CURRENT ADVANCES IN AGRICULTURAL AND ENVIRONMENTAL SCIENCES

EDİTORS;

PROF. DR. VECİHİ AKSAKAL

ASSOC. PROF. DR. ÜMİT YILDIRIM

CURRENT ADVANCES IN AGRICULTURAL AND ENVIRONMENTAL SCIENCES

Editors

Prof. Dr. Vecihi AKSAKAL
Assoc. Prof. Dr. Ümit YILDIRIM

Authors

Prof. Dr. Erdoğan ÖZTÜRK

Prof. Dr. Ümmügülsüm ERDOĞAN

Prof. Dr. Vecihi AKSAKAL

Assoc. Prof. Dr. Ümit YILDIRIM

Assoc. Prof. Dr. Yaşar ERDOĞAN

Lecturer PhD. Betül GIDIK

Lecturer PhD. Sadık ÇIVRACI

Lec. Umut Barış USTABULUT

PhD. Onur GÜVEN

PhD. Bayram YURTVERMEZ

Master Student Ayşegül YAVUZ

Master Student Ayşenur KELEŞ

Master Student Kübra KILIÇ

Institution of Economic
Development and Social
Researches Publications®
(The Licence Number of Publicator: 2014/31220)
TÜRKİYE TR: +90 342 606 06 75
USA: +1 631 685 0 853
E mail: iksadyayinevi@gmail.com
www.iksadyayinevi.com

ISBN: 978-625-378-064-7
Cover Design: Mehmet Ali BİRDANE - Sevcan YILDIZ
December / 2024
Ankara / Türkiye
Size = 16 x 24 cm

CONTENTS

PREFACE

Our era is characterized by various environmental problems brought about by rapid industrialization and urbanization. The effects of these processes on agriculture are essential for our planet's sustainability and humanity's future. Agriculture is a sector that directly uses our natural resources and an activity that plays a key role in preserving environmental balance. Considering the critical role that agriculture plays in meeting humanity's basic needs, emphasis should be placed on what needs to be done to disseminate sustainable agricultural techniques and increase environmental awareness. In this process, individuals' and societies' active participation and support are indispensable in building a successful and sustainable future.

This book aims to raise awareness about the environmental effects of agriculture and to shed light on the steps that need to be taken for a more sustainable world. It includes critical studies that will guide society for the agricultural and environmental policies we will need to achieve goals such as ending poverty, eliminating hunger, and access to clean water and sanitation services, among the Sustainable Development Goals of the United Nations.

We would like to thank the authors who contributed to the book, believing that small but effective changes can lead to significant transformations to make possible a future in which we can all live together in harmony with nature.

Editors

Prof. Dr. Vecihi AKSAKAL
Assoc. Prof. Dr. Ümit YILDIRIM

CHAPTER 1

TWENTY YEARS OF BAYBURT (TURKEY) IN TERMS OF ENVIRONMENT (2000-2019)

Assoc. Prof. Dr. Ümit YILDIRIM[1*], Lec.Umut Barış USTABULUT[2], PhD. Onur GÜVEN[3]

DOI: https://dx.doi.org/10.5281/zenodo.14544619

[1] * Bayburt University, Faculty of Applied Sciences, Department of Emergency Aid and Disaster Management, Bayburt, Turkey. ORCID ID: 0000-0002-7631-7245 umityildirim@bayburt.edu.tr
[2] Bayburt University, Vocational School of Technical Sciences, Photography and Videography Program, Bayburt, Turkey. ORCID ID: 0000-0002-2870-7644 umutbarisustabulut@bayburt.edu.tr
[3] Bayburt University, Central Research Laboratory, Bayburt, Turkey. ORCID ID: 0000-0001-5608-7633. onurguven@bayburt.edu.tr

1. POPULATION

Population is one of the most important factors in the development and growth of cities. In the first census in 1927, the population of Turkey was 13,695,945 people, and in the census conducted in 2000, it was 67,803,927.

According to the census conducted in Bayburt in 1927, the population of the city was 48,970. Until 1975, there was a continuous increase in the population of Bayburt, as in the population of Turkey, and the city reached its highest population in 1975 (Figure 1). With the 1980 census, the increase that had been continuing for 53 years entered a downward trend. In 1985, the population increased again, reaching 109,422 people, but in 1990 and 2000, there was a decline in population statistics again. In the Millennium (2000) period, the city's population dropped back to two digits, reaching 97,358.

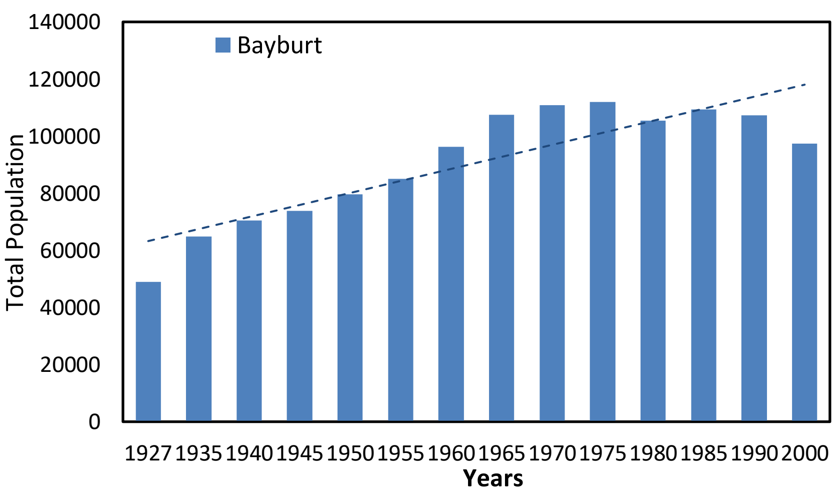

Figure 1. Graph of Bayburt population change between 1927-2000.

The population of Turkey was 67,803,927 in 2000 and 83,154,997 in 2019. In the population statistics data of Bayburt city, it was seen that it had a population of 97,358 people in 2000 and this figure decreased after the 2000s and was 84,843 in 2019 (TUİK, 2020a).

2. ENVIRONMENT

2.1. CLIMATE

2.1.1.PRECIPITATION AND RELATIVE HUMIDITY

Bayburt is located in the Eastern Anatolia region and is close to the Eastern Black Sea. For this reason, the city has a transitional climate between Eastern Anatolia and the Eastern Black Sea climate with predominant continental characteristics. Summers are cool and dry and winters are cold and rainy.

The average annual precipitation of Turkey and Bayburt region is presented below (Table 1). The average annual precipitation amounts of Turkey in general and Bayburt between 1970-2019 were obtained.

Table 1. Average annual precipitation and relative humidity values in Turkey and Bayburt (MGM, 2020).

Years	Average rainfall (mm) Turkey	Average rainfall (mm) Bayburt	Average relative humidity (%) Bayburt
1970	600.0	416.4	47.1
1971	641.1	421.4	45.8
1972	637.8	419.7	54.0
1973	485.4	350.2	51.2
1974	554.5	310.0	50.2
1975	697.9	307.4	50.7
1976	696.7	373.1	50.9
1977	560.2	454.2	48.6
1978	721.1	339.8	47.7
1979	701.4	620.8	48.5

Table 1. Continued.

1980	655.3	382.1	47.7
1981	731.0	419.5	47.0
1982	643.7	318.2	47.1
1983	665.3	424.6	48.6
1984	619.0	333.8	46.0
1985	601.1	464.6	48.9
1986	565.9	390.1	48.7
1987	685.1	517.2	48.5
1988	812.1	560.4	53.0
1989	525.4	352.1	46.4
1990	501.6	435.5	46.6
1991	637.1	509.4	46.8
1992	634.0	420.6	49.6
1993	605.0	369.1	53.1
1994	612.6	371.9	50.0
1995	709.6	543.7	52.4
1996	621.7	485.5	48.5
1997	709.9	464.8	48.7
1998	734.8	602.1	48.0
1999	647.2	521.8	39.1
2000	596.8	331.3	40.7
2001	552.9	455.0	41.8
2002	742.0	495.7	41.8
2003	675.7	395.6	41.3
2004	691.2	519.4	36.9
2005	642.3	602.7	37.2
2006	656.6	498.7	35.8
2007	540.6	469.0	36.6

Table 1. Continued.

2008	540.3	450.0	35.9
2009	731.6	498.5	36.3
2010	739.9	507.5	34.5
2011	697.7	486.1	37.6
2012	666.0	493.0	35.3
2013	561.8	380.8	34.0
2014	641.6	441.6	33.3
2015	637.8	421.8	32.4
2016	650.7	584.5	33.3
2017	553.4	431.3	30.5
2018	639.2	564.1	33.0
2019	639.7	380.5	30.1

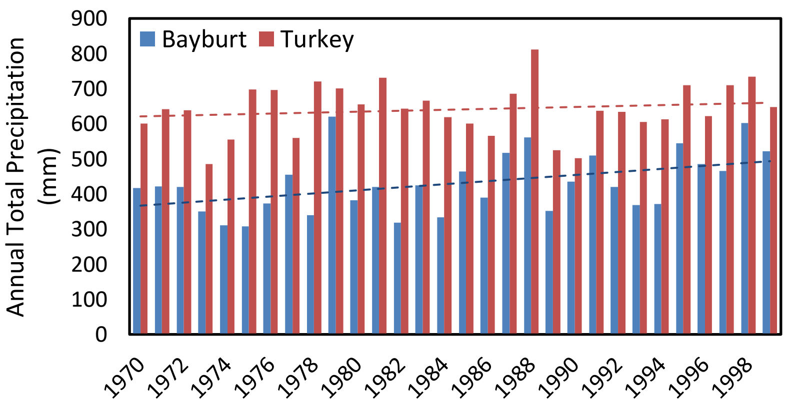

Figure 2. Comparative precipitation graph of Turkey in general and Bayburt city between 1970-1999.

Bayburt city has always received precipitation below the average of Turkey in the fifty-year period shown in the table. The lowest precipitation was in 1975 and the highest in 1979 (Figure 2). Although the amount of precipitation falling in the region varies over the years, it is understood that the ups and downs are visible between 1970-1999. It is concluded that the average rainfall in Turkey between 1970-1999 was 640 mm, while the average rainfall in Bayburt was 430 mm.

In the period from 2000 to 2019, the average precipitation amount shows less variability compared to the years 1970-1999 (Figure 3). It can be said that Bayburt city is closest to the average of Turkey in the years 2005, 2016 and 2018. It was concluded that the average precipitation in Turkey was 639.69 and the average precipitation in Bayburt city was 470 mm between 2000-2019. It was determined that there was an increase in the amount of precipitation falling in the region after 2000.

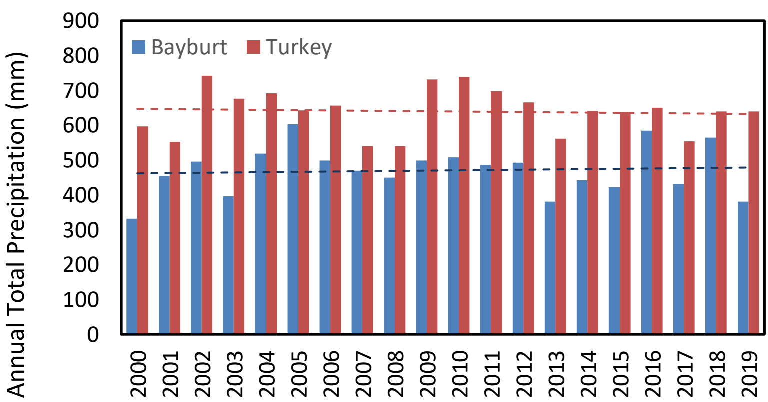

Figure 3. Comparative precipitation graph of Turkey in general and Bayburt city between 2000-2019.

The annual average of the relative humidity values of Bayburt province between 1970 and 1999 was 48.6%, the lowest annual average value was measured in 1999 with 39.1% and the highest annual average value was measured in 1970 with 54% (Figure 4a). Between 2000 and 2019, the average relative humidity value was 35.9%, the highest annual average relative humidity value was measured in 2019 with 30.1% and the highest annual average value was measured in 2001 with 41.8% (Figure 4b).

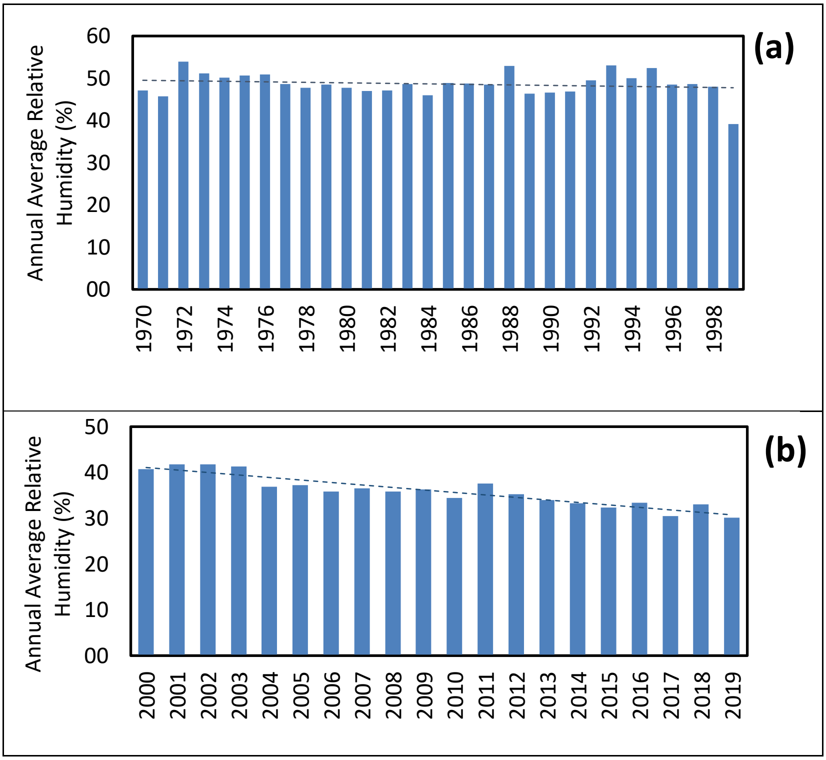

Figure 4. Annual average relative humidity change graph of Bayburt city between 1970-1999 **(a)** and 2000-2019 **(b)**.

Between 1970-1999, no significant increasing-decreasing trend was observed in the annual average relative humidity values of Bayburt province. On the other hand, it was observed that the annual average relative humidity values decreased significantly between 2000-2019 (Figure 4b). Again, as can be seen in Figure 3 and Figure 5, total annual precipitation and average annual temperature increased during these years, respectively. Temperature is inversely proportional to relative humidity, and the relative humidity decreased with the increase in temperature, resulting in precipitation. The reason for the increase in temperature, decrease in relative humidity and increase in precipitation is thought to be due to the ponds and dams constructed after 2000 in the vicinity of Bayburt, as well as the general global climate change.

2.1.2.TEMPERATURE

It is understood that the continental climate characteristics prevailing in the region cause the temperature values to show low indicators. The average temperatures of Turkey and Bayburt city between 1970-2019 are presented below (Table 2).

Table 2. Annual average temperature values of Turkey in general and Bayburt province between 1970-2019 (MGM, 2020).

Years	Average temperature Turkey	Average temperature Bayburt
1970	13.17	7.68
1971	12.45	6.99
1972	12.67	5.44
1973	12.87	6.08
1974	13.10	6.40
1975	12.02	6.19
1976	13.40	5.53
1977	13.15	6.48
1978	13.97	7.05
1979	12.92	7.89
1980	13.45	6.56
1981	12.72	8.00
1982	12.12	5.83
1983	12.52	6.51
1984	13.37	7.13
1985	12.85	6.43
1986	13.55	7.10
1987	12.75	6.44
1988	12.87	5.80
1989	13.47	6.78

Table 2. Continued.

1990	13.10	5.98
1991	13.35	7.18
1992	11.90	4.79
1993	12.27	5.86
1994	14.42	7.73
1995	13.30	7.01
1996	13.37	8.13
1997	13.10	6.50
1998	14.15	7.71
1999	14.35	7.94
2000	13.65	6.98
2001	14.65	8.03
2002	13.82	6.92
2003	13.40	7.16
2004	13.72	6.84
2005	13.55	6.98
2006	13.95	7.85
2007	14.07	7.33
2008	13.97	6.83
2009	13.90	7.73
2010	15.47	10.20
2011	13.47	7.21
2012	14.07	7.73
2013	13.70	6.94
2014	14.50	9.06
2015	13.80	8.37
2016	14.00	7.74
2017	13.70	8.28
2018	15.10	9.88
2019	14.40	9.03

Bayburt city shows temperature averages below Turkey's average every year in the fifty-year period shown in the table. The lowest average temperature between 1970 and 1999 was 4.79 °C in 1992 and the highest average temperature was 8.13 °C in 1996. Between 1970 and 1999, Turkey's average temperature indicator was 13.09 °C and Bayburt's average temperature indicator was 6.70 °C (Figure 5).

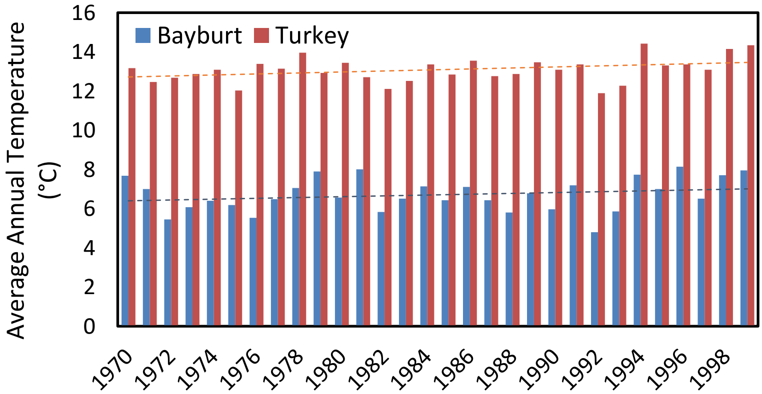

Figure 5. Comparative temperature graph of Turkey in general and Bayburt city between 1970-1999.

