Figure 4). Its important comes from Its role in the NADPH production system and its genetic conservation used traditionally for species identification.

Glyceraldehyde-3-phosphate dehydrogenase can be located in Cytosol (GAPC) and plastid (GAPCp). Although the requirenment and catalytic function of GAPC/GAPCp in the regulation of fruit ripening is still unclear, it has been known that GAPC/GAPCp participates in the regulation of plant stress response and growth and development.

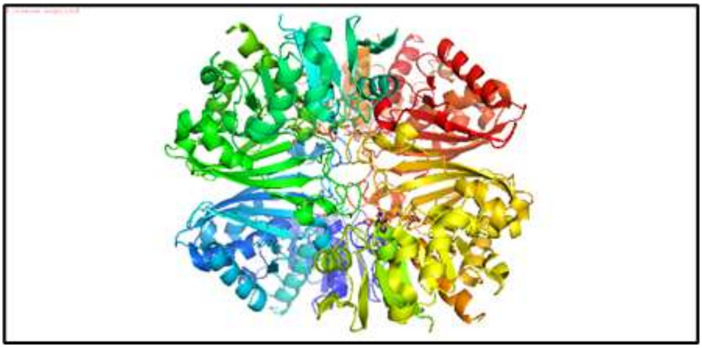

Figure 4. Crystal Structure of Human Liver Glyceraldehyde 3-Phosphate Dehydrogenase GAPDH (PDB ID: 1ZNQ)

Phosphoglycerate mutase (EC 5.4.2.11)

Phosphoglycerate mutase (PGM) (EC 5.4.2.1) is a key enzyme in the glycolysis pathway of fruits (Figure 5). This enzyme catalyzes the reversible interconversion of 3-phosphoglycerate and 2-phosphoglycerate during carbohydrate metabolism. According to cofactor requirement, it has two type of PGM enzyme: 1) Cofactor-dependent; PGM-d (requires 2,3-isphosphoglycerate as a cofactor and 2) Cofactor-independent; PGM-i. A catalytic amount of 2,3-diphosphoglyceric acid is required for PGM activity.

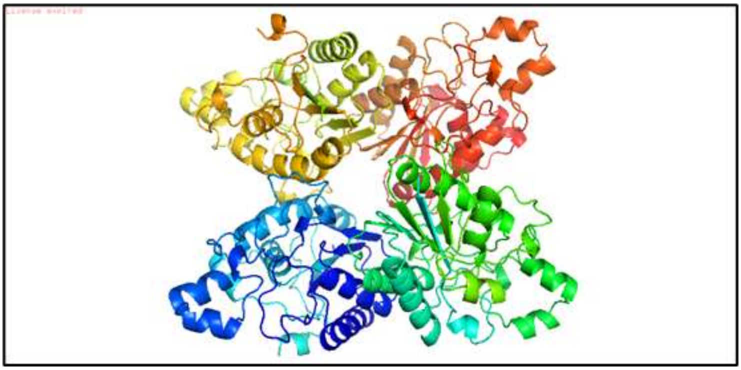

Figure 3. Structure of Phosphoglycerate Mutase Belonging to Saccharomyces Cerevisiae (PDB ID: 4PGM)

Pyruvate kinase (EC 2.7.1.40)

Pyruvate kinase involved in the last step of glycolysis may exist as compartment- and/or tissue-specific isoforms (Figure 6). The expression of this enzyme can be differentially chanced in response to environmental stress or during development. The formation of one pyruvate and one ATP molecule is catalyzed by Pyruvate kinase. Pyruvate kinase's role here is to transfer a phosphate group from phosphoenolpyruvate (PEP) to adenosine diphosphate (ADP). Pyruvate kinase activity is related with fruit ripening that involves a series of complex biochemical events.

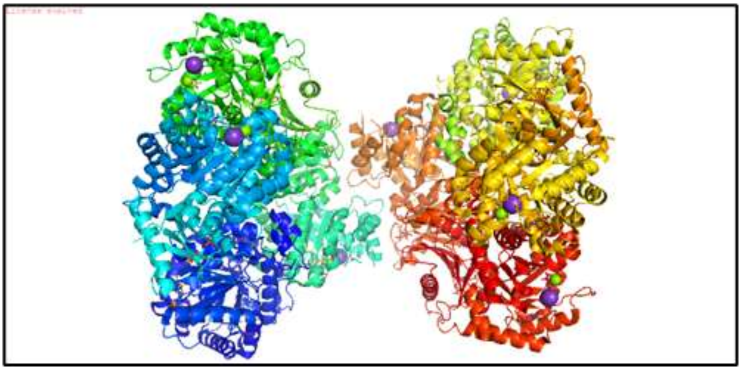

Figure 4. Structure of Liver Pyruvate Kinase in Complex with Anthraquinone Derivative. (ODB ID: 5SDT)

2. Photosynthesis Enzymes

Photosynthesis is a vital metabolic process for all living things. It is a series of reactions that makes it possible for plants and some other organisms to convert light energy into chemical energy.

In plants, photosynthesis takes place in the chloroplast organelles in their cells. The basic processes in photosynthesis are the production of carbohydrate (glucose) compounds and oxygen molecules by using water and carbon dioxide with the effect of light. The food of all phototrophic vs heterotrophic living things is mainly supplied by the metabolism of photosynthesis.

Photosynthesis reactions are possible as a result of the coordinated activities of many genes, proteins and enzymes. Enzymes taking part in photosynthesis reactions are very important in terms of their structure and functions. Some of the photosynthetic enzymes will be discussed in this section.

Ribulose-1,5-bisphosphate carboxylase (EC 4.1.1.39)

RuBisCoRibulose-1,5-bisphosphate carboxylase, one of the most abundant enzymes on Earth, is also known as "RuBisCO". RuBisCO is involved in the first stage of carbon fixation in photosynthesis reactions. It chemically catalyzes the carboxylation of ribulose-1,5-bisphosphate (RuBP) (Figure 7).

Figure 5. RUBISCO Activated Unliganded Spinach. (PDB ID: 1AUS)

Phosphoglycerate kinase (EC 2.7.2.3)

Phosphoglycerate kinase catalyzes transfer of a phosphate group from 1,3-bisphosphoglycerate to 3-phosphoglycerate and ATP (Figure 8). This reaction is reversible. It is found not only in fruits but also in all living organisms and is one of the two ATP-producing enzymes in glycolysis. The gene coding Phosphoglycerate kinase is used as housekeeping gene as control for some analysis such as RT-qPCR or microarray.

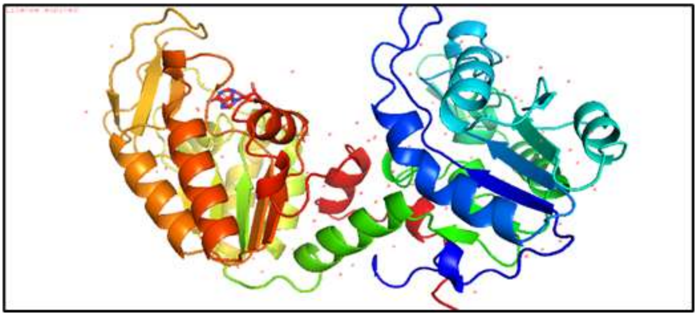

Figure 8. Structure of 3-Phosphoglycerate Kinase Belonging to Saccharomyces Cerevisiae (PDB ID: 1QPG)

Triose-phosphate isomerase (EC 5.3.1.1)

Triose-phosphate isomerase enzyme is a very important enzyme as it is an allergenic agent in fruits as well as taking part in photosynthesis metabolism (Figure 9). Research and identification of food allergens is important as approximately 1% of adults and 2-8% of children suffer from food allergies. Thanks to international transportation, the consumption of exotic fruits such as kiwi, mango and lychee is increasing. As a result, several diseases occur.

Individual foods contain a variety of allergens, whether of fruit, vegetable, or animal origin. Studies reveal that the allergenic effect in exotic lychee fruit (Litchi chinensis SONN.) is due to triose-phosphate isomerase molecules.

Its structure is dimeric, and each monomer consists of approximately 250 amino acid residues. In the three-dimensional structure of a subunit, there are eight parallel β helices on the inside and eight outer α helices on the outside.

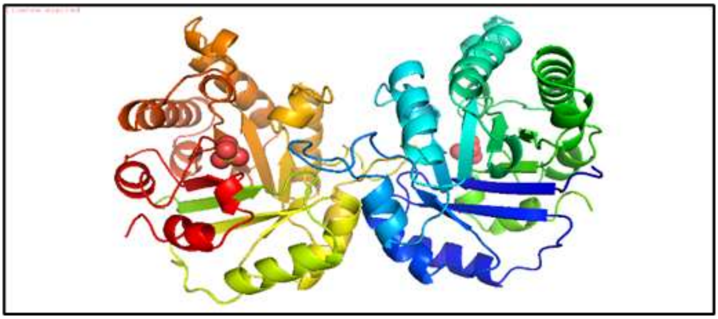

Figure 6. Structure of Triose Phosphate Isomerase.

Phosphoenolpyruvate carboxykinase (EC 4.1.1.32)

Like NADP-malic and NAD-malic enzymes, Phosphoenolpyruvate carboxykinase (PEPCK) plays a role in the inorganic carbon concentration mechanisms of C4 and CAM plants (Figure 10). For some terrestrial C4 and Crassulacean acid metabolism plants, phosphoenolpyruvate carboxykinase (PEPCK) is the decarboxylase enzyme providing CO_2 required for refixation by RuBisCo.

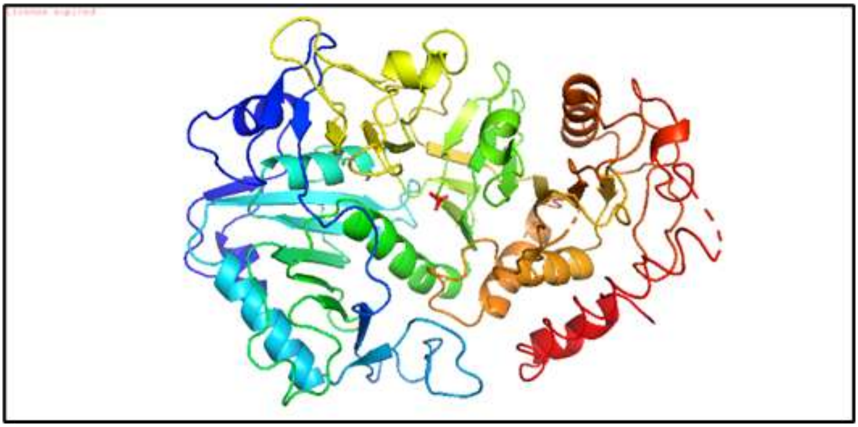

Figure 7. Structure of *E. Coli* Phosphoenolpyruvate Carboxykinase (PDB ID: 1OEN)

Malate dehydrogenase (EC 1.1.1.37)

Malate dehydrogenase is an important enzyme that reversibly catalyzes the oxidation of malate to oxaloacetate (Figure 11). This enzyme reduce the NAD+ molecules to NADH. This reaction is part of many metabolic pathways such as the citric acid cycle.

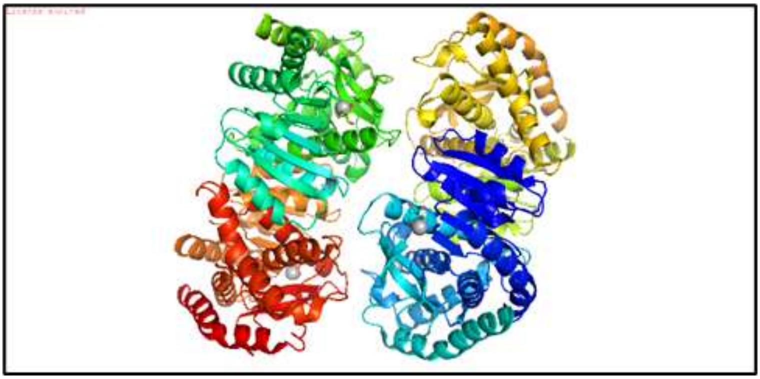

Figure 8. Structure of Silver-Bound *E.Coli* Malate Dehydrogenase (PDB ID: 6KA0)

Phosphoribulokinase (PRK) (EC 2.7.1.19)

Phosphoribulokinase (PRK) is an essential photosynthetic enzyme in fruits (Figure 12). PRK catalyzes the ATP-dependent phosphorylation of ribulose 5-phosphate (RuP) into ribulose 1,5-bisphosphate (RuBP). Both Rup and RuBP are important intermediates in the Calvin Cycle. Its main function PRK is to regenerate RuBP molecules, which is the initial substrate and CO_2-acceptor molecule of the Calvin Cycle.

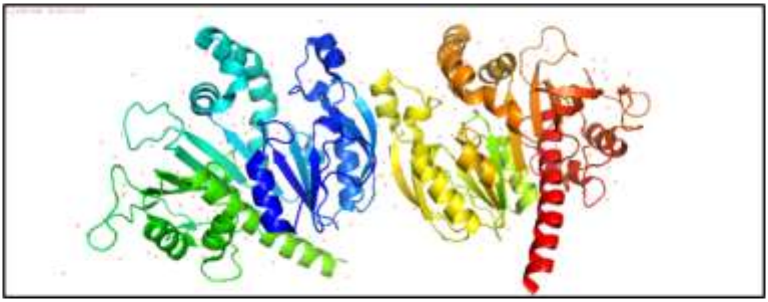

Figure 9. The Structure of Phosphoribulokinase from *Arabidopsis Thaliana*. (PDB ID: 6KEW)

3.Immune/Defense enzymes

Antioxidant Enzymes

Antioxidants are special substances that can protect human health by preventing or slowing damage to cells caused by free radicals. These free radicals are unstable molecules produced by our bodies as a reaction to environmental and other pressures. When a body processes food or our cells reacts to the environment, the cells produce some waste substances called "free radicals" or “reactive oxygen species (ROS)”.

It is very important being processed or removed of free radicals efficiently for health, otherwise oxidative stress can result. Fortunately, some compounds called antioxidants can be prevent us from harmful effects of these free radicals. Antioxidants are known as "endogenous antioxidants" or "exogenous antioxidants". Endogenous antioxidants are produced by body, but exogenous antioxidants come from outside the body.

Catalase (CAT, EC 1.11.1.6)

Although the concentration of catalase is variable, all fruits include it in different amounts (Figure 13). For example, kiwi, cherries, peaches, bananas, apricots, watermelon, and pineapple have high amounts of catalase, but apples and grapes have lower amounts.

Catalase provides a protective effect by two mechanisms: 1) Catalytic effect and 2) Peroxidative effect. The catalytic effect is the main task of catalase and the enzymatic breakdown of hydrogen peroxide. The peroxidic effect is achieved by electron donating small molecules.

Figure 10. The Structure of Catalase Belonging to Homo Sapiens. (PDB ID: 1QQW)

Recent studies demonstrated that it is possible to apply the catalase to indicate heat stress in dried fruits slices processed at different temperatures, such as mango.

Glutathione reductase (GR) (EC 1.8.1.7)

This enzyme has great importance in the fruit industry. Because glutathione reductase is an enzyme with a high detoxification and protection effect in the fabrication processes. Cysteine-containing tripeptide Glutathione is the major transport and storage form of reduced sulfur in plants.

Glutathione peroxidase (GR) is a NADPH-dependent enzyme and catalyzes the reduction of oxidized glutathione (GSSG) to GSH (Figure 14). GSH is stable in neutral and slightly acidic environments. In alkaline conditions, GSH gradually undergoes autooxidation to GSSG. This autoxidation make GSH ineffectual as a reducing agent.

Figure 11. The Structure of Glutathione Reductase Belonging to Homo Sapiens (PDB ID: 1GRE)

Glutathione peroxidase (GPx) (EC 1.11.1.9)

Glutathione peroxidase (GPx) (EC 1.11.1.9) is an important enzyme protecting fruits from oxidative damage (Figure 15). Glutathione peroxidases reduce lipid hydroperoxides in fruits to their corresponding alcohols. It also reduces free hydrogen peroxide to water. Therefore, it can be said that its main function is to catalyze the reduction of hydroperoxides.

Glutathione peroxidase, which is a cytosolic enzyme, contains tetrameric Se atom in its structure, but it does not contain HEM and other prosthetic groups. Glutathione peroxidase, which is extremely important for human health, is the strongest and most effective antioxidant against oxidant stress in erythrocytes. Therefore, fruits with high Glutathione peroxidase concentration are important in this view.

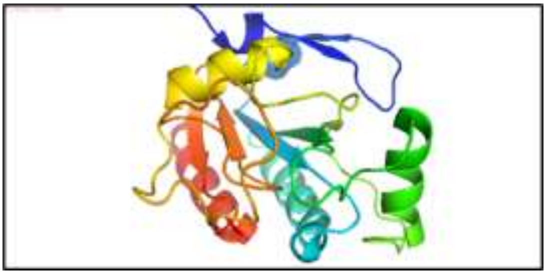

Figure 12. The Structure of Glutathione Peroxidase 5 of Homo Sapiens. (PDB ID: 2I3Y)

Glutathione S-transferase (GST EC.2.5.8.18)

Glutathione S-transferases (GSTs) are important enzymes catalyzing the conjugation of the reduced form of glutathione (GSH) to xenobiotic substrates for the purpose of detoxification (Figure 16). This protective effect of GST in plants appears to prevent cellular damage. With this prevention, it is possible for plants to maintain a high level of metabolic activity and growth.

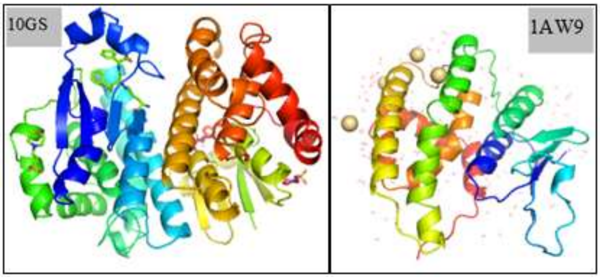

Figure 13. The Structure of Glutathione S-Transferase Belonging to A) Homo Sapiens (PDB ID: 1OGS) And B) Zea Mays (PDB ID: 1AW9)

Glutathione S-transferases (GSTs) are important enzymes catalyzing the conjugation of the reduced form of glutathione (GSH) to xenobiotic substrates for the purpose of detoxification (Figure 16). This protective

effect of GST in plants appears to prevent cellular damage. With this prevention, it is possible for plants to maintain a high level of metabolic activity and growth.

Superoxide dismutase (SOD) (EC.1.15.1.1)

Superoxide dismutase is an important antioxidant defense metalloenzymes (Figure 17, Figure 18, Figure 19). This enzyme alternately catalyzes the dismutation of the superoxide radicals ($O-2$) into hydrogen peroxide (H_2O_2) and molecular oxygen (O_2). Most organisms have these enzymes, and they play a key role in cellular protection against oxidative stress conditions.

The classification of Superoxide dismutases are generally based on the metal cofactor.

1. Copper-zinc-containing Superoxide Dismutase (Cu/Zn-SOD)
2. Manganese-containing Superoxide Dismutase (Mn-SOD)
3. Iron-containing Superoxide Dismutase (Fe-SOD)

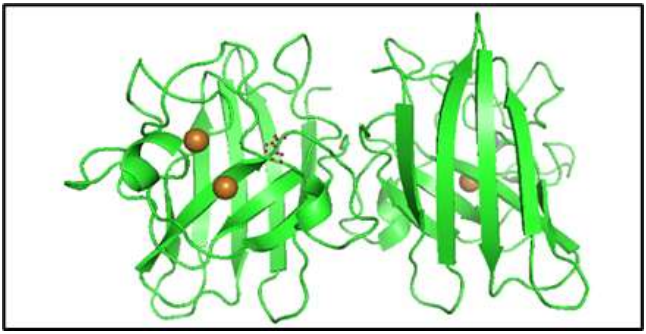

Figure 14. The Structure of Copper, Zinc Superoxide Dismutase Belonging to Bos Taurus. (PDB ID: 1CB4)

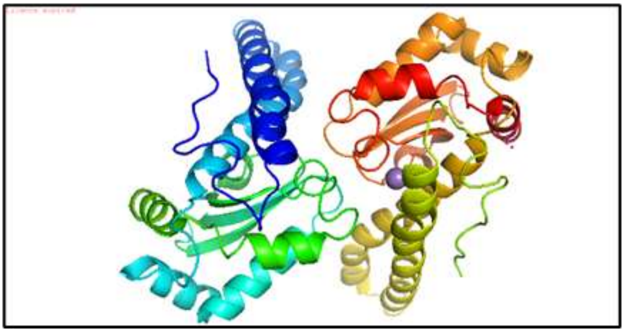

Figure 15. The Structure of Manganese Superoxide Dismutase of Human Mitochondria. (PDB ID: 1AP5)

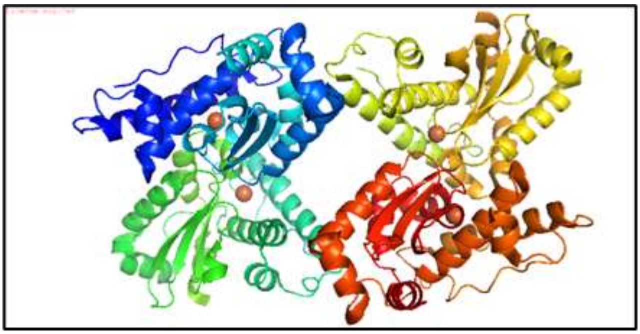

Figure 16. The Structure of Iron-Containing Superoxide Dismutase of *E. Coli*. (PDB ID: 2BKB)

4. References

Backhausen, J., Vetter, S., Baalmann, E. et al. NAD-dependent malate dehydrogenase and glyceraldehyde 3-phosphate dehydrogenase isoenzymes play an important role in dark metabolism of various plastid types. Planta 205, 359–366 (1998). https://doi.org/10.1007/s004250050331

Berg, J. M., Tymoczko, J. L., Stryer, L., Denizli, A., & Özden, A. K. (2014). Biochemistry. Palme Publications, Ankara, Türkiye.

Bizzoca, M. E., Leuci, S., Mignogna, M. D., Muzio, E. L., Caponio, V., & Muzio, L. L. (2022). Natural compounds may contribute in preventing SARS-CoV-2 infection: a narrative review. *Food Science and Human Wellness*, *11*(5), 1134–1142. https://doi.org/10.1016/j.fshw.2022.04.005

Cordenunsi, B. R., Oliveira do Nascimento, J. R., Vieira da Mota, R., & Lajolo, F. M. (2001). Phosphoglucose isomerase from bananas: partial characterization and relation to main changes in carbohydrate composition during ripening. *Bioscience, biotechnology, and biochemistry*, *65*(10), 2174–2180. https://doi.org/10.1271/bbb.65.2174

Devlin, T. M. (Ed.). (2010). Textbook of biochemistry with clinical correlations. John Wiley & Sons publishers, England.

Di Matteo, A., Sacco, A., Anacleria, M. *et al.* The ascorbic acid content of tomato fruits is associated with the expression of genes involved in pectin degradation. *BMC Plant Biol* **10**, 163 (2010). https://doi.org/10.1186/1471-2229-10-163

Foyer, C., Lelandais, M., Galap, C., & Kunert, K. J. (1991). Effects of Elevated Cytosolic Glutathione Reductase Activity on the Cellular Glutathione Pool and Photosynthesis in Leaves under Normal and Stress Conditions. *Plant physiology*, *97*(3), 863–872. https://doi.org/10.1104/pp.97.3.863

Gozukara E.M. (2001). Biochemistry. 4th Edition Volume-2 Nobel Medical Bookstores publishers, İstanbul, Türkiye.