The average temperature graph of Turkey and Bayburt city between 2000-2019 is given below (Figure 6). Again in this time period, it is seen that the region has an average temperature below the average of Turkey. The lowest average temperature between 2000-2019 was 6.83 °C in 2008 and the highest average temperature was 10.20 °C in 2010. The average temperature in Turkey between 2000-2019 was 14.04 °C. In Bayburt, the average temperature in these years was 7.85 °C. Compared to the period between 1970-1999, there is an increase of 1 °C in the average temperature values in both Turkey and Bayburt between 2000-2019.

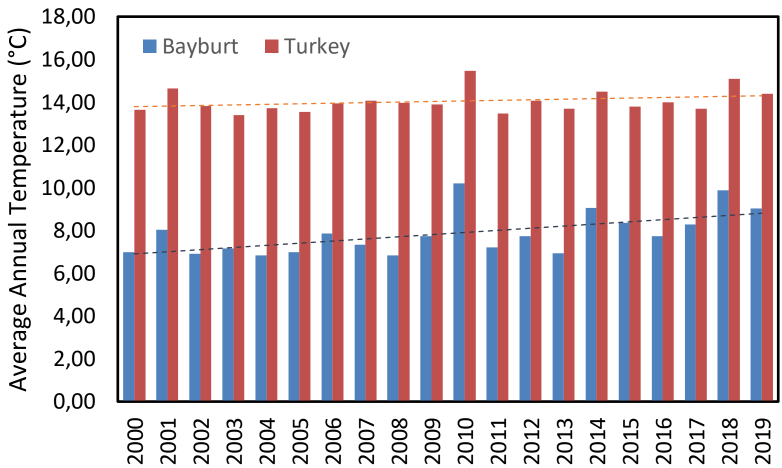

Figure 6. Comparative temperature graph of Turkey in general and Bayburt city between 2000-2019.

In the Bayburt region, especially after 2010, an increase in average temperature values is noticeable. Since 2014, we can say that annual temperature values have not fallen below 7.74 °C.

2.2. MUNICIPAL DRINKING AND POTABLE WATER STATISTICS

The water covered by this scope are water that are generally used for drinking, cooking, cleaning and other domestic purposes and for the preparation, processing, storage and marketing of foodstuffs and other products for human consumption, regardless of origin, in their original form or purified, either from the source or from the distribution network, and that meet the parameter values specified in the regulation on waters for human consumption and are not offered for sale for commercial purposes.

Table 3 presents the statistics of daily water withdrawal per capita for municipal drinking water in Turkey and Bayburt.

Table 3. Daily water withdrawal per capita in Turkey and Bayburt province between 2001-2018 (TUİK, 2020b).

Years	Bayburt (Liters/person-day)	Turkey (Liters/person-day)
2001	177	252
2002	194	255
2003	202	259
2004	210	255
2006	236	245
2008	246	215
2010	281	216
2012	281	216
2014	219	203
2016	104	217
2018	231	224

In the drinking and potable water comparison graph, it is seen that Bayburt was below the average of Turkey between 2001-2007. Since 2008, the rate of drinking and potable water withdrawal in Bayburt has been above Turkey's average, and although it fell below Turkey's average in 2016, it has risen above Turkey's average again in 2018 (Figure 7). In 2008, the opening of Bayburt University and the addition of new academic units every year thereafter has been a major factor in the increase in the total amount of water withdrawn, affecting both the living spaces and the increase in the population residing in the city, although not registered in the city population. In addition, dynamic changes in the city population are also among the factors that cause the amount of water withdrawn to show different trends.

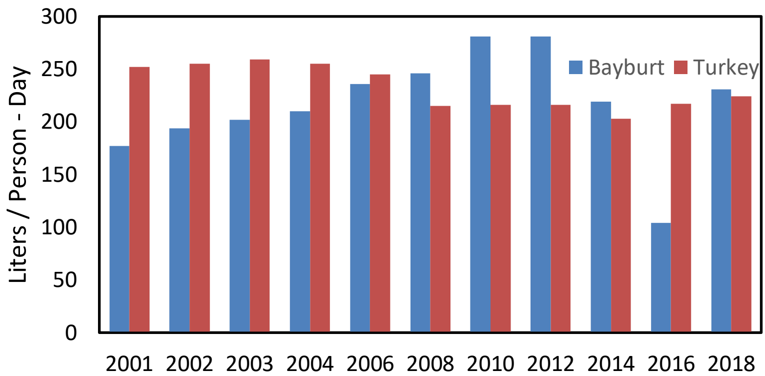

Figure 7. Graph of change in annual average daily water withdrawal per capita for Turkey in general and Bayburt province between 2001-2018.

The total annual withdrawal amount for drinking and potable water network of Bayburt province between 2001-2018 is presented in the table and graph below (Table 4, Figure 8). The average drinking and potable water withdrawal between 2001-2018 was 3,994 m^3. The lowest consumption was 2336 m^3 in 2016 and the highest consumption was 4993 m^3 in 2012.

Table 4. Total annual water withdrawals for drinking and municipal water in Turkey and Bayburt province between 2001-2018 (TUİK, 2020b).

Years	Bayburt (thousand.m^3 /year)	Turkey (thousand.m^3 /year)	% Rate
2001	3512	4664411	0.075
2002	3841	4813097	0.080
2003	4045	4918477	0.082
2004	4168	4954292	0.084
2006	3931	5163500	0.076
2008	4091	4546574	0.090
2010	4633	4784734	0.097
2012	4993	4936342	0.101
2014	3978	5237407	0.076
2016	2336	5838561	0.040
2018	4226	6193158	0.068

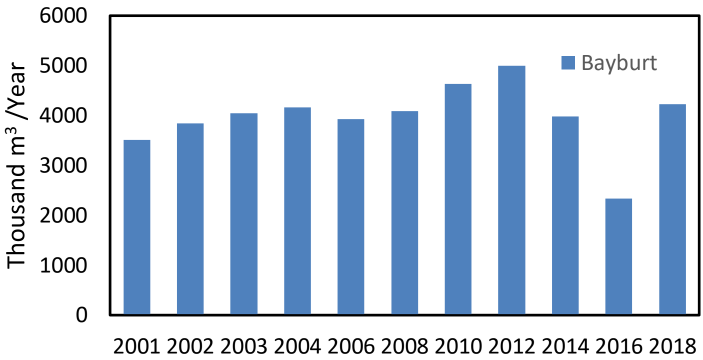

Figure 8. Graph of change in the annual total amount of water withdrawn for drinking and potable water network in Bayburt province between 2001-2018.

Table 4 and Figure 9 show the total amount of water withdrawn annually from the drinking and potable water network in Turkey between 2001-2018. It is observed that drinking and potable water withdrawal has increased in parallel with the increase in population. The average drinking and potable water withdrawal in Turkey between 2001-2018 was 5,095,504 m^3.

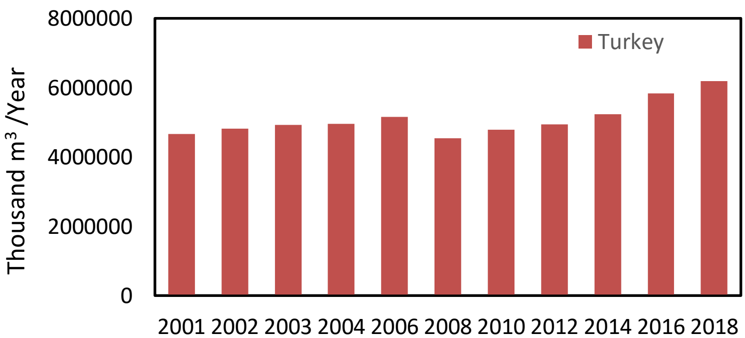

Figure 9. Graph of the change in the annual total amount of water withdrawn from the drinking and potable water network in Turkey between 2001-2018.

When we look at the ratio of the total amount of water withdrawn in Bayburt between 2001 and 2018 with that of Turkey in general, it is seen that there was a noticeable increase from 2001 to 2012, and this ratio started to decrease after 2012 (Figure 10). This decreasing trend is thought to be affected by the undeniable population living in other cities, even though they are registered to Bayburt population.

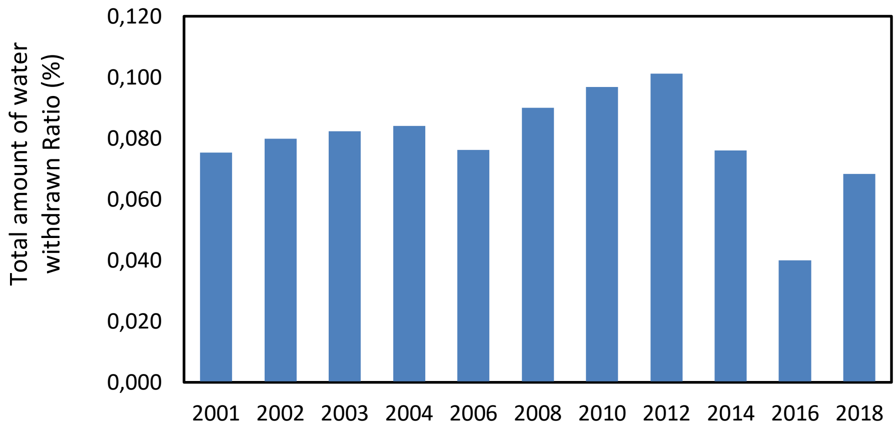

Figure 10. The graph of the change in the ratio of the total amount of water withdrawn annually for drinking and potable water network in Bayburt province between 2001-2018 to Turkey in general.

2.2.1. WASTE WATER TREATMENT

While only 93 thousand cubic meters of wastewater was treated annually in 2008, with the Bayburt Wastewater Treatment Plant, which became operational in 2015, 1887 million cubic meters of wastewater was treated annually in 2016 and 2611 million cubic meters in 2018 (TÜİK, 2020b) (Figure 11). Prior to 2015, most of the wastewater was discharged into the Çoruh River in the middle of the city, while some was released onto the land. This caused pollution of soil and water, which are indispensable resources for living life. With the commissioning of the wastewater treatment plant, the management of our soil and water resources in terms of quality and quantity has started to be provided more effectively and has ensured that our surface and underground water resources, which are under the pressure of climate change, which we face on a global scale, remain of better quality and usable quality.

Considering the increase in the amount of wastewater generated in parallel with the gradual increase in population, the value added to environmental health by the continuously increasing wastewater treatment capacity of Bayburt province is undeniable.

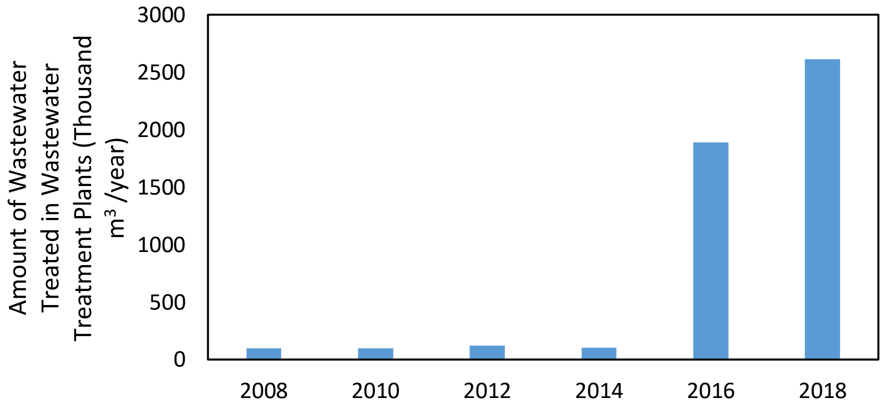

Figure 11. Graph of change in the amount of wastewater treated by municipal wastewater treatment plants in Bayburt between 2008-2018.

2.3. AIR QUALITY

In determining urban air quality, monitoring of various parameters (SO_2, NOx, COx, O_3, PM10, PM 2.5, etc.) taking into account the source profile of the city and the region (industrial area, heavy traffic, dense urbanization, etc.) and monitoring of PM_{10} suspended in the air and SO_2 gas from fossil fuel combustion will give a sufficient idea for a city with a small population and very little industrial and traffic density.

PM_{10} refers to particles suspended in the air that are less than 10 micrometers in diameter. Exposure to PM10 also causes adverse respiratory effects, including asthma attacks (EPA). The maximum limit value of PM10 in Turkey is 40 μg/m^3 per year. Values above this limit pose a threat to human environmental health.

SO_2 is a colorless, asphyxiating and acidic gas produced by the combustion of sulfur compounds found naturally in fossil fuels. Short-term exposure to SO_2 is linked to respiratory effects such as difficulty breathing and increased asthma symptoms. Children and the elderly are most at risk (EPA). The maximum limit value of SO_2 in Turkey is 20 μg/m^3 per year. Values above this limit pose a threat to human health in the human environment. PM10 and SO2 measurements in the air in Bayburt province have started to be measured since 2006. Table 5 shows the annual PM10 and SO_2 values measured in Bayburt province between these years and Turkey averages.

Table 5. Annual average PM10 and SO_2 values measured in Turkey and Bayburt province between 2006-2019 (ÇMO, 2019).

Years	Bayburt		Turkey	
	PM10 (μg/m^3)	**SO_2 (μg/m^3)**	**PM10 (μg/m^3)**	**SO_2 (μg/m^3)**
2006	51	23.0	105.0	112
2007	57	37.0	87.5	56
2008	68	27.0	81.7	31
2009	43	25.0	73.7	19
2010	67	16.0	72.3	16
2011	48	9.0	63.3	20
2012	65	4.0	61.7	17
2013	53	7.7	59.4	19
2014	53	5.0	55.3	18
2015	24	5.5	56.9	17
2016	54	6.9	55.7	15
2017	38	5.7	55.3	13
2018	44	5.6	51.0	12
2019	34	8.9	45.0	11

The average amount of PM10 in the air in Bayburt province is 49.44 µg/m^3 , the lowest amount was measured as 24 µg/m^3 in 2015 and the highest amount was measured as 68 µg/m^3 in 2008. In terms of the limit values valid in Turkey, when the PM10 amounts measured in Bayburt are evaluated, it is observed that between 2006 and 2019, only in 2015, 2017 and 2019, values below the limit value of 40 µg/m^3 were observed, while the limit values were exceeded in other years (Table 5). The annual variations of the Turkey average of PM10 vary between 45 µg/m^3 (2019) and 105 µg/m^3 (2006) (Table 5). In Turkey, national limit values for PM10 were exceeded in all years between 2006 and 2019. Only in 2012, the PM10 value measured in Bayburt province was above the national average (Table 5).

It is seen that there is a general decrease in the amount of PM10 in the air in Bayburt province from 2006 to 2019 (Figure 12). In parallel with this, Figure 12 shows that the annual average amount of PM10 in Turkey has clearly decreased.

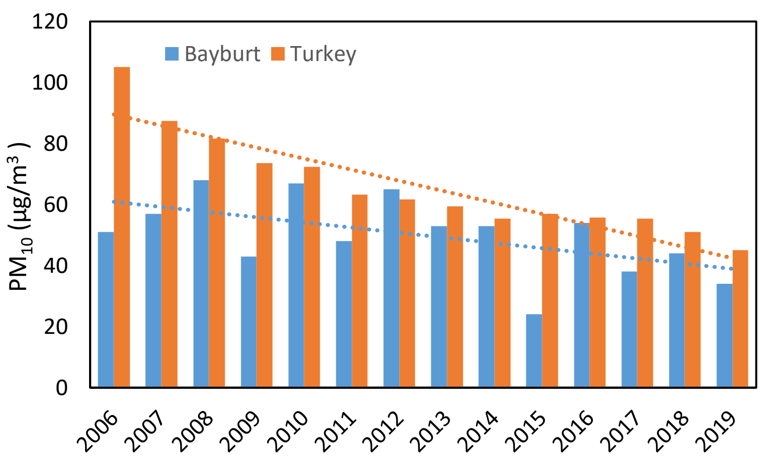

Figure 12. Graph of change in annual average PM10 amounts measured in the air in Turkey and Bayburt.

The average amount of SO_2 in the air in Bayburt province is 14.2 µg/m^3 , the lowest amount was measured as 4 µg/m^3 in 2012 and the highest amount was measured as 37 µg/m^3 in 2007.

In terms of the limit values valid in Turkey, when SO_2 amounts measured in Bayburt are evaluated, it is observed that between 2006 and 2019, only in 2010 and the following years, values below the limit value of 20 µg/m^3 were observed, while the limit values were exceeded in other years (Table 5).

The annual changes of the Turkey average of SO_2 vary between 11 µg/m^3 (2019) and 112 µg/m^3 (2006) (Table 5). In Turkey, between 2006 and 2019, amounts below the national limit values in terms of SO_2 were observed in 2009 and the following years, while the limit values were exceeded in other years. Only in 2009, SO_2 values measured in Bayburt province were above the national average (Table 5).

It is seen that there is a general decrease in the amount of SO_2 in the air in Bayburt province from 2006 to 2019 (Figure 13). In parallel with this, it is seen in Figure 13 that the annual average amount of SO_2 in Turkey has also decreased clearly. One of the most important factors of the decrease in the amount of SO_2 in the air both in Bayburt and in Turkey is the transition of the heating system in houses to the natural gas system. The transition to natural gas in Bayburt started in 2008 and then gradually all households in the city center were brought together with natural gas (www.haberler.com). The effect of this situation on the amount of SO_2 in the air is clearly seen in Figure 13.

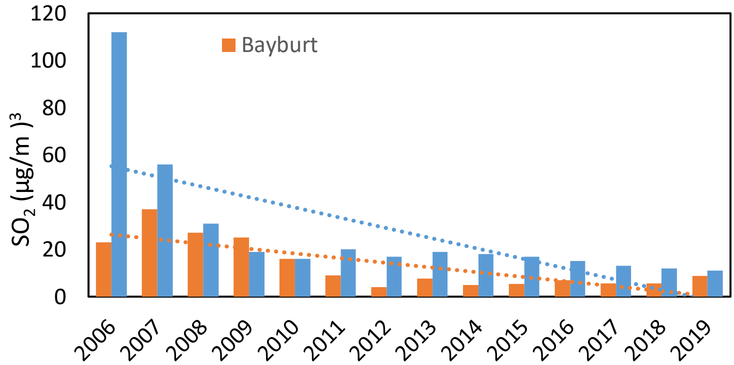

Figure 13. Graph of the variation of annual average SO_2 amounts measured in the air in Turkey and Bayburt.