Hoppe, S., Steinhart, H & Paschke, A. (2006). Identification of a 28 kDa lychee allergen as a triose-phosphate isomerase. *Food and Agricultural Immunology, 17*(1), 9–19. doi:10.1080/09540100500538307

José M Sala, J. M. (1998). Involvement of oxidative stress in chilling injury in cold-stored mandarin fruits. Postharvest Biology and Technology, Volume 13, Issue 3, p. 255-261.

Kacar, B., Katkat, V., & Öztürk, Ş. (2002). Plant Physiology, Uludag Univ. Empowerment Foundation, Publishers, İstanbul, Türkiye.

Karabulut, H. & Gülay, M. Ş. (2016). ANTİOKSİDANLAR. Veterinary Journal of Mehmet Akif Ersoy University, 1 (1), 65-76. DOI: 10.24880/maeuvfd.260790

Mazarei, M., Lennon, K.A., Puthoff, D.P. et al. Expression of an Arabidopsis phosphoglycerate mutase homologue is localized to apical meristems, regulated by hormones, and induced by sedentary plant-parasitic nematodes. Plant Mol Biol 53, 513–530 (2003). https://doi.org/10.1023/B:PLAN.0000019062.80459.80

Meloni, D.A., Oliva, M.A., Martinez, C.A., & Cambraia, J.N. (2003). Photosynthesis and activity of superoxide dismutase, peroxidase and glutathione reductase in cotton under salt stress. *Environmental and Experimental Botany, 49*, 69-76.

Mitrovic, S. M., Pflugmacher, S., James, K. J., & Furey, A. (2004). Anatoxin-a elicits an increase in peroxidase and glutathione S-transferase activity in aquatic plants. *Aquatic toxicology (Amsterdam, Netherlands)*, *68*(2), 185–192. https://doi.org/10.1016/j.aquatox.2004.03.017

Moon, K. M., Kwon, E. B., Lee, B., & Kim, C. Y. (2020). Recent Trends in Controlling the Enzymatic Browning of Fruit and Vegetable Products. *Molecules (Basel, Switzerland)*, *25*(12), 2754. https://doi.org/10.3390/molecules25122754

Nelson, D. L., and Cox, M. M. (2005). Lehninger Principles of Biochemistry, Translation Editor: Prof. Dr. Nedret Kılıç, Translation from the Third Edition, Palme Publishers, Türkiye.

Ramírez, N., Briceño, H. (2022). Ecology of morphological fruit types, and fruit and seed colors in 27 Venezuelan plant communities. Acta Oecologica, Volume 116, 2022,

Reiskind, J. B., & Bowes, G. (1991). The role of phosphoenolpyruvate carboxykinase in a marine macroalga with C4-like photosynthetic characteristics. *Proceedings of the National Academy of Sciences of the United States of America*, *88*(7), 2883–2887. https://doi.org/10.1073/pnas.88.7.2883

Sala, J.M., & Lafuente, M.T. (2000). Catalase enzyme activity is related to tolerance of mandarin fruits to chilling. *Postharvest Biology and Technology, 20*, 81-89.

Sokoloff, D.D., Jura-Morawiec, J., Zorić, L., & Fay, M.F. (2021). Plant anatomy: at the heart of modern botany. *Botanical Journal of the Linnean Society, 195*, 249-253.

Tabares, L. C., Bittel, C., Carrillo, N., Bortolotti, A., & Cortez, N. (2003). The single superoxide dismutase of Rhodobacter capsulatus is a cambialistic, manganese-containing enzyme. *Journal of bacteriology*, *185*(10), 3223–3227. https://doi.org/10.1128/JB.185.10.3223-3227.2003

Telephone, A. (1997). Enzymology. Graduate Summer School Ege University, Kuşadası, Aydın, Türkiye.

Telephone, A., Salnikow, J., Zihnioglu, F., & Kilinc, A. (2002). Proteome Analysis Methods and Applications. Ege University Press, Izmir, Türkiye.

Whitford, D. (2005). Proteins: structure and function. John Wiley & Sons publishing, England.

https://www.genome.jp/dbget-bin/www_bget?ec:2.4.1.1 (Erişim tarihi:18.09.2002)

https://www.genome.jp/dbget-bin/www_bget?ec:5.4.2.2 (Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/5.3.1.9 (Erişim tarihi:18.09.2002)

https://www.genome.jp/dbget-bin/www_bget?ec:1.2.1.12 (Erişim tarihi:18.09.2002)

https://www.genome.jp/dbget-bin/www_bget?ec:5.4.2.11 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/2.7.1.40 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/4.1.1.39 **(**Erişim tarihi:18.09.2002) https://www.genome.jp/entry/2.7.2.3 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/5.3.1.1 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/4.1.1.32 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/1.1.1.37 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/2.7.1.19 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/1.11.1.6 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/1.8.1.7

https://www.genome.jp/entry/1.11.1.9 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/1.6.4.2 **(**Erişim tarihi:18.09.2002)

https://www.genome.jp/entry/1.8.1.7 **(**Erişim tarihi:18.09.2002

https://www.genome.jp/entry/1.15.1.1 **(**Erişim tarihi:18.09.2002

CHAPTER 10

FRUITS IN GEOGRAPHICALLY INDICATED AGRICULTURAL PRODUCTS

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1. Introduction

Popular culture, in other words, an urban culture, which is independent of folk culture, is far from the traditional cultures, and it is also changeable and appeals to the wider masses. Elements of folk culture, which is based on the countryside and shaped by daily practices, are gradually decreasing, losing their importance and even disappearing in world societies because of the industrial production activities (Tanrıkulu and Doğandor, 2021).

Industrial production triggers and threatens diseases such as cancer (Bowen and Zapata, 2009). Therefore, the use of products of unknown origin (Meral and Şahin, 2013) causes consumer demands to change.

In recent years, nowadays, people's consumption patterns have changed, healthy products are preferred (Bowen and Zapata, 2009; Meral and Şahin, 2013; Doğan, 2015), being more conscious, and a sense of quality and trust in products are sought due to factors such as increasing socio-economic levels, became the most important features. This situation has increased the demand for traditional, organic (ecological), natural (non-additive), and local products. Consumer preferences have shifted to products with origin and authenticity certificates, especially for food products (Yılmaz and Güven, 2019) and agricultural products.

Moreover, the concept of “geographical indications” has emerged in order to protect local products and to enable people living in the areas where these products are sourced to take advantage of this issue (Kan et al., 2010).

Besides, a geographical indication concept is a tool for revitalizing rural areas and protecting local culture against globalization (Kan and Gülçubuk, 2008; Zografos, 2008; Albayrak et al., 2017; Nizam, 2020). At the same time, geographical indications are a system that ensures the sustainability of cultural heritage and traditional production to be transferred to future generations (Zografos, 2008; Bowen and Zapata, 2009; Çalışkan and Koç, 2012; Çekal and Aslan, 2017; Polat Üzümcü, 2017; Doğanlı, 2020).

Some legal arrangements have been made in the world to brand and protect traditional and local products. In this context, geographical indication; is an arrangement that represents quality, trust, and locality (Köşker, 2020). The definition of geographical indications, the foundations of which were first laid in Europe and later globalized, has an important for the development of the regions and countries where they are located (Şahin and Meral, 2012; Doğanlı, 2020).

In addition, the fact that consumers eat healty and prefer organic products by paying attention to food safety has increased the importance of geographical indications. These products are obtained as a result of mass production. The fact that these products are produced differently from similar products obtained as a result of mass production has led specific markets to turn into smaller markets while meeting the needs of the target audience. Because of this situation, geographical indications are a kind of these market to meet the individual needs of fewer target groups (Çakaloğlu, 2015).

Turkey, with its geographical location advantages (Doğanlı, 2020), having different climatic zones, soil structures, diversity of cultural heritage, and financial budgets, has got products and usage methods specific to these lands (Gökovalı, 2007).

For Turkey, which hosts a large number of products that can be registered with geographical indications, besides having a wide variety and quality agricultural product range, it also has a rich regional production knowhow with a developed gastronomy culture and traditional production styles from its deep historical roots (Kantaroğlu and Demirbaş, 2018). Most of the geographical indications registered in the world and in Turkey consist of agricultural products (Kantaroğlu and Demirbaş, 2018). Fruits, which provide the majority of agricultural products, have an important place in human health and nutrition, especially because they are rich in vitamins and minerals (Karadeniz, 2004).

Many studies on geographically indicated products have been examined in terms of law, geography, gastronomy, economy, culture, and tourism. These studies play an important role in the examination of fruits in terms of agricultural products, which have an important place in human nutrition, are considered one of our natural and organic resources in line with the wishes of consumers, and are the livelihood of a large part of society. In this section, the fruits of agricultural products registered in Turkey with geographical indications were examined.

2. Definition of Geographical Indications Products

A geographical indication and designation of origin is an industrial property right describing a product originating from any region or attributable to any region due to its quality, reputation, or other characteristic. Geographical indication is defined as a mark used on products with a certain geographical origin and the quality or reputation arising from that origin (WIPO, 2022). In order to function as a geographical indication, a sign must identify a product as originating in a given place.

In Turkey geographical indications are registered by the Turkish Patent and Trademark Office. According to the Turkish Patent and Trademark Office:

Geographical Indication

The sign indicating the product identified with the region, area, or country where the origin is located in terms of distinctive quality, reputation, or other characteristics is called a “geographical indication”. Food, agriculture, mining, handicrafts, and industrial products may be subject to geographical indication registration. Geographical indications are registered as a designation of origin and geographical indication.

“Designation of origin” refers to the name of a product whose quality or properties are essentially or exclusively due to natural and human factors of a geographically defined location. All steps of production, processing, and preparation must take place within the established limits (e.g. Piraziz apple). Such products cannot be produced outside of their territory. Because products gain their properties only in the region where they are made available.

The geographical indications, which are identified with a specific geographical area in terms of their distinctive quality, reputation, or other characteristics, are called "geographical indications" (e.g. Isparta Carpets). At least one of the production, processing, or other operations must take place within the specified geographical area (Turkish Patent and Trademark Office, 2022a).

Briefly, products with the designation of origin can only be produced in the aforementioned region, while products with the geographical indication can be produced in different regions (Gökovalı, 2007; Doğan 2015).

Traditional Specialty Guaranteed

The products that cannot be registered as a designation of origin or geographical indication can be registered as “traditional specialty guaranteed” products specialty guaranteed if it can be proven that the product is on the traditional market for at least 30 years. In order to register these products as traditional specialty guaranteed products, these products should have been made by either traditional production, processing, traditional composition, or traditional materials (Turkish Patent and Trademark Office, 2022a).

The historical background of geographical indication concept is based on the Paris Convention for the Protection of Industrial Property in 1883. The Madrid Convention was signed in 1891. The Lisbon Agreement signed in 1958 revealed the international acceptance and protection of geographical indications (Kan et al., 2010). In Turkey, it started with the Decree Law No. 555, which entered into force in 1995.

Policies are generally aimed at eliminating information asymmetry to prevent both consumer fraud and unfair competition (Barjolle et al., 2011; Vural, 2021). Geographical indication protection policies are important in improving added value and market access, especially in developing countries (Barjolle et al., 2011, Özdemir and Dülger, 2018; Vural, 2021).

In 2006, "Council Regulation No. 510/2006 dated 20 March 2006 on the Protection of Geographical Indications and Names of Origin in Agricultural Products and Foodstuffs" was rearranged by the EU. The innovations brought have brought innovations in the application process, labeling of PDOs (Protected Designation of Origin) and PGIs (Protected Geographical Indication), application activities, and control of compliance with conditions.

Products registered in the EU do not need to be registered by the member states. When the requirements of the EU application for the product and its mark are fulfilled and an equal protection guarantee is provided, non-EU states can also benefit from the registration (Goldberg, 2001; Turkish Patent and Trademark Office, 2022b). PDO, PGI, and TSG logos are used by consumers to know which country the geographically marked products belong to (Fig. 1).

PDO **Protected Designation of Origin**	**PGI** **Protected Geographical Indication**	**TSG** **Traditional Speciality Guaranteed**

Figure 1. Logo for the protection of agricultural and food products in the European Union

The logo of agricultural and food products with geographical indication registered used in Turkey is given in Fig. 2.

PDO **Protected Designation of Origin**	**PGI** **Protected Geographical Indication**	**TSG** **Traditional Speciality Guaranteed**

Figure 2. Logo for the protection of agricultural and food products in Turkey.

Geographical indication registered fruits and other products should be sold with logo on them (Fig. 3).

Aydın Chestnut | Silifke Strawberry | Alanya Avocado | Tarsus Sarıulak Olive

Figure 3. Logo on fruits with geographical ındication registered.

3. Geographically Indicated Fruits

There are 1042 registered geographical products and 733 on going applications available in Turkey (Turkish Patent and Trademark Office, 2022c). When these application numbers are examined, it is seen that there are products from 7 regions and different territory of Turkey (Table 1). The registered geographical indication types are given in Fig. 4. On the basis of provinces, Gaziantep was the province with the highest number of geographical indications with 98 registrations. When we look at the number of geographical indication applications and registrations by years, geographical indication has increased its popularity in Turkey in recent years (Fig. 5) (Turkish Patent and Trademark Office, 2022d). It is understood from these data that the awareness of producers or organizations about geographical indication has increased.

In addition to these, 8 geographical indications have already been registered in the European Union, which is valid at the international level. These; are Antep Baklava, Aydın Fig, Aydın Chestnut, Bayramiç White, Malatya Apricot, Milas Olive Oil, Taşköprü Garlic and Giresun Chubby Hazelnut (Turkish Patent and Trademark Office, 2022e). 5 of our 8 registered geographical indications are in the fruit group (Product category; Class 1.6. Fruit, vegetables and cereals fresh or processed) (eAmbrosia, 2022).

Table 1. Distribution of total registered and continuing geographical ındications by regions

Geographical Region	Registered	Applied
The Mediterranean Region	110	54
Eastern Anatolia Region	105	156
Aegean Region	153	99
Southeast Anatolia Region	193	94
Central Anatolia Region	175	119
Black Sea Region	208	132
Marmara Region	98	79
Total	**1042**	**733**

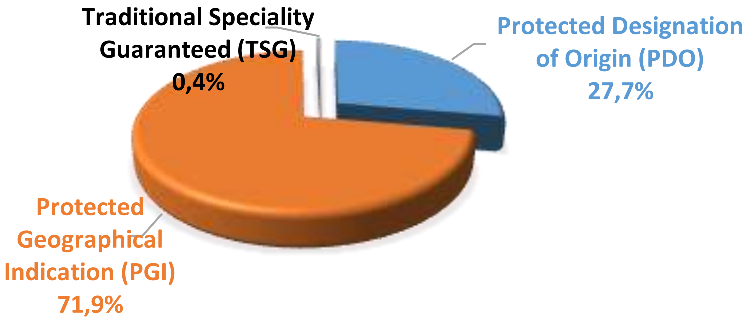

Figure 4. Registration types.

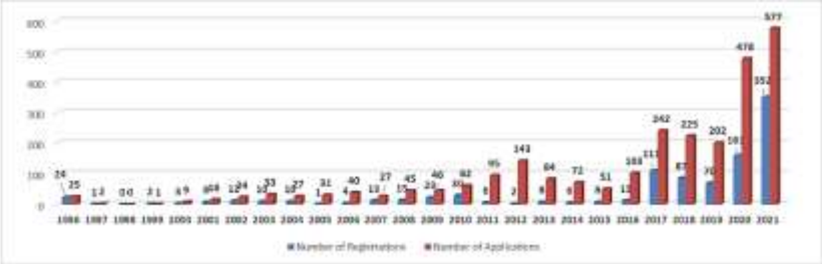

Figure 5. Distribution of total registered and continuing geographical indications by years.

A wide range is included in the classification made for products with geographical indication protection. Among these product groups, meals and soups take the first place (27.5%). Agricultural products (processed and unprocessed fruits and vegetables and mushrooms) take second place with a rate of 20.7%. Turkey has 248 geographical indication registrations in the processed and unprocessed fruits and vegetables and mushrooms group. Of these, 204 received the designation of origin and 44 received the geographical indication. Within this product group, fruits have a share of 51.6% (Fig. 6). A total of 128 fruits received geographical indication registration. 120 out of 128 fruits were registered with the designation of origin and 8 with the geographical indication of origin geographical indication. No reference was made in the traditional product name field (Table 2) (Turkish Patent and Trademark Office, 2022f).

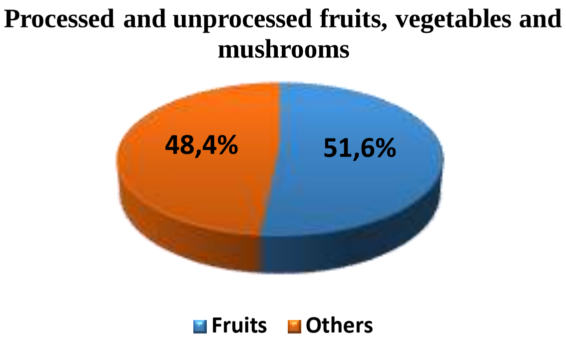

Figure 6. Processed and unprocessed fruits and vegetables and mushrooms product group.

Table 2. Geographical indication registration area or number of fruits whose application is ongoing and registration type (until 13.09.2022)

Number of Fruits Registered with Geographical Indication			Number of Fruits with Geographical Indication Application		
PDO	PGI	TSG	PDO	PGI	TSG
120	8	-	59	21	-

Grapes (25) received the most geographical indications in the fruit group. This is followed by cherry (12), olive (10), walnut (8), fig (6), apple (6), strawberry (6), hazelnut (5), pomegranate (5), mulberry (5), mandarin (4), chestnut (4), banana (3), gilaburu (3), apricot (3), orange (3), cherry (3), kiwi (2), pear (2), peach (2), plum (2). In addition to these, Alanya avocado, Alanya loquat, Antep pistachio, Bayramiç white (nectarine), Demirci jujube, Virtuous Lamas lemon, Geyve quince, Kahta almond, and Yalova aronia are fruits registered with the geographical indication (Fig. 7, Table 3). It can be seen from the numbers and variety of fruits here that our country has a very rich flora in terms of fruit growing. 49 out of 81 provinces received a geographical indication in the fruit group. The city with the highest number of geographical indications in the fruit group was Mersin with 8 registrations (Fig. 8, Fig. 9).

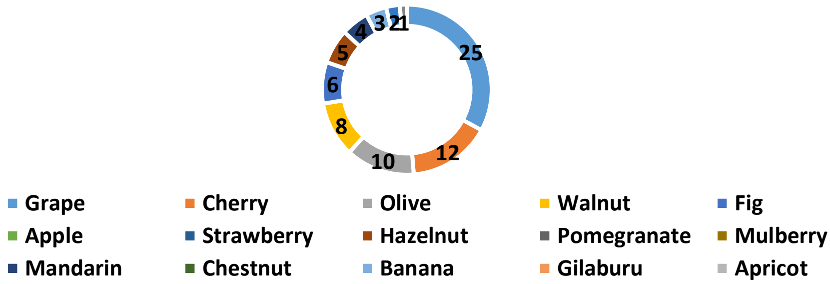

Figure 7. Geographical indication registered fruit varieties.

Table 3. Fruits with geographical indication registered

Geographical Indication Registered Grape	Registration Date	Registration Types	Province
Adıyaman Besni Grape (Adıyaman Besni Üzümü)	08.06.2018	PDO	Adıyaman
Arapgir Kohnu Grape (Arapgir Köhnü Üzümü)	24.06.2008	PDO	Malatya
Bornova Misket Grape (Bornova Misket Üzümü)	07.04.2021	PDO	İzmir
Bozcaada Cavus Grape (Bozcaada Çavuş Üzümü)	02.06.2020	PDO	Çanakkale
Cimin Grape (Cimin Üzümü)	25.06.2002	PDO	Erzincan
Denizli Calkarasi Grape (Denizli Çalkarası Üzümü/Denizli Çalkarası)	07.12.2020	PDO	Denizli
Diyarbakir Bogazkere Grape (Diyarbakır Boğazkere Üzümü)	10.03.2021	PDO	Diyarbakır
Aegean Sultana Grape (Ege Sultani Üzümü)	29.11.2004	PDO	İzmir
Elazig Bogazkere Grape (Elazığ Boğazkere Üzümü)	11.02.2019	PDO	Elazığ
Elazig OkuzgozuGrape (Elazığ Öküzgözü Üzümü)	06.03.2009	PDO	Elazığ
Ercis Grape (Erciş Üzümü)	20.11.2020	PDO	Van
Igdir White Grape (Iğdır Beyaz Üzümü /Miskalı)	09.08.2021	PDO	Iğdır
Kavacik Grape (Kavacık Üzümü)	20.12.2019	PDO	İzmir
Malatya Banazi Black Grape (Malatya Banazı Karası Üzümü)	26.03.2021	PDO	Malatya
Manisa Sultani Seedless Grape (Manisa Sultani Çekirdeksiz Üzümü)	18.02.2019	PDO	Manisa
Midyat Zeynebi Grape (Midyat Zeynebi Üzümü)	08.02.2022	PDO	Mardin
Saruhanli Seedless White Grape (Saruhanlı Çekirdeksiz Beyaz Üzümü)	12.08.2021	PDO	Manisa
Senirkent Dimrit Grape (Senirkent Dimrit Üzümü)	10.02.2022	PDO	Isparta
Tarsus White Grape (Tarsus Beyazı Üzüm (Topacık))	14.06.2005	PDO	Mersin

Omerli Karfoki Grape (Ömerli Karfoki Üzümü)	08.02.2021	PDO	Mardin
Incesu Karaevrek Grape (İncesu Karaevrek Üzümü)	26.08.2016	PDO	Kayseri
Isabey Seedless Grape (İsabey Çekirdeksiz Üzümü)	01.08.2006	PDO	Denizli
Iznik Muskule Grape (İznik Müşküle Üzümü)	20.08.2021	PDO	Bursa
Antep Black Raisin (Antep Karası Kuru Üzümü)	07.04.2022	PGI	Gaziantep
Kalecik Black Grape (Kalecik Karası Üzümü)	06.07.2007	PGI	Ankara
Geographical Indication Registered Cherry	**Registration Date**	**Registration Types**	**Province**
Aksehir Cherry (Akşehir Kirazı)	04.08.2005	PDO	Konya
Amasya Cherry (Amasya Kirazı)	18.07.2022	PDO	Amasya
Darboğaz Cherry (Darboğaz Kirazı)	28.09.2020	PDO	Niğde
Eregli White Cherry (Ereğli Beyaz Kirazı)	03.01.2019	PDO	Konya
Honaz Cherry (Honaz Kirazı)	22.03.2021	PDO	Denizli
Kemalpasa Cherry (Kemalpaşa Kirazı)	24.03.2021	PDO	İzmir
Kütahya Pazarlar Cherry (Kütahya Pazarlar Kirazı)	28.06.2021	PDO	Kütahya
Malatya Dalbasti Cherry (Malatya Dalbastı Kirazı)	08.12.2017	PDO	Malatya
Salihli Cherry (Salihli Kirazı)	03.09.2008	PDO	Manisa
Sultandagi Gilli Cherry (Sultandağı Gılli Kirazı)	08.01.2021	PDO	Afyonkarahisar
Sultandagi Cherry (Sultandağı Kirazı)	08.01.2021	PDO	Afyonkarahisar
Uluborlu Cherry (Uluborlu Kirazı)	26.10.2020	PDO	Isparta
Geographical Indication Registered Olive	**Registration Date**	**Registration Types**	**Province**
Akhisar Domat Olives (Akhisar Domat Zeytini)	13.12.2012	PDO	Manisa
Akhisar Uslu Olives (Akhisar Uslu Zeytini)	13.12.2012	PDO	Manisa
Antalya Tavsan Yüregi Olive (Antalya Tavşan Yüreği Zeytini)	06.09.2018	PDO	Antalya
Aydın Memecik Olive (Aydın Memecik Zeytini)	07.05.2021	PDO	Aydın
Aydın Yamalak Yellow Olives (Aydın Yamalak Sarısı Zeytini)	21.04.2021	PDO	Aydın
Edremit Körfezi Green Scratched Olives (Edremit Körfezi Yeşil Çizik Zeytini)	31.07.2015	PDO	Balıkesir
Gemlik Olive (Gemlik Zeytini)	03.10.2005	PDO	Bursa
Milas Oily Olive (Milas Yağlı Zeytini)	28.08.2019	PDO	Muğla
Tarsus Sarıulak Olive (Tarsus Sarıulak Zeytini)	16.04.2018	PDO	Mersin
Milas Cekiske Olive (Milas Çekişke Zeytini)	17.05.2022	PGI	Muğla
Geographical Indication Registered Walnut	**Registration Date**	**Registration Types**	**Province**
Hekimhan Walnut (Hekimhan Cevizi)	27.05.2019	PDO	Malatya
Kaman Walnut (Kaman Cevizi)	09.12.2020	PDO	Kırşehir
Karamanli Walnut (Karamanlı Cevizi)	28.08.2020	PDO	Burdur
Kavaklıdere Walnut (Kavaklıdere Cevizi)	28.08.2020	PDO	Muğla
Niksar Walnut (Niksar Cevizi)	17.12.2013	PDO	Tokat
Oguzlar Walnut (Oğuzlar Cevizi)	13.03.2020	PDO	Çorum
Catak Walnut (Çatak Cevizi)	06.08.2021	PDO	Van
Caglayancerit Walnut (Çağlayancerit Cevizi)	30.07.2013	PDO	Kahramanmaraş

Geographical Indication Registered Apple	**Registration Date**	**Registration Types**	**Province**
Amasya Misket Apple (Amasya Misket Elması)	14.03.2019	PDO	Amasya
Bayramic Apple (Bayramiç Elması)	16.12.2016	PDO	Çanakkale
Kagizman Long Apple (Kağızman Uzun Elması)	25.12.2017	PDO	Kars
Piraziz Apple (Piraziz Elması)	21.12.2016	PDO	Giresun
Posof Apple (Posof Elması / Badele Elması)	22.04.2019	PDO	Ardahan
Yomra Apple (Yomra Elması)	15.12.2020	PGI	Trabzon
Geographical Indication Registered Strawberry	**Registration Date**	**Registration Types**	**Province**
Huyuk Strawberry (Hüyük Çileği)	13.04.2021	PDO	Konya
Black Sea Eregli Ottoman Strawberry (Karadeniz Ereğli Osmanlı Çileği)	05.07.2021	PDO	Zonguldak
Koprubaşi Strawberry (Köprübaşı Çileği)	02.11.2021	PDO	Manisa
Sason Strawberry (Sason Çileği)	10.02.2021	PDO	Batman
Silifke Strawberry (Silifke Çileği)	01.10.2019	PDO	Mersin
Sultanhisar Strawberry (Sultanhisar Çileği)	30.11.2020	PGI	Aydın
Geographical Indication Registered Fig	Registration Date	Registration Types	Province
Aydın Fig (Aydın İnciri)	20.08.2007	PDO	Aydın
Bursa Black Fig (Bursa Siyah İnciri / Bursa Siyahı / Siyah Bursa İnciri)	14.11.2018	PDO	Bursa
Aegean Fig (Ege İnciri)	12.06.2006	PDO	İzmir
Fethiye Rock Fig (Fethiye Kaya İnciri)	11.08.2021	PDO	Muğla
Melli Fig (Melli İnciri)	30.07.2018	PDO	Burdur
Midyat Fig (Midyat İnciri)	10.03.2021	PDO	Mardin
Geographical Indication Registered Hazelnut	**Registration Date**	**Registration Types**	**Province**
Akcakoca Yellow Hazelnut (Akçakoca Sarı Fındığı)	27.02.2019	PDO	Düzce
Bolu Dag Hazelnut (Bolu Dağ Fındığı)	18.12.2020	PDO	Bolu
Giresun Black (Giresun Kalınkara Fındığı/Giresun Karası)	18.09.2019	PDO	Giresun
Giresun Sivri Hazelnut (Giresun Sivri Fındığı)	18.09.2019	PDO	Giresun
Giresun Tombul Hazelnut (Giresun Tombul Fındığı)	10.10.2001	PDO	Giresun
Geographical Indication Registered Pomegranate	**Registration Date**	**Registration Types**	**Province**
Gaziantep Oguzeli Pomegranate (Gaziantep Oğuzeli Narı /Antep Oğuzeli Narı)	02.09.2019	PDO	Gaziantep
Kahta Pomegranate (Kahta Narı)	24.03.2021	PDO	Adıyaman
Karakopru Pomegranate (Karaköprü Narı)	22.08.2019	PDO	Şanlıurfa
Kuytucak Pomegranate (Kuytucak Narı)	15.02.2021	PDO	Adana
Suruc Pomegranate (Suruç Narı)	27.07.2021	PDO	Şanlıurfa
Geographical Indication Registered Mulberry	**Registration Date**	**Registration Types**	**Province**
Ayas Mulberry (Ayaş Dutu)	22.09.2021	PDO	Ankara
Kemaliye Mulberry (Kemaliye Dutu / Eğin Dutu)	27.07.2021	PDO	Erzincan
Cemisgezek Ulukale Mulberry (Çemişgezek Ulukale Dutu)	08.03.2019	PDO	Tunceli
Sebinkarahisar Black Mulberry (Şebinkarahisar Karadutu)	13.09.2021	PDO	Giresun
Adıyaman Tut Mulberry (Adıyaman Tut Dutu)	30.11.2020	PGI	Adıyaman

Geographical Indication Registered Mandarin	Registration Date	Registration Types	Province
Bodrum Mandarin (Bodrum Mandarini)	20.11.2012	PDO	Muğla
Dortyol Mandarin (Dörtyol Mandarini)	31.10.2019	PDO	Hatay
Gumuldur Mandarin (Gümüldür Mandalinası (Gümüldür Mandarini))	18.08.2020	PDO	İzmir
Seferihisar Mandarin (Seferihisar Mandalinası)	04.07.2019	PDO	İzmir
Geographical Indication Registered Chestnut	**Registration Date**	**Registration Types**	**Province**
Aydın Chestnut (Aydın Kestanesi)	30.12.2013	PDO	Aydın
Buldan Chestnut (Buldan Kestanesi)	20.11.2020	PDO	Denizli
Simav Chestnut (Simav Kestanesi)	21.06.2022	PDO	Kütahya
Akcakoca Kaplandede Chestnut (Akçakoca Kaplandede Kestanesi)	25.08.2022	PGI	Düzce
Geographical Indication Registered Banana	**Registration Date**	**Registration Types**	**Province**
Alanya Banana (Alanya Muzu)	25.07.2022	PDO	Antalya
Anamur Banana (Anamur Muzu)	09.07.2003	PDO	Mersin
Erdemli Banana (Erdemli Muzu)	18.12.2020	PDO	Mersin
Geographical Indication Registered Viburnum Opulus	**Registration Date**	**Registration Types**	**Province**
Akkisla Viburnum Opulus (Akkışla Gilaburusu)	12.02.2021	PDO	Kayseri
Bunyan Viburnum Opulus (Bünyan Gilaburusu)	22.10.2018	PDO	Kayseri
Gemelek Viburnum Opulus (Gemerek Gilaburusu)	23.11.2017	PDO	Sivas
Geographical Indication Registered Apricot	**Registration Date**	**Registration Types**	**Province**
Igdir Apricot (Iğdır Kayısısı)	17.09.2018	PDO	Iğdır
Malatya Kayısısı	26.02.2002	PDO	Malatya
Mut Kayısısı (Yaş Sofralık)	15.10.2007	PDO	Mersin
Geographical Indication Registered Orange	**Registration Date**	**Registration Types**	**Province**
Finike Orange (Finike Portakalı)	26.12.2008	PDO	Antalya
Kozan Orange (Kozan Portakalı)	16.09.2020	PDO	Adana
Koycegiz Orange (Köyceğiz Portakalı)	24.05.2022	PDO	Muğla
Geographical Indication Registered Sour Cherry	**Registration Date**	**Registration Types**	**Province**
Cay District Sour Cherry (Çay İlçesi Vişnesi)	10.09.2007	PDO	Afyonkarahisar
Cubuk Sour Cherry (Çubuk Vişnesi)	18.04.2022	PDO	Ankara
Saphane Sour Cherry (Şaphane Vişnesi)	27.02.2020	PDO	Kütahya
Geographical Indication Registered Kiwi	**Registration Date**	**Registration Types**	**Province**
Ordu Kiwi (Ordu Kivisi)	05.09.2019	PDO	Ordu
Yalova Kiwi (Yalova Kivisi)	17.08.2021	PDO	Yalova
Geographical Indication Registered Pear	**Registration Date**	**Registration Types**	**Province**
Gursu Deveci Pear (Gürsu Deveci Armudu)	10.09.2019	PDO	Bursa
Korkuteli Karyagdi Pear (Korkuteli Karyağdı Armudu)	30.07.2018	PDO	Antalya
Geographical Indication Registered Peach	**Registration Date**	**Registration Types**	**Province**
Bursa Peach (Bursa Şeftalisi)	3.5.2019	PDO	Bursa
Lapseki Peach (Lapseki Şeftalisi)	10.5.2022	PDO	Çanakkale

Geographical Indication Registered Plum	Registration Date	Registration Types	Province
Gezende Plum (Gezende Eriği)	20.12.2021	PDO	Mersin
Katamonu Uryani Plum (Kastamonu Üryani Eriği)	17.07.2021	PGI	Kastamonu

Geographical Indication Registered And Other Fruits	Registration Date	Registration Types	Province
Alanya Avocado (Alanya Avokadosu)	15.10.2018	PDO	Antalya
Alanya Loquat (Alanya Yenidünyası)	07.08.2018	PDO	Antalya
Antep Pistachio (Antep Fıstığı)	17.05.2000	PDO	Gaziantep
Bayramic White (Bayramiç Beyazı)	01.01.2012	PDO	Çanakkale
Demirci Jujube (Demirci Hünnabı)	22.07.2020	PDO	Manisa
Erdemli Lamas Lemon (Erdemli Lamas Limonu)	21.10.2019	PDO	Mersin
Geyve Quince (Geyve Ayvası)	17.06.2020	PDO	Sakarya
Kahta Almond (Kahta Bademi)	05.04.2021	PDO	Adıyaman
Yalova Aronia (Yalova Aronyası)	24.06.2021	PDO	Yalova

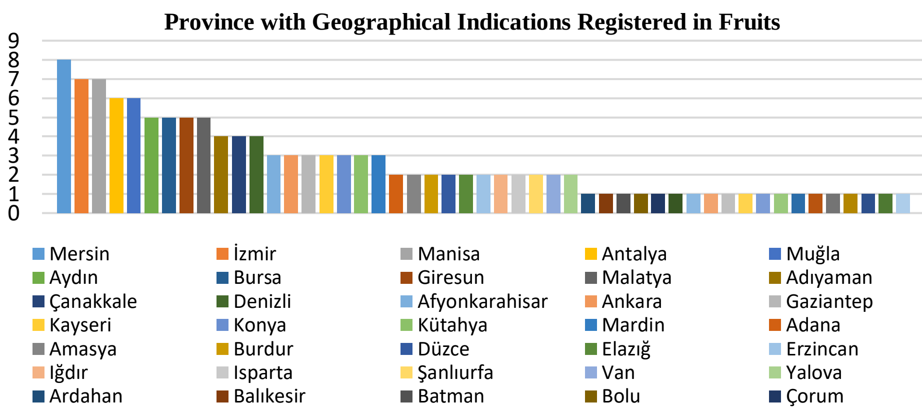

Figure 8. Province with geographical indications registered in fruits.

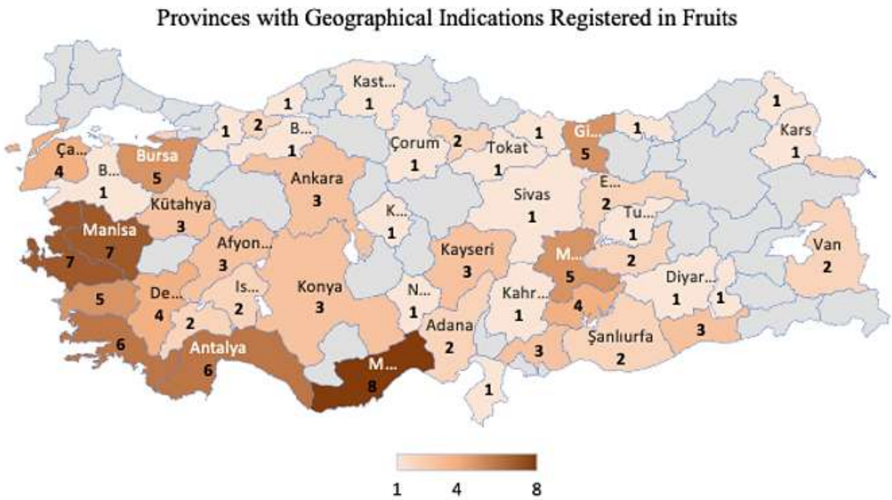

Figure 9. Distribution of fruits with geographical indication by provinces.

4. The Effect of Geographical Indication on Fruits in the Agricultural Products Group

In recent years, the prestige and market shares of local agricultural products have been increasing. This is a positive development, especially for the producers of agricultural products, and is extremely important for rural development.

Increasing industrialization with the increasing urbanization and the deterioration of natural resources has started to create an unhealthy social structure. In addition to this negative situation, the increasing education level and socio-economic conditions have changed the perspective on the production of agricultural products in today's world. Consumers have started to prefer organic, local products with a certain source.

Geographical indications protect traditional knowledge and cultural values, support local production and rural development, contribute to tourism, and create new business areas.

Producing the geographically indicated product in the territory and increasing business opportunities will help prevent migration from the village to the city (Oraman, 2015).

Geographical indications not only ensure the sustainability of local products, but also contribute to economic development by increasing the trust of consumers and the earnings of producers.

Along with the protection of biodiversity, the transfer of traditional knowledge to the future will also be ensured.

Today, geographical indication products are used as a development tool for agricultural enterprises all over the world. It is known that the geographical indications registered under the auspices of the EU during the EU accession process are important for Turkey's international branding (Yılmaz and Güven, 2019). Turkey has a high potential in terms of rich flora, fauna, social and human resources geographical indications (Çalışkan and Koç, 2012; Yılmaz and Güven, 2019).

Geographical indication labeling has changed the structure of the agricultural products market and has led to an increase in consumers' willingness to pay for products liked most (Vural, 2021; Callois, 2004).

In one of study, consumers' perceptions of Finike Orange with geographical indication and Tavşan Yüreği Olive (currently registered) for which geographical indication registration was applied were measured. As a result of the study, it has been observed that most of the people who believe that Finike Orange has got a brand value. Besides, the importance of obtaining geographical indication registration is probably to pay the extra price for that product. Consumers preferred to pay the less extra price for the Tavşan Yüreği Olive, which was supported in the way of branding and for which geographical indication registration application was made, compared to the Finike Orange, as they did not know this olive very well (Çakaloğlu, 2015).

Meral and Şahin (2013) found in their study that 58.9% of consumers would pay more for a geographically marked food and consumers could pay 29.8% more for a geographically marked Gemlik olive.

Studies show that the value and popularity of fruits in the agricultural product group are increasing. In addition, geographically indication products are protected against unfair competition. Sustainability of the positive effects can be achieved by determining the borders, especially in agricultural production areas, and preventing excessive production and destruction of nature.

It is of great importance to clearly determine the geographical boundaries of geographical indications (Şahin, 2014). The fact that the boundaries of one area are not determined somehow is a technically important problem. Geographical indication type is registered as origin in agricultural products. However, in some cases, the original sign has been taken. For example, the geographical indication type of the Kalecik Karası grape, which is one of the geographical indications in the agricultural products group, is the geographical indication. Others are designation of origin. In the report of the Kalecik Karası grape, "the unique taste, smell and aroma can only be formed if it is grown in the ecological conditions of Kalecik district" statement is included based on. This interpretation so, the Kalecik Karası grape should have originated as a type of designation of origin (Çalışkan and Koç, 2012).

In order to increase the quality of the products, attention should be paid to the protection of geographical indications and the determination of the quality standardization of these marks. Traceability, control, and content of the geographical indication registration file are very important (Dokuzlu and Güldaş, 2019).

In the absence of traceability of the geographical indication, consumers can be misled by making informal production. This poses a big problem for consumers (Doğan, 2015).

For agricultural products, coordination between the production and marketing phases should be ensured and organized by local cooperatives (Ertan, 2010; Kantaroğlu and Demirbaş, 2018; Tanrıkulu and Doğandor, 2021).

5. Conclusion

It is necessary to reproduce the uniqueness of regional quality with traditional and cultural techniques (Nizam, 2020), to protect, promote and transfer our local resources to future generations, and to preserve our fruit variety and product range in accordance with the traditional for a healthier future. According to the data we have obtained, it has been observed once again that fruit cultivation is carried out in all regions of our country in terms of agricultural products. All regions of our country have rich variety of fruits.

Therefore, many fruits with their own characteristics are still available in local regional markets all over our country and are not offered to large masses. Revealing these products are possible if they are among the geographically marked products in terms of awareness and reliability.

References

Albayrak, M., Güneş, E., Keskin, B. (2017). Geographical Indications and Legislation Developments on Food and Agricultural Products in Turkey. Cataloging-In-Publication Data, 787

Barjolle, D., Sylvander, B., Thevenod-Motted, E. (2011). Public Policies and Geographical Indications. Labels of Origin for Food: Local Development, Global Recognition, CAB International, Wallingford

Bowen, S., Valenzuela Zapata, A. (2009). Geographical indications, terroir, and socioeconomic and ecological sustainability: The case of tequila. *Journal of Rural Studies* 25:108-19

Çakaloğlu, M. (2015). *Brand products, geographical indication and consumer perception* (Master Thesis) Akdeniz University Institute of Social Sciences, Antalya

Çalişkan, V., Koç, H. (2012). Evaluation of distributional characteristics of geographical indications and the potential for geographical indications in Turkey. *Eastern Geographical Review* 17(28):193-214

Callois, J.M. (2004). Can quality labels trigger rural development? A microeconomic model with co-operation for the production of a differentiated agricultural good. p:3, working paper 2004/6

Çekal, N., Aslan, B. (2017). Tarhana as a gastronomic value and its significance in the geographical indication. *Journal of Current Tourism Research* 1(2):124-135

Doğan, B. (2015). The importance of the protection of geographical indications in developing countries. *Social Sciences* 10(2):58-75

Doğanlı, B. (2020). Geographical indication, branding and rural tourism relations. *Journal of Humanities and Social Sciences* 3(2):525-541

Dokuzlu, S., Güldaş, M. (2019). Geographical indications of animal originated products in Turkey. *Wydawnictwo Uniwersytetu Rzeszowskiego* 85-100 eAmbrosia. (2022). https://ec.europa.eu/info/food-farming-fisheries/food-safety-and-quality/certification/quality-labels/geographical-indications-register/, (Date Accessed:15.09.2022)

Ertan, A. (2010). Promoting the quality and geographic indication concepts to sell prestigious agricultural products and in this concept the importance of agricultural sales cooperative. *Journal of Süleyman Demirel University Institute of Social Sciences* (12):157-170

Gökovalı, U. (2007). Geographical indications and their economic effects: The case of Turkey. *Trends in Business and Economics* 21(2), 141-160

Goldberg, S.D. (2001). Who Will Raise the White Flag-The Battle Between the United States and the European Union over the Protection of Geographical Indications. U. Pa. J. Int'l Econ. L., 22:107

Kan M., Gülçubuk B. (2008). Geographical indications for recovery and local owned of rural economy. *Journal of Agricultural Faculty of Uludag University* 22(2):57-66

Kan, A., Kan, M., Gülçubuk, B., Küçükçongar, M. (2010). Karaman Divle Skinbag Cheese as a geographical indication. Karamanoglu Mehmetbey University Journal of Social and Economic Research 12(19):15-23

Kantaroğlu, M., Demirbaş, N. (2018). Evaluation of Production Potential of Food Products Geographical Indicated in Turkey. VIII. IBANESS Congress Series 21(22):514-520 Plovdiv/Bulgaria

Karadeniz, T. (2004). Curative Fruits (Nutrition and Treatment with Fruits), Ordu

Köşker, H. (2020). Bibliometric analysis of postgraduate theses written on geographical indications. *Journal of Humanities and Tourism Research* 10(4):775-787

Meral, Y., Şahin, A. (2013). Consumers' perceptions of product with geographical indication: The case of Gemlik Olives. KSU *Journal of Natural Sciences* 16(4):16-24

Nizam, D. (2020). How to use geographical indication for the democratization of agricultural production: a comparative analysis of geographical indication rent-seeking strategies in Turkey. III. Chapter:87-99, London and New York

Oraman, Y. (2015). Geographical indication products inTurkey. *Balkan and Near Eastern Journal of Social Sciences* 1(1):76-85

Özdemir, G., Dülger Altıner, D. (2018). Cheese Types of Turkey Registered With Geographical Indications. *International Gastronomy Tourism Studies Congress*. 20-22 September, 1(11), Kocaeli, Turkey

Polat Üzümcü, T. (2019). A bibliometric study on tourism education. *Journal of Turkish Tourism Research* 3(4):1433-1449

Şahin, A., Meral, Y. (2012). Turkey's geographical marking and local products. *Turkish Journal of Scientific Reviews* 5(2):88-92

Şahin, G. (2014). Groundnut (*Arachis hypogaea* L.)cultivation in Türkiye and Osmaniye peanut as a geographical indication. *Gaziantep University Journal of Social Sciences* 13(3):619-644

Tanrıkulu, M., Doğandor, E. (2021). Geographical indications of Bolu province and its potential. ÇAKÜ, *Journal of Institute of Social Sciences* 12(1):223-257 Türk Patent ve Marka Kurumu. (2022a). https://ci.turkpatent.gov.tr/sayfa/co%C4%9Frafi-i%C5%9Faret-nedir, (Date Accessed:13.09.2022)

Türk Patent ve Marka Kurumu. (2022b). https://www.turkpatent.gov.tr/en/geographical-indication, (Date Accessed:13.09.2022)

Türk Patent ve Marka Kurumu. (2022c). https://ci.turkpatent.gov.tr/Statistics/RegistrationAndApplication, (Date Accessed:13.09.2022)

Türk Patent ve Marka Kurumu. (2022d). https://ci.turkpatent.gov.tr/Statistics/Type, (Date Accessed:13.09.2022)

Türk Patent ve Marka Kurumu. (2022e). https://ci.turkpatent.gov.tr/sayfa/avrupa-birli%C4%9Finde-co%C4%9Frafi-i%C5%9Faret, (Date Accessed:13.09.2022)

Türk Patent ve Marka Kurumu. (2022f). https://ci.turkpatent.gov.tr/veri-tabani, (Date Accessed:13.09.2022)

Vural, B.M. (2021). Trade effects of geographical indications on Turkish agricultural products and foodstuff. *Turkish Journal of Agriculture-Food Science and Technolog* 9(8):1419-1425

WIPO. (2022). World Intellectual Property Organization (WIPO). https://www.wipo.int/geo_indications/en/, (Date Accessed:15.09.2022)

Yılmaz, S., Güven, O. (2019). Geographical indication of Turkish food products in the process of accession to the European Union. *International Journal of Agriculture Forestry and Life Sciences*, 3(2):287-294

Zografos, D. (2008). Geographical Indications and Socio-Economic Development. Working Paper 3:21

CHAPTER 11

NEW TECHNOLOGIES USED IN FOOD LABELING

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1. Introduction

Food safety and traceability are today a constant concern for consumers and all actors in the food chain, including the fruit and vegetable sector. There is an increase in both the product variety and consumption capacity due to the innovative changes that occur during the applications in production, food processing, storage, distribution, and consumption. With this increase, consumers who consume food that reaches almost every corner of the world are concerned about the safety of the food they buy. In order to address these concerns, the labels on the foods function as the identity documents of the products (Akgüngör, 2011). Labels containing all the necessary information about the packaging, the manufacturer and the product are also used in the cash registers in the markets and in the barcode systems of the products of the manufacturers (Akgüngör, 2011).