2.4. SOLID WASTE AMOUNT AND DISPOSAL

The average amount of solid waste per capita per day in Bayburt province between 2001 and 2018 was 1.42 kg, the highest waste per capita per day was 2.22 kg in 2003 and the lowest was 0.9 kg in 2018 (Table 6). The daily amount of waste per capita for Bayburt province decreased considerably from 2001 to 2018, and the rate, which was above the average of Turkey until 2006, fell below the average of Turkey after 2006 (Figure 14).

Table 6. Average amount of municipal solid waste per capita in Bayburt province between 2001-2018 (TUIK, 2020c).

Years	Waste Amount (Kg/Person-Day)	
	Bayburt	**Turkey**
2001	1.66	1.35
2002	1.63	1.34
2003	2.22	1.38
2004	1.85	1.31
2006	2.17	1.21
2008	1.03	1.15
2010	1.09	1.14
2012	0.95	1.12
2014	1.16	1.08
2016	0.77	1.17
2018	0.9	1.16

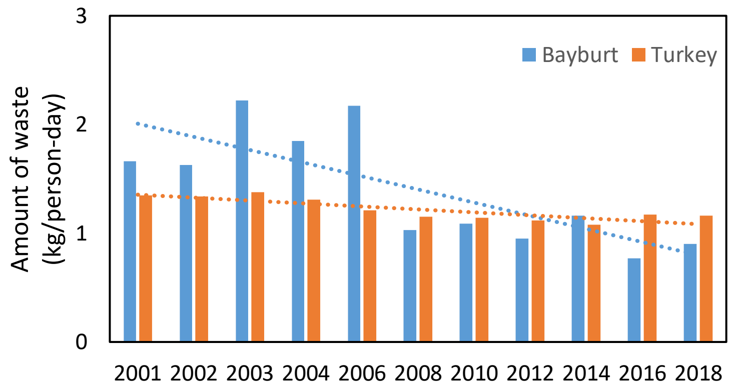

Figure 14. Graph of the change in the average amount of municipal solid waste per capita in Turkey and Bayburt Province between 2001-2018.

As can be seen in Table 7, many different methods are used for the disposal of waste. In the early 2000s, wastes were mostly stored in municipal dumps, but were also disposed of by burial, dumping in rivers or lakes and open burning. In 2008, with the commissioning of Bayburt Solid Waste Landfill, 73% of the total amount of waste was disposed of by landfilling in 2009, while this rate increased to approximately 92% in 2018. The annual changes in waste amounts according to the methods used in waste disposal are detailed in Table 7. The regular storage and disposal of solid waste provides a great advantage in terms of environmental health. With the increase in population, the total amount of waste generated annually will gradually increase the pressure of these wastes on environmental health. In this case, storage and disposal of wastes with correct and healthy methods will become even more important. The Landfill Site currently in use in Bayburt province has minimized the negative impacts of wastes on the environment for Bayburt province. In addition, with the "Site Determination Study for Landfills and Alternative Solid Waste Disposal Systems Research

Project" (Yıldırım et al., 2017) supported by DOKAP (Eastern Black Sea Project Regional Development Administration), alternative landfills for Bayburt province and the possibility of landfilling for the future have been provided in terms of site selection.

Table 7. Waste amounts of Bayburt province according to solid waste disposal methods between 2001-2018 (TUIK, 2020c).

Waste Amount by Disposal Method (tons/year)	Years										
	2001	2002	2003	2004	2006	2008	2010	2012	2014	2016	2018
Open Burning	540	-	-	-	-	-	-	-	-	-	-
Storage in Another Municipal Landfill	2068	-	1825	1830	2109	-	-	-	-	-	-
Municipal Landfill Storage	29805	31115	42845	35027	33789	14592	2546	393	395	2500	1390
Other Disposal Operations	-	1338	-	366	-	-	2356	4265	3960	-	-
Landfill	-	-	-	-	-	2261	13013	12179	16690	14593	15093
Embedding	673	476	-	-	191	-	-	-	-	-	-
Dumping into Rivers, Streams and Lakes	450	-	-	-	-	-	-	-	-	-	-

3. CONCLUSION AND EVALUATION

In Bayburt, which has a transitional climate between the Eastern Black Sea region with abundant rainfall and the Eastern Anatolia region with short and cool summers and cold and long winters, summers are cool and dry and winters are cold and rainy. The average annual precipitation measured in Bayburt between 1979 and 2019 varies between 307.4 mm and 620.8 mm, and the average annual temperature between 4.79 °C and 10.20 °C. The average annual precipitation and temperature amounts measured in all years during this period are below the average of Turkey. Although the long and cold winters affect open field agriculture and animal husbandry activities in the region, the cool summers increase the quality of life in the region. Under the changing climate pressure, increasing temperatures on a global scale and decreasing precipitation increase the pressure on existing water resources, which further increases the importance of water resources management.

In Bayburt province, drinking and potable water needs are met from some groundwater and surface water sources. Between 2001 and 2018, the annual average daily water withdrawal per capita for Bayburt province varied between 104 liters and 281 liters and this amount increased continuously from 2001 to 2012 and showed an irregular trend after 2012. After 2006, except for 2016, the annual average amount of water withdrawn per capita in Bayburt province has shown values above the average of Turkey. Considering the ongoing climate pressures, it is thought that this high amount of water use may lead to future water use and resource problems. For this reason, the amount of water withdrawn and used should be evaluated and planned under an integrated water management plan in terms of existing water resources and utilization.

In order to determine the air quality in Bayburt province, measurement stations were established in 2006 and PM10 (particles suspended in the air with a diameter of less than 10 micrometers) and SO_2 (a colorless, suffocating and acidic gas released as a result of the combustion of sulfur compounds in the natural structure of fuels) parameters were started to be measured in terms of air quality. The annual average amount of PM10 varies between 24 µg/m^3 and 64 µg/m^3 between 2006-2019 and it is seen that the amount of PM10 in the air decreased towards 2019 in general. In addition, the PM10 values measured in Bayburt province during the measurement period are generally below the average of Turkey and only in 2012, the value measured in Bayburt province showed a value above the average of Turkey. However, even though these values are below the average of Turkey, the annual average limit value of PM10 in Turkey is 40 µg/m^3 and according to the values measured in Bayburt, this value was not exceeded only in 2015, 2017 and 2019. The fact that this limit value was exceeded in other years, even though it was not exceeded in high amounts, shows that measures should be taken for air quality in the city. The annual average amounts of SO_2 measured in Bayburt between 2006-2019 vary between 4.0 µg/m^3 and 37.0 µg/m^3 . The annual average amounts of SO_2 have shown a continuous decrease from 2006 to 2019 and except for 2009, these amounts have been below the average of Turkey during the other years of measurement. From 2006 to 2009, the annual average of SO_2 in the air in Bayburt was above 20 µg/m^3, which is the limit value specified for Turkey, while the limit value was never exceeded after 2009 and the amounts of SO_2 showed very low values. This situation has resulted from the decreasing use of fossil fuels with the increase in the use of natural gas in the city. In order to maintain the air quality at healthy levels, the use of resources such as natural gas instead of fossil fuels should be increased, and exhaust gases emitted from vehicles should also be monitored. For a cleaner and greener Bayburt in the future (the lack of industry and low traffic are important advantages for Bayburt in this regard, and it may be the first province to receive the title of Green City). Preparation of Clean Air Action Plans and structuring the city accordingly will be important for the future of the city.

REFERENCES

EPA. Air Pollution Can Affect Our Health and Environment in Many Ways.

TMMOB, Chamber of Environmental Engineers (ÇMO), (2019). Air Pollution Report. 113 s.

MGM, (2020). General Directorate of Meteorology. Ankara.

TUİK, (2020a). 2020 Population Statistics Data. Ankara: Turkish Statistical Institute.

TUİK, (2020b). 2020 Municipal Water Statistics. Ankara: Turkish Statistical Institute.

TUİK, (2020c). 2020 Municipal Waste Statistics. Ankara: Turkish Statistical Institute.

Yıldırım, V., Bediroğlu, Ş., Erbaş, Y.S., Memişoğlu, T. et al. (2017) Final Report of the Research Project on Location Study for Landfills and Alternative Solid Waste Disposal Systems. Republic of Turkey Ministry of Development Eastern Black Sea Project Regional Development Administration (DOKAP) Environment and Tourism Coordinatorship, 249s.

https://www.haberler.com/bayburt-ta-dogalgaz-altyapi-calismalari-basladi-haberi/ (accessed on 23.01.2020 at 20:04).

CHAPTER 2

MEDICINAL AROMATIC PROPERTIES AND USES OF ARONIA (*Aronia melanocarpa* L.)

Lecturer PhD. Betül GIDIK[1], PhD. Bayram YURTVERMEZ[2], Kübra KILIÇ[3]

DOI: https://dx.doi.org/10.5281/zenodo.14544648

[1] Bayburt University, Faculty of Applied Sciences, Department of Organic Agriculture Management, Bayburt 69000, Turkey. https://orcid.org/0000-0002-3617-899X

[2] Bayburt University, Graduate School of Education, Department of Organic Agriculture Management, PhD Program, Bayburt 69000, Turkey. https://orcid.org/ 0000-0001-9726-3672

[3] Bayburt University, Graduate School of Education, Department of Organic Agriculture Management, Master's Program with Thesis, Bayburt 69000, Turkey. https://orcid.org/0009-0002-3331-0737

INTRODUCTION

Plants have been used in many areas such as food, fuel, clothing and medicine since the existence of humanity. As the first data, in the graves where human remains were found in Şanidar Cave in Northern Iraq in 1957, plant remains such as cornflower, purple hyacinth, yarrow, ragweed, hollyhock and ephedra, which are thought to be 60 thousand years old, are accepted The first records of the use of plants for treatment purposes were encountered in the civilizations living in Mesopotamia in 5000 BC, and the remains of 250 plant drugs belonging to this period were identified (Lewin, 2000; Heinrich, Barnes, & Gibbons, 2004; Williamson, 2004).Later on, the communication between humans and plants developed continuously, researches increased and this communication led to the birth of ‘ethnobotany’, a field accepted by the whole world (Koçyiğit, 2005).

Concept of Medicinal Aromatic Plants (MAP)

Medicinal aromatic plants do not have a specific meaning as a Word.This name is formed by combining the terms "medicinal," meaning healing and therapeutic, with "aromatic," meaning a plant that gives off a pleasant smell and taste, creating a meaningful whole. While medicinal plants are preferred for cosmetic, physical health, food and ambient odour purposes, aromatic plants are used to give a good smell to the environment and to flavour food (Anonymous, 2005a). The medicinal qualities, low toxicity, ease of availability, and affordability of herbal pharmaceutical medicines and supplements have made them more and more popular in recent years (Gerçek et al., 2022). According to the

World Health Organisation (WHO), medicinal and aromatic plants are plants that can be used in complementary (traditional) medicine, in the prevention of physiological and psychological diseases, identification and treatment of them, as well as in maintaining a quality life in terms of health, also are the whole of knowledge, skills and practices that may change according to cultures and beliefs (Anonymous, 2005b). Many plants are known to have numerous key pharmacological properties, including anti-Alzheimer's disease, antioxidant, antidiabetic and anti-inflammatory effects (Bahadori et al., 2016; Yuca et al.,2024).

In recent years, the increase in the use of synthetic products has revealed many new diseases. This situation has taken people back to the past and encouraged them to use herbal origin products (Aslan and Karakuş. 2019). With the development of technology, plants have started to be used not only in pure form and as food, but also in many areas such as medicine, cosmetics, paint industry, textile and landscaping. In recent years, interest in herbal products has increased and extensive research has been conducted on their bioactive effects such as antioxidant, antimicrobial, anti-inflammatory and anticancer effects (Sefalı, 2023). This increased interest in plants has naturally led to the re-establishment of the supply-demand balance and the interest in medicinal aromatic information reached high levels in a short time (Yurtvermez and Gıdık, 2021).

Turkey is one of the countries that has the necessary ecological conditions for the cultivation of medicinal and aromatic plants and its alternative usage areas are increasing day by day. However, among these biological riches, plants containing essential oils have an important place in economic terms (Göktaş and Gıdık, 2019). One of these plants is Aronia (*Aronia melanocarpa*), a grape fruit.

Grape Fruits

In plant science, grape fruits are generally known as fleshy fruits produced from a single ovary. The most widely known berries in the society are blueberry (*Vaccinium corymbosum*), blackberry (*Rubus fruticosus*), red raspberry (*Rubus idaeus*), black raspberry (*Rubus occidentalis*), colour grape (*Ribes nigrum*), strawberry (*Fragaria ananassa*), cranberry (*Vaccinium macrocarpon*), black elderberry (*Sambucus nigra* L.) and bird cherry (*Aronia melanocarpa*) (Ağaoğlu and Gerçekcioğlu 2013).

Grape fruits contain bioactive components such as phenolic acids, flavonoids, tannins, stilbenes, flavanols, vitamins and minerals, especially anthocyanins; rates of these components may vary according to their species, genetic diversity, growing conditions and harvest time differences (Çağlar and Demirci, 2017).

Aronia (Chokeberry)

Aronia is defined as;

Department of Angiosperms (Closed seeds),

Subdivision of Eudicolydon (Dicotyledons),

Class of Meloideae

Team of Rosales,

Family of Rosaceae (Rosaceae)

Subfamily of Amygdaloideae

Genus of Aronia

Rosaceae is an important family consisting of fruits, nuts, ornamental plants and medicinal plants with high nutritional value, health benefits and economic importance. It consists of 3 subfamilies, approximately 3000 species and 95 genera (Brand, 2010). It is known that the fruit parts of some species have the potential to prevent cancer thanks to the phytochemicals and antioxidants they contain. Species belonging to the genus *Rosa* are valuable for their antioxidant and antimicrobial properties. Especially the fruits are reported to be richer in antioxidants than the seeds (Gıdık et al., 2019). Aronia (Chokeberry) is one of these species.

Aronia grows naturally in the eastern parts of North America and Canada, under trees and in swampy areas. It was first brought to Russia from the American continent in the early 1900s and began to be grown in this region. It has been naturalized in Eastern Europe, mainly in Germany, since 1950; its production has increased considerably, especially in Poland (Borowska and Brzoska, 2016).

There are three different species of the Aronia genus, known as chokeberry: *A. melanocarpa* (black chokeberry), *A. prunifolia* (purple chokeberry) and *A. arbutifolia* (red chokeberry). *A. prunifolia* is considered a hybrid formed by the combination of two other species (Figure 1.) (Özder. 2021).

A. arbutifolia *A. prunifolia* *A. melanocarpa*

Figure 1: Aronia species (Özder. 2021)

Aronia (*Aronia melanocarpa*)

Aronia plant is a perennial type of grape fruit in the form of a bush. The plant can reach up to 2-2.5 meters in height, its leaves are pointed, oval-shaped, green and hairy. The root system is thin, fibrous without hairs. It is a long-lived species whose roots can spread up to 3 m from the base of the plant (Figure 2.) (T.V.O. 2022).

Figure 2: Aronia *(Aronia melanocarpa)* plant (T. V. O. 2022)

Aronia plant, although its natural distribution areas are generally temperate, humid, sunny or partially sunny places, can grow not only in temperate climate conditions but also in temperatures below -35° C due to its resistant and durable structure against cold. Towards the end of spring, small white flowers bloom and over time the fruits ripen and turn into a shiny black color, and they fully ripen between August and September. The diameter of the fruits varies between 6-13 mm and their weight varies between 0.5-2 gr. Studies have reported that the highest grain weight and optimum anthocyanin content in terms of quality are in fruits collected in early September (Özdiz, 2021).

It is known that the fruit and leaf parts of Aronia, which has an important place in human history, have been used by the natives for centuries as food and as a medicine for the treatment of colds, that its dried fruits are added to meals and its leaves are dried and consumed as tea. Aronia, which has a very rich structure in terms of antioxidants, is the fruit with the highest antioxidant content among grape fruits. Aronia, also known by names such as Aronia Berry and Black Chokeberry, is a dense source of minerals and vitamins. For this reason, it is also described as a 'Super Fruit' (Şahin and Erdoğan. 2022).

Although different parts of the Aronia plant are used in many areas, the most used part is its fruits. Fruit size can vary between 7-18 mm and its weight can vary between 0.9-2.1g. Aronia fruits, which are rich sources of anthocyanins, mainly contain components such as cyanidin-3- o-galactoside, cyanidin-3- o-xyloside, cyanidin-3- o-arabinoside and cyanidin-3- o-glucoside. It is also rich in polyphenols, which are a subclass of anthocyanin (Özbucak and Gümüş, 2024). As a result of the studies, its positive effects on cardiovascular diseases, diabetes, urinary tract inflammation and various viral diseases have been proven due to its rich bioactive component content.

In addition to its main polyphenolic compounds and high antioxidant capacities, Aronia also has anti-inflammatory, anticancer, antimicrobial, antidiabetic, antiatherosclerotic, antiviral, anti-inflammatory, antiplatelet and hypotensive properties (Table 1) (Şahin and Erdoğan. 2022).

Table 1: Antioxidant capacity of some grape fruits (SORAGE method)

Type	Antioxidant Capacity (µmol Trolox/g)	References
Aronia (*Aronia melanocarpa*)	160.2	(Zheng and Wang, 2003)
Black Currant (*Ribes nigrum*)	36.9-93.1	(Moyer et al., 2002)
Bilberry (*Vaccinium myrtillus*)	44.6	(Prior et al., 1998)
Blueberry (*Vaccinium corymbosum*)	16.8-42.3	(Prior et al., 1998)
Strawberry (*Fragaria ananassa*)	15.3-24.3	(Wang et al., 1996) (Proteggente ve ark., 2002)
Blackberry (*Rubus fruticosus*)	14.8-22.6	(Jiao and Wang, 2000)
Raspberry (*Rubus ideaus*)	18.49	(Proteggente et al., 2002)
Cranberry (*Vaccinium macrocarpon*)	8.2-14.1	(Wang and Stretch, 2001)

It has been determined that approximately 40% of the antioxidant activity of aronia is due to procyanidins, the content of total procyanidins reaches the highest value in unripe fruits, and as fruit maturity increases, the content of procyanidins and antioxidant activity gradually decrease (Sidor and Gramza-Michałowska, 2019).