Label is a tool that provides information about the product to be transferred to the consumer understandably and simply during the purchase of goods or services, identifying the product and containing information that can be printed in different ways (Aksulu, 1996). The labels on the foods are effective in people's choice of healthy foods. The extent of this effect is directly related to the type of nutritional label applied. The use of food labels depends in part on how comprehensible the information is. Plain logos, emblems, guiding labels, and adhesive labels are labels that make the message more understandable (Akgüngör, 2011).

Labels, which are beneficial in providing the consumer with the necessary information about the food and for the food to find a place in the sector, should be able to provide valuable and non-false information to the consumer. This includes helping protect the consumer's health, preventing misunderstandings, and taking precautions against danger and abuse. On the other hand, it regulates the competition between companies. The fact that the label manages and regulates such complex processes has necessitated new regulations by legislators. Although many benefits of labels have been mentioned so far, the most valuable contribution is undoubtedly the one related to protecting consumer health. The American Food and Drug Administration reports that 600-1200 people can be prevented from getting heart disease in a year if consumers follow the saturated fat levels on the labels and consume food (Consumer Report on Health, 2003).

Labels that carry valuable information about products have become increasingly crucial among consumers. According to Ekşi (2012), the rules such as labels, nutrition information, health information, and daily coverage rates on food packaging are to support people in choosing food according to their health status, regulate food prescriptions, and reduce chronic ailments depending on consumption. The increase in individuals' behaviors towards consuming products according to the label information on the products necessitates the labels to be more detailed. Because scientific studies have shown that with conscious consumption, there is an 80% decrease in diabetes, 80% in cardiovascular diseases, 70% in colon cancer and 7% in stroke (Bal, 2019). For this reason, new systems that can be understood more easily by the consumer in labeling are gaining importance.

The expressions of the nutritional elements on the labels are used to warn consumers against obesity, which is defined as one of the biggest health problems today. The display of diet products and high-calorie products facilitates the selection of these products. For this purpose, some countries have started to use traffic lights on labels. The Food Standards Agency, the authority on food in the UK, has started encouraging the application of traffic lights on food labels (Hawkes, 2010). These signs are in three colors as red, green and yellow and differ in color according to the total calorie of the product. This makes it easier for consumers to choose products according to their calories. Developing smart tags technology, according to its working principles; time-temperature indicators, freshness indicators, pathogen indicators, biosensors, gas concentration indicators and radio frequency identification (RFID) systems (Bal, 2019).

In this section, information is given about new technologies used in labeling, as well as how consumers can access detailed information about products by examining product label information, how to make retrospective traceability, and how to learn about the freshness and quality of products.

2. Identification and Labeling of Foods

The identification and numbering of commercial objects and the processing of these numbers into barcodes provide accuracy and practicality in logistics applications such as goods acceptance processes, inventory processes, preparation, and shipment of products in areas such as production places, warehouse and logistics center. The codes and barcodes on the commercial product provide the automation of all the process steps that occur from the production stages of that product to the end consumer, thus enabling these steps to be done in the electronic field (electronic commerce) (Cebeci, 2006).

Good traceability: It is the ability to trace and track plant and animal products, food and feed, the animal or plant from which the food is obtained, a substance intended or expected to be present in food and feed, throughout all stages of production, processing and distribution. Traceability covers all stages from primary production to final consumer sales, including production and distribution stages, and aims to protect human health at the highest level in the relevant food. The traceability system defines all products and inputs, units, or lots; It includes the stages of collecting and storing information about where, when and where they move, and the establishment of a system that will associate these two data with each other (Yaralı, 2018).

Food definitions are divided into primary and secondary definitions. The primary definition of food traceability is the identity of the food, which is determined by some anatomical, physiological, and biochemical biological processes. Secondary or tag (data carriers) based identification consists of techniques that use a series of alpha-numeric character sequences to identify the product (Yaralı, 2018). Secondary data includes data stipulated by EC 178/2002, 1830/2003,

EUREP-GAP, IFS, HACCP, ISO9000, BRC, GLP, GMP, GHP and similar standards, application guidelines and different legislation (Verdenius and Koenderink, 2003; Cebeci, 2006). Links to the primary identifier can be made from the secondary identifier, especially from domains where the primary identifier is stored as a knowledge base or database. Metadata (metadata) can be used to support the automatic identification of the source of the food being produced and to separate the types of information (Cebeci, 2006).

3. Smart Packaging Methods

Smart packaging, which has started to develop rapidly since the 2000s (Vanderroost et al., 2014), can be defined as a packaging technique that displays some characteristics of the environment or food in which the packaging is kept and informs the manufacturer, retailer, and consumer about the status of these features (Dobrucka, 2013). In another definition, it can also be defined as labels or markers printed on packaging or packaging material that provide information about the quality and safety of food and contain an internal or external indicator (Huff, 2008; Kocaman and Sarımehmetoğlu, 2010).

In recent years, the use of smart packaging has started to gain importance to be able to detect changes that may occur in food in the early period after the production of food until it reaches the consumer. One of them, CheckPoint ®, is a simple label affixed to food packages to check product freshness (Figure 1). These labels respond to time and temperature in the way the food product reacts, thus giving a signal about the freshness status and remaining shelf life. The initially green dot gradually turns yellow as the product approaches the end of its shelf life. The reaction is irreversible and proceeds faster as the temperature increases and more slowly as the temperature decreases (Kuswandi et al., 2011). The classification of the main smart packaging with different structural features is given in Table 1 (Karagöz and Demirdöven, 2017).

Barcodes, RFID tags, indicators and biosensors are used in smart packaging because of their potential to sense, monitor and signal (Üçüncü, 2011). Smart packages, which enable foods' physical, chemical, or biological deterioration to be noticed before the product is sold, are divided into three according to their working principles. These are packaging based on sensors, indicators and radio frequency recognition systems (Table 1). All of these helps reduce possible food-borne risks, protect the seller's reputation, and ensure that the end user receives healthy and quality products (Kokangül and Fenercioğlu, 2012).

Sensors, widely used in food packaging, transmit the oxygen and carbon dioxide amounts released in the product as a signal to the reader, as a result of the physical and chemical changes that occur in the food in the package, with its receiver and converter properties. In this way, they provide food safety and help the end consumer to reach quality products (Aday and Caner, 2010).

Indicators used in smart packaging are leakage, freshness, and temperature-time indicators (Karagöz and Demirdöven, 2017). Leakage indicators are systems that change color due to chemical and enzymatic reactions occurring in food, indicating the presence or absence of some food-derived gases. The most commonly used leak indicators are oxygen and carbon dioxide indicators (Yezza, 2008; Özçandır and Yetim, 2010). Another indicator used in a publication is the freshness indicators. They are used to prevent freshness-related losses that affect the quality of food, such as chemical, biochemical, physical or physicochemical, throughout the shelf life of the food. Today, as freshness indicators; There are indicators sensitive to pH, volatile nitrogen compounds, hydrogen sulfide and microbial metabolites (Üçüncü, 2011). Temperature-time indicators, on the other hand, are measurement tools that provide a visual indication of the temperature history of the food with irreversible reactions throughout the entire food distribution chain (Purma and Serdaroğlu, 2006). These indicators are used primarily for perishable foods (such as meat and meat products, fish, dairy products, and frozen foods) (Kocaman and Sarımehmetoğlu, 2010). Changes in critical temperature in such foods put the product's safety at risk. For example, while structural changes occur with thawing in frozen foods, it is also possible for pathogenic microorganisms to form (Kuswandi et al., 2011). Producers can easily control the temperature changes of the foods in the production area with the systems and technologies they use. However, there is a food safety risk in processes such as logistics, storage and display for the food leaving the production area. Temperature-time labels used to eliminate these risks are an essential factor in ensuring the continuity of food safety, observing temperature changes during shipment and storage, and maintaining quality (Gün and Orhan, 2011). RFID technology, another indicator, is a transponder technology (Figure 2), and it is used in health, livestock, education, library, security, etc., including supply chains. It is a technology that can be applied in many areas (Maraşlı and Çıbuk, 2015; Yaralı, 2018). Unlike barcodes, RFID allows the data on a product package to be read automatically by a reader; It is based on electromagnetic wave techniques at different wavelengths such as microwave and long wave (Cebeci, 2006).

Figure 1. An example of a smart tag that provides information about food safety and freshness (Kuswandi et al., 2011).

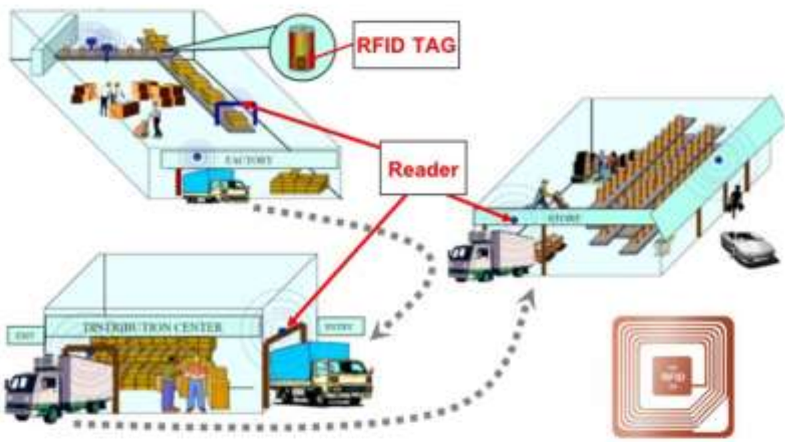

Figure 2. RFID technology (Yaralı, 2018)

Table 1. Smart packaging classification (Karagöz and Demirdöven, 2017).

Classification		Working Principles	References
Sensors	Gas Sensors	They are devices that respond by changing the physical parameters of the sensor in the presence of the gas being analyzed and are monitored by an external device. The system cannot be used for commercial products since the integrity of the packaging is compromised in the use of these sensors. It is not inconvenient to use the same packages with back-sealing for subsequent analyses.	Kerry et al., 2006
	Fluorescence-Based Gas Sensors	Fluorescent or phosphorescent dyes are placed inside polymer molds. The gas in the food package penetrates the polymer in question by diffusion, reaches the fluorescent dye and makes the package glow. The amount of gas in the environment is quantified by measuring the luminescence parameters.	Shimoni, 2001; Gök, 2007
	Biosensors	They are devices that detect, record, and transmit biological reactions occurring in packaged foods. Biosensors consist of a bioreceptor (enzyme, antigen, etc.) and an energy converter (transducer). The “Food Sentinel SystemTM” (FSS) is a biosensor system capable of continuously detecting pathogens in food packaging.	Kerry et al., 2006
	Nanosensors	It consists of a series of nanosensors sensitive to the gases produced by food spoilage and indicates whether the food is fresh or not according to a color scale.	Kocaman and Sarımehmetoğlu, 2010

Indicators	Leak Indicators	Leakage indicators change color as a result of chemical and enzymatic reactions. Ageless-Eye® branded oxygen gas indicators can be given as an example for this. When the oxygen gas level in the package in which this indicator is placed falls below 0.1%, the color of the indicator label turns pink, and when it exceeds 0.5%, it turns blue.	Purma and Serdaroğlu, 2006; Yezza, 2008; Özçandır and Yetim, 2010
	Freshness Indicators	It is based on the principle of observing the color change in response to pH, volatile nitrogen compounds, hydrogen sulfide and various microbial metabolites, which are formed due to freshness due to the reactions of foods throughout their shelf life.	Üçüncü, 2011
	Temperature-Time Indicators	It is based on mechanical, chemical, electrochemical, enzymatic, and irreversible color changes. These change rates depend on temperature; As the temperature increases, the color change rate also increases.	Gök, 2007; Üçüncü, 2011
RFID Tags		It is a system that identifies with radio waves and allows remote product monitoring. The tag in the RFID system responds to the signals it receives from a reader antenna and transmits the numbers back to the reader. RFID tags can hold simple information (such as barcode numbers) or more complex information such as temperature and relative humidity data, nutritional information, and cooking instructions.	El Matbouly et al., 2022

3.1. Sensors

Sensors are units that can detect and transmit changes in the product, the environment within the product or the package itself. It consists of sensor, receptor and transducer units (Biji et al., 2015).

3.1.1. Gas sensors/Indicators (Leak Indicators)

Different gas-sensing smart label solutions track the spoilage gases created by some foods when they deteriorate or follow the packaging gases. Modified Atmosphere Packaging (MAP) system, one of the common standard used in packaging foods, as the name suggests, is a method of packaging foods by changing the atmosphere we normally breathe. Gas sensors are systems that show the presence or absence of some gases used in modified atmosphere packaging and provide information about packaging integrity and leaks (Özçandır and Yetim, 2010). As a result of leakage, the atmosphere inside the protective package is destroyed, and microorganism is transmitted from outside to inside. Therefore, it shows the shortening of the shelf life and deterioration in quality by changing color depending on the amount of oxygen and microorganisms that enter due to the opening or destruction of the packaging. The leakage indicators used are of two types. These; They are oxygen and carbon dioxide indicators and are based on the principle of irreversible color change as a result of chemical or enzymatic reaction (Çelik and Tümer, 2016). Gas sensors/indicators (Figure 3) are equipment that tries to ensure the continuity of quality and safety by showing the gas feature of the packaging vehicle and/or the environment. Gas composition in the package; often changes as a result of food activity or packaging leaks, depending on the package's nature and the package's environmental conditions (Yam et al., 2005). In general, oxygen and carbon dioxide indicators are preferred to monitor food quality. However, they can be used as leak indicators, to test package integrity, or to confirm the effectiveness of scavengers such as oxygen scavengers used in active packaging systems. These indicators must be in contact with the gaseous environment in the package and thus are in direct contact with the food (De Jong et al., 2005).

Gas sensors are used in the package to detect gases such as O_2, CO_2, water vapor, ethanol, ethylene, and metal oxide. For their detection, optochemical sensors consisting of fluorescent-based, pH-sensitive, or absorption-based colorimetric indicators are used (Ahmed et al., 2018). There is no literature on the application of these sensors in fresh fruits and vegetables. CO_2 and O_2 sensors are the most used systems commercially (Çelik and Tümer, 2016).

In smart packaging, CO_2 is considered as an indicator of spoilage caused by fermentation or microorganism. Many systems have been developed to detect the amount of CO_2. Some of those; include (I) non-dispersive infrared (NDIF) sensor, (2) Severinghous electrochemical type, (3) wet optical CO_2 sensor (pH-based), (4) fluorescent CO_2 sensor, (5) dry optical CO_2 sensor, (6) thin suspension gel (sol-gel) based optical CO_2 indicator, (7) photonic crystal sensor, (8) anhydrase catalysis CO_2 sensor and (9) IrOx pH electrode-based sensors. Especially optical CO_2 sensor technologies are one step ahead of others.

This is because of its higher chemical and mechanical stability (Ergun, 2016). The CO_2 sensor usage area is generally designed for meat and meat products and is not yet used for fresh fruits and vegetables (Meng et al., 2014). Moreover, at the end of the harvest, fresh fruits and vegetables produce little or much CO_2 due to respiration, depending on the species, and it is not possible with current technology to distinguish it from microorganism origin (Ergun, 2016).

It is stated that gas indicators are used for water vapor, ethanol, hydrogen sulfide and other gases. There are also many different forms of O_2 indicators (Yam et al., 2005). Typical oxygen indicators; consists of redox dye (methylene blue), reducing substances (reducing sugar), and alkaline compounds (sodium hydroxide) (Purma and Serdaroğlu, 2006). Indicators; It can be in the form of tablets, labels, or prints, or it can be formulated by coating a polymer film. They are widely used and commercialized oxygen gas indicators for this purpose. When the oxygen gas level in the package in which this indicator is placed falls below 0.1%, the color of the indicator label turns pink, and when it rises above 0.5%, it turns blue (Kokangül and Fenercioğlu, 2012).

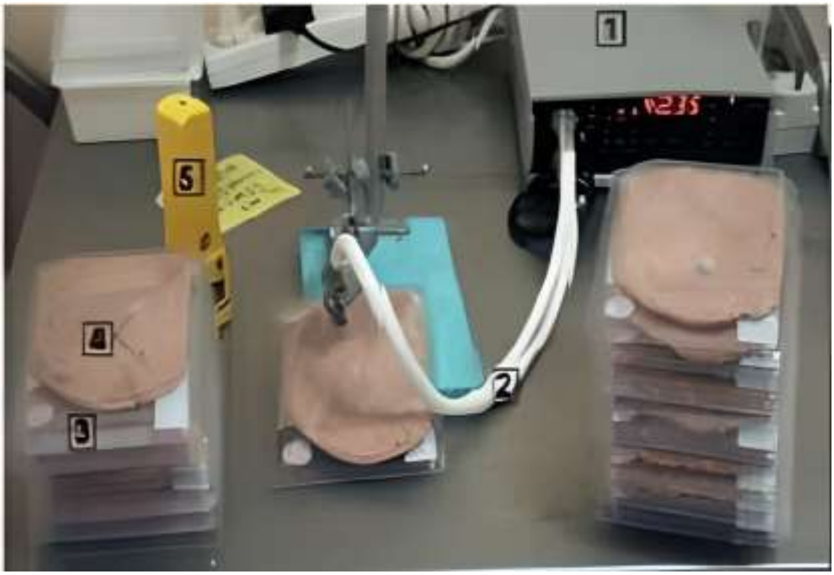

Figure 3. Gas sensor (Updated from Hepsag and Varol, 2018)

3.1.2. Fluorescent-Based gas sensors

Fluorescent-based gas sensors provide remote measurement of gases formed in the space at the top of the package. In fluorescent-based gas sensors, phosphorescent and fluorescent dyes are placed in polymer containers. When gas production begins to occur due to deterioration in the product, the packaging glows and gives information (Gök, 2007). The working principle is as follows; fluorescent or phosphorescent dyes are placed in polymer molds. The paint-polymer coating is applied as a thin film coating on a suitable solid support. The gas in the package penetrates the polymer with diffusion, reaches the fluorescent dye and makes the package glow. This process is reversible and has no by-products. Most oxygen sensors can operate over a wide temperature range. Figure 4 shows some optical oxygen sensors (Kokangül and Fenercioğlu, 2012).

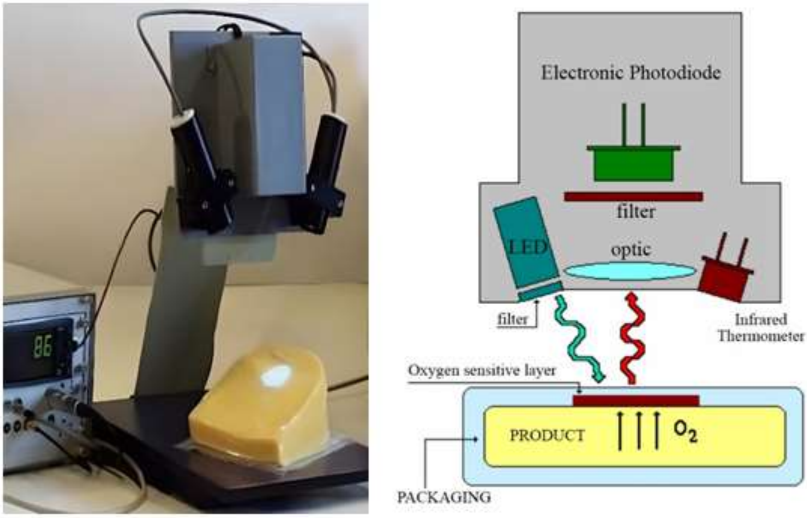

Figure 4. Fluorescent-based gas sensors (Kokangül and Fenercioğlu, 2012; Gök, 2007).

3.1.3. Biosensors

Biosensors are systems that have the capacity to detect, record and transmit information about biological reactions and are used to determine the quality of products (Yam et al., 2005). Many different types of biosensors are used to detect the reactive changes that occur as a result of spoilage in foods. The type of biosensor to be used is determined by the type of compound released into the environment when the deterioration of the food in it begins. Biosensors detect changes in cells and molecules used to measure and identify the substance to be tested. They are effective even at deficient concentrations of the material to be tested. Like other sensors, it consists of a receptor (bioreceptor) and transducer (Alocilja and Radke, 2003). It can be composed of organic or biological materials such as bioreceptors, enzymes, hormones, nucleic acids, antigens, and microbes. The transducer can be visual, auditory or electrochemical. For example, the “Food Sectional System” biosensor integrated into the barcode warns the target audience by making the barcode illegible in case of pathogen development in the product (Yam et al., 2005). The recognition system called Toxin Guard, developed by Toxin Alert (Canada), contains antibodies in polyethylene-based plastic package films and can detect microorganisms such as *Salmonella* sp, *Campylobacter* sp., *Escherichia coli* 0157 and Listeria sp. Packaging material visually signals when antibodies encounter a target pathogen (Fig. 5) (Kerry et al., 2006). When sensors are integrated into food packaging, they can detect chemicals, pathogens and toxins in food. Many biosensors, including integrated optics, immunoassays and surface chemistry, have been developed to detect deadly Salmonella bacteria in meat. For example, biosensors detect *Staphylococcus* enterotoxin B, *E. coli*, *Salmonella* spp. (Tiju and Morrison, 2006) and Listeria moncytogenes have been developed (Liu et al., 2007). When the material binds to the biological component, the transducer generates a signal proportional to the amount of material. In other words, if the concentration of bacteria in food is high, the biosensor generates a strong signal that the food is not safe (Demirbilek, 2015). Sensors can also detect protein allergens in foods, such as peanuts, and tree nuts, and prevent adverse reactions to gluten (Doyle, 2006). However, due to the many studies carried out in the field of sensors related to foodstuffs, progress in this field has gained significant momentum in recent years.

Figure 5. An example of a biosensor from the food sentinel system (SIRA Technologies, California, USA) resulting in an unreadable barcode in the event of a food safety risk (Yezza, 2008).

In smart packaging, biosensor technology is generally used as a toxin indicator. These indicators only work specific to the toxin of a microorganism. The application of toxin indicators is that harmful microorganisms are often found in foods or on the surface, even in low concentrations. For this reason, the sensor to be applied must be susceptible and entirely in contact with food (De Jong et al., 2005). To identify microorganisms that are harmful to health, SIRA Technology (USA) has developed a biosensor/barcode combination based on the principle of immunochemical reaction, also called the Food Watch System, in food packaging. The way the system works is quite simple. In this system, the antibodies of disease-causing microorganisms are added to the membrane part of the barcode. In case of contamination of microorganisms, it causes a localized dark bar to appear on the barcode, and the barcode cannot be read (Yam et al., 2005).