Phenolic compounds are known as the most common antioxidant group. Ascorbic acid, vitamin E and carotenoids are the most common antioxidants. Grape fruits are known for containing a wide variety of bioactive compounds such as organic acids, tannins, flavonoids, anthocyanins and phenolic compounds (Kokotkiewicz et al., 2010; Acet et al., 2020). Evaluation of the Effects of Rosemary (*Rosmarinus officinalis*) Essential Oil and Aronia (*Aronia melanocarpa*) Extract on Liver Damage in Rats. Studies have shown that they are more concentrated in aronia than other grape plants (Sakallı, 2023). Phenolic compounds are secondary metabolites synthesized by plants in stress conditions (infection, injury, and UV radiation) in addition to natural processes such as growth and development (Table 2). These compounds play a role in the defense mechanisms of plants against pests such as insects, parasites and viruses. They also contribute to the properties of foods such as taste, color, odor, astringency, bitterness, and oxidative stability (Tokuşoğlu, 2018).

Table 2: Phenolic compound content ratios of some grape fruits (mg/100 g fresh fruit)

Type	Phenolic compounds (mg/100 g fresh fruit)	References
Aronia (*Aronia melanocarpa*)	662.5-690.2	(Benvenuti et al., 2004)
Black Currant (*Ribes nigrum*)	498-1342	(Moyer et al., 2002)
Bilberry (*Vaccinium myrtillus*)	525	(Prior et al., 1998)
Blueberry (*Vaccinium corymbosum*)	261-585	(Prior et al., 1998)
Strawberry (*Fragaria ananassa*)	317.2-443.4	(Skupień and Oszmiański, 2004)
Blackberry (*Rubus fruticosus*)	417-555	(Jiao and Wang, 2000)
Raspberry (*Rubus ideaus*)	192-359	(Anttonen, and Karjalainen, 2005)
Cranberry (*Vaccinium macrocarpon*)	120-176.5	(Wang and Stretch, 2001)

More than 49 volatile compounds have been identified in aronia, such as benzaldehyde cyanohydrin, phenylacetaldehyde, hydrocyanic acid, benzaldehyde, benzyl alcohol and 2- phenylaethanol. The main components of the aqueous part obtained from aronia fruit are compounds belonging to chemical groups, which are 48.9%, 5.8% acids, 2.9% aldehydes, 0.6% terpenes, 0.3% esters, 0.2% hydrocarbons and 1.3% others (Metiner and Ersus, 2023).

All data obtained from studies on the effect of Aronia fruit parts on human health have revealed that the plant has a high value compared to many other fruits in terms of anthocyanin amount and antioxidant çapacıya. It has been determined that consuming Aronia fruits plays a protective role against colds, stomach diseases, digestive system diseases, cardiovascular diseases, liver, gallbladder diseases and some cancer diseases (Engin, 2020).

The fact that aronia berries play a protective role in many diseases and have biochemical contents shows that they are a good medicinal aromatic plant, and they are accepted as a medicinal plant in Russia (TVO, 2020).

Usage areas of aronia (*Aronia melanocarpa*)

Today, with the increasing interest in healthy and natural nutrition, Aronia, which is a functional medicinal aromatic food thanks to its nutritional properties, is consumed as fresh fruit, and in addition, the use of its processed products such as fruit juices, jams, wines and liqueurs is increasing in Turkey and the World (Figure 3.).

Figure 3: Different usage areas of Aronia (*Aronia melanocarpa*) fruits (T. V. O. 2022)

Known for its high antioxidant capacity, Aronia berries have been used in various industries thanks to its hard, sour and bitter taste and permanent dark purple color, Aronia berries are used in the production of fruit juice, cake, bread, yogurt, sauce, ice cream, wine, spices, marmalade, alcoholic beverages, gum and vinegar, in addition to being used as fresh fruit (Kulling and Rawel, 2008). Aronia juice is used in the food and pharmaceutical industries to increase color intensity, antioxidant capacity, flavonoid and nutritional value. It is also used as a natural colorant in the food industry (Del Bo and Ark, 2015). Anthocyanins found in Aronia, which have become increasingly popular in almost every part of the world in recent years, are used in dietary supplements and syrups as a blood pressure supporter in healthy or overweight adults, for their lipid-lowering and cardiovascular disease-reducing effects (Demirezer, 2010).

Modern pharmacological studies show that the biological activities of Aronia fruit extract that is rich in anthocyanin, includes antioxidative, anti-hyperglycemic, anti-mutagenic and cardioprotective properties, and also has numerous health benefits and health-promoting activities, and does not have any toxic effects on healthy cells (Doshi et al. 2006, Yılmaz et al. 2021). Aronia is also an important source of energy and vitamins (Table 3). It is refered to a functional food due to the high antioxidant activity of its fruit content (Poyraz et al., 2016).

Table 3: Content ratio of Aronia berries (g/100 g)

Contents	Ratio (g/100 g)
Water	70-80 g/100 g
Fiber	5,62 g/100 g
Glucose and fructose	13-17,6 g/100 g
Oil	0,14g/100 g
Protein	0,7 g/100 g

Aronia plant leaves are used as ornamental plants due to their white flowers in spring, red leaves and red-black fruits in autumn, and the fruits can also be consumed as dried snacks (Figure 4.).

a.Spring Aronia flowers b.Autumn Aronia leaves

Figure 4: Aronia flowers and leaves (T. V. O. 2022)

Studies show that the majority of the phenolic content in the fruit of Aronia is procyanidins and anthocyanins. In dried fruits, the weight ratio varies between 0.66-5.18% procyanidin, 0.60-2.00% anthocyanins, and the total phenolic content varies between 2-8 thousand mg/100g. In addition, thanks to their high pectin content, they can be used in mixed jam production with low-pectin fruits and can be used as an addition to improve the color, taste and antioxidant properties of jams (Jurikova et al., 2017).

In vitro and in vivo studies have shown that aronia berries have antiviral, anticancer, antidiabetic, antibacterial, anti-inflammatory, antimutagenic, gastroprotective, cardioprotective, hepatoprotective, radioprotective and immunomodulatory activities (Pop et al., 2022). In addition, studies on their antioxidative activities have shown that they significantly inhibit LDL (low-density lipoprotein) oxidation (Gralec et al., 2019).

Aronia plants are also used as landscape plants. They are attractive ornamental plants for gardens, especially with their reddened leaves in winter. They are naturally forest edge plants and grow well under semi-shaded trees. Some species, especially *A. melanocarpa,* Autumn magic and Chokeberries*, A. arbutifolia* 'Brilliant' species, are grown for their leaf colors in autumn (Sağlam, 2024).

Although they can grow in almost any type of soil, less fertile soils are preferred for species grown specifically for landscaping purposes, as smaller-sized individuals are selected (Lavefve et al., 2021).

Aronia is a slow-growing shrubby plant. Depending on the environment and growth rate of the plant, it starts to bear fruit in its second and third years. If suitable climatic conditions occur and the plant's development is complete, it reaches its maximum yield of 8-10 kg of fruit per plant at the age of 10. It is usually harvested by hand from the end of August to October, but it can also be harvested mechanically. When the fruits are not picked, they dry on the branch without rotting, so the fruit can be harvested at any time (Koçyiğit, 2005).

Although Aronia spread to the world from the USA, most of its production has been done in Poland in recent years. Poland is still ranked 1st in the world with aronia production in an area of approximately 15,000 acres. 90% of the production is exported as fruit juice concentrate. Aronia production in Poland has increased by 2,698% from 65 acres to 1,819 acres in the last 10 years (Fidancı, 2015)

Aronia has been noticed in Turkey in recent years. First, in 2008, experimental studies were carried out with 30 seedlings brought from Tatarstan, and when successful results were obtained and the desired yield was achieved, a plantation was established in the experimental area of the Atatürk Horticultural Central Research Institute in 2012 and seedling production studies were started. This successful initiative paved the way for aronia production in Turkey and offered farmers a new alternative product. Aronia seedlings were registered in Turkey in 2017 and certified seedling production has started since then. Commercial aronia gardens have been established in various cities such as Yalova, Kırklareli, Konya and Manisa (Engin, 2020).

Turkey's climate is quite suitable for aronia cultivation, as it has the feature of experiencing four seasons. Aronia plant prefers slightly acidic and moist soils with a pH value between 5.5 and 7.0. However, it can also grow in clayey and sandy soils. In order for the plant to provide regular high yields, it is recommended that it be grown in nitrogen-rich soils. Aronia plant is a durable species that is not affected by pests and diseases. This situation makes aronia cultivation attractive with its lower maintenance costs (Everhart, 2013).

Aronia production has significant potential in Turkey, both in the domestic market and in terms of export. Aronia fruit, which is in demand worldwide thanks to its health benefits, has begun to take its place among Turkey's agricultural export products. The establishment of aronia gardens stands out as an investment that provides high returns at low costs. According to economic analyses conducted in Turkey, the establishment costs of aronia gardens begin to amortize themselves from the 3rd year onwards. In addition, it is seen that aronia fruit is a profitable agricultural product for producers with its high unit area yield.

REFERENCES

Acet, T., Özcan, K., & Sefalı, A. (2020). Biological activity of Psephellus appendicigerus as a natural agent. Plant Biosystems - An International Journal Dealing with All Aspects of Plant Biology, 155(5), 1013–1018. https://doi.org/10.1080/11263504.2020.1837281

Ağaoğlu, S., Gerçekcioğlu, R., (2013). Üzümsü Meyveler 1. s. 19-54. Ed:.. Tomurcukbağ Bağcılık ve Şarapçılık Ltd. Şti. Eğitim Yayınları, Kalecik, Ankara

Anonim (2005)a. Tübitak - Türkiye taksonomik tür veritabanı. Web sitesi: http://bioces. tubitak.gov.tr/ Erişim tarihi: 10.5.2005.

Anonim (2005)b. Tübitak - Türkiye Bitkileri Veri Servisi. Web sitesi: http://www.tubitak. gov.tr/tubives/ Erişim tarihi: 10.5.2005.

Aslan. R., & Karakuş. Z. (2019). Gelenekten günümüze tıbbi ve aromatik bitkiler. Göller Bölgesi Aylık Hakemli Ekonomi ve Kültür Dergisi, 6:73.

Bahadori MB, Dinparast L, Zengin G. (2016). The Genus Heracleum: a comprehensive review on ıts phytochemistry, pharmacology, and ethnobotanical values as a useful herb. Compr Rev Food Sci Food Saf. 15(open in a new window)(6(open in a new window)):1018–1039. doi:10.1111/1541-4337.12222.

Bakanlığı, T. V. O., & Müdürlüğü, B. Ü. G. Aronya 2022.

Borowska, S.,Brzóska, M.M. 2016. Chokeberries (Aronia melanocarpa) and their products as a possible means for the prevention and treatment of noncommunicable diseases and unfavorable health effects due to exposure to xenobiotics. Comprehensive Reviews in Food Science and food safety, 15(6):982-1017.

Brand, M. (2010). Aronia: Native shrubs with untapped potential. *Arnoldia*, *67*(3), 14-25.

Ćujić, N., Kardum, N., Šavikin, K., Zdunić, G., Janković, T., & Menković, N. (2018). Potential of Chokeberry (Aronia melanocarpa L.) as a Therapeutic Food. In *Therapeutic Foods* (pp. 209-237). Academic Press.

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

Del Bo, C., Martini, D., Porrini, M., Klimis-Zacas, D., Riso, P. (2015). Berries and oxidative stress markers: an overview of human intervention studies. Food & Function, 6(9), 2890-2917.

Demirezer, L.Ö. (2010). Bitkilerin tedavide kullanımları. Bitkilerle Tedavi Sempozyumu , 5-6.

Doshi, P., Adsule, P., Banerjee, K. (2006). Phenolic composition and antioxidant activity in grapevine parts and berries (Vitis vinifera L.) cv. Kishmish Chornyi (Sharad Seedless) during maturation. International Journal of Food Science & Technology, 41(s1), 1-9

Engin, S. P. (2020). *'Nero've'Viking'Aronya (Aronia melanocarpa (Michx) Elliot) Çeşitlerinin Agromorfolojik Özellikleri ve Farklı Olgunluk Seviyelerindeki Meyve Kalite Parametrelerinin Belirlenmesi* (Doctoral dissertation, Bursa Uludag University (Turkey)).

Everhart, E.2013. Aronia–A New Crop for Iowa. Retrieved May,24.

Fidancı A, 2015. Türkiye için yeni bir minör meyve: aronya bitkisi ve yetiştirme teknikleri. VII. Ulusal Bahçe Bitkileri Kongresi Bildirileri, Bahçe (Özel Sayı), Cilt I: Meyvecilik, s: 1177-80.

Gıdık, B., Akar, Z., Can, Z., Sefalı, A., Erturk, O. Determination of antioxidant, antimicrobial activities, phenolic compounds of wild *Rosa* L. species Bayburt, Turkey. Fresenıus Envıronmental Bulletın 2019; 28: 9973–9982.

Gerçek YC, Acar Şhain A, Nesrin Ecem Bayram NE, Çelik S, Sefalı A, Gıdık B, Cevahir Öz G, Pinar NM. 2022. Anatomy, trichome micromorphology and phytochemical profile of Stachys rizeensis R. Bhattacharjee from Turkey. S Afric J Bot. 149:19–28.

Gralec, M., Wawer, I., & Zawada, K. (2019). *Aronia melanocarpa* berries: Phenolics composition and antioxidant properties changes during fruit development and ripening. *Emirates Journal of Food and Agriculture*, *31*(3), 214-221.

Göktaş, Ö., & Gıdık, B. (2019). Tıbbi ve aromatik bitkilerin kullanım alanları. Bayburt Üniversitesi Fen Bilimleri Dergisi, 2(1), 145-151.

Jurendić, T., & Ščetar, M. (2021). *Aronia melanocarpa* products and by-products for health and nutrition: A review. *Antioxidants*, *10*(7), 1052.

Jurikova, T., Mlcek, J., Skrovankova, S., Sumczynski, D., Sochor, J., Hlavacova, I., Snopek L.,Orsavova, J. 2017. Fruits of black chokeberry Aronia melanocarpain the 91 prevention of chronic diseases. Molecules,22(6), 944.

Koçyiğit, A. (2005). The Denizli graben-horst system and the eastern limit of western anatolian continental extension: basin fill, structure, deformational mode, throw amount and episodic evolutionary history, SW Turkey. Geodinamica Acta, 18(3-4), 167-208.

Kokotkiewicz, A., Jaremicz, Z., & Luczkiewicz, M. (2010). Aronia plants: a review of traditional use, biological activities, and perspectives for modern medicine. *Journal of medicinal food*, *13*(2), 255-269.

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.

Lavefve, L., Howard, L.R., Carbonero, F. (2020). Berry polyphenols metabolism and impact on human gut microbiota and health. Food & Function, and grape variety on colour, and anthocyanin and phenolic composition of red wines. Journal of Food Composition and Analysis, 22 (3), 204-211.

Lewin, R. (2000). Modern İnsanın Kökeni, TÜBİTAK Popüler Bilim Kitapları, Çeviri: N.

Metiner, E. E., & Ersus, S. (2023). The effects of different drying methods on the quality of Aronia (Aronia melanocarpa) fruit and its dried powder.

Özbucak, T., & Gümüş, A. F. (2024). Aronya Meyvesinin Ekolojik ve Fitokimyasal Varyasyonlarının Belirlenmesi. Türk Tarım Ve Doğa Bilimleri Dergisi, 11(4), 1035-1045. https://doi.org/10.30910/turkjans.1499475.

Özder, A. (2021). *Bazı Aronya Çeşitlerinin (Aronia melanocarpa L.) Gelişme Performanslarının Belirlenmesi* (Master's Thesis, Aydın Adnan Menderes Üniversitesi Fen Bilimleri Enstitüsü).

Özdiz, A. (2021). Bazı Organik Preparatların Viking Aronya (*Aronia melanocarpa* (Michx.) Elliot) Çeşidinin Fidanlarının Gelişimi Üzerine Etkileri.

Perez-Magarino, S., Ortega-Heras, M., Cano-Mozo, E., González-Sanjosé, L., 2009. The influence of oak wood chips, micro-oxygenation treatment,

Poyraz Engin, S., Mert, C., Fidancı, A., Boz, Y., 2016. Aronya (*Aronia melanocarpa* (Michx.) Elliot) Meyve Türünde Morfolojik İncelemeler. Bahçe 45 (Özel Sayı 2): 71-78.

Pop, L., Costa, R., Asănică, A., & Tudoreanu, L. (2022). Mineral nutritional value of products containing Aronia fruits and juices: a review. *Scientific Papers. Series B. Horticulture*, *66*(1).

Prior, R. L., Cao, G., Martin, A., Sofic, E., McEwen, J., O'Brien, C., ... & Mainland, C. M. (1998). Antioxidant capacity as influenced by total phenolic and anthocyanin content, maturity, and variety of Vaccinium species. Journal of agricultural and food chemistry, 46(7), 2686-2693.

Sakallı, G. (2023). Sıçanlarda Oluşturulan Karaciğer Hasarında Biberiye (*Rosmarinus officinalis*) Uçucu Yağı ile Aronya (*Aronia melanocarpa*) Ekstresinin Etkilerinin Değerlendirilmesi.

Sefalı, A. (2023). Bayburt İlinde Yetişen Yabani Meyvelerin Tespiti ve Bazı İncelemeler. Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 6(1), 52-67. https://doi.org/10.47495/okufbed.1100152

Sidor, A., & Gramza-Michałowska, A. (2019). Black chokeberry Aronia melanocarpa L.—A qualitative composition, phenolic profile and antioxidant potential. *Molecules*, *24*(20), 3710.

Şahin, A., & Erdoğan, Ü. (2022). Dünya 'da ve Ülkemizde Aronya (Aronia melanocarpa Michx Elliot) Üretimi ve Değerlendirilme Şekilleri. *Turkish Journal of Agriculture-Food Science and Technology*, *10*(1), 81-85.