3.1.4. Nanosensors

Today, nanotechnology developments are trendy and are used in many fields such as scientific research, materials and manufacturing, electrical electronics and computer technology, space studies and aviation, medicine and health, and environment and energy. One of these areas is nanosensors used in packaging systems to detect whether foods are spoiled (Öksüztepe and Beyazgül, 2015). Nanosensors can quickly detect microorganisms that produce toxins or cause food poisoning with the color, mass and temperature changes they cause and molecular recognition systems. For example, when the oxygen concentration in the package increases as a result of microbial growth in packages with MAP applied, nano-TiO_2 and nano-SnO_2 oxygen sensors, these nanoparticles sensitize the redox dyes in the polymer environment to light and bleaching is observed in the sensor color in the package (De Azeredo, 2009; Mills and Hazafy, 2009; Yılmazer and Altay, 2014).

For this purpose, semiconductor systems containing nano-sized metal oxides are mostly preferred (Figure 6). While conductivity is low in the air, an increase in conductivity is observed with gases such as carbon dioxide. The sensor's electrical resistance is measured (Sozer and Kokini, 2009). The main problem in the food industry is the inability to identify and develop an effective packaging material. With smart packaging materials designed with nanotechnological methods, the continuity of the freshness and quality of the food can be ensured (Çelik and Tümer, 2016). Nanocomposite materials formed by integrating some nano metals or metal oxides into polymers show antimicrobial properties. The antimicrobial properties of nanoparticles are utilized. These materials slow down the growth of microorganisms in foods and ensure a long shelf life (Sürengil and Kılınç, 2011). Apart from these, the inclusion of foods produced with nanoparticles in the food chain and such uses of nanotechnology may cause food toxicity and the accumulation of this toxicity in the human body. What is important here is whether the foods produced with nanotechnology will be classified as new or unnatural materials. Due to their characteristic properties, nanoparticles can pass through the cell or enter the bloodstream directly through the lungs and reach all organs. Therefore, they can be much more dangerous than materials larger than themselves. In addition to the application of nanotechnological developments in food science, regulations regarding risky nanomaterials and toxicity should be carefully considered (Kokangül and Fenercioğlu, 2012; Demirbilek, 2015).

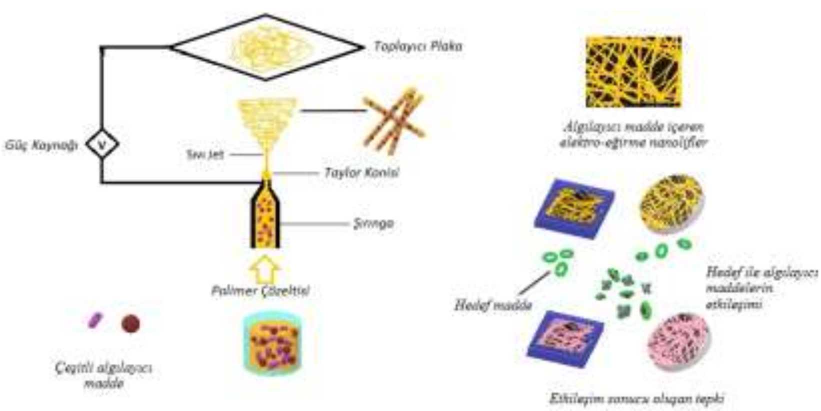

Figure 6. Schematic diagram of a simple nanosensor detection mechanism (Yılmaz and Altan, 2017).

3.1.5. Time-Temperature indicators

"Smart Labels," designed according to the shelf life and storage conditions of each product, work with a color-coded system for all temperature-sensitive foods. “Temperature-Time Labels,” which are used to prevent the consumption of foods that are presented or stored under adverse conditions, convey information to the producer and the consumer with color change (Bal, 2019).

Time-temperature indicators (Time-Temperature Indicators/TTI); These are the labels prepared to ensure the continuity of food safety and quality and to monitor the temperature changes of the product throughout the entire supply chain (Shimoni et al., 2001; Gök et al., 2006).

The basis of this indicator; is the change of color depending on the pH decrease caused by the breakdown of fat components in foods as a result of enzymatic reactions. In systems where these indicators are used, the control of the entire distribution chain is carried out effectively. It is mainly used for perishable foods such as dairy products, meat, fish, poultry, frozen fruits and vegetables, and frozen meats (Riva et al., 2001; Giannakourou and Taoukis, 2002, Vainionpää et al., 2004).

It is reported that Time-Temperature Indicators can also be used as a “freshness indicator” when an appropriate selection is made for the type of food (Riva et al., 2001, Yam et al., 2005). It provides conveniences such as following the history of the temperature and confirming the accuracy of the shelf life (Bobelyn et al., 2006). Advantages over different tracking systems; It is reported as a low-cost and active specific placement possibility in packages. Another benefit is the new methods such as "giving the product on time or with the earliest shelf life" instead of the usual "first in, first out, last in, last out" in inventory tracking and management (Riva et al., 2001). Bobelyn et al. (2006) reported that the working life of time-temperature indicators should be the same as the shelf life of the food in their study conducted to detect the quality loss of mushrooms through this indicator. In this case, the application of product combinations with the relevant time-temperature indicators could be successful.

These indicators are sensitive to environmental factors; they indicate the chemical, enzymatic, microbial and mechanical changes that occur in the product due to external factors such as heat and humidity to which the product is exposed (Figure 9). Therefore, it has widespread use. It can be placed on the products one by one, or it can be placed in parcels or containers depending on the vehicle. According to the working principles of time-temperature indicators, there are three types “Polymer-based”, “Diffusion based,” and “Enzymatic based” (Riva et al., 2001; Taoukis and Labuza, 2003; Kokangül and Fenercioğlu, 2012).

The polymer-based time-temperature indicator provides information about the freshness of the product. In this indicator, there is a reference ring to enable the consumer to understand the freshness of the product easily. Riva et al., (2001) preferred "Fresh Check" labels, which are based on the polymerization reaction of diacetylenic monomers and cause color change in the center of the label. The sensitive areas of these labels, which can take the form of sticky labels and become part of the package, change color. The outer part is a non-polymer structure with a reference color ring. The colors of the inner ring and the outer ring are compared (Figure 7). By comparing the color inside this ring with the color of the ring, the consumer understands that the product is fresh and should be consumed as soon as possible or should not be consumed (Taoukis and Labuza, 2003). Since these indicators are activated by temperature, they are stored in deep-freezing cabinets before use. Since the indicator has a deterioration time of 9.36 days at 5ºC, it is recommended to be used in fresh foods such as ready-to-eat products that must be kept at refrigerator temperature for 7 days (Bal, 2019).

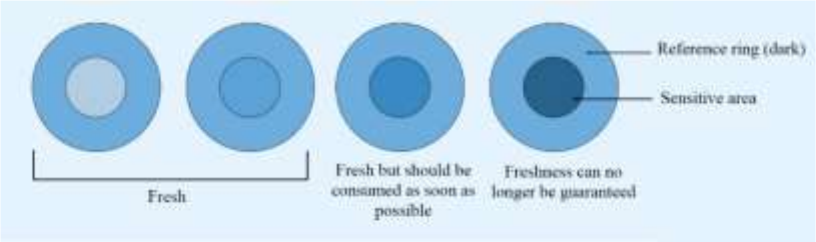

Figure 7. Example of polymer-based time-temperature indicator (Update from Öcal and Çakmak Karapınar, 2016; Riva et al., 2001).

Diffusion-based time-temperature indicators are used extensively in the monitoring of products that need to be stored at 10°C and below. This indicator, like the polymer-based indicator, informs the consumer with color change. Ester dye is used as an indicator, and it shows the temperature changes that the product is exposed to by adjusting the type and concentration of the ester dye (Robertson, 2006) (Figure 8).

Figure 8. Diffusion based time-temperature indicators (Öksüztepe and Beyazgül, 2015).

Time-temperature indicators show temperature changes during logistics and storage. Temperature indicators are usually labeled on the packaging and indicate the temperature exposed during shipment and transportation processes due to mechanical, chemical, electrochemical, enzymatic or microbial changes with the color changes on the indicator (Bal, 2019). It is an indicator of deviations from the reference temperature and temperature changes throughout the whole process (Taoukis and Labuza, 1989).

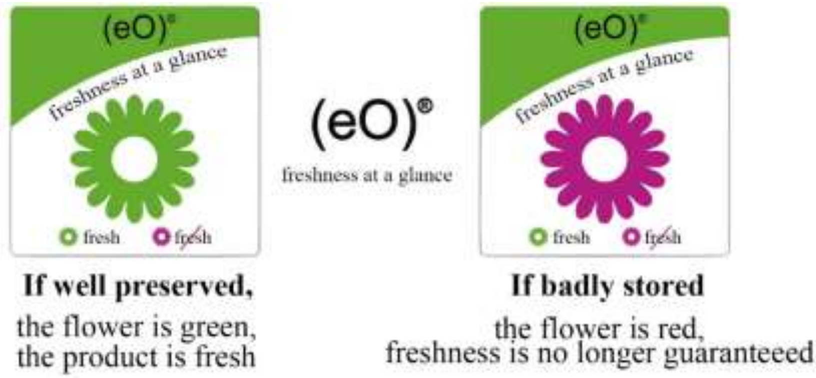

Figure 9. Time-temperature indicator based on microbial growth (Kokangül and Fenercioğlu, 2012).

The commercially available 3M Monitor Mark indicator is preferred for foods stored below 0°C (Figure 10). This label reports temperature deviations by changing color in temperature changes. If the color of the shape in the circle is lighter than the color inside the circle, it has been maintained at the appropriate temperature-time (Taoukis and Labuza, 2003).

Figure 10. Example of 3M monitor mark indicator (Yezza, 2008).

Vaikousi et al. (2008) developed a microbial-based time-temperature indicator. This type, unlike other time-temperature indicators, shows the deterioration directly. The principle of changing the color of the chemical chromatic indicator depending on the decrease in pH as a result of the growth and metabolism of *Lactobacillus sakei* on the selected substrate is discussed.

It is stated that there are more than 200 patented time-temperature indicators with different mechanization (polymerization, diffusion and enzymatic reactions) commercially in many countries (Kerry et al., 2006). Enzymatic-based time-temperature indicators work based on the logic of the pH indicator changing color with the destruction of the barrier between it and the other sac as a result of the enzyme in one sac being activated with an increase in temperature (Taoukis and Labuza, 2003) (Figure 11). These indicators are preferred in the packaging of foods such as UHT milk, pasteurized milk, cold fruit juices, frozen hamburgers, frozen raspberries, and frozen fish products (Singh and Wells, 1987).

Figure 11. Enzymatic based time-temperature indicators (Öcal and Çakmak Karapınar, 2016).

3.1.6. Leakage and freshness indicators

Freshness indicators work with the principle of changing the color of the indicator with the effect of metabolites produced by microorganisms in contaminated food. It can be used both as a package label and on the packaging film. It allows us to easily observe the gas changes occurring in the packaging (Gök et al., 2006). These metabolites are glucose, ethanol, volatile nitrogen compounds, organic acids, biogenic amines, sulfur compounds and carbon dioxide (Lechuga, 2006, Zeuthen and Bogh-Sorensen, 2003; Gök et al., 2006). While freshness indicators are product specific, they are susceptible. A robust relationship is required between target metabolite, product type, organoleptic quality and trust. For this reason, it is positioned in the package. However, it is necessary to test their usability for each product (De Jong et al., 2005). Randell et al. (1995) determined that the ethanol level increased depending on the storage time in marinated chickens packaged in a modified atmosphere, while Okuma et al. (2000) determined that the diamine concentration increased with the increase in the total bacterial count in chicken meat. An example of a freshness indicator is given in Figure 12. These indicators give an idea about the freshness of the products by using the effects such as pH changes, formation of toxic compounds, formation of foul odor, formation of gas and lubricity as a result of microbial development, together with the color change of the markers (Figure 13). Metabolite residues such as glucose, biogenic amines, organic acids, volatile nitrogen compounds, CO_2, ATP degradation products, sulfur compounds, and ethanol are considered degradation factors (Dainty, 1996; Kruijf et al., 2002). Organic acids such as lactic acid and acetic acid are the most essential compounds produced by lactic acid bacteria fermenting glucose.

Figure 12. The Fresh-Check® TTI label (Fresh-check is a registered brand of the TEMPTIME Corporation, Morris Plains, NJ, USA) of which the color of the inner circle changes (depending on time and temperature) and needs to be compared to the outer circle to establish use-by status.

Figure 13. A sensor that monitors carbon dioxide as an indication for the freshness of the desert golden drop (Nopwinyuwong et al., 2010).

The expiry dates on the food packages are determined by assuming that the food is stored under normal conditions. However, there are many times and places that cannot be kept under control, from the production to the consumption of the product. Production and distribution processes are held under the control of companies. However, when the product from the companies reaches the retailers, the product's shelf life may vary depending on the way it is kept in the warehouse or on the shelf, the way of sale, and the way the consumers store the product. These indicators (Table 2), which have a wide application area, are sensitive to environmental factors and inform consumers of color changes that occur on the label as a result of mechanical, chemical, enzymatic or microbial deterioration due to incorrect temperatures.

Table 2. Various freshness indicators and their mechanism of action (Gök, 2007)

Metabolic Product Method	**Indicator**
CO_2	Color change in bromothymol compound
CO_2, SO_2, NH_4	Color change in packaging material of indicators such as xylene blue, bromcresol blue, cresol, and phenolphthalein.
CO_2, NH_4, amines, H_2S	Color changes in CO_2, NH_4 amine sensitive dyes and due to H_2S.
Acetic acid, lactic acid, acetaldehyde, ammonia	Color changes in pH dyes and labels
E. coli O157 enterotoxin changes	Color in polydiacetylene-based polymers
Diacetyl	Optical changes in aromatic orthodiamines
Microbial enzymes	Color changes on chromogenic substrates of microbial enzymes

Shu et al. (1993) reported that L-lactic acid concentration decreased, but D-lactate increased during storage in meat and fish and showed that D-lactate could be used instead as freshness indicator. Kaniou et al. (2001), on the other hand, found that there was an increase in acetate density in fish during the preservation of fresh fish.

Along with lactic acid and acetic acid, ethanol is the compound that emerges after the fermentation of lactic acid bacteria. Rehbein (1993) pointed out that the increasing ethanol concentration during storage in fish and meat parallels the increase in microorganisms. Ethanol and volatile nitrogenous compounds (TVB-N) such as ammonia, dimethylamine and trimethylamine are the most important compounds that cause deterioration in fish. First of all, trimethylamine compounds are known as quality marks in fish. Along with the compounds above, biogenic amines, ATP degradation products, CO_2, and sulfurous compounds are reference compounds for freshness indicators, such as in Figure 14 and Figure 15 (Rodríguez et al., 1999).

Leakage indicators are systems that show the presence or absence of some gases used in modified atmosphere packaging and provide information about packaging integrity and leaks. As a result of the leakage, the protective atmosphere is destroyed, and the microorganism is transmitted from the outside to the inside. For these reasons, microbial growth accelerates, and the product deteriorates in a shorter time. Leakage indicators change color as a result of chemical and enzymatic reactions. Two leak indicators are used, namely oxygen and carbon dioxide (Özçandır and Yetim, 2010). Indicators; It can be in the form of tablets, labels, or prints or formulated by coating a polymer film. A widely used and commercialized example for this purpose is AgelessEye® branded oxygen gas indicators. When the oxygen gas level in the package in which this indicator is placed falls below 0.1%, the color of the indicator label turns pink, and when it exceeds 0.5%, it turns blue (Purma and Serdaroğlu, 2006).

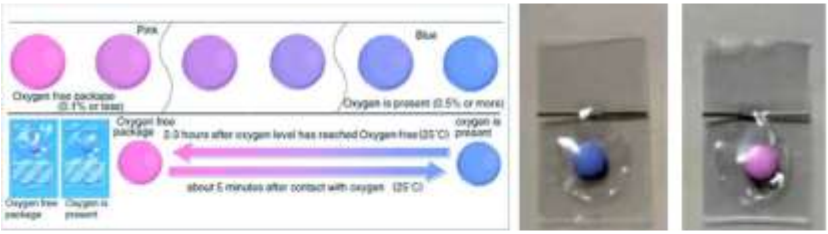

Figure 14. The color of the ageless eye oxygen indicator changes from pink to blue in the presence of oxygen (Wang and Wolfbeis, 2014).

Figure 15. Disposable freshness indicator, a commercial product of the TIMESTRIP® Brand (Gök, 2007)

3.2. RFID tags

RFID (Radio Frequency Identification Systems) is a system that uses radio frequency waves to identify and track objects (Turhan, 2009). There are three important components of the RFID system. These are a chip with an antenna, a reader with an antenna, and computer software that receives and analyzes data transmitted by radio waves (Özçandır and Yetim, 2010). RFID, which is used to track the product during the transportation and storage process, can keep simple information such as the barcode number of the product, as well as more complex data such as temperature changes, nutritional values or usage information (Figure 16). When choosing RFID technology to be used in products, the 13.56 MHz band is preferred because it adapts to flexible tags and is not easily affected by ambient humidity (Kokangül and Fenercioğlu, 2012).

Depending on the power source, they are divided into active and passive tags (Tajima, 2007). Passive tags; do not have a battery; the reader activates them. Active tags, on the other hand, have their battery, generate their energy and send signals to the reader (Vanderroost et al., 2014). In addition, semi-passive tags use waves from both the battery and the reader (Angeles, 2005).

With the establishment of the RFID system in the markets, information such as how many pieces of a product are left on the shelf, how much stock is in the warehouse, which products are about to complete their shelf life, and whether they are kept at the right temperature can be accessed automatically. Unlike barcode reading systems, it is unnecessary to read all the products in the shopping cart one by one, and the system automatically calculates when the products approach the cashier. This provides gain from both time and workforce (Kavas, 2007). RFID technology can be used for all commercial goods, including fresh fruit and vegetables (Ruiz-Garcia and Lunadei, 2011). With RFID, values such as temperature, relative humidity, light intensity, pressure and pH can be recorded perfectly.

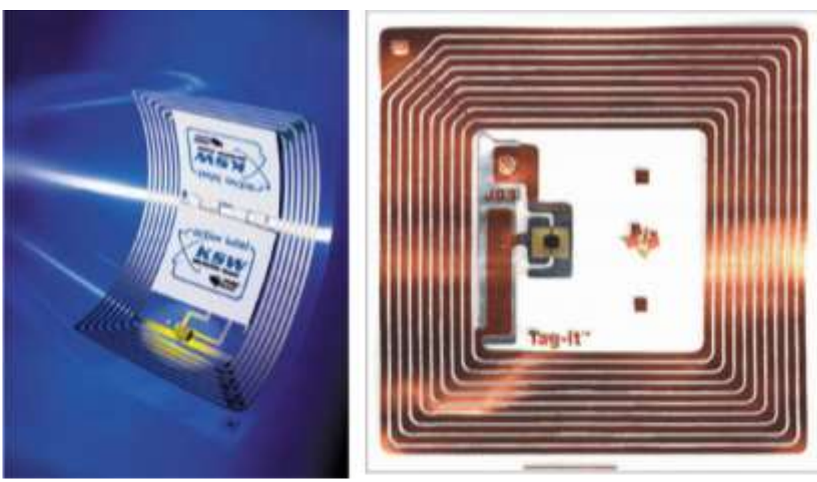

Figure 16. RFID tags (Yezza, 2008).

4. Conclusion

It is not always possible to control foods' freshness and other quality characteristics at all stages, from production to consumption. Therefore, in the smart packaging technology, indicators developed based on detecting various metabolite residues formed during storage are integrated both into the package and into the packaging material. At all stages of distribution and storage, information can be obtained about the freshness of foods and whether appropriate temperature time is applied in storage. By using smart packaging technology, both the health of the consumer is protected, and economic losses can be prevented. At the same time, since the changes in the products are noticed beforehand, there is no loss of prestige and trust in the eyes of the consumer. The risk of insufficient agricultural products produced in the face of the increasing world population in the future makes it even more severe that the products are spoiled and thrown away. Another advantage of smart packaging is that waste will be reduced as people will be warned thanks to smart packaging techniques. On the other hand, the disadvantages of smart packaging are that they are specific to certain foods or metabolites and their costs are high. With the new technologies developed, it aims to ensure food safety by adding smartness to labels and packaging, making traceability efficient and continuously improving food quality.

Although smart packaging systems have become available for processed food products, they have only recently been used for fresh fruits and vegetables. The purpose of using advanced packaging technology in fresh fruits and vegetables is to protect the quality, safety and product integrity by using natural active ingredients when necessary. The primary purpose is to extend the shelf life. There is a need to investigate whether packaging systems developed for other food products are also suitable for fresh fruits and vegetables. Development and improvement studies for suitable ones are needed. Traditional packaging methods are insufficient, especially in packaging freshly chopped or freshly prepared (fresh-cut) fruits and vegetables. In this context, with innovative systems such as active/intelligent packaging and nanotechnology, the functions of food packaging, which is an important factor in preserving food, have been increased, and the consumer has been allowed to have information about the condition of the food in the package. In addition, with some features added to the packaging, the shelf life of the food has been extended, and the food has been kept fresh for a longer time. Considering all these factors, the importance of packaging is understood, and it is expected that the properties of food packaging will be increased in parallel with the developing technology daily.

5. References

Aday, M. S., & Caner, C. (2010). Ambalajlamada Yeni Teknolojiler; Akıllı Gıda Ambalajları. Bilim ve Teknik, 4, 86-89.

Ahmed, I., Lin, H., Zou, L., Li, Z., Brody, A. L., Qazi, I. M., ... & Sun, L. (2018). An overview of innovative packaging technologies for monitoring safety and quality of meat and meat products. Packaging Technology and Science, 31(7), 449-471. https://doi.org/10.1002/pts.2380

Akgüngör, S., Van Trijp, H., Van Herpen, E., Gülcan, Y., & Kuştepeli, Y. (2011). Gıda etiketlerine yönelik dikkat ve algı: Dokuz Eylül Üniversitesi'nde uygulanan göz hareketleri izleme deneyi sonuçları. Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 13(3), 7-18.

Aksulu, İ. (1996). Ambalajlı Gıda Ürünlerinde Etiketin Önemi ve Tüketici Duyarlılığı. Pazarlama Dünyası Dergisi. 57, 2-9.

Alocilja, E.C., Radke, S.M., 2003. Market Analysis of Biosensors for Food Safety. Biosensors and Bioelectronics. 18: 841-846.

Angeles, R. (2005). RFID technologies: supply-chain applications and implementation issues. Information systems management, 22(1), 51-65. https://doi.org/10.1201/1078/44912.22.1.20051201/85739.7

Bal, İ. (2019). Gıda etiketleme sistemleri (Master's thesis, Namık Kemal Üniversitesi).

Biji, K. B., Ravishankar, C. N., Mohan, C. O., & Srinivasa Gopal, T. K. (2015). Smart packaging systems for food applications: a review. Journal of food science and technology, 52(10), 6125-6135. http://dx.doi.org/10.1007/s13197-015-1766-7

Bobelyn, E., Hertog, M. L., & Nicolaï, B. M. (2006). Applicability of an enzymatic time temperature integrator as a quality indicator for mushrooms in the distribution chain. Postharvest Biology and Technology, 42(1), 104-114. https://doi.org/10.1016/j.postharvbio.2006.05.011

Bodenhamer, W. T., Jackowski, G., & Davies, E. (2004). U.S. Patent No. 6,692,973. Washington, DC: U.S. Patent and Trademark Office.