Tokuşoğlu, Ö. (2018). Aronia berry based new food products and shelf life stability studies. *Food Health and Technology Innovations*, *1*(3), 97-99.

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.

Yuca, H., Sefalı, A., Aydın, B., Karadayı, M., Gülşahin, Y., Yazıcı, A., … Güvenalp, Z. (2024). Phytochemical analysis and biological evaluation of essential oils and extracts from Heracleum pastinacifolium subsp. incanum (Boiss. & A.Huet) P.H.Davis, an endemic plant from Turkey. Natural Product Research, 1–11. https://doi.org/10.1080/14786419.2024.2372661

Yurtvermez, B., & Gıdık, B. (2021). Yağlı Tohumlu Bitkiler ve Kullanım Alanları. Bayburt Üniversitesi Fen Bilimleri Dergisi, 4(2), 139-145.

Zhang, L., Wang, X., Cueto, R., Effi, C., Zhang, Y., Tan, H., ... Wang, H. (2019). Biochemical basis and metabolic interplay of redox regulation. Redox biology, 26, 101284.

Zheng, Y., Wang, S. Y., Wang, C. Y., & Zheng, W. (2007). Changes in strawberry phenolics, anthocyanins, and antioxidant capacity in response to high oxygen treatments. LWT-Food Science and Technology, 40(1), 49-57.

CHAPTER 3

POTATO PRODUCTION WITH STEM CUTTINGS AND APPLICATION TECHNIQUE

Prof. Dr. Erdoğan ÖZTÜRK [1]

DOI: https://dx.doi.org/10.5281/zenodo.14544705

[1] Atatürk University Faculty of Agriculture, Department of Field Crops, Erzurum, Turkey
E-mail: erozturk@atauni.edu.tr, ORCID ID 0000-0001-8746-3005

INTRODUCTION

Potato is one of the most important and widespread crops, being a staple food for most of the world's population and carrying many health benefits. Rich in carbohydrates, vitamins, proteins, and minerals, potatoes are consumed by more than one billion people worldwide (CIP, 2010; FAO, 2008). High adaptability, high nutrient content, lower cost, high yields, and relative ease of cultivation are the obvious characteristics that make potato an important source of income and food for developing countries.

Potato's protein content of 1.26-2.48%, starch content of 11-12%, high protein biological values, and starch digestibility make it an important dietary and energy plant (Sencer et al., 1994; Karadoğan and Özer, 1997). 100 g of potatoes boiled without peeling can meet a daily human need for 16% of vitamins B6 and C, 15% of potassium, 11% of manganese, and 5% of protein. In addition, it quickly creates a feeling of satiety and provides 93 calories (389 kj) of energy makes it a nutritious dietary food (Günel et al. 2010). Studies show that potato, which has 75% to 58% more food energy per unit area than wheat and rice, provides 78% more protein than rice and 54% more protein than wheat. In this respect, potato ranks sixth after sugarcane, maize, paddy, and wheat, the most produced crops in the world (FAO, 2022).

In order to meet the nutrient needs of the rapidly growing world population, production needs to be increased accordingly. For these purposes, either new lands should be opened to agriculture or the productivity of existing agricultural lands should be increased. Today, obtaining high quality and high yields from the agricultural lands at the limit makes it necessary to utilize special production techniques in plant cultivation.

The production, cultivation, and utilization of plants are a series of activities that require special knowledge, experience, and techniques. The fact that plants have very different physical and genetic characteristics, require very different environments and environmental conditions and have very different types of reproduction and development has made it necessary to use very different methods and techniques in their production and has made them changeable according to the conditions. It is only possible to produce plants in desired quantities and easily with the knowledge of these methods and techniques to be applied. Obtaining maximum yield and quality production from the potato plant is through the correct and timely implementation of cultivation techniques and compliance with scientific principles.

Seed is one of the most important inputs in potato production and the yield capacity of potato depends largely on the quality of seed. The use of high-quality seed is much more effective on productivity in potatoes than in other field crops. In addition, the size of the tubers to be used as seeds also has a significant effect (Aslan, 1975; Çalışkan, 1997). To obtain more plants and tubers from one tuber, to increase the available seed potatoes, and to obtain healthy and robust seed tubers, there is a need to increase the production of quality seed and to develop new production techniques. To temporarily solve the problem shortly, different production techniques should be used. In some countries, a system has been introduced in which tubers are not used as starting material in clonal selection. Instead, side shoots of the plants to be propagated are used as cuttings. Therefore, one of these rapid production techniques is cuttings.

The main objective of the cuttings production technique is to obtain starting material that is free from some bacterial and fungal diseases transmitted by the tuber. In this technique, clones are rooted from plant-side shoots used as cuttings instead of tubers, increasing the reproduction rate of the seed and reducing the damage of many pathogens. Yield, quality, and uniformity are increased. In this method, tests can be applied for many potato diseases that may be a problem during the production season. Propagation by cuttings and similar production methods allows rapid multiplication of potato plant material. With these methods, it is also easy to obtain virus-free plant material and thus preserve healthy material.

1. POTATO PRODUCTION STUDIES WITH STEM CUTTINGS

Propagation of potato seed stocks by root cuttings was developed in 1960 (Jones, 1991) as a way of eliminating bacterial and fungal pathogens normally carried by tuber propagation.

Buck and Akely (1966) reported that obtaining a large number of plants from one tuber would have many pathological benefits and reduce the amount of seed used in potato cultivation. In this study, the researchers utilized cuttings from a tuber grown in pots. They reported that they obtained 21 shoots and 20 plants from one tuber. Root cuttings used as a rapid propagation technique can produce 20-60 cuttings from each mother plant (Bryanet al., 2000).

Cole and Wright (1967) determined that 20-60 cuttings can be obtained from a tuber by cuttings production technique and that these cuttings form strong and high-yielding plants when grown under field conditions after rooting. They also reported that this method was used to obtain the desired sub-clones rapidly and extensively.

Caligari and Powell (1989) reported that for rapid selection in potatoes, stem internodes are the most suitable source of explants for propagation.

In a study conducted in Uganda, it was found that the number of tubers per plant and yield obtained from potato production by cuttings were higher than the traditional method (Rukuba et al., 2000).

Öztürk (2006) recommends the use of cuttings for healthy seed potato production and rapid seed multiplication.

Dahshan et al. (2018) investigated their potential to produce good-quality potato tubers using cuttings. They reported that propagation of potatoes by stem cuttings as an asexual vegetative propagation tool is very promising.

2. POTATO PRODUCTION WITH STEM CUTTINGS

Stem-cutting production is the separation of the side shoots from the mother plant in potato plants, rooting them in environments with suitable environmental conditions and obtaining offspring or offspring with all the characteristics of the mother plant.

Propagation by cuttings has been practiced in various plants since time immemorial. Since some plants are much easier to propagate from cuttings than from seeds, these plants are normally propagated by cuttings. Many plants that are very difficult to grow from cuttings are also grown by rooting with special treatments. This method is widely used, especially for ornamental plants and fruit trees. There is a possibility that important plant material, which has its characteristics, may deteriorate in seed production and the material may disappear. To prevent this danger, production with branch cuttings is used.

In potatoes, cuttings production is a method used especially in the first stages of breeding to reproduce the disease-free ones among the existing plants. As it is known, very few seeds are obtained in the first stages of breeding studies. The point to be considered in the reproduction of these new plants or disease-free plants obtained by tissue culture from diseased material, which is determined to be free from very important diseases potato, the causative agents of which are bacteria, fungi, and viruses, is to produce a quick and affordable seed production. Production with cuttings is done to produce more seed at the first moment (Arslan, 1976).

The main objective of the cuttings production technique is to obtain starting material that is free from some bacterial and fungal diseases transmitted by the tuber. In this method, plant side shoots are rooted as cuttings and used instead of tubers, increasing the reproduction rate of the seed and reducing the damage of many pathogens. Yield, quality, and uniformity are increased.

Cuttings and similar production methods are used for the rapid propagation of potato plants. With these methods, it is possible to obtain virus-free plant material and to preserve healthy material. These production techniques are also suitable for shortening the time required to produce certified seed. On the other hand, these production techniques are expensive in terms of facilities and manpower (Jordens-Rottger, 1984).

The cutting production technique is very healthy compared to many other techniques. This production technique is widely used in general seed programs because it eliminates non-systemic diseases, insects, and other pests that damage plants since the contact between the cuttings and the soil is prevented (Bryan, 1984). The use of root cuttings can effectively eliminate diseases caused by pathogens such as *Erwinia spp*., *Rhizoctonia solani*, and *Synchytrium endobioticum* (wart) by cutting off contact with tuber and soil-borne non-systemic diseases and nematodes (Bryan et al., 2000).

The year of production with cuttings constitutes the first year of a potato production program, and the propagation of the clones obtained at the end of the first year is carried out within the clonal selection production program and by using tubers as seed (Özbayram, 1978).

3. APPLICATIONS IN STEM CUTTINGS PRODUCTION TECHNIQUE

3.1. Cultivation of plants to be cuttings

Cuttings are prepared by selecting healthy and in good condition mother tubers produced in previous years. These tubers are pre-germinated and germinated. They are also checked for viruses, bacteria, and fungal diseases and only healthy ones are selected. Then, these healthy plants are planted in pots filled with special mortar soil (1/3 sand, 1/3 soil, 1/3 farmyard manure). Each pot is labeled to indicate which variety is in it. This process is very important to obtain good quality and healthy potato plants.

3.2. Disease tests

When the plants in the pots are about 15 cm tall, leaf samples are taken from each plant and tested for diseases. These tests help to identify diseased plants at an early stage and thus help to protect healthy plants. If diseased plants are present, they are eliminated and not used for cuttings. This ensures that only healthy individuals are used in the cutting process.

3.3. Tip removal for stem cuttings

The apical growth point of each stem of the 25-30 cm tall plants in the pots is cut and the tip is removed. Because side shoots are mostly preferred as cuttings, this practice encourages the development of the side shoots that we will use as cuttings. It is also important to determine the amount of cuttings needed. In the period when much more cuttings are needed, more formation of side shoots is ensured by leaf stripping.

3.4. Taking and rooting cuttings

When the side shoots reach 5-8 cm in length, they are cut with a disinfected razor blade and planted in polyethylene bags containing mortar soil for rooting. The average time fromplanting the main tubers in the greenhouse until the cuttings are taken is about 4 weeks. This should also be taken into consideration as it will be difficult to root the cuttings to be taken when flowering begins. Cuttings are planted by hand with the help of a metal rod. A label is placed in front of each cuttings. No hormone compounds are used in rooting. For rooting, the cuttings are kept in greenhouses for an optimum period of 10-15 days and watered with a filter bucket.

Figure 1. Cuttings sample taken from a plant

3.5. Taking the cuttings to the field

Cuttings rooted in greenhouse conditions should not be taken directly to the field. These plants are placed in compartments prepared in the outer part of the greenhouse, which we can call cold cushions, which are closed at a height of 25 cm. We can call the period that the plants will spend in these compartments the blooming period. This period is approximately 10-15 days. The field where the cuttings will be planted should not have been cultivated with potatoes before and should be isolated from the surrounding fields and orchards, in short, from sources of infection. In addition, the field should be prepared in advance, appropriate fertilizers should be given and cultural practices should be fully implemented. Before planting, the polyethylene bags containing the cuttings are torn and discarded, and planting is done by hand at the determined inter-row and over-row distances. Immediately after planting, the throat is filled and life water is given.

During the growing season, the necessary care procedures are carried out for the potato plant produced by cuttings. In the end, the plants reaching harvest maturity are harvested. Clones obtained after the cuttings production year can be propagated within a clonal selection program.

Figure 2. Rooted and ready for planting cuttings

REFERENCES

Arslan, N., 1975. Seed in Potato. Research on the Effects of Tuber and Eye ProductionTechnique on Yield. Ph. D. Thesis Ankara University, 123 s.

Arslan, N., Ilisulu, K., 1976. Effect of pre-germination, seed size and variety on potato yield. Ankara Uni. Yearbook, 26, 464-478.

Bryan, J.E., 1984. Methods of rapid multiplication. In: Innovative Methods for Propagating potatoes. Report of the XXVIII planning conference, Lima, Peru.

Buck, R.W.J., Akeley, R.V., 1966. How to obtain the most plants from one potato tuber. Amer. Potato J. 43: 128-130.

Caligari, P.D.S., Powell, W., 1989. Variability in response of response of potato cultivars to micropropagation: In vitro performance. Annals of applied biology, 115 (1), 115-121.

CIP, 2010. Facts and figures about potato. International potato center. http://www.cipotato.org/potato.html. Retrieved 2st march 2014.

Cole, E.G.B., Wright, N.S., 1967. Propagation of potato by stem-cuttings. American Potato Journal, 44: 301-304.

Calışkan, M.E., 1997. Seed Tuber Size in Early Grown Potato Cultivation. The Effects of Tuber Cutting and Planting Density on Plant Growth. Yield and Economic Value of the Product. Ph. D. Thesis Çukurova University Graduate School of Naturel and Applied Sciences Department of Field Crops.

Dahshan, A.M., Zaki, H.E., Moustafa, Y.M., Abdel-Mageed, Y.T., Hassan, M.A., 2018. Effect of some growth regulators and natural extracts on yield and qualityof potato. Minia Journal of Agriculture Research and Development, 38(2), 271- 295.

FAO, 2008. International year of potato. Food and Agricultural Organization of the United Nations, Rome, Italy. http://www.potato2008.org/en/index.html.

FAO, 2022. Statistical Database-Agriculture, http://www.fao.org.

Günel, E., Çalışkan, M.E., Kuşman, N., Tuğrul, K.M., Yılmaz, A., Ağırnalıgil, T., Onaran, H., 2010. Starch and Sugar Crops Production. VII. Technical Congress of TurkishAgricultural Engineering, January 11-15, 2010, Ankara, pp. 377-396.

Jones, E.D., 1991. Progress in seed production technology. Am. Potato J., 68: 247-248.

Jordens - Rottger, D., 1984. Rapid multiplication techniques used for production of basic seed in the Philippines - German seed potato program. Abstract of conference papers of the 9th Triennial Conference of the European Association for potato research, 42 pp.

Karadoğan, T., Özer, H., Oral, E., 1997. The Effect of Fertilization on Some Characteristics of Potato. Ataturk Univ. Faculty of Agriculture. J., 28 (3): 441- 453.

Özbayram, Ç., 1978. Potato seed production technique with cuttings. Eastern Anatolia Regional Agricultural Research Institute Directorate, Publication No: 1, Erzurum.

Öztürk, E., 2006. Investigation on yield, yield components and fungal agents with insect population of potato (*Solanum tuberosum* L.) growth in field and netting-greenhouse produced by different methods. Ph. D. Thesis Ataturk University, Graduate School of Naturel and Applied Sciences Department of Field Crops.

Rukuba, D. Wagoire, W.W., Hakiza, J.J., Adipala, E., 2000. Comparison of conventional and stem-cutting multiplication of potato under South western Uganda conditions.

Sencer, Ö., Gökmen, S., Yıldırım, A., Kandemir, N., 1994. Field Crops Production. Gazi Osmanpaşa University, pp 244-251, Tokat.

CHAPTER 4

QUALITY OF BOTTLED WATER SOLD IN BAYBURT REGION (NE TÜRKİYE)

PhD. Onur GÜVEN[1], Assoc. Prof. Dr. Ümit YILDIRIM[2], Prof. Dr. Vecihi AKSAKAL[3]

DOI: https://dx.doi.org/10.5281/zenodo.14544711

[1]*Bayburt University, Central Research Laboratory, Bayburt, Türkiye. ORCID ID: 0000-0001-5608-7633.onurguven@bayburt.edu.tr
[2]Bayburt University, Faculty of Applied Sciences, Department of Emergency Aid and Disaster Management, Bayburt, Türkiye.ORCID ID: 0000-0002-7631-7245.umityildirim@bayburt.edu.tr
[3] Bayburt University, Faculty of Applied Sciences, Department of Organic Farming Management, Bayburt, Türkiye. ORCID ID: 0000-0001-5701-0726. vecihiaksakal@bayburt.edu.tr

INTRODUCTION

The quality of bottled water in Türkiye has garnered increasing attention due to its rising consumption and implications for public health and safety. As of 2020, Turkiye's bottled drinking water production reached approximately 10.5 billion liters, with a per capita consumption of 126 liters, indicating a significant market presence compared to other regions, although still lower than that of the European Union (Turhan et al., 2021). The bottled water market in Turkiye has evolved since its inception in the mid-1980s, with a notable increase in consumption driven by consumer perceptions of safety and quality (Dirican, 2019). This trend is particularly pronounced in urban areas, where concerns about tap water quality have led many to prefer bottled alternatives (Kanat, 2017).

Research indicates that the physicochemical quality of bottled natural spring waters varies significantly across different brands and regions in Turkiye. A study examining bottled waters in Sivas highlighted variations in mineral content, which can affect consumer choices and perceptions (Dirican, 2019). Furthermore, the presence of natural radionuclides in bottled mineral waters has raised concerns regarding their potential health impacts, necessitating regular monitoring and assessment of these products (Altıkulaç et al., 2022; Seid et al., 2020). Especially in regions under drought and pollution pressure, the public perceives bottled water as safer regarding water quality than tap water. (Kanat, 2017).

Moreover, demographic factors play a crucial role in bottled water consumption patterns in Turkiye. Studies have shown that factors such as age, marital status, and economic conditions significantly influence purchasing behaviors (Seçer and Bulut, 2021; Bulut and Seçer, 2019). The bottled water industry is not only a vital segment of the beverage market but also reflects broader social dynamics, including health consciousness and environmental considerations (Bal and Oraman, 2019; Parag et al., 2023). The rapid growth of this sector raises important questions about sustainability and the environmental impact of plastic waste associated with bottled water consumption (Aslani et al., 2021).

The quality of bottled water in Turkiye is shaped by a complex interplay of production standards, consumer perceptions, and demographic influences. As the market continues to expand, ongoing research and regulatory oversight will be essential to ensure the safety and quality of bottled water, addressing both public health concerns and environmental sustainability.

This study was conducted to determine the quality of bottled natural spring waters offered for sale in Bayburt (NE Türkiye) and their suitability for consumption as drinking water. In this context, samples were taken from 11 different brands, and physical parameters, major anion/cation, and trace element analyses were performed. The results were evaluated according to the European Economic Community Council Directive (2020/2184) implemented in Türkiye.

1. MATERIALS AND METHODS

1.1. SAMPLE COLLECTION

The bottled natural spring water samples from commercial establishments such as buffets, markets, and supermarkets in Bayburt province (NE Türkiye) were collected randomly for quality assessment in this study. Sample collection was carried out in October 2024, and nine 0.5 L samples from eleven different brands were included in the study. Samples were stored at +4 °C until the analysis process started.

1.2. ANALYTICAL PROCEDURES

Physical parameter analyses of water samples (pH, Eh, Dissolved oxygen, Electrical conductivity) were measured using a WTW 3430 model multiparameter device. Major anion (Table 1) analyses were carried out using VITLAB brand digital burette and Merck, Prove 100 model spectrophotometer device, major cation (Table 1) and trace element (Table 1) analyses were realized using Agilent 7800 model ICP-MS devices. All analyses were carried out at Bayburt University, Central Research Laboratory, and the analytical method information and the measurement units of the parameters are shown in Table 1.

Table 1. Parameters analyzed in this study and their analytical measurement methods with the measurement units.

Parameter	Units	Analytical Methods	Device
pH	-	Sentix 41 probe	WTW Multi 3430
Eh	mV	Sentix 41 probe	WTW Multi 3430
Electrical Conductivity (EC)	µS/cm	Tetracon 325 graphite probe	WTW Multi 3430
Dissolved Oxygen (DO)	mg/L	FDO 925	WTW Multi 3430
Bicarbonite (HCO_3^-)	mg/L	Titrimetry	VITLAB digital burette
Nitrate (NO_3^-)	mg/L	Cadmium reduction	Spectrometry/ Merck, Prove 100
Nitrite (NO_2^-)	mg/L	Diazotization	Spectrometry/ Merck, Prove 100
Chloride (Cl-)	mg/L	Mercuric thiocyanate	Spectrometry/ Merck, Prove 100
Sulphate (SO_4^{2-})	mg/L	Barium sulfate turbidity	Spectrometry/ Merck, Prove 100
Fluoride (F-)	mg/L	SPADNS	Spectrometry/ Merck, Prove 100
Ca, Mg, Na, K, Si	mg/L	Mass spectrometry	ICP-MS/Agilent 7800
Al, As, B, Ba, Br, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, Se, Sr, Ti, V, Zn	µg/L	Mass spectrometry	ICP-MS/Agilent 7800

1.3. DATA COMPARISON

The data obtained from physical-chemical analyses were discussed according to the limit values specified in the Council Directive No. 2020/2184 (EEC, 2020), accepted by the European Economic Community and used in Türkiye, and by the World Health Organization (WHO, 2022). In addition, the analysis results of the samples belonging to each brand were compared with the measurement results stated on the brands' labels.

2. RESULTS AND DISCUSSIONS

2.1. CONCENTRATIONS OF PHYSICAL PARAMETERS

In Türkiye, natural spring water, natural mineral water, and processed drinking water are generally described as packaged water (Güler, 2007), and all of the water analyzed in this study represents natural spring water). The physical-chemical contents of natural waters are determined by climate, rock chemistry, topography, and residence time in the aquifer (Güler vd., 2002).

Descriptive statistical results of physical parameters are presented in Table 2. The value ranges of the parameters are as follows: 7.25−8.02 for pH; -55.2 to -9.5 mV for Eh; 7.39−9.08 mg/l for dissolved oxygen (DO); and 68−196 µS/cm for electrical conductivity (EC). Among the physical parameters, only the acceptable value range and limit value of pH and EC were reported by EEC. All bottled waters have appropriate values in terms of these parameters (Table 2).

Table 2. Descriptive statistics of bottled water's physical parameters and their comparison to the EEC (2020) and WHO (2022) standards.

Parameter	Bottled Water (*n*=11)						
	Min.	**Max.**	**Med.**	**Mean**	**Std.**	**EEC (limit value)**	**WHO (limit value)**
pH	7.25	8.02	7.69	7.64	0.25	6.5−9.5	−
Eh (mV)	-55.2	-9.5	-35.7	-32.1	14.4	−	−
DO (mg/l)	7.39	9.08	8.27	8.26	0.5	−	−
EC (µS/cm)	68	196	85	119	51	2500	−

Min: minimum, Max.: maximum Med.: median Std.: Standard deviation

2.2. CONCENTRATIONS OF MAJOR ANIONS AND MAJOR CATIONS

The effects of major anions on human health are multifaceted and can vary significantly depending on the particular anion. Anions such as fluoride, nitrite, nitrate, and sulfate are being evaluated extensively for their health effects, particularly in relation to water quality and environmental exposure. We see the concrete example of this situation as the drinking water limit values reported by internationally recognized organizations (EEC, 2020; WHO, 2022). All bottled waters examined were compared with the limit values reported by EEC and WHO, and no bottled water samples with concentrations above the limit values were detected. The major anion and cation results of the examined bottled waters are shown in Table 3 and Table 4. The chloride, bicarbonate, fluoride, nitrite, nitrate and sulfate concentration ranges (in ppm) of the waters are 1.3−48.3; 28.0−99.6; 1.06−1.42; 0.04−0.18; 0.7−16.1; and 1.0−12.0, respectively, and the calcium, magnesium, sodium, potassium and silicon concentration ranges (in ppm) are 6.2−34.4; 1.8−12.3; 0.8−11.6; 0.26−1.85; and 0.8−19.9, respectively. Also, the box plot showing the statistical values of major ions is presented in Figure 1.

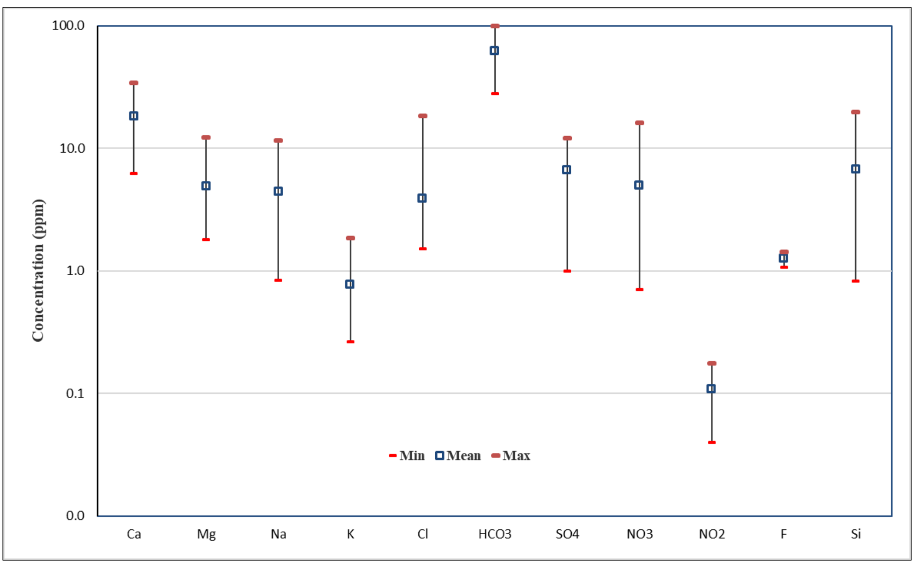

Figure 1. Box plot of major anions and cations

The effects of major cations on human health can be evaluated from both positive and negative perspectives. For example, calcium and magnesium are critical cations, particularly for bone health and metabolic functions. Calcium is essential for bone density and strength, and magnesium is an important mineral for more than 300 enzymatic reactions in the body (Pégorier et al., 2006). The balance of major cations is important. High sodium intake can lead to increased calcium excretion, potentially adversely affecting bone health (Wodschow et al., 2018). However, excessive sodium intake is linked to hypertension and cardiovascular diseases (Cao et al., 2017). The World Health Organization recommends limiting sodium intake to reduce the risk of these health problems (WHO, 2022). The sodium concentrations of the bottled waters examined in the study are below the reference EEC and WHO limit values. Since no standards have been specified by international organizations for HCO_3^-, Ca, Mg, K and Si, no comments could be made on these parameters.

Table 3. Descriptive statistics of bottled water's major anions (in ppm) and their comparison to the EEC (2020) and WHO (2022) standards.

	Bottled Water (*n*=11)						
Parameter	**Min.**	**Max.**	**Med.**	**Mean**	**Std.**	**EEC (limit value)**	**WHO (limit value)**
Cl^-	1.3	48.3	2.3	6.6	13.2	250	–
HCO_3^-	28.0	99.6	58.1	65.7	24.1	–	–
F^-	1.06	1.42	1.27	1.27	0.11	1.5	1.5
NO_2^-	0.04	0.18	0.12	0.11	0.04	0.5	3.0
NO_3^-	0.7	16.1	3.7	4.97	4.2	50	50
SO_4^{2-}	1.0	12.0	7.0	6.6	3.4	250	–

Min: minimum, Max.: maximum Med.: median Std.: Standard deviation

Table 4. Descriptive statistics of bottled water's major catıons (in ppm) and their comparison to the EEC (2020) and WHO (2022) standards.

	Bottled Water (*n*=11)						
Parameter	**Min.**	**Max.**	**Med.**	**Mean**	**Std.**	**EEC (limit value)**	**WHO (limit value)**
Ca	6.2	34.4	11.0	18.1	11.6	–	–
Mg	1.8	12.3	4.4	4.9	2.7	–	–
Na	0.8	11.6	3.2	4.5	3.3	200	–
K	0.26	1.85	0.52	0.77	0.57	–	–
Si	0.8	19.9	4.5	6.7	6.2	–	–

Min: minimum, Max.: maximum Med.: median Std.: Standard deviation

2.3. CONCENTRATIONS OF HEAVY METALS

Heavy metals such as nickel and lead pose significant health risks when present in the environment or food supply. Lead exposure is associated with neurological disorders, especially in children, and can lead to developmental delays and cognitive deficits (Farr at al., 2008). Cadmium is linked to kidney damage and is classified as a carcinogenic heavy metal (Sahin-Tóth, 2000). The presence of such toxic heavy metals in drinking water and food sources is a major public health concern that requires stringent regulatory measures to limit exposure (Qiu et al., 2021). A study conducted on spring waters from the Mediterranean and Central Anatolia regions of Türkiye found unacceptable levels of boron, manganese and arsenic concentrations in the waters (Dönderici et al., 2010). The study revealed that highly toxic chemicals such as arsenic are possible in bottled water (Güler & Alpaslan, 2009).

Descriptive statistics of heavy metal contents of bottled water sold in Bayburt province are shown in Table 5 and Table 6. The concentration ranges (in ppb) of these heavy metals in bottled water are as follows: 0−35.86 for Al; 0.09−5.35 for As; 5.19−334.8 for B; 3.25−24.62 for Ba; 5.98−24.23 for Br; 0.00−0.01 for Cd; 0.00−0.13 for Co; 0.00−1.87 for Cr; 0.00−0.26 for Cu; 0.00−19.12 for Fe; 0.00−35.86 for Mn; 0.92−6.83 for Mo; 0.00−0.99 for Ni; 0.00−0.02 for Pb; 0.26−0.48 for Sb; 0.12−1.05 for Se; 28.01−137.06 for Sr; 0.05−2.24 for Ti; 0.01−9.02 for V; and 0.00−0.79 for Zn. The box plot showing these values is presented in Figure 2.

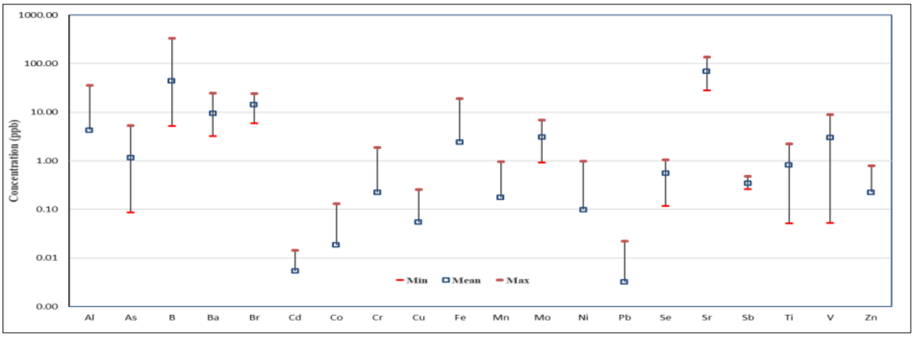

Figure 2. Box plot of heavy metals

The heavy metal levels of the examined bottled waters do not pose any risk according to the EEC and WHO references and evaluated for drinking water. The heavy metal concentrations of these waters are at very low levels and they are suitable for use for health reasons.

Table 5. Descriptive statistics of bottled water's heavy metals (in ppb) and their comparison to the EEC (2020) and WHO (2022) standards.

	Bottled Water (*n*=11)						
Parameter	**Min.**	**Max.**	**Med.**	**Mean**	**Std.**	**EEC (limit value)**	**WHO (limit value)**
Al	0.00	35.86	1,35	4.26	1.44	200	–
As	0.09	5.35	0.60	1.16	1.44	10	10
B	5.19	334.8	12.44	43.43	97.47	1500	2400
Ba	3.25	24.62	8.53	9.43	6.29	–	1300
Br	5.98	24.23	15.62	14.36	5.01	–	–
Cd	0.00	0.01	0.00	0.01	0.01	5	3
Co	0.00	0.13	0.01	0.02	0.04	–	–
Cr	0.00	1.87	0.00	0.22	0.53	25	50
Cu	0.00	0.26	0.00	0.05	0.09	2000	2000
Fe	0.00	19.12	0.84	2.41	5.30	200	–
Mn	0.00	0.95	0.03	0.17	0.29	50	80
Mo	0.92	6.83	1.72	3.05	2.08	–	–
Ni	0.00	0.99	0.00	0.10	0.28	20	70
Pb	0.00	0.02	0.00	0.00	0.01	10	10
Sb	0.26	0.48	0.31	0.34	0.07	5	20
Se	0.12	1.05	0.70	0.55	0.33	10	40
Sr	28.01	137.1	57.68	68.48	33.84	–	–
Ti	0.05	2.24	0.54	0.81	0.76	–	–
V	0.01	9.02	1.12	2.96	3.23	–	–
Zn	0.00	0.79	0.00	0.22	0.33	–	–

Min: minimum, Max.: maximum Med.: median Std.: Standard deviation

2.4. ANALYSIS RESULTS AND LABEL VALUES COMPARISON

The values of some physical-chemical parameters on the labels of bottled waters, which are all natural spring water and sold in Bayburt province, were compared with the values obtained as a result of the analysis. The labels of the examined bottled waters include analysis results showing pH, EC, chloride, bicarbonate, fluoride, sulfate, calcium, magnesium, sodium, potassium, aluminum, iron and manganese values (Table 7 and Table 8). Brand names are kept confidential and each bottle of water sample is assigned a code number. Parameters with the "-" symbol are not included on the relevant bottled water label.

The numerical results of these parameters are accompanied by the expression N.A. on the labels. This statement is accepted as an indication that the analyzed parameter cannot be assigned. Although these parameters are not at a level that would limit use for drinking purposes, they have been determined. The results of this study on the physico-chemical parameters that are included in the labels and cannot be detected are listed below.

- Undetectable fluoride, sodium and potassium values of sample B1 were found to be 1.21 ppm, 0.83 ppm, and 0.26 ppm, respectively. Iron was also undetectable.
- Undetectable chloride, aluminum, iron and manganese values of sample B3 were found to be 1.5 ppm, 2.02 ppb, and 0.95 ppb, respectively.

- The undetectable aluminum, iron and manganese values of sample B4 were found to be 0.40 ppb, 0.27 ppb and 0.03 ppb, respectively.
- Undetectable chloride and iron values of sample B5 were found to be 1.5 ppm and 1.02 ppb, respectively.
- The undetectable iron value of sample B6 was found to be 0.84 ppb.
- Undetectable aluminum, iron and manganese values of sample B7 were found to be 1.69 ppb, 1.67 ppb, and 0.34 ppb, respectively.
- Undetectable aluminum, iron and manganese values of sample B9 were found to be 1.35 ppb, 1.06 ppb, and 0.04 ppb, respectively.
- Undetectable aluminum and iron values of sample B10 were found to be 0.07 ppm and 0.67 ppb. Manganese was also undetectable
- The label of sample B11 stated that iron was less than five ppb. However, according to our analysis results, the iron concentration of sample B1 is 19.12 ppb.

Apart from the information stated above, there is a critical difference between the values on the label and the results we obtained from our analysis.

Table 6. Physical parameters and major anion values on bottled water labels.

Code	Bottled Water (n=11)					
	pH	EC (µS/cm)	Cl^- (ppm)	HCO_3^- (ppm)	F^- (ppm)	SO_4^{2-} (ppm)
B1	7.50	–	0.3	51.2	N.A	2.5
B2	7.59	87.7	8.5	–	–	3.8
B3	7.51	129.5	N.A	–	–	11.8
B4	7.79	172.2	2.6	–	–	7.7
B5	7.07	93.0	N.A	–	–	0.9
B6	7.55	–	4.1	86.9	0.10	2.7
B7	7.80	141.1	0.4	–	–	4.8
B8	8.22	–	1.2	104.9	0.04	6.9
B9	7.04	55.4	0.6	–	–	3.8
B10	7.43	77.9	0.8	–	–	2.7
B11	7.34	55.8	0.2	–	–	8.4

Table 7. Major cation and heavy metal concentrations on bottled water labels.