Cebeci, Z. (2006). Gıda İzlenebilirliğinde Bilgi Teknolojileri. Ulusal Tarım Kurultayı, 15-17 Kasım 2006, Çukurova Üniversitesi, Adana. Bildiriler s. 189-195.

Consumer Report on Health (2003). New Food Labels Help Consumers Avoid The Worst Fats December, p:3.

Çelik, İ., & Tümer, G. (2016). Gıda ambalajlamada son gelişmeler. Akademik Gıda, 14(2), 180-188.

Dainty, R. H. (1996). Chemical/biochemical detection of spoilage. International journal of food microbiology, 33(1), 19-33. https://doi.org/10.1016/0168-1605(96)01137-3

De Azeredo, H. M. (2009). Nanocomposites for food packaging applications. Food research international, 42(9), 1240-1253. https://doi.org/10.1016/ j.foodres.2009.03.019

De Jong, A. R., Boumans, H., Slaghek, T., Van Veen, J., Rijk, R., & Van Zandvoort, M. (2005). Active and intelligent packaging for food: is it the future?. Food additives and contaminants, 22(10), 975-979. https://doi.org/10. 1080/02652030500336254

Demirbilek, M. E. (2015). Tarımda ve gıdada nanoteknoloji. Gıda ve Yem Bilimi-Teknolojisi Dergisi 15: 46-53.

Dobrucka, R. (2013). Application of active packaging systems in probiotic foods. Sci J Logistic 9(3): 167-175.

Doyle, M. E. (2006). Nanotechnology: a brief literature review. Food Research Institute, UW-Madison. http://www.wisc.edu/fri/briefs/FRIBrief_Nanotech_Lit_Rev.pdf (19/09/2022)

Ekşi, A. (2012). Yeterli ve dengeli beslenme iletişimi açısından gıda etiketi. https://www.google.com/search?q=Yeterli+ve+dengeli+beslenme+ileti Erişim Tarihi: 19.09.2022.

El Matbouly, H., Nikbakhtnasrabadi, F., & Dahiya, R. (2022). RFID Near-field Communication (NFC)-Based Sensing Technology in Food Quality Control. In Biosensing and Micro-Nano Devices (pp. 219-241). Springer, Singapore. https://doi.org/10.1007/978-981-16-8333-6_9

Ergun, M. (2016). Taze Meyve ve Sebzeler için Aktif, Zeki veya Akıllı Paketleme Teknolojileri. alatarım, 15(2), 51-60.

Giannakourou And, M.C. & Taoukis, P. S. (2002). Systematic application of time temperature integrators as tools for control of frozen vegetable quality. Journal of food science, 67(6), 2221-2228. https://doi.org/10.1111/j.1365-2621.2002.tb09531.x

Gök, V. (2007). Gıda paketleme sanayinde akıllı paketleme teknolojisi. Gıda Teknolojileri Elektronik Dergisi, 1(1), 45-58.

Gök, V., Batu, A., Telli, R. (2006). Akıllı paketleme teknolojisi. Türkiye 9. Gıda Kongresi; s. 45-48

Gün, İ. and Orhan, H. (2011). Süt ve ürünleri tüketicilerinin etiket bilgi düzeylerinin incelenmesi. Journal of the Institute of Science and Technology, 1(1), 45-51.

Hawkes, C. (2010). Government and voluntary policies on nutrition labelling: a global overview. Innovations in food labelling, 37-58. https://doi.org/10. 1533/9781845697594.37

Hepsağ, F., & Varol, T. (2018). Intelligent packaging use in food industry and traceability. Adyütayam, 6(1), 29-39.

Huff, K. (2008). Active and intelligent packaging: innovations for the future. Department of Food Science & Technology. Virginia Polytechnic Institute and State University, Blacksburg, Va, 1-13.

Kaniou, I., Samouris, G., Mouratidou, T., Eleftheriadou, A., & Zantopoulos, N. (2001). Determination of biogenic amines in fresh unpacked and vacuum-packed beef during storage at 4 C. Food Chemistry, 74(4), 515-519. https://doi.org/10.1016/S0308-8146(01)00172-8

Karagöz, Ş., & Demirdöven, A. (2017). Gıda Ambalajlamada güncel uygulamalar: modifiye atmosfer, aktif, akıllı ve nanoteknolojik ambalajlama uygulamaları. Gaziosmanpaşa Bilimsel Araştırma Dergisi, 6(1), 9-21.

Kavas, A. (2007). Radyo Frekans Tanımlama Sistemleri. Elektrik Mühendisliği Dergisi. 430, 74- 80.

Kerry, J. P., O'grady, M. N., & Hogan, S. A. (2006). Past, current and potential utilisation of active and intelligent packaging systems for meat and muscle-based products: A review. Meat science, 74(1), 113-130. https://doi.org/10.1016/j.meatsci.2006.04.024

Kocaman, N., & Sarımehmetoğlu, B. (2010). Gıdalarda akıllı ambalaj kullanımı. Veteriner Hekimler Derneği Dergisi, 81(2), 67-72.

Kokangül, G., Fenercioğlu, H., 2012. Gıda endüstrisinde akıllı ambalaj kullanımı. Gıda Teknolojileri Elektronik Dergisi 7(2): 31-43.

Kruijf, N. D., Beest, M. V., Rijk, R., Sipiläinen-Malm, T., Losada, P. P., & Meulenaer, B. D. (2002). Active and intelligent packaging: applications and regulatory aspects. Food Additives & Contaminants, 19(S1), 144-162. https://doi.org/10.1080/02652030110072722

Kuswandi, B., Wicaksono, Y., Abdullah, A., Heng, L. Y., & Ahmad, M. (2011). Smart packaging: sensors for monitoring of food quality and safety. Sensing and Instrumentation for Food Quality and Safety, 5(3), 137-146. https://doi.org/10.1007/s11694-011-9120-x

Lechuga, L. M. (2006). Micro-and nanoimmunosensors: technology and applications. Analytical and bioanalytical chemistry, 384(1), 44-46. https://doi.org/10.1007/s00216-005-0180-9

Liu, Y., Chakrabartty, S., & Alocilja, E. C. (2007). Fundamental building blocks for molecular biowire based forward error-correcting biosensors. Nanotechnology, 18(42), 424017. https://doi.org/10.1088/0957-4484/18/42/424017

Maraşlı, F., & Çıbuk, M. (2015). RFID teknolojisi ve kullanım alanları. Bitlis Eren Üniversitesi Fen Bilimleri Dergisi, 4(2), 249-275.

Meng, X., Kim, S., Puligundla, P., & Ko, S. (2014). Carbon dioxide and oxygen gas sensors-possible application for monitoring quality, freshness, and safety of agricultural and food products with emphasis on importance of analytical signals and their transformation. Journal of the Korean Society for Applied Biological Chemistry, 57(6), 723-733. https://doi.org/10.1007/s13765-014-4180-3

Mills, A., & Hazafy, D. (2009). Nanocrystalline SnO2-based, UVB-activated, colourimetric oxygen indicator. Sensors and Actuators B: Chemical, 136(2), 344-349. https://doi.org/10.1016/j.snb.2008.12.048

Nopwinyuwong, A., Trevanich, S., & Suppakul, P. (2010). Development of a novel colorimetric indicator label for monitoring freshness of intermediate-moisture dessert spoilage. Talanta, 81(3), 1126-1132. https://doi.org/10.1016/j.talanta.2010.02.008

Okuma, H., Okazaki, W., Usami, R., & Horikoshi, K. (2000). Development of the enzyme reactor system with an amperometric detection and application to estimation of the incipient stage of spoilage of chicken. Analytica Chimica Acta, 411(1-2), 37-43. https://doi.org/10.1016/S0003-2670(00)00739-X

Öcal, D., & Çakmak Karapınar, D. (2016). Akıllı Ambalajlama Sistemlerinin Tüketicilere Yansımaları. 5. Uluslararası Matbaa Teknolojileri Sempozyumu, İstanbul, Türkiye, Tam Metin Kitabı.

Öksüztepe, G., & Beyazgül, P. (2015). Akıllı ambalajlama sistemleri ve gıda güvenliği. Fırat Üniversitesi Sağlık Bilimleri Veteriner Dergisi, 29(1), 67-74.

Özçandır, S., & Yetim, H. (2010). Akıllı ambalajlama teknolojisi ve gıdalarda izlenebilirlik. Electronic Journal of Food Technologies, 5(1), 1-11.

Purma, Ç., & Serdaroğlu, M. (2006). Akıllı ambalajlama sistemlerinin gıda sanayinde kullanımı. Türkiye, 9, 24-26.

Randell, K., Ahvenainen, R., Latva-Kala, K., Hurme, E., Mattila-Sandholm, T., & Hyvönen, L. (1995). Modified atmosphere-packed marinated chicken breast and rainbow trout quality as affected by package leakage. Journal of Food Science, 60(4), 667-672. https://doi.org/10.1111/j.1365-2621.1995.tb06203.x

Rehbein, H. (1993). Assessment of fish spoilage by enzymatic determination of ethanol. Archiv für Lebensmittelhygiene, 44(1), 3-6.

Riva, M., Piergiovanni, L., & Schiraldi, A. (2001). Performances of time–temperature indicators in the study of temperature exposure of packaged fresh foods. Packaging Technology and Science: An International Journal, 14(1), 1-9. https://doi.org/10.1002/pts.521

Robertson, G. (2006). Food Packaging Principles and Practices. Taylor & Francis, Boca Raton, Fla, USA.

Rodríguez, C. J., Besteiro, I., & Pascual, C. (1999). Biochemical changes in freshwater rainbow trout (Oncorhynchus mykiss) during chilled storage. Journal of the Science of Food and Agriculture, 79(11), 1473-1480. https://doi.org/10.1002/(SICI)1097-0010(199908)79:11%3C1473::AID-JSFA389%3E3.0.CO;2-C

Ruiz-Garcia, L., & Lunadei, L. (2011). The role of RFID in agriculture: Applications, limitations and challenges. Computers and Electronics in Agriculture, 79(1), 42-50. https://doi.org/10.1016/j.compag.2011.08.010

Shimoni, E., Anderson, E. M., & Labuza, T. P. (2001). Reliability of time temperature indicators under temperature abuse. Journal of Food Science, 66(9), 1337-1340. https://doi.org/10.1111/j.1365-2621.2001.tb15211.x

Shu, H. C., & Mattiasson, B. (1993). D-lactic acid in pork as a freshness indicator monitored by immobilized D-lactate dehydrogenase using sequential injection analysis. Analytica Chimica Acta, 283(2), 727-737. https://doi.org/10.1016/0003-2670(93)85287-T

Singh, R. P., & Wells, J. H. (1987). Monitoring quality changes in stored frozen strawberries with time-temperature indicators. International journal of refrigeration, 10(5), 296-300. https://doi.org/10.1016/0140-7007(87)90074-0

Smolander, M. (2003). The use of freshness indicators in packaging. Novel food packaging techniques, R Ahvenainen (eds), pp. 127-143.

Sozer, N., & Kokini, J. L. (2009). Nanotechnology and its applications in the food sector. Trends in biotechnology, 27(2), 82-89. https://doi.org/10.1016/j.tibtech.2008.10.010

Sürengil, G., & Kılınç, B. (2011). Gıda ambalaj sektöründe nanoteknolojik uygulamalar ve su ürünleri açısından önemi. Journal of Fisheries Sciences 5(4): 317-325. DOI: 10.3153/jfscom.2011036

Tajima, M. (2007). Strategic value of RFID in supply chain management. Journal of purchasing and supply management, 13(4), 261-273. https://doi.org/10.1016/j.pursup.2007.11.001

Taoukis, P. S., & Labuza, T. P. (1989). Applicability of time-temperature indicators as shelf life monitors of food products. Journal of Food Science, 54(4), 783-788. https://doi.org/10.1111/j.1365-2621.1989.tb07882.x

Taoukis, P. S., & Labuza, T. P. (2003). Time-temperature indicators (TTIs). Novel food packaging techniques. Ahvenainen R (ed). Woodhead Publishing Ltd.: Cambridge, England, 103–126

Tiju, J., & Morrison, M. (2006). Nanotechnology in agriculture and food. Institute Nanotechnology. European Nanotechnology Gateway. http://www.nanowerk.com/nanotechnology/reports/reportpdf/report61.pdf. (19/09/2022)

Turhan, K. N. (2009). Gıda Ambalajlamada Yeni Teknolojiler. Dünya Gıda Dergisi. 7(2):31-43.

Üçüncü, M. (2011). Gıda Ambalajlama Teknolojisi. Ambalaj Sanayicileri Derneği İktisadi İşletmesi, İstanbul.

Vaikousi, H., Biliaderis, C. G., & Koutsoumanis, K. P. (2008). Development of a microbial time/temperature indicator prototype for monitoring the microbiological quality of chilled foods. Applied and Environmental Microbiology, 74(10), 3242-3250. https://doi.org/10.1128/AEM.02717-07

Vainionpää, J., Smolander, M., Alakomi, H. L., Ritvanen, T., Rajamäki, T., Rokka, M., & Ahvenainen, R. (2004). Comparison of different analytical methods in the monitoring of the quality of modified atmosphere packaged broiler chicken cuts using principal component analysis. Journal of Food Engineering, 65(2), 273-280. https://doi.org/10.1016/j.jfoodeng.2004.01.025

Vanderroost, M., Ragaert, P., Devlieghere, F., & De Meulenaer, B. (2014). Intelligent food packaging: The next generation. Trends in food science & technology, 39(1), 47-62. https://doi.org/10.1016/j.tifs.2014.06.009

Verdenius, F., & Koenderink, K. (2003). Development of traceability Systems. In Food Trace Conference Sitges.

Wang, X. D., & Wolfbeis, O. S. (2014). Optical methods for sensing and imaging oxygen: materials, spectroscopies and applications. Chemical Society Reviews, 43(10), 3666-3761. https://doi.org/10.1039/C4CS00039K

Yam, K.L., Takhistov, P.T., Miltz, J. (2005). Intelligent Packaging: Concepts and Applications. Journal of Food Science. 70: 1-10. https://doi.org/ 10.1111/j.1365-2621.2005.tb09052.x

Yaralı, E. (2018). Gıda zincirinde izlenebilirlik. Harran Tarım ve Gıda Bilimleri Dergisi, 23(1), 108-119.

Yezza, I. A. (2008). Active/intelligent packaging: Concept, applications and innovations. In 2008 Technical Symposium New Packaging Technologies to Improve and Maintain Food Safety.

Yılmaz, M., & Altan, A. (2017). Elektro Eğirme Yöntemine Dayalı Nanosensörlerin Gıda Alanındaki Uygulamaları. GIDA/The Journal of FOOD, 42(6). 708-725. doi: 10.15237/gida.GD17057

Yılmazer, M., & Altay, F. (2014). Gıda Ambalajlarında Nanoteknolojik Uygulamalar ve Faz Değişim Materyalleri. GIDA/The Journal of FOOD, 39(6). 371-378. doi: 10.15237/gida.GD14024

Zeuthen, P., & Bogh-sorensen, L. (2003). Monitoring the effectiveness of food preservation. Food Preservation Techniques. CRC Press-Boca Raton Boston NewYork Washington, DC. Woodhead Publishing Limited, 24, 553-565.

CHAPTER 12

BIOTECHNOLOGICAL APPLICATIONS IN FRUIT BREEDING

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Fruits are extremely important nutrients for human health. Fruits are important components of the health sector as they contain antimicrobial, antiviral, antioxidant and anticarcinogenic compounds in their biochemical structures. In addition, fruits themselves or their wastes are used directly or indirectly in animal feed. For these reasons, fruit growing in Turkey and around the world has a great commercial potential.

However, there are many problems in fruit growing from past to present. Because of these problems, plenty of research are carried out and financial funds are spent on the protection, development, and classification of existing fruit species at the international level. In Turkey, there are institutes established specifically for fruit research under the Ministry of Agriculture. For example, Republic of Türkiye Ministry of Agriculture and Forestry “Fruit Research Institute”, “Fig Research Institute”, “Hard Fruit Research Institute” etc.

The biggest part of these expenditures and waste of time is made in the field of "fruit breeding". However, breeding a fruit variety requires a long period of about 20-25 years. It is clearly understood that this period is too much time for a human life. For this reason, it is very difficult to do plant breeding with traditional methods and it is an inevitable and undeniable need and necessity to be supported with today's biotechnological techniques.

Today's biotechnology techniques are based on ancient times. However, the recent invention of the microscope, discovery of DNA, Discovery of the PCR method and the development of PCR devices, developments in bioinformatics with computer technologies, development of android systems and artificial intelligence, development of computer-based smart farming applications, development of automation analysis devices in laboratory infrastructure, development of production technologies of laboratory consumables, development of international information sharing systems and hundreds of scientific and technological developments that can be listed are events that should be associated with plant breeding.

These developments that should be associated with fruit breeding (and many that are not mentioned here) are issues that need to be dealt with very broadly, each separately. However, here, only the technologies in the fields of molecular biology, genetics and biotechnology will be discussed and related to fruit breeding in order not to disperse the subject.

We can divide the biotechnological researches on fruits into 2 main parts as shown in Fig.1.

Biotechnological Research

1.Recombinant DNA-based method

- Gene cloning focused
- No "Marker Primer" is used
- "Coding" regions are targeted.
- Structural and/or Regulatory regions of genes are cloned
- Sequence similarity/difference is not the focus
- Provides DNA-Protein-Phenotype interaction information
- Provides gene expression information

- PCR
- RT-qPCR
- EMSA
- ChIP
- Western Blot
- Nother Blot
- Southern Blot
- Restriction Enzyme Digestion
- Ligastion
- Transformation
- Agarose Jel Electrophoresis
- Gen expression analysis
- Protein purification
- SDS-PAGE Analysis

2.Molecular Marker-based Methods

- PCR based
- Standard or special "Marker Primers" are used
- «Non-Coding» /repeated regions are targeted
- Provides information about sequence similarities or differences
- Does not provide information on Gene-DNA-Protein-Gene expression interactions
- No recombinant protein is used
- No recombinant gene is used
- Does not elucidate molecular mechanisms

• AFLP	• ALP
• AR-PCR	• ASAP
• AS-PCR	• CAPS
• DAF	• DGGE
• ESTP	• ISSR
• RAPD	• RAMP
• SAP	• SCAR
• SNPs	• SPAR
• SRAP	• SSCP
• SSLP	• SSR
• STS	• TRAP
• VNTR	

Figure 1. Recombinant DNA-based methods (1) and Molecular Marker-based Methods (2)

1. Recombinant DNA-based methods

Recombinant DNA-based methods focus on gene cloning strategies. Marker Primers are not used to generate a recombinant DNA. Unlike molecular marker techniques, Recombinant DNA methods usually target coding regions such as the structural region or regulatory region of a gene.

Cloning is the process of making copies of the entire genome or a specific region of DNA. In the cloning process, while coding region elements are targeted depending on different purposes such as obtaining active protein or investigating the expression conditions of a gene, non-coding regions can also be cloned for purposes such as taxonomic research and DNA fingerprinting and genome mapping.

In recombinant DNA techniques, similarities or differences between organisms are not considered and are not compared. On the contrary, unique primers of each sequence are designed and used. Thanks to recombinant DNA techniques, DNA-Protein-Phenotype relationships can be elucidated, and data can be obtained at the level of gene expression.

2. Molecular Marker-based Methods

Molecular marker-focused searches are PCR-based and use certain standard or special "marker primers". Molecular marker studies target non-coding regions, not coding regions. In some cases, coding regions are also targeted but not cloned.

The strongest and most important function of molecular marker methods is to reveal the similarities and differences between genomes and sequences. Gene-DNA-Protein-Gene expression in molecular marker studies relationships cannot be clarified. Recombinant protein and recombinant gene are not used, and the molecular mechanism of any phenotype cannot be explained.

Molecular marker studies are divided into two according to the use of the PCR method: 1) non-PCR-based methods and 2) PCR-based methods.

A. Non-PCR-based methods

1. Restriction Fragment Length Polymorphism (RFLP)

The RFLP method can detect polymorphisms, i.e., variations in homologous DNA sequences. Therefore, the RFLP method is a very important technique that can distinguish individuals, populations, or species, and determine the locations of genes in a DNA sequence. However, the RFLP method is an effective method developed before PCR was discovered. Since many new methods have been developed after the discovery of PCR, its use is much less. However, it is still preferred in private studies.

The RFLP method is based on 3 basic processes: 1) Restriction Enzyme (RE) digestion, 2) Agarose gel electrophoresis, 3) Southern Blotting. Because restriction enzymes recognize and cut a specific sequence on DNA, the DNA fragments formed because of RE cutting may differ from DNA molecule to DNA molecule. A difference in the DNA sequence causes the restriction enzyme to be unable to recognize the DNA region and cut that region. Accordingly, pieces of different lengths are formed at the end of the cut. When these DNA molecules obtained in different or same lengths are separated in agarose gel electrophoresis, they show distribution according to their lengths. After the DNA fragments separated according to their length in the agarose gel are transferred onto the nitrocellulose membrane, they are hybridized with the biochemically labeled probe DNA molecules. Each fragment length is considered as "an allele" and used in subsequent genetic analysis. But the alleles may contain a coding region or not (Fig.2).

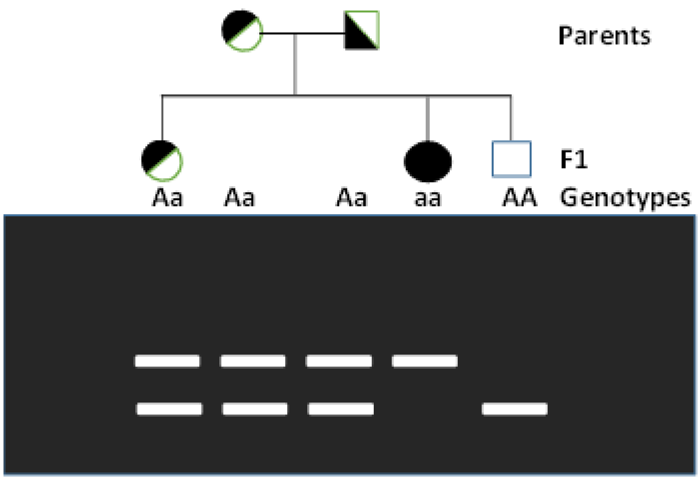

Figure 2. RFLP markers can determine heterozygote genotype.

RFLP methods is useful, if researchers were trying to determine in fruits the chromosomal location of a particular characteristic such as a disease gene, seconder metabolite genes or anyone. It is possible to identify a recombination rate in the loci between restriction sites. RFLP analysis is also used for dentification and differentiation of fruits by analyzing unique patterns in genome.

As with other molecular markers, RFLP markers have some advantages and disadvantages. RFLP analyzes can be used in phylogenetic studies, enable the determination genetic diversity at intraspecific, genus and family level, and determine the relationships of closely related taxa. Although the level of polymorphism is moderate, it is reliable in terms of being reproducible. RFLP markers are codominant. Being codominant is effective in the identification and characterization of heterozygotes.

However, RFLP analyzes are expensive procedures. It also requires a lot of time and labor. Generally, using radioactive labeling method is harmful for employee health. The DNA molecules used in the application must be of high quality. In some cases, large gaps appear on RFLP maps. The reason for this is that the low-copy sequences cluster at certain points in the genomes and accordingly, the RFLP markers cannot show random distribution on this genome.

B. PCR-based methods

1. Amplified Fragment Length Polymorphism (AFLP)

AFLP is a PCR-based technique that combines the RFLP technique and the PCR technique. On the other hand, it was developed to eliminate the negativities of RAPD markers. In AFLP analysis, firstly, DNA is digested by restriction enzymes. Then the digested DNA fragments are amplified a selectively. A subset of amplified DNA is used to generate unique fingerprints for genomes of interest and then they are compared.

Generally, AFLP include five main steps: STEP-1) Genomic DNA is digested by Restriction enzymes and ligated to adaptors, STEP-2) A subset of the restricted fragments is selected by PCR amplification (preselection), STEP-3) Selective PCR amplification and reducing of fragment number, STEP-4) Amplified DNA fragments are separated by electrophoresis, STEP-5) Scoring and interpretation of the data.

The electrophoresis gel used in the AFLP method is polyacrylamide gel. Since the DNA fragments formed in each reaction are 50-100, the polymorphism rate in the AFLP method is high.

The electrophoresis gel used in the AFLP method is polyacrylamide gel. Since the DNA fragments formed in each reaction are 50-100, the polymorphism rate in the AFLP method is high.

It is a preferred method in fruit genetic analysis. Because it has high repeatability and high number of polymorphic bands. It is a powerful method for determining intercultural variations and degrees of kinship. It is a method that does not require prior sequence knowledge of genomic DNA and is suitable for automation. However, it is a disadvantageous method in that it is mostly a dominant marker and transfers between different genetic maps are difficult.

2. Arbitrarily Primed PCR (AP-PCR)

The random primer PCR (AP-PCR) is a variant of random-amplified polymorphic DNA (RAPD) markers. AP-PCR method allows the characterization of DNA surrounding a region of a known sequence, as in reverse PCR and adapter-ligation PCR methods. A single arbitrarily selected primer or two such primers are used to produce a PCR fingerprint of a complex DNA in AP-PCR reactions. The complex DNA may belong to a bacterial or eukaryotic genome. The primer of arbitrary sequence can be paired with a primer that binds to a region of known sequence and transposons are generally the target regions for AP-PCR (Fig. 3). One of the important applications of arbitrarily primed PCR fingerprinting is genetic mapping of anonymous genomic sequence polymorphisms.

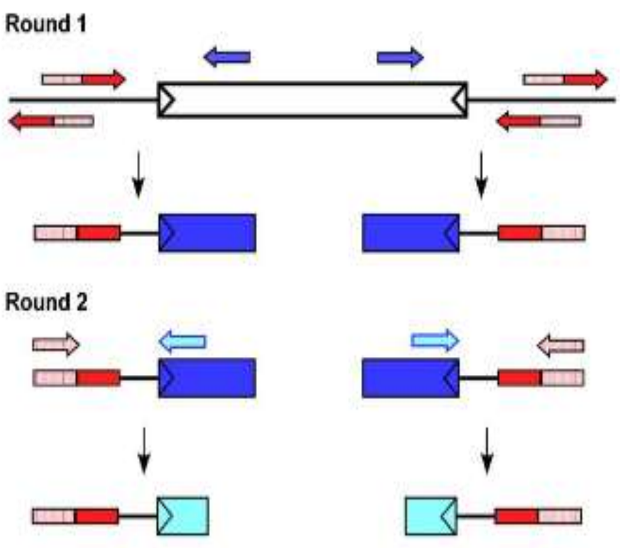

Figure 3. This illustration shows the principles of the AP-PCR method and how primers are used. The figure is taken from S. Das et all. (2005)

3. Allele Specific Associated Primers (ASAP)

Allele specific associated primers (ASAP) is a variation of random-amplified polymorphic DNA (RAPD) markers. ASAP is a simple, PCR-based method and has been developed for the rapid genotyping of large numbers of samples.

ASAP is a sequence of a decamer oligonucleotide and used in PCR derived from normal random-amplified polymorphic DNA (RAPD). ASAP marker can be used in combination with a SCAR marker.

In this method, an absence/presence polymorphism is generated, and these absence/presence polymorphisms do not require electrophoretic separation of the sample. Because direct staining of DNA with ethidium bromide is enough to identify the samples processing the appropriate allele.

4. AS-PCR Allele Specific PCR

Allele Specific PCR is also known as ARMS (Amplification Refractory Mutation System) or PASA (PCR Amplification of Specific Allele). To detect SNPs will only have very efficient conventional maps of Restriction Fragment Length Polymorphism (RFLP). RFPL is rely on use of site-specific restriction enzymes.

But it may not be possible every time to find useful sequences for Re on DNA samples. In these cases where it is not possible to use a restriction enzyme, the AS-PCR method is used. AS-PCR ensure to detect a single base chance (SNP, including the transition, transversion and insertion/deletion polymorphism) by using sequence-specific primers.

5. Cleaved Amplified Polymorphism Sequence (CAPS)

The principle of Cleaved Amplified Polymorphism Sequence (CAPS) relies on genetic differences between individuals. The differences may result creation or abolishment of restriction endonuclease restriction sites. By the way these differences can be detected in the resulting DNA fragment length after digestion. Technically CAPS method is an extension to the restriction fragment length polymorphism (RFLP) method. Both polymerase chain reaction (PCR) is used to analyze the results more quickly.

The important strategy in the CAPS method is to direction of PCR amplification across the altered restriction site and then to digest the products with the restriction enzyme. the digested PCR products are fractionated by agarose or polyacrylamide gel electrophoresis and distinguished the patterns of bands on the gel.

6. DNA Amplification Fingerprinting (DAF)

DNA Amplification Fingerprinting (DAF) is also a variant of random-amplified polymorphic DNA (RAPD) markers. In the DNA amplification fingerprinting (DAF) method, PCR amplification of DNA polymorphisms is directed by single small, arbitrary oligonucleotide primers only eight to 10 nucleotides in length. The PCR product are separated by polyacrylamide gel electrophoresis (PAGE). As a result, an array of amplicons yielding a banding fingerprint is achieved. The fingerprints are characteristic for each combination of short primer and DNA source.

7. Denaturating Gradient Gel Electrophoresis (DGGE)

The principle of Denaturing Gradient Gel Electrophoresis (DGGE) is using the differences in melting behavior among double-stranded (ds) DNA molecules induced by nucleotide sequence variation to differentiate alleles. This method is rapid, nonradioactive, and extremely sensitive technique to examine nucleotide sequence variation in large-scale population surveys. DGGE can detect over 99% of single-nucleotide sequence variation.

The discriminating power of the DGGE method is due to its ability to discriminate genes of the same size according to different denaturation points determined based on their base pair sequences.

Some usage aims of DGGE are identification of alleles in population surveys, separation of alleles for direct sequencing, phylogenetic analysis of bacterioplankton and detection of specific mutations in disease studies. For DGGE analysis, it is most suitable the DNA fragments between 50 and 500 bp in length, preferably with a single melting domain. In DGGE, a polyacrylamide denaturing gradient gel is prepared with a gradient of chemical denaturant such as urea and formamide. PCR products, which is amplified dsDNA fragments, are loaded directly onto gel and electrophoresed.

When applying the DGGE, a sample (fragment) reaches its denaturing point in the gel and then it begins to dissociate. In this point, the fragment migration is retarded. The important factor for dissociation is being or not a difference of even a single nucleotide between fragments. Even a single nucleotide difference in DGEE can alter their relative melting behaviors.

8. Expressed Sequence Tag Polymorphism (ESTP)

An Expressed Sequence Tag (EST) markers are a short sub-sequence of a cDNA sequence. ESTs are generally short sequences of 300-500 bp and have very low implementation costs. ESTs represent sequence information only for proteins of known function. Using these data, a partial genome of a non-model organism can be created.

EST data have become publicly available including approximately 74.2 million ESTs. This method has long been used for gene discovery and the usage of ESTs is expanding to different areas. First of all, EST markers provide an alternative to full-length cDNA sequencing. It is possible to identify gene transcripts, and to use as an instrument in gene discovery and in gene-sequence determination.

ESTs represent “the expressed parts” of genomes and they are more immediately informative about the transcriptomes. However, ESTs are not suitable for the studies related to “the control parts” of genomes. For example, it is not useful ESTs for studying promoters and transcription enhancing/inhibiting elements.

Studying the EST data requires bioinformatics tools such as databases, data retrieving tools and analysis algorithms. Bioinformatics resources are also required to deal with EST errors and contaminations. It is possible to use many of these tools freely if you are in an academic community. EST markers can be searched using BLAST programs from databases called dbEST in bioinformatics tools.

9. Inter Simple Sequence Repeat (ISSR)

Inter simple sequence repeat (ISSR) markers involves the use of microsatellite sequences as primers to generate multilocus markers. They are highly polymorphic and are useful in studies on phylogeny, genetic diversity, genome mapping, evolutionary biology, and gene tagging.

10. Random Amplified Polymorphic DNA (RAPD)

Random Amplified Polymorphic DNA (RAPD) methods uses short synthetic oligonucleotides (10 bases long) of random sequences as primers. RAPD markers is obtained as DNA fragments from PCR amplification of random segments of genomic DNA with single primer of arbitrary nucleotide sequence. It is possible to amplify nanogram amounts of total genomic DNA under low annealing temperatures by PCR.

In the RAPD method, amplification products obtained by PRC are separated on agarose gels and stained with ethidium bromide. RAPD methods is different from conventional PCR. Because the length of the random primers, amplification conditions and visualization methods differ from the standard PCR condition. In RAPD-PCR, a single oligonucleotide of random sequence is used, and no prior knowledge of the genome subjected to analysis is required.

11. Randomly Amplified Microsatellite Polymorphism (RAMP)

Random amplified microsatellite polymorphism (RAMP) is one of the PCR-based markers. The principle of RAMP is using a combination of simple sequence repeat (SSR) and random amplified DNA polymorphism (RAPD) markers. For the study of genetic relationships in cultivated plant species, it is useful RAMP markers, because they are potentially valuable molecular marker.

The RAMP method is more advantageous than the SSR and RAPD methods in that it has an easy and low-cost application and reflects the high polymorphism that is widely distributed throughout the genome.

12. Specific Amplification Polymorphism (SAP)

Specific Amplification Polymorphism (SAP) markers are widely used in several plant species and developed through modification of the AFLP method. In SAP protocol, genomic DNA is digested with a restriction enzyme and then an adaptor is ligated to the digested DNA fragments. SAP-PCR amplification is performed with a combinations of e long terminal repeat (LTR) sequence-specific and adaptor sequence-specific primer.

13. Sequence Characterized Amplification Region (SCAR)

Sequence Characterized Amplified Regions (SCAR) is a genomic DNA sequence located at a single locus defined genetically. This locus is identified by PCR amplification using a pair of specific oligonucleotide primers.

In fact, SCAR markers are invented to improve the reliability of the RAPD markers. Because accuracy and reliability are needed for identification of genotypes. Although Random Amplified Polymorphic DNA (RAPD) markers are the most common method for identification, RAPD markers are sensitive to minor changes in reaction condition during PCR amplification and difficult to reproduce. Thus, SCAR markers are advantages over RAPD markers. Because SCAP-PCR amplification is less sensitive to reaction condition and reproducible and can be easily scored. In addition, SCAR marker analysis is straight forward, rapid, and easy to perform.

14. Single Nucleotide Polymorphisms (SNPs)

A single nucleotide polymorphism (SNP, /snip/) is a genomic variant in the DNA corresponding to a single base position. Although SNPs are generally seen as broadcasts in non-coding DNA regions, they can also be seen in gene regions. There are two types of SNPs in the coding region of gene: 1) Synonymous SNPs and 2) Nonsynonymous SNPs.

15. Simple sequence Repeats (SSR)

Simple sequence repeats markers, also known as microsatellites, are one of widely used markers in plants. SSR markers have many usage areas as follows: i) Quantitative trait loci (QTL) mapping, ii) Cultivar fingerprinting, iii) Linkage map development, iv) Marker-assisted selection (MAS), v) Gene flow, vi) Parentage analysis, vii) Genetic diversity studies, and viii) Evolutionary studies.

These molecular markers are powerful tools for basic and applied studies and useful to develop robust genetic marker for molecular breeding.

16. Variable Number of Tandem Repeats (VNTR)

Variable number tandem repeats (or VNTRs) are locations in genomes where short nucleotide sequences (20–100 bp) that vary in copy number and organized as a tandem repeat (Figure 23). These locations can be found on many chromosomes. They often show variations in length (number of repeats) among individuals.

Because each variant acts as an inherited allele, VNTRs can be used for personal or parental identification. Thus, VNTR analysis is useful in genetics and biology research, forensics, and DNA fingerprinting. VNTR markers are the most discriminating and least time consuming of the genotyping methods.

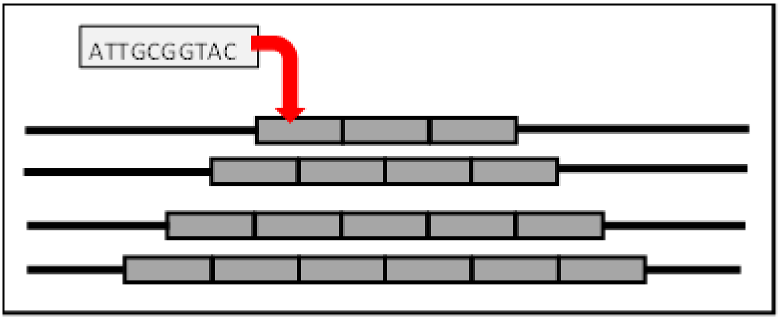

Figure 4. The depiction of VNTR markers. Th repat sequence may occur 10-100 nucleotides. The sequence repeat may be 5-50 times.

VNTR analysis method has been widely used during the last 15 years for genotyping. VNTR analysis is also being used to study genetic diversity and breeding patterns in populations of wild or domesticated animals and plants. In addition, VNTRs markers are one of the important sources of RFLP genetic markers used in linkage analysis (mapping) of diploid genomes.

References

Adhikari, S., Saha, S., Biswas, A. et al. Application of molecular markers in plant genome analysis: a review. *Nucleus* 60, 283–297 (2017). https://doi.org/10.1007/s13237-017-0214-7

Apablaza, P., Brevik, Ø.J., Mjøs, S. *et al.* Variable Number of Tandem Repeats (VNTR) analysis of *Flavobacterium psychrophilum* from salmonids in Chile and Norway. *BMC Vet Res* **11**, 150 (2015). https://doi.org/10.1186/s12917-015-0469-7

Arribas, R., Tòrtola, S., Welsh, J., McClelland, M., Peinado, M.A. (1997). Arbitrarily Primed PCR and RAPDs. In: Micheli, M.R., Bova, R. (eds) Fingerprinting Methods Based on Arbitrarily Primed PCR. Springer Lab Manuals. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-60441-6_8

Aslan, N. , Coşkun, Ö. F. , Dalda Şekerci, A. & Gülşen, O. (2021). Moleküler markörler kullanarak çerezlik kabaklarda (Cucurbita pepo L.) saflık düzeylerinin tahmin edilmesi . Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi , 26 (3) , 759-769 . DOI: 10.37908/mkutbd.995779

Bahar, E. , Korkutal, İ. , Şahin, N. , Sağır, F. S. , Kök, D. , Ergönül, O. , Uysal, T. & Orhan Özalp, Z. (2019). Ganos Dağları Doğal Florasında Bulunan Kültür Asmalarının (Vitis vinifera L.) Moleküler ve Ampelografik Karakterizasyonu . Tekirdağ Ziraat Fakültesi Dergisi , 16 (1) , 92-102 . DOI: 10.33462/jotaf.399858

Bardakcı, F. (2001) "Random Amplified Polymorphic DNA (RAPD) Markers," Turkish Journal of Biology: Vol. 25: No. 2, Article 10. Available at: https://journals.tubitak.gov.tr/biology/vol25/iss2/10

Bassam, B. J., Caetano-Anollés, G., & Gresshoff, P. M. (1992). DNA amplification fingerprinting of bacteria. *Applied microbiology and biotechnology*, *38*(1), 70–76. https://doi.org/10.1007/BF00169422

Bhattarai, G., Shi, A., Kandel, D.R. *et al.* Genome-wide simple sequence repeats (SSR) markers discovered from whole-genome sequence comparisons of multiple spinach accessions. *Sci Rep* **11**, 9999 (2021). https://doi.org/10.1038/s41598-021-89473-0

Çetinkaya, E. & Ayhan, K. (2012). Mikrobiyolojide Kullanılan Bazı Moleküler Teknikler . Karaelmas Fen ve Mühendislik Dergisi , 2 (1) , 53-62 . Retrieved from https://dergipark.org.tr/tr/pub/karaelmasfen/issue/57131/806062

Das, S., Noe, J. C., Paik, S., & Kitten, T. (2005). An improved arbitrary primed PCR method for rapid characterization of transposon insertion sites. *Journal of microbiological methods*, *63*(1), 89–94. https://doi.org/10.1016/j.mimet.2005.02.011

Devran, Z. (2016). Moleküler İşaretleyicilerin Dayanıklılık Islahında Kullanılması . Derim , 20 (1) , 1-6 . Retrieved from http://www.derim.com.tr/tr/pub/issue/4555/62540

Domínguez, O., & López-Larrea, C. (1994). Gene walking by unpredictably primed PCR. *Nucleic acids research*, *22*(15), 3247–3248. https://doi.org/10.1093/nar/22.15.3247

Egert, M., & Friedrich, M. W. (2003). Formation of pseudo-terminal restriction fragments, a PCR-related bias affecting terminal restriction fragment length polymorphism analysis of microbial community structure. *Applied and environmental microbiology*, *69*(5), 2555–2562. https://doi.org/10.1128/AEM.69.5.2555-2562.2003

Elçi, E. & Hançer, T. (2016). Bazı Ekmeklik Buğday Çeşitlerinde Fotoperiyodizm Geninin Moleküler Markörler ile Tespiti . Journal of Agricultural Faculty of Gaziosmanpaşa University (JAFAG) , 33 (3) , 39-45 . DOI: 10.13002/jafag978

Filiz, E. & Koç, İ. (2011). Bitki Biyoteknolojisinde Moleküler Markörler . Journal of Agricultural Faculty of Gaziosmanpaşa University (JAFAG) , 2011 (2) , . Retrieved from https://dergipark.org.tr/tr/pub/gopzfd/issue/7330/95929

Gu, W. K., Weeden, N. F., Yu, J., & Wallace, D. H. (1995). Large-scale, cost-effective screening of PCR products in marker-assisted selection applications. *TAG. Theoretical and applied genetics. Theoretische und angewandte Genetik*, *91*(3), 465–470. https://doi.org/10.1007/BF00222974

Güleç, T. E. , Yıldırım, A. & Sönmezoğlu, Ö. A. (2010). Bitkilerde Markör Destekli Seleksiyon. Türk Bilimsel Derlemeler Dergisi, (2), 67-79. Retrieved from https://dergipark.org.tr/tr/pub/derleme/issue/35078/389027

Karataş, A. , Turan Büyükdinç, D. , İpek, A. , Yağcıoğlu, M. , Sönmez, K. & Ellialtıoğlu, Ş. Ş. (2017). Türkiye'de Fasulyede Yapılan Morfolojik ve Moleküler Karakterizasyon Çalışmaları . Türk Bilimsel Derlemeler Dergisi , 10 (1) , 16-27 . Retrieved from https://dergipark.org.tr/tr/pub/derleme/issue/35685/397256

Kaundun, S.S. and S. Matsumoto (2004) PCR-based amplicon length polymorphisms (ALPs) at microsatellite loci and indels from noncoding DNA regions of cloned genes as a means of authenticating commercial Japanese green teas. J. Sci. Food Agric. 84: 895–902.

Kaya, E. & Yılmaz Gökdoğan, E. (2015). Molecular Characterization of Some Turkish Olive Cultivars Using Random Amplified Polymorphic DNA (RAPD) Markers . Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi , 19 (1) , 103-106 . Retrieved from https://dergipark.org.tr/tr/pub/sdufenbed/issue/20806/222204

Kırcalıoğlu, G. (2001). Bazı Buğday Tescilli Çeşit Ve İleri Hatlarının Biyokimyasal Markörler İle Tanımlanması . Anadolu Ege Tarımsal Araştırma Enstitüsü Dergisi , 11 (2) , . Retrieved from https://dergipark.org.tr/tr/pub/anadolu/issue/1779/21893

Lauerman, L. H., Chilina, A. R., Closser, J. A., & Johansen, D. (1995). Avian mycoplasma identification using polymerase chain reaction amplicon and restriction fragment length polymorphism analysis. *Avian diseases*, *39*(4), 804–811.

Liu, J., Huang, S., Sun, M. *et al.* An improved allele-specific PCR primer design method for SNP marker analysis and its application. *Plant Methods* **8**, 34 (2012). https://doi.org/10.1186/1746-4811-8-34

Miller, K. M., Ming, T. J., Schulze, A. D., & Withler, R. E. (1999). Denaturing gradient gel electrophoresis (DGGE): a rapid and sensitive technique to screen nucleotide sequence variation in populations. *BioTechniques*, *27*(5), . https://doi.org/10.2144/99275rr02

Nie, Y. C., Wang, B., Zhao, Z. Q., & Zhou, H. G. (2014). *Fa yi xue za zhi*, *30*(4), 282–287.

Nicot, N., Chiquet, V., Gandon, B.et al Study of simple sequence repeat (SSR) markers from wheat expressed sequence tags (ESTs). Theor Appl Genet 109, 800–805 (2004). https://doi.org/10.1007/s00122-004-1685-x

Parker, J. D., Rabinovitch, P. S., & Burmer, G. C. (1991). Targeted gene walking polymerase chain reaction. *Nucleic acids research*, *19*(11), 3055–3060. https://doi.org/10.1093/nar/19.11.3055

Paun, O., & Schönswetter, P. (2012). Amplified fragment length polymorphism: an invaluable fingerprinting technique for genomic, transcriptomic, and epigenetic studies. *Methods in molecular biology (Clifton, N.J.)*, *862*, 75–87. https://doi.org/10.1007/978-1-61779-609-8_7

Pınar, H. , Ata, A. , Keleş, D. , Mutlu, N. , Denli, N. & Ünlü, M. (2013). Domates hatlarında Fusarium oxysporum f. sp. lycopersici'ye dayanıklılığın moleküler markörler yardımıyla belirlenmesi . Derim , 30 (1) , 15-23 . Retrieved from http://www.derim.com.tr/tr/pub/issue/4574/62656

Poyraz, İ. & Gümüş, N. (2016). Comparison of Resistance Rates and Detection of Five Resistance Genes (Bts) in Ten Local Wheat Varieties against Common Bunt Disease . Anadolu University Journal of Science and Technology C - Life Sciences and Biotechnology , 5 (1) , 37-45 . DOI: 10.18036/btdc.78679

Ravikumar, R. L., Salimath, P. M., Thippeswamy, S., & Patil, B. S. (2003). Verification of an allele specific associated primer with wilt susceptibility in commonly used parental lines of chickpea. *INDIAN JOURNAL OF GENETICS AND PLANT BREEDING*, *63*(03), 259–260. https://doi.org/.