Code	Bottled Water (n=11)						
	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Al (ppb)	Fe (ppb)	Mn (pp)
B1	12.4	2.3	N.A	N.A	–	N.A	–
B2	–	–	4.2	–	2.3	0.92	0.10
B3	–	–	7.3	–	N.A	N.A	N.A
B4	–	–	2.3	–	N.A	N.A	N.A
B5	–	–	5.9	–	113.6	N.A	18.68
B6	19.4	4.0	2.2	<0.2	–	N.A	–
B7	–	–	1.9	–	N.A	N.A	N.A
B8	32.2	4.2	5.4	0.2	–	0.00	–
B9	–	–	2.5	–	N.A	N.A	N.A
B10	–	–	7.5	–	N.A	N.A	N.A
B11	–	–	2.2	–	12.1	<5	<5

3. CONCLUSION

This study measured and analyzed the physical and chemical parameters of bottled waters of 11 different brands obtained from various sales points in Bayburt province. The analyzed parameters were examined under four headings: physical, major anion, major cation and heavy metal. It was determined that the examined bottled waters were suitable for drinking purposes in the light of the analyzed parameters. Because all parameters were below the reference EEC and WHO drinking water limit values. The values of the parameters on the labels of the bottled waters were compared with the values of the analyzed parameters. It was concluded that there was no significant difference between the data obtained from this comparison and the label values. Particularly, the low concentration of heavy metals has been positive for human health and consumer safety.

REFERENCES

Altıkulaç, A., Kurnaz, A., Turhan, Ş., Kutucu, M. (2022). Natural radionuclides in bottled mineral waters consumed in Turkey and their contribution to radiation dose. Acs Omega, 7(38), 34428-34435. https://doi.org/10.1021/acsomega.2c04087

Aslani, H., Pashmtab, P., Shaghaghi, A., Mohammadpoorasl, A., Taghipour, H., Zarei, M. (2021). Tendencies towards bottled drinking water consumption: challenges ahead of polyethylene terephthalate (pet) waste management. Health Promotion Perspectives, 11(1), 60-68. https://doi.org/10.34172/hpp.2021.09

Bal, D. and Oraman, Y. (2019). A contemporary approach for strategic management: the research in bottled water industry. Journal of Global Strategic Management, 13(1), 5-15. https://doi.org/10.20460/jgsm.2020.273

Bulut, M. and Seçer, A. (2019). Bottled water consumption habits and purchase behaviours of consumers in the urban areas of Adana. Turkish Journal of Agriculture - Food Science and Technology, 7(5), 767-773. https://doi.org/10.24925/turjaf.v7i5.767-773.2405

Cao, Y., Chen, X., Bu, Z., & Zeng, L. (2017). Spatial variations in the surface water chemistry of subtropical peatlands (central china) linked to anthropogenic pressures. *Water*, *9*(7), 505. https://doi.org/10.3390/w9070505

Dirican, S. (2019). A study on physicochemical quality of bottled natural spring waters consumed in Sivas, Turkey. International Journal of Research Studies in Biosciences, 7(6). https://doi.org/10.20431/2349-0365.0706003

Dönderici, Z. S., Dönderici, A., & Başarı, F. (2010). Kaynak Sularının Fiziksel ve Kimyasal Kaliteleri Üzerine Bir Araştırma. *Türk Hijyen Ve Deneysel Biyoloji Dergisi*, *67*(4), 167-172.

EEC, (2020). Council Directive 2020/2184 of 23 December 2020 on the quality of water intenden for human consumption (recast). Official Journal of the European Commities L 435, 1-62.

Farr, C. R., Skousen, J., Edwards, P. J., Connolly, S. J., & Sencindiver, J. (2008). Acid soil indicators in forest soils of the cherry river watershed, west virginia. *Environmental Monitoring and Assessment*, *158*(1-4), 343-353. https://doi.org/10.1007/s10661-008-0588-8

Güler, C., Thyne, G., Mccray, J., & Turner, A. (2002). Evaluation of graphical and multivariate statistical methods for classification of water chemistry data. *Hydrogeology Journal, 10*(4), 455-474.

Güler, C. (2007). Evaluation of maximum contaminant levels in Turkish bottled drinking waters utilizing parameters reported on manufacturer's labeling and government-issued production licenses. *Journal of Food Composition and Analysis*, *20*(3-4), 262-272. https://doi.org/10.1016/j.jfca.2006.10.005

Güler, C., & Alpaslan, M. (2009). Mineral content of 70 bottled water brands sold on the Turkish market: Assessment of their compliance with current regulations. *Journal of Food Composition and Analysis*, *22*(7-8), 728-737. https://doi.org/10.1016/j.jfca.2009.03.004

Kanat, G. (2017). Risk perception and bottled drinking water consumption in Istanbul City. Global Nest Journal, 19(3), 521-532. https://doi.org/10.30955/gnj.002378

Qiu, C., Zhang, X., Zhang, Y., Tang, Q., Yuan, Z., Hoop, C. F. D., … & Huang, X. (2021). Bamboo-based biofoam adsorbents for the adsorption of cationic pollutants in wastewater: methylene blue and cu(ii). *ACS Omega*, *6*(36), 23447-23459. https://doi.org/10.1021/acsomega.1c03438

Parag, Y., Elimelech, E., Opher, T. (2023). Bottled water: an evidence-based overview of economic viability, environmental impact, and social equity. Sustainability, 15(12), 9760. https://doi.org/10.3390/su15129760

Pégorier, S., Wagner, L. A., Gleich, G. J., & Pretolani, M. (2006). Eosinophil-derived cationic proteins activate the synthesis of remodeling factors by airway epithelial cells. *The Journal of Immunology*, *177*(7), 4861-4869. https://doi.org/10.4049/jimmunol.177.7.4861

Sahin–Tóth, M. (2000). Human cationic trypsinogen. *Journal of Biological Chemistry*, *275*(30), 22750-22755. https://doi.org/10.1074/jbc.m002943200

Seid, A., Turhan, Ş., Kurnaz, A., Bakır, T., Hançerlioğulları, A. (2020). Radon concentration of different brands of bottled natural mineral water commercially sold in turkey and radiological risk assessment. International Journal of Environmental & Analytical Chemistry, 102(19), 7469-7481. https://doi.org/10.1080/03067319.2020.1830989

Seçer, A. and Bulut, M. (2021). Demographic factors affecting regular bottled water consumption: Adana province/Turkey. Türk Tarım Ve Doğa Bilimleri Dergisi, 8(1), 235-240. https://doi.org/10.30910/turkjans.766621

Turhan, Ş., Kurnaz, A., Hançerlioğulları, A. (2021). Comparison of mineral content of bottled spring and mineral waters marketed in Turkey. Turkish Journal of Agriculture - Food Science and Technology, 9(8), 1567-1572. https://doi.org/10.24925/turjaf.v9i8.1567-1572.4487

Wodschow, K., Hansen, B., Schullehner, J., & Ersbøll, A. K. (2018). Stability of major geogenic cations in drinking water—an issue of public health importance: a danish study, 1980–2017. *International Journal of Environmental Research and Public Health*, *15*(6), 1212. https://doi.org/10.3390/ijerph15061212

World Health Organization (WHO). (2022). *Guidelines for Drinking-water Quality: Fourth edition incorporating the first addendum.* Geneva: WHO Publications.

CHAPTER 5

EFFECTS OF SOME BIOSTIMULANT APPLICATIONS ON YIELD AND PRODUCTION OF STRAWBERRY

Ayşegül YAVUZ [1], Prof. Dr. Ümmügülsüm ERDOĞAN[2]

DOI: https://dx.doi.org/10.5281/zenodo.14544733

[1] Department of Organic Agriculture Management, Graduate Education Institute, Bayburt University, 69000 Bayburt, Türkiye; https://orcid.org/0000-0001-5988-3758.
[2] Department of Food Engineering, Engineering Faculty, Bayburt University, 69000 Bayburt, Türkiye; gulsum25@gmail.com, https://orcid.org/0000-0002-0490-2285

INTRODUCTION

The term biostimulants is used for substances and microorganisms that increase plant growth and plant yield, prevent adverse environmental and soil conditions, and biostimulants are defined as materials/substances that support plant growth in small amounts (Zhang and Schmidt, 1997). It is known that when biostimulants are applied in certain formulations as plant nutrients (except pesticides), they contribute to the yield, development and physiological stages of the plant (du Jardin, 2012). The European Biostimulant Industry Council states that biostimulants increase the nutrient uptake of plants and that the plant can more easily reach the microorganisms in the soil and the nutrients given to the plant. Biostimulants maintain soil health for a sustainable agriculture by increasing the biodiversity of the soil (EBIC, 2022).

Plant biostimulants are also described as fertilizers (excluding chemicals and pesticides) mixed with plant-feeding elements (Colla and Rouphael, 2015). Biostimulants are expressed as humic and fulvic acids, bacteria (microbial inoculants), vegetable and animal protein hydrolysates, mycorrhizal fungi and seaweed extracts (Canellas et al., 2015; Ruzzi and Aroca, 2015; Colla et al., 2015; Rouphael et al., 2017; Battacharyya et al., 2015). *Rhizobium, Azotobacter, Azospirillum*, which are also used as biostimulators, act as nitrogen-fixing bacteria (Rouphael and Colla, 2020). Biostimulants increase the availability of available nutrients by stimulating the nutrients in the soil (Ertani et al., 2020).

Humic substances, one of the biostimulants used in agriculture, can directly and indirectly increase plant growth. Humic substances improve soil fertility, soil structure and plant growth. They positively affect the diversity and activity of microorganisms that are effective in plant growth, and increase the nutrient uptake in the roots by providing the biochemical and physiological processes of the plant, root development in the plant and stimulating growth. Humic acid, which is accepted as an organic molecule, is an important part of a good soil and facilitates mineral uptake for plants. Humic acids regulate the permeability of the plant membrane and help regulate the water holding capacity of the soil by keeping the nutrients in the soil. They can contribute to the root development of the plant by acting as a good buffer for the nutrients (Ca, Fe, Mg, Zn, Mn) in the soil (Navya et al., 2021; Varanini and Pinton, 1995; Khaled and Fawy, 2011).

Fulvic acids are carbon-based small molecules and ensure the delivery of nutrients to the plant (Navya et al., 2021). The presence of humic and fulvic acids, which have important roles in soil and plant nutrition, in the soil ensures higher plant yield and plant quality. At the same time, humic-fulvic acids are important elements that make up the building blocks of healthy plants and fertile soil. Humic-fulvic acids, which can be used as an alternative to prevent the damage caused by excessive use of fertilizers to the soil, contribute to the restoration of the soil over time, and in this return, it first acts by increasing the plant yield (Pettit, 2004).

Bacteria that promote plant growth prevent environmental pollution, contribute to a sustainable agriculture, and increase the productivity of the soil while maintaining the continuity of the resources used. It has been reported that PGPR, which provides growth and development in plants, can be a good alternative to chemical fertilizers used in agriculture (Çakmakçı, 2005).

Strawberry is a plant that has an important place in the world and in our country and its production is increasing day by day. Although there are many studies on yield and quality in strawberry cultivation, alternatives continue to be found to support plant growth. Strawberry, which has an important place in the berry group, is a perennial and herbaceous plant (Ağaoğlu and Gerçekcioğlu, 2013). *F. virginiana* and *F. chiloensis* species were brought to Europe from America in 1600-1700 AD, and these species formed the origin of the strawberry varieties used today (Darrow, 1966). The fact that the strawberry plant can be grown in different soil and climatic conditions increases the demand in strawberry cultivation (Türemiş et al., 2000). Strawberry, which is beneficial for human health, is rich in antioxidants, organic acids and phenolic compounds, increasing its popularity (Kuru Berk, 2021). At the same time, strawberry is a fruit that can be consumed by people of all ages in terms of flavor and taste, as well as consumed in different forms such as jam, marmalade, fruit juice (Türemiş et al., 2000). Strawberries contain especially high amounts of salicylic acid, fiber and vitamins A, B, C and Fe, P, Ca, B, S are present in trace amounts (Türemiş et al., 2000). Strawberry fruit is known as a cancer protector thanks to its ellagic acid and phenolic content (Agaoglu and Gerçekcioglu, 2013).

The world population is expected to increase by more than 2.3 billion by 2050. However, it is estimated that arable land will increase by 5% until 2050 in order to meet the nutritional needs of population growth. It is known that 5% increase in arable land according to the population growth rate will not be sufficient and it is thought that it will not be able to meet the nutritional needs of the population. FAO says that by 2050, food production must increase by 70% to adequately feed the world's population. In order to solve the food shortage of the increasing population, it is necessary to ensure the continuity of sustainable agriculture. At the same time, increasing urbanization, decreasing the rural population, and increasing the production by obtaining high efficiency with less labor from the usable agricultural lands will reduce the anxiety of the future (FAO, 2021a). With agriculture being the livelihood of more than 2.5 billion people in the world, 7.9 billion people are provided with food. It is known that sustainable agricultural systems are needed in order to meet the food needs of people and to produce sufficient food in agricultural production affected by climate change (FAO, 2021b).

Sustainable agriculture envisages the conservation of resources and the use of agricultural technologies that do not harm the environment. It is known that as a result of excessive and unmeasured use of synthetic fertilizers, the natural balance is disturbed and human nutrition is negatively affected, as well as harming all living things in nature. Realizing that the resources used are not unlimited, it is necessary to reduce the use of synthetics that disrupt the natural balance and to prevent the difficulties that may arise in the future for a sustainable agriculture (Turhan, 2005). In this review, the effects of important categories of biostimulants on yield and quality in strawberry cultivation were investigated.

1. Studies Humic and Fulvic Acid

In a study carried out by Aghaeifard et al. (2016) investigated the effects of humic acid and salicylic acid on yield and plant growth on Camarosa (Fragaria x ananassa Duch.) strawberry cultivar. Humic acid was applied to plant leaves at the rates of 0, 25, 50 and 100 mg L^{-1}, with concentrations of 0, 1, 2, 3 and 4 mM in SA. As a result of all parameters measured for 150 days, the highest HA ratio was found 25 mg L^{-1} (116.20%) in total plant yield compared to the control. HA 25 mg L^{-1} also increased the total yield of the plant at all concentrations formed with SA. HA application alone increased the average fruit weight and fruit size compared to the control, as well as increased P (39.11%) and K (69.73%) ratios. Titratable acidity was found to be higher in HA applications than in the control.

In a study carried out by Dolatiyan et al. (2016) investigated the effects of humic acid on some growth parameters of Selva cultivar. Humic acid obtained from vermicompost in combination with 10 mg of indole acetic acid. The experiment was applied in three replications as 0, 15, 30 mg/L (from the leaf). They reported that the highest yield, chlorophyll, and total soluble solids were obtained from the application of 15 mg/L humic acid to the leaves of Selva strawberry cultivar. The highest dry root weight value was obtained from the combination of humic acid and indole acetic acid obtained from 30 mg/L vermicompost.

Humic acid was applied to Festival strawberry cultivar at different rates (0, 200, 400 mg/L) soil application and seaweed leaf application (0, 500, 1000, 1500 mg/L) and plant growth, yield, fruit quality was determined. criteria were examined. As a result of the examinations, humic acid and seaweed gave high values in all criteria and according to the results, the application of humic acid 400 mg/L and seaweed 1500 mg/L increased the parameter values in Festival strawberry variety (Alkharpotly et al., 2017).

Kilic et al. (2021), Albion, San Andreas, Monterey strawberry cultivars were used in their study and investigated the plant soluble solids content, total acidity, fruit firmness, vitamin C, specific sugars, organic acid values of chemical and organic fertilizers. Considering the results of the fertilizers on the plant, the soluble solids content and glucose value of the organic fertilizer application were found to be more important than the chemical fertilizer application. They reported that strawberry fruits with higher chroma value and higher color ratio were found in organic fertilizers.

Kaviani et al. (2022), applied humic acid to Local and Selva strawberry cultivars in their study and the growth and development parameters of the plant were followed. Humic acids were applied to the plant at rates of 0, 300, 600, 1000 mg l^{-1}. Considering the results, the highest fruit weight of humic acid in the plant was obtained from the Selva strawberry variety with a ratio of 1000 mg l^{-1} and they reported that the application of humic acid increased the yield and growth of the strawberry plant.

The biostimulants applied to the root zone of the Monterey and Portola strawberry cultivars were applied to the fruit yield, number of fruit per plant, leaf color (L*, a*, b*), fruit color (L*, a*, b*) in both strawberry cultivars. Hueo, C), SCT, pH, titratable acidity, chlorophyll, CAT, POD, SOD, mineral matter (N, P, K, Ca, Mg, S, Na, Mn, Fe, Zn, B, Cl), amino acid (aspartate, glutamate, asparagine, serine, glutamine, histidine, glycine, thionine, arginine, alanine tyrosine, cystine, valine, methionine, tryptophan, phenylalanine, leucine, lysine, hydroxyproline, sarcosine, proline), organic acid (oxalic, propionic , tartaric, butyric, malonic, malic, lactic, citric, maleic, fumaric, succinic) and sensory analysis values were found to be more effective than control (Yavuz, 2022).

2. PGPR Studies

Pırlak and Köse (2009) investigated the effects of plant growth promoting rhizobacteria [(Pseudomonas BA-8 (biological control agent), Bacillus OSU-142 (N2-stabilizer) and Bacillus M-3 (N2-stabilizer and phosphate solubilizer)] on Selva strawberry variety in their study conducted in 2002-2003, and determined that Pseudomonas BA-8 and Bacillus OSU-142 have a great potential in increasing strawberry yield and development when used alone or together.

In the application of three different fertilizers (diazotrophic bacteria Klebsiella planticola liquid inoculum (PGPR1), Azotobacter, Derxia and Bacillus combined liquid inoculum (PGPR2) and Multi KMg fertilizer) to Senga Sengana strawberry variety under greenhouse conditions, the highest yield per plant was recorded in PGPR1-applied plants with 520 g/plant. It was also determined that all three applications had a significant effect on the chemical properties of strawberry fruits (Pesakovic et al. 2013).

In a study examining the effects of biostimulants on the growth of strawberries (Fragaria x ananassa), researchers found that biostimulants have significant effects on plant growth. Three different biostimulants were used in plants and they reported that biostimulants have significant effects on root diameter, surface area, plant height, root area, and above-ground plant growth in plants (Dong et al., 2020).

Considering the studies discussed in the review, it is seen that biostimulants have positive effects on crop yield, plant growth and resistance to stress factors in strawberry cultivation. In this process, where the food needs of the increasing population are tried to be met, it is possible to reduce the excessive and unconscious use of agricultural inputs such as pesticides and fertilizers with the use of biostimulants, thus preventing environmental pollution caused by agricultural chemicals. The basic idea in the use of biostimulants is to protect the natural environment and resources, to support the soil flora and to support a sustainable agriculture by increasing the yield and quality parameters of the product. The studies show that biostimulants generally play a positive role on yield and quality in strawberry plants. For this reason, it can be thought that the results obtained can form a basis for further research.