Rice W. C. (2008). Evaluation of genome-derived amplicon length polymorphism PCR primers for the genetic evaluation of related strains of Salmonella. *Letters in applied microbiology*, *47*(3), 158–166. https://doi.org/10.1111/j.1472-765X.2008.02400.x

Rozee, K., & Johnson, W. (1991). DNA amplification fingerprinting: Another diagnostic tool?. *The Canadian journal of infectious diseases = Journal canadien des maladies infectieuses*, *2*(4), 165–166. https://doi.org/10.1155/1991/429765

Salazar, J.A., et al. (2014) Low-Cost Strategies for Development of Molecular Markers Linked to Agronomic Traits in Prunus. Agricultural Sciences, 5, 430-439. http://dx.doi.org/10.4236/as.2014.55044

Sütyemez, M. , Boyacı, S. , Kuşçuoğlu, N. , Özcan, A. , Bükücü, Ş. B. , Yıldırım, E. & Bardak, A. (2021). A research on the determination of phenological and molecular characterization in open-pollinated genotypes in walnut . Harran Tarım ve Gıda Bilimleri Dergisi , 25 (4) , 418-437 . DOI: 10.29050/harranziraat.986501

Syed, N. H., & Flavell, A. J. (2006). Sequence-specific amplification polymorphisms (SSAPs): a multi-locus approach for analyzing transposon insertions. *Natur e protocols*, *1*(6), 2746–2752. https://doi.org/10.1038/nprot.2006.407

Şensoy, R. İ. G. & Balta, F. (2011). Van Yöresine Ait Bazı Yerli Asma Formlarının Tespiti ve RAPD Markörleriyle Tanımlanması . Journal of the Institute of Science and Technology , 1 (3), 41-56 . Retrieved from https://dergipark.org.tr/tr/pub/jist/issue/7926/104243

Thakur, V. V., Tiwari, S., Tripathi, N., & Tiwari, G. (2019). Molecular identification of medicinal plants with amplicon length polymorphism using universal DNA barcodes of the *atpF-atpH*, *trnL* and *trnH-psbA* regions. *3 Biotech*, *9*(5), 188. https://doi.org/10.1007/s13205-019-1724-6

Topaklı, F. & Hepaksoy, S. (2019). Türkiye'deki Zeytin Çeşitlerinin Moleküler Analizlerinin Genel Değerlendirmesi . Yuzuncu Yıl University Journal of Agricultural Sciences , 29 (2) , 362-372 . DOI: 10.29133/yyutbd.543047

Uçar, C. & Şensoy, S. (2022). Validity Control of Markers Used in Molecular Marker Assisted Selection in Tomato . Yuzuncu Yıl University Journal of Agricultural Sciences , 32 (2) , 300-309 . DOI: 10.29133/yyutbd.1039398

Uncu, A. T. & Uncu, A. O. (2018). High-Throughput Genomic Simple Sequence Repeat (SSR) Marker Development and Construction of a High Resolution

Physical Map in Button Mushroom (Agaricus bisporus) Genome . Mantar Dergisi , 9 (1) , 28-35 . Retrieved from https://dergipark.org.tr/tr/pub/mantar/issue/36725/391682

Welsh, J., Chada, K., Dalal, S. S., Cheng, R., Ralph, D., & McClelland, M. (1992). Arbitrarily primed PCR fingerprinting of RNA. *Nucleic acids research*, *20*(19), 4965–4970. https://doi.org/10.1093/nar/20.19.4965

Yorgancılar, M. , Yakışır, E. & Tanur Erkoyuncu, M. (2016). Moleküler Markörlerin Bitki Islahında Kullanımı . Bahri Dağdaş Bitkisel Araştırma Dergisi , 4 (2) , 1-12 . Retrieved from https://dergipark.org.tr/tr/pub/bdbad/issue/25865/272665

Yuskianti, V., & Shiraishi, S. (2010). Sequence Characterized Amplified Region (SCAR) Markers in Sengon (Paraseriathes falcataria (L.) Nielsen. *Hayati Journal of Biosciences*, *17*, 167-172.

Zalapa, J. E., Cuevas, H., Zhu, H., Steffan, S., Senalik, D., Zeldin, E., McCown, B., Harbut, R., & Simon, P. (2012). Using next-generation sequencing approaches to isolate simple sequence repeat (SSR) loci in the plant sciences. *American journal of botany*, *99*(2), 193–208. https://doi.org/10.3732/ajb.1100394

Wang, X., Yang, S., Chen, Y. *et al.* Comparative genome-wide characterization leading to simple sequence repeat marker development for *Nicotiana*. *BMC Genomics* **19**, 500 (2018). https://doi.org/10.1186/s12864-018-4878-4

Waugh, R., McLean, K., Flavell, A. J., Pearce, S. R., Kumar, A., Thomas, B. B., & Powell, W. (1997). Genetic distribution of Bare-1-like retrotransposable elements in the barley genome revealed by sequence-specific amplification polymorphisms (S-SAP). *Molecular & general genetics : MGG*, *253*(6), 687–694. https://doi.org/10.1007/s004380050372

CHAPTER 13

THE EFFECTS OF FIELD CROPS IN INTERCROPPING ON FRUIT GROWING

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Introduction

In international agricultural trade, our country has one of the strongest and most competitive sectors in the field of fresh vegetable and fruit growing. For this reason, in order to provide the most effective and efficient production in the field of fruit growing, intercropping should be developed and expanded.

Turkey has an important potential in terms of horticultural agriculture. Our country has a total of 234,728,774.3 decares of agricultural land and 15.30% of this area is horticultural (TUIK, 2021). Fruit cultivation in horticulture has a great potential in terms of production. However, since fruit trees are perennial, it takes a long time to reach full yield. Therefore, it takes many years to obtain the expected product and income from orchards. For this reason, by making intercropping product agriculture in the empty areas among the fruit trees, it provides both the productivity of the soil and the opportunity for the farmer to provide additional income.

In this chapter; Researches on the effect of field crops on plant growth and development, land use efficiency and yield potential in fruit growing in intercropping is mentioned.

Intercropping and Use in Agricultural Fields

Intercropping is the cultivation of two or more, often different, plants on the same piece of land. With the full use of available resources in the vineyard and orchard areas, it not only provides a sustainable income to the producer, but also affects the soil health and nutrient status of the soil. In other words, intercropping is expressed as the cultivation of another plant in the empty spaces between fruit trees. Intercropping is defined as intercropping in orchards, intercropping in field crops and intercropping in forests. Intercropping in horticulture practices can be applied in orchards grown under irrigated farming conditions, as well as in pistachio, olive and vineyard plantations where irrigation is not available (Agturk, 2010).

In the first plant establishment, fruit trees have a wide root and crown structure, unlike vegetables and field products, but this situation is taken into account when making a garden plant. In the first years of the establishment, there are large areas among the fruit trees. It may be appropriate to evaluate these areas with intermediate agriculture in terms of both garden productivity and additional income on the basis of producers.

In addition, fruit growing plants have a perennial structure. They usually start to bear fruit after a long waiting period of 3-7 years. During this period, the fallow spaces between the rows of trees and the empty spaces between the rows of trees can be used appropriately for intercropping. In the current situation, while the amount of land per capita is decreasing, intercropping will make the use of existing land resources more profitable. This will only be possible when resources and inputs are used efficiently and maximum outputs are achieved in the per-unit usage cost of inputs. Intercropping is valuable in terms of minimizing the production cost per unit area, increasing additional income and maintaining the ecological balance.

Since the expansion of agricultural areas is limited due to the increasing population in the world, it is necessary to increase the amount of product to be obtained from the unit area. Depending on the climatic conditions, growing more than one product per year increases the yield to be obtained from the unit area. This is possible by growing more than one plant species together in the same land and garden areas (Midmore, 1993).

Advantages and Disadvantages of Intercropping

In order to increase plant production, which has decreased with the decrease of existing agricultural areas in the world, different systems have been applied that can increase the yield to be obtained from agricultural areas. One of these systems is intercropping.

Among the positive aspects of intercropping, it prevents erosion, increases the organic matter content in the soil, facilitates the uptake of plant nutrients, increases the quality of the product and increases income.

Intercropping has the effect of increasing the organic matter of the soil ((Montagnini ve P. K. R. Nair, 2004). Whyte et al. (1955). At the same time, the effect of intercropping on the accumulation of organic matter in the soil varies depending on factors such as soil cultivation techniques as well as plant type. In addition to reducing the cultivation of the soil, the cultivation of forage crops with both above-ground and underground parts will contribute positively to the increase of organic matter in the soil.

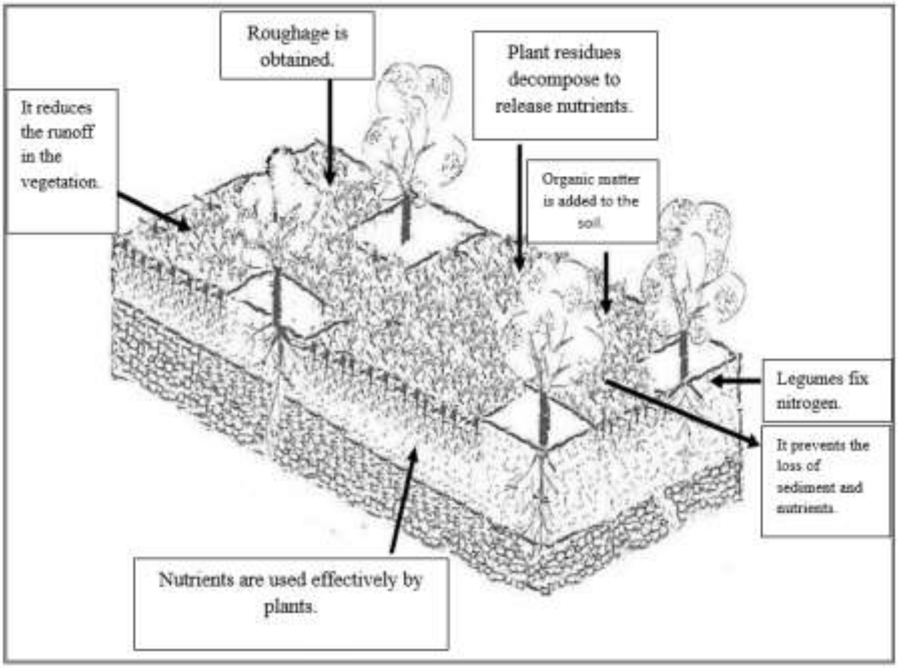

Figure 1. Schematic view and functions of intercropping in horticulture (Kang et al., 1986).

In addition, microorganisms in the soil decompose the organic matter content of the soil and enable its conversion into useful nutrients for plants. The enrichment of nitrogen content in the soil occurs when legume forage plants attach the free nitrogen in the air to the plant roots. Forage crops also increase the uptake of available phosphorus and potassium in the soil with their plant root systems. This provides a more effective use of nutrients in the soil (Barber, 1989). Thus, intercropping cultivation is more efficient than monoculture cultivation (Anil et al., 1998). Whether the leguminous plants preferred as intercropping crops in orchards improve the contribution of soil nutrient and increased nutrient cycle to tree nutrition will depend on the specific nutrient in the soil, the amount of nutrient elements and the row spacing of the cultivated legumes and existing fruit trees. While a legume plant planted as an intercropping contributes to the N nutrition of its associated fruit tree, the results for other nutrients such as P, Ca or K may be completely different (Lehman et al., 1999).

A high and stable production that not only grows complementary products in fruit and garden fields, but also reduces the harmful effects of diseases and pests, prevents pollution and results in effective use of resources is preferred (Tirasci et al., 2017). However, it can be said that intercropping culture is more profitable than monoculture cultivation (Caballero and Goicoechea, 1995). Intercropping has the characteristics of faster growth rate, reduction of weeds, pests and infectious diseases, and more efficient use of inputs due to differences in resource consumption (Eskandri, 2012; Eskandari et al., 2009; Watiki et al., 1993; Willey, 1990).

Some plants used in intercropping can create competition and suppress weeds both during growth and after completing their biological cycle. However, the plant parts remaining after the harvest of the intercropping plant form a layer of mulch on the soil surface, preventing the emergence of the next dominant weed species (Blackshaw et al., 2001). In the control of weeds in perennial crops, it has been observed that the cover plants planted in winter suppress weeds, however, the cover plant can reduce the weed population as a result of competition, and at the same time, the cover plants planted in mixtures significantly reduce the weed population compared to the traditional herbicide application (Doll, 2019).

In the control of weeds that are a problem in citrus orchards in the Çukurova Region of our country, mechanical, chemical and intercropping crop plants (clover, purple clover, white clover, underground clover, red clover, vetch, hairy vetch) are struggled. Although mechanical control is the most effective method, it has been found that the use of vetch cover crops has a similar effect with herbicide application (Koloren and Uygur, 2006).

In terms of diseases and pests, the above-ground vegetative parts and underground root parts of some plants cultivated in garden and vineyard areas as intercropping products can be mixed into the soil. These mixed plant materials can form a soil layer rich in organic matter or a layer where new roots can form without any pathogens. Intercropping plants, which contribute to the accumulation of organic matter in the soil, can benefit the control of soil-borne plant diseases.

However, saprophytic organisms can create competitive power with pathogens by decomposing organic matter. In this way, disease control can be achieved by the production of antipathogenic toxin (Evans et al., 1988). One of the most important criteria for plants selected as intercropping products is the absence of sensitivity to diseases and pests that may occur in fruit trees. If these plants are sensitive, they can be intermediate or main hosts together with weeds. As a result, they may cause damage to the cultivated plants. Although intercropping crops host beneficial insects that fight pests, it has been observed that the damage of spider mite (*Tetranychus* spp.) and leafhopper (Empoasca spp.) can be reduced in fruit and vineyard areas where intercropping crops are planted without tillage (Thomas et al., 2002).

Although intercropping has many advantages in fruit growing, attention should be paid to the selection of plants to be used in intercropping due to the competition between fruit trees and intercropping plants for light, nutrients and water in the soil (Agturk, 2010).

Use of Field Crops in Intercropping

Intercropping plants can add nutrients to the soil, clean or balance the soil, depending on the selected species. In agricultural areas such as vineyards, gardens and land, leguminous (Fabaceae) species can be preferred because they provide nitrogen to the soil naturally. Among the preferred legumes are plants such as alfalfa, clover, vetch, soybean, and chickpea and should be selected from varieties adapted to the region to be planted (Figure 2). These plants fix nitrogen to vineyard, garden and land soils in autumn and winter, filter nitrate, which is the useful form of nitrogen, and as a result prevent it from being lost by leakage from the soil. Jarvis-Shean and Lightle, 2019).

It is also seen that leguminous forage crops and grasses grown together with them enrich the soil in terms of organic matter (Gökkuş, 2011). Thanks to the nodules in the roots of legume forage plants, they enrich the soil in terms of nitrogen by binding the free nitrogen of the air to the soil (Figure 1.). Thus, forage plants are plowed during the flowering period and buried in the soil, enriching the soil in terms of nitrogen (Storm, 2011). As a result of the study conducted by Tarman (1972), it was observed that the alfalfa plant left organic matter in the soil at 3700 kg/da after 9 years. Organic matter in the soil improves soil fertility both physically and chemically.

Figure 2. Soybean as an intercropping crop in the orchard.

In fruit and garden areas, not sticking to a single culture plant (monoculture) and in regions where agricultural systems are applied, intercropping farming is one of the ways for businesses to gain productive profits.

While the roughage obtained in this system provides cheap input for the animals in the enterprise, it contributes to reducing the risk of monoculture agriculture in the animals raised. Thus, farmers can maximize their operating income by using their limited resources such as land and labor optimally. However, forage crops in intercropping cultivation have a significant potential to meet the need for roughage in livestock. In animal nutrition, legumes and grasses come to the fore as a source of protein and carbohydrates. Depending on the ecological characteristics in the production regions, approximately 300 to 1000 kg of dry grass is obtained in Turkey on average (Hatipoglu, et. al., 2009). Forage crops grown in orchards such as pistachios, olives, citrus fruits, peaches, apples and apricots in the Mediterranean and Southeastern Anatolia regions constitute an important intercropping cultivation potential (Agturk, 2010).

Results

It has been determined that mixed cultivation can be done with plant species that can affect the growth and yield of the plant species used in intermediate agriculture, and as a result of the researches done in the world, intermediate agriculture can be more productive than mono culture agriculture. However, higher productivity and resource use in agricultural ecosystems in intermediate crop agriculture will provide higher productivity (Lithourgidis et al., 2011).

Intercropping cultivation increases soil carbon and nitrogen, as well as increasing global food security. This system, which is the cultivation of more than one plant at the same time in a single garden, also has the feature of increasing soil fertility due to the complementarity of species.

At the same time, intercropping plants grown between rows in orchards; They are plants that are not grown for the purpose of providing financial income and harvesting, but are very useful for fruit trees grown in the production system. Among the points to be considered in these plants are the ability to adapt and provide a harvestable surface before planting in the cultivated fruit fields. However, it is necessary to pay attention to the characteristics of these plants such as shade tolerance and drought resistance, slow growing and covering the soil surface, and not being in a wrapping and climbing form (Temel and Torun, 2020).

In addition, the points to be considered include; the selection of intermediate crop plants that are less competitive with fruit trees, to prefer leguminous plants that will create a useful nitrogen source for fruit trees by binding the free nitrogen of the air to the soil, resistance of intermediate crop plants to diseases and pests, competitiveness with weeds. Finally, in intercropping cultivation; It has been observed that there is no negative effect on fruit yield, it has a reducing effect on fruit drop, and it contributes positively to increasing fruit quality, growth parameters, soil fertility, soil health and NPK status in leaves. Leguminous crops used in intercropping cultivation have a greater effect on soil properties to improve the biological environment. This agricultural system makes the chemical composition of the fruit desired by consumers higher quality. It is recommended to grow intermediate products in orchards in order to improve the quality of the fruits, improve the physico-chemical properties of the soil, and also make full use of all input sources (Gamble, 2020).

References

Agturk, R. (2010): Effects of Forage Plants Grown as Intercropping in Pistachio Orchards on Soil Water Content. – Kahramanmaraş Sütçü İmam University, Institute of Science, Department of Soil Science, M.Sc. Thesis, Kahramanmaraş.

Anıl, L., Park, J., Phıpps, R.H., Mıller, F.A. (1998). Temperate Intercropping Of Cereal Forage: A Review Of The Potential For Growth And Utilization With Particular Referance The Uk. Grass And Forage Science, 53: 301-317.

Barber, S. A. (1989). Soil Nutrient Availability: A Mecanistic Approach. John Wiley and Sons, New York.

Blackshaw R.E., Moyer J.R., Doram R.C., Boswell A.L. (2001). Yellow sweetclover, green manure, and its residues effectively suppress weed during fallow. Weed Science, 49: 406-413

Caballero, R., Goicoechea, E. L. (1995). Forage yield quality of common vetch and oat sown varying seeding ratios and seeding rates of vetch. Field Crops Research, 41: 135-140.

Doll, D. (2019). Cover crop research review: How can it help almonds? Posted on June 30. (16.01.2020).

Eskandari, H., (2012). Intercropping of maize (*Zea mays*) with cowpea (Vigna sinensis) and mungbean (*Vigna radiata*): effect of complementarity of intercrop components on resource consumption, dry matter production and legumes forage quality. Journal of Basic and Applied Scientific Research, 2: 355-360.

Eskandari, H., A. Ghanbari-Bonjar, M. Galavai and M. Salari, (2009). Forage quality of cow pea (*Vigna sinensis*) Int. J. Curr. Microbiol. App. Sci. (12): 745-755 753 intercropped with corn (Zea mays) as affected by nutrient uptake and lightinter- ception. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 37.

Evans D.O., Joy R.J., Chia C.L. (1988). Cover Crops for Orchards in Hawaii. College of Tropical Agriculture and Human Resources, University Of Hawaii, Research Extension Series 094.

Firtina, T. (2011). The Effect of Some Intercropping Plants on Shoot Growth of Pistachio Trees Grown in Southeastern Anatolia Arid Conditions. Master Thesis, Kahramanmaras Sutcu Imam University, Institute of Science and Technology. p46.

Gökkuş, A. (2011). The Role and Importance of Grassland and Forage Crops in Turkey's Forage Production. *Journal of Atatürk University Faculty of Agriculture*, 25(2).

Hatipoğlu, R., Avcıoğlu, R., Karadağ, Y. (2009). The Place of Forage Crops in Sustainable Agriculture. Forage Crops Volume I. General Chapter. T.R. T.K.B. General Directorate of Agricultural Production and Development. Emre Press, Izmir.

Jarvis-Shean K.J., Lightle D. (2019). Your source for orchard news & information in the Sacramento Valley Orchard. Cover Crop Seed Selection. Posted on July 17. http://www.sacvalleyorchards.com/almonds/horticulture/cover-crop-seed-selection/ (16.01.2020)

Kang, B.T., Kruijs, V.D., M., A.C.B., Cooper, D.C. (1986). Alley Cropping For Food Production in The Humid And Subhumid Topics. (B.T. Kang and L Raynolds Edited by). Prodeecings of a workshop on alley farming, Ibadan, Niger, IDCR, Ottowa, Canada.

Kolören O., Uygur F.N. (2006). The effect of different weed control methods in citrus orchard in Cukurova Region. Turkish Journal of Weed Science, 9(1): 9-16.

Kumar, N. P. (2020). Effect of intercropping on fruit crops: a review. *Int J Curr Microbiol Appl Sci*, *9*, 745-755.

Lehmann, J., Da Silva, J. P., Trujillo, L., Uguen, K. (1999). Legume cover crops and nutrient cycling in tropical fruit tree production. In *II ISHS Conference on Fruit Production in the Tropics and Subtropics 531* (pp. 65-72).

Lithourgidis, A.S., Dordas, C.A., Damalas, C.A and Vlachostergios, D.N. (2011). Annual Intercrops: an Alternative Pathway for Sustainable Agriculture. Australian Journal of Crop Science, 2011, 5(4): 396-410.

Midmore, D.J., (1993). Agronomic modification of resource use and intercrop productivity. Field Crops Research, 34, 357-380.

Montagnını, F. Ve Naır, P. K. R. (2004). Carbon Sequestration: An Underexploited Environmental Benefit Of Agroforestry Systems. Agroforestry Systems, 61: 281–295.

Tarman, Ö. (1972). Forage Crops, Meadow and Pasture Culture. Volume 1. General Principles. Ankara Univ. Faculty of Agriculture Publications (464,157), Ankara.

Temel, N., Torun, H. (2020). Cover Plant Selection Criteria in Vineyards and Gardens, Ecological Contributions and Their Place in Weed Control. *Turkish Journal Of Weed Science*, *23*(2), 177-187.

Thomas F., Mayse A., Chaney D. (2002). Cover Cropping In Orchards & Vineyards. University of California, Division of Agriculture and Natural Resources Sustainable Agriculture Research and Education Program.

Tiraşçi, S., Ekinci, M., Dursun, A., and Yildirim, E. (2017). Effect of intercropping system on yield, plant growth and yield of red cabbage (Brassica oleracea L. var. rubra) and Lettuce (Lactuca sativa L.). In CONGRESS BOOK (p. 540).

Tüik (2021). Turkish Statistical Institute, Crop Production Database. http://tuik.gov.tr (Date of access: 16.09. 2022)

Vandermeer, J. (1989). The Ecology of Intercropping. Cambridge University Press, p 237, Cambridge, UK

Watiki, J., S. Mfukai, J.A. Banda and B.A. Keating, (1993). Radiation interception and growth of maize/cowpea intercrop as an affected by maize plant-density and cow pea cultivar. Field Crop Research, 35: 123-133.

Whyte, R. O, Fıssner, G.N., Trumble, H.C. (1955). Les Legumineuses En Agriculture. Etudes Agricoles De La Fao, No: 21, Rome, Italie, S. 45.

Willey, R.W. (1990). Resource use in intercropping systems. Journal of Agriculture and Water Management, 17:215-231.

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