REFERENCES

Aghaeifard F, Babalar M, Fallahi E, Ahmadi A. 2016. Influence of humic acid and salicylic acid on yield, fruit quality, and leaf mineral elements of strawberry (*Fragaria* × *Ananass*a duch.) cv. Camarosa. Journal of Plant Nutrition, 39: 1821-1829. doi: 10.1080/01904167.2015.1088023

Ağaoğlu YS, Gerçekcioğlu R. 2013. Üzümsü Meyveler. Ankara: Tomurcukbağ Ltd.Şti. Eğtim Yayınları No:1.

Alkharpotly A, Mohamed R, Shehata M, Awad A. 2017. Impact of soil humic acid soil application and seaweed extract foliar spray on growth, yield, and fruits quality of strawberry plants grown under Aswan conditions. Journal of Soil Sciences and Agricultural Engineering, 8: 307-315. doi: 10.21608/jssae.2017.37496

Battacharyya D, Babgohari M, Rathor P, Prithiviraj B. 2015. Seaweed extracts as biostimulants in horticulture. Scientia Horticulturae, 196: 39-48. doi: 10.1016/j.scienta.2015.09.012

Canellas L, Olivares F, Aguiar N, Jones D, Nebbioso A, Mazzei P, Piccolo A. 2015. Humic and fulvic acids as biostimulants in horticulture. Scientia Horticulturae, 196: 15-27. doi: 10.1016/j.scienta.2015.09.013

Colla G, Rouphael Y. 2015. Biostimulants in horticulture. Scientia Horticulturae, preface, 196, 1-2.

Çakmakçı R. 2005. Bitki gelişimini teşvik eden rizobakterilerin tarımda kullanımı. Atatürk Üniversitesi Ziraat Fakültesi Dergisi, 36: 97-107.

Darrow GM. 1966. The strawberry; history, breeding and physiology. Publisher: Holt, Rinehart and Winston, urn:oclc:record:1036887792

Dolatiyan N, Fotowat A, Tehranifar A. 2016. The effect of humic acid on some growth and physiological characteristics of *Fragaria ananassa* var: Selva in greenhouse conditions. Journal of Soil and Plant Interactions-

Isfahan University of Technology, 7(1), 71-84. doi:10.18869/acadpub.ejgcst.7.1.71

Dong C, Wang G, Du M, Niu C, Zhang P, Zhang X, Bao Z. 2020. Biostimulants promote plant vigor of tomato and strawberry after transplanting. Scientia Horticulturae, 267, 109355. doi: 10.1016/j.scienta.2020.109355

du Jardin P. 2012. The Science of Plant Biostimulants–A bibliographic analysis. Ad hoc study on bio-stimulants products. Contract 30-CE0455515/00-96, Final report.

EBIC, 2022. The European Biostimulant Industry Council. Plant biostimulants contribute to climate-smart agriculture. Available from: https://biostimulants.eu/issue/plant-biostimulants-contribute-to-climate-smart-agriculture/ [Accessed 18 December 2022]

Ertani A, Schiavon M, Serenella N. 2020. Humic substances (HS) as plant biostimulant in agriculture. 55-76. In: Rouphael Y, du Jardin P, Brown P, De Pascale S, Colla G, (editors). Biostimulants For Sustainable Crop Production, Burleigh Dodds Science Publishing. pp. 386-408. ISBN: 9781003047865

FAO, 2021a. Food and Agriculture Organization of the United Nations. FAOSTAT. Available from: http://www.fao.org/faostat/en/#data/QC [Accessed 13 October 2022]

FAO, 2021b. Tracking progress on food and agriculture-related SDG indicators 2021. Available from: https://www.fao.org/platforms/water-scarcity/Knowledge/knowledge-products/detail/tracking-progress-on-food-and-agriculture-related-sdgs-indicators-2021-a-report-on-the-indicators-under-fao-custodianship [Accessed 28 February 2022]

Kaviani B, Ashegh J. 2022. Leaf application of humic acid on morphologic, flowering and fruit traits of ‘Local’ and ‘Selva’ strawberry cultivars under different cultivation beds. Journal of Horticultural Science, 35: 135-151. doi: 10.22067/JHS.2021.61935.0

Khaled H, Fawy H. 2011. Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. Soil and Water Research, 6: 21-29. doi: 10.17221/4/2010-SWR

Kılıc N, Türemiş NF, Daşgan HY. 2021. The effect of fertilizers on crop yield, fruit quality and plant nutrition of organically grown strawberry (Fragaria x ananassa Duch.). Applied Ecology and Enviromental Research, 19: 2201-2211. doi: 10.15666/aeer/1903_22012211

Kuru Berk S. 2021. Arbusküler mikorhizal fungus ve putresin uygulamalarının çileğin fizokimyasal özellikleri üzerine etkisi. PhD Dissertation. Institute of Graduate Education, Bolu Abant İzzet Baysal University, Bolu, Turkey.

Navya M, Deepthi C, Mubeena P, Thomas U. 2021. Humic Substances: An Elixir to Plant Growth. Biotica Research Today, 3: 435-436. Article: RT620

Pešaković M, Karaklajić-Stajić Ž, Milenković S, Mitrović O. 2013. Biofertilizer affecting yield related characteristics of strawberry (Fragaria× ananassa Duch.) and soil micro-organisms. Scientia Horticulturae, 150: 238-243. doi: 10.1016/j.scienta.2012.11.016

Pettit RE. 2004. Organic matter, humus, humate, humic acid, fulvic acid and humin: their importance in soil fertility and plant health. CTI Research, 10, 1-7. Corpus ID: 15995040

Pırlak L, Köse M. 2009. Effects of plant growth promoting rhizobacteria on yield and some fruit properties of strawberry. Journal of Plant Nutrition, 32: 1173-1184. doi: 10.1080/01904160902943197

Rouphael Y, Colla G, Graziani G, Ritieni A, Cardarelli M, De Pascale S. 2017. Phenolic composition, antioxidant activity and mineral profile in two seed-propagated artichoke cultivars as affected by microbial inoculants and planting time. Food chemistry, 234: 10-19. Doi: 10.1016/j.foodchem.2017.04.175

Rouphael Y, Colla G. 2020. Biostimulants in agriculture. Frontiers in Plant Science, 11, 40. Article. doi: 10.3389/fpls.2020.00040

Ruzzi M, Aroca R. 2015. Plant growth-promoting rhizobacteria act as biostimulants in horticulture. Scientia Horticulturae, 196: 124-134. doi: 10.1016/j.scienta.2015.08.042

Turhan Ş. 2005. Tarımda sürdürülebilirlik ve organik tarım. Tarım Ekonomisi Dergisi, 11: 13-24.

Türemiş N, Özgüven AI, Paydaş S. 2000. Güneydoğu Anadolu Bölgesinde Çilek Yetiştiriciliği. Türkiye Bilimsel ve Teknik Araştırma Kurumu, Türkiye Tarımsal Araştırma Projesi Yayınları, Adana.

Varanini Z, Pinton R. 1995. Humic substances and plant nutrition. In: Dietmar Behnke H, Lüttge U, Esser K, Kadereit JW, Runge M(editors). Progress in Botany. Botany (Part of the book series, volume 56) Springer. pp. 97-117. ISBN: 978-3-642-79249-6.

Yavuz A. 2022. Biyostimülan Uygulamalarının Bazı Çilek Çeşitlerinde Verim ve Gelişme Üzerine Etkileri. MSc Thesis, Institute of Graduate Education, Bayburt University, Bayburt, Turkey.

Zhang X, Schmidt RE. 1997. The İmpact Of Growth Regulators On Alpha-Tocopherol Status of Water-Stressed Poa pratensis L. International Turfgrass Society Research Journal, 8 (part 2): 1364-1371.

CHAPTER 6

CLEANING AND HYGIENE IN BEEKEEPING

Assoc. Prof. Dr. Yaşar ERDOĞAN[1]

DOI: https://dx.doi.org/10.5281/zenodo.14544741

[1] Bayburt University, Demirözü Vocational School, Department of Veterinary Medicine, Bayburt, Türkiye. yasarerdogan@hotmail.com

INTRODUCTION

The establishment, maintenance, care and management of colonies of any species of social bees is defined as beekeeping. Beekeeping is a form of agricultural production that is carried out with little capital, without being dependent on land, and where idle labor can be utilized (Yaşar Erdoğan, 2019a). Honeybee colonies are housed in areas called apiaries and boxes called beehives (Erdogan, Dodologlu, & Emsen, 2009; Yaşar Erdoğan, 2019b). As a result of beekeeping activities, bee products such as honey, pollen, royal jelly and bee venom are produced (Yaşar Erdoğan, Turan, & Technology, 2022).

Beekeepers want to work with healthy and strong bee colonies. They want to offer the beekeeping products they obtain as a result of beekeeping activities to their customers in a pure and clean way.

In order to achieve this, beekeepers need to have at least basic information about disinfection principles.

Microorganisms are widespread all over the world. Most microorganisms are useful; a small portion are harmful (pathogenic). Pathogenic microorganisms can cause diseases under certain conditions. Disinfection and sterilization aim to eliminate pathogenic microorganisms.

Today, the development of antibiotics that eliminate microorganisms does not mean that disinfection or sterilization should be abandoned. This is also valid for beekeeping. Instead of using antibiotics for treatment or preventive purposes against all kinds of diseases, it is necessary to work hygienically and prevent diseases from spreading to the colonies.

Hygiene is of great importance for the protection of the health of bees and bee products such as honey, pollen, propolis, etc.

Therefore, the importance of disinfection in beekeeping is increasing day by day. Disinfection can be defined as killing microorganisms in the environment to a number that will not cause disease or food spoilage. Disinfection involves the destruction of pathogenic microorganisms, while sterilization involves killing all microorganisms, both vegetative and sporogenic forms. Disinfectants are chemicals used to destroy microorganisms in the environment. (Bojanıć Rašovıć, 2021)

BASIC PRINCIPLES OF DISINFECTION

Disinfection can be defined as the destruction or killing of microorganisms found in water, air and intact skin. The purpose of disinfection in beekeeping is to prepare environments free from all kinds of pathogenic microorganisms that can cause bees to become sick or weakened (Öngen, 2009; Titěra, 2009).

If the infection spreads between bee colonies, through contact with each other (spoiling, plundering) or through an intermediary (*Varroa jacopsoni*), disinfection is completed with medicated intervention. When defining disinfection, sterilization must also be considered. The most important difference between disinfection and sterilization is that disinfection eliminates pathogenic microorganisms, while sterilization eliminates all microorganisms and other life forms (Öngen, 2009; Titěra, 2009).

When considering a specific epidemiological situation, there are two types of disinfection:

a) Preventive (prophylactic) disinfection

b) Disinfection against the target microorganism (suppressive)

Preventive disinfection

Preventive disinfection is carried out when there is no infectious disease in the apiary or in nearby apiaries. In fact, preventive disinfection is part of regular hygienic duties.

It is linked to the cleaning of the apiary's beekeeping tools and equipment. This duty also includes the provision of clean and healthy water for the bees. Preventive disinfection should also be carried out during the harvesting and processing of bee products (Titěra, 2009).

Disinfection against a targeted microorganism

Targeted disinfection is performed to eliminate microorganisms at the focus of the infection in order to prevent excessive spread of the infection.

The following should be done along with disinfection against the targeted microorganism:

- Determining the ways infections spread
- Knowing the effectiveness of disinfectants

- Considering the negative effects of the disinfectant on the material and environment to which it is applied.

Target disinfection can be achieved as follows

a) Effective veterinary measures from the moment the disease appears (destruction of infected bee colonies and equipment).
b) It means a one-time action that is ultimately preceded by the elimination of the focal point and the withdrawal of extraordinary veterinary provisions (Titěra, 2009).

General requirements for disinfection

Disinfection must be carried out by experts and approved chemicals and procedures must be used in the disinfection process.

Points to consider during the disinfection process

- Effectiveness of the selected disinfectant and disinfection procedure against target microorganisms.
- Depends on the method of application of the disinfectant (wiping, immersion, spraying, foam).
- Concentration of the disinfectant
- Time required for the disinfection process to be effective
- Disinfected environment
- Effect of the disinfection procedure on the material to be disinfected
- Financial cost of the disinfection process.Dezenfektanların

Effects on microorganisms

Disinfectants are chemical substances that cause negative changes in the living environments of microorganisms. Effects of disinfectants on microorganisms.

Cidal effect; effect by killing microorganisms.

Static effect; effect by temporarily stopping their reproduction or stopping their growth (Öngen, 2009).

Disinfection methods

Disinfectants are effective by disrupting the metabolism and enzymes of microorganisms. Disinfection against microorganisms is carried out in different ways depending on the structure of the material to be disinfected (Table 1).

Table 1. Disinfection methods

Dip	The materials to be disinfected are immersed in the disinfection solution for a certain period of time.
Wipe	By wiping with a cloth or mop dampened with disinfectant.
Spraying	It is applied by spraying disinfectant in appropriate concentrations with appropriate pressure and mechanical sprayers.
In the form of gas	Disinfectant substance is applied in gaseous form.
In the form of steam	If the area to be disinfected is large, it is disinfected with this method.
In foam form	Disinfectants are applied with foam generators; this method is more suitable for cleaning walls and ceilings..

(Titěra, 2009)

Disinfection methods

Disinfection is done physically, chemically, or a combination of the two.

Physical disinfection methods

Physical disinfection methods are more environmentally friendly than chemical methods. This method is based on the use of dry or wet heat and radiation. The methods applied do not have the same level of killing power against pathogenic microorganisms.

Methods that can be used in the disinfection of beekeeping equipment:

* Incineration (in cases of highly contagious diseases such as brood rot, this method is used in the disinfection of equipment such as hives, bee remains, frames and cover cloths).

* Boiling (boiling in water at 100 0C for 15 minutes)(Öngen, 2009).

*Boiling in autoclave (boiled for 20 minutes).

*Disinfecting by washing in washing machines at 90 °C (disinfection of protective clothing).

*Holding in ovens at 110 °C to 150 °C for 30 minutes. Higher temperatures and humidity increase the disinfection effect.

*Pasteurization consists of rapid heating to 85-90 °C for a few seconds and then cooling (Forbes, Sahm, & Weissfeld, 2007; Russell, Microbiology, & Infections, 2010).

* Steam disinfection with a fixed or mobile steam generator.

*Use of ultraviolet (UV) light (Öngen, 2009; Titěra, 2009).

UV only affects microorganisms directly on the irradiated surface (Boyd & Hoeri, 1995). The dust layer on the surface reduces the efficiency of UV. Microorganisms in water are killed only to a depth of 0.1 to 1 mm (Russell et al., 2010).

The spore form of bacteria is resistant to ultraviolet radiation. UV rays destroy some viruses very well.

*Ionizing radiation (radioactivity). Ionizing radiation in a certain wavelength range of 240-280 nm has a very high power to kill bacteria (Öngen, 2009).

Radiation in this wavelength is called gamma radiation. The minimum dose required to kill bacteria is 5 kJ/kg.Since this disinfection method is widely used in the production of bandages and the packaging of spices, there is no doubt that it can be easily used and useful in beekeeping.The most important disadvantage of this method is the high cost and the need to transport the materials to be disinfected to radiation facilities.

Chemical disinfection methods

This disinfection method is superior to physical methods in terms of its effects on microorganisms and its application. The following chemical reactions are used very frequently in the disinfection process (Table 2).

Table 2. Mechanisms of chemical disinfection

Mechanism	Active substance
Oxidation	Chlorine, hydrogen peroxide, ozone, ethylene oxide
Hydrolysis	Acids, caustic soda
Formation of protein salts	Salts of alkali metals and heavy metals
Coagulation of intracellular proteins	Quaternary ammonium salts, phenols, alcohols, metals
Change in permeability of cell membranes	Quaternary ammonium salts
Penetration into the enzymatic system	Metals, formaldehyde, phenol
Disruptions in the mechanical structure of cells	Quaternary ammonium salts

(Titěra, 2009)

Chemical disinfection is carried out in two stages,

1-Mechanical cleaning

2-Disinfection

These two stages can be combined by using disinfectants with washing and cleaning properties.

For chemical disinfection to be successful,

*Disinfection solutions, active ingredients and water should be prepared by carefully weighing them (Table 3).

*When preparing solutions, attention should be paid to the concentration of the active ingredient.

*The solution should be used immediately after preparation.

*The effectiveness of some solutions increases even more at high temperatures. For example, the effectiveness of chlorinated, phenolic and quaternary ammonium salts increases at 50-60 °C, and hydroxides at 80 °C.

*Active ingredients with different chemical structures should be used alternately so that microorganisms do not develop resistance to the active ingredient.

*When working with disinfectants, protective equipment such as gloves, goggles and disposable overalls should be used.

Disinfectants should be selected by considering their effectiveness, odor, biodegradability, shelf life and price.

*When diluting, water should be added first, then the active ingredient.

Table 3. Amounts of water and disinfectant to be used when preparing disinfection solutions.

Solution volume	Solution concentration			
	% 0.5	% 1	% 2	% 5
	Amount of disinfectant (grams or ml)			
1liter	5	10	20	50
2 liter	10	20	40	100
5 liter	25	50	100	250
10 liter	50	100	200	500

(Titěra, 2009)

Factors affecting the activity of disinfectants:

*Type of microorganism

*Number of microorganisms

*Resistance of microorganisms

*Temperature and pH

*Concentration of disinfectant

*Density of organic matter

*Structure of the surface to be disinfected

*Contact time

*Type of water used in preparing the solution (Hardness degree)(Öngen, 2009).

Chemical Substances That Can Be Used As Disinfectants

Hydroxydes and Alkaline Salts

Hydroxide and alkali salt solutions act through high concentrations of hydroxyl anions (OH). Solutions with a pH higher than 12 are most effective.

Chemicals in this group

- Ammonium hydroxide NH4+.OH-
- Potassium hydroxide, KOH:
- Sodium hydroxide, NaOH
- Sodium carbonate, Na2CO3
- Calcium hydroxide, Ca(OH)2

Inorganic acids

These chemicals are effective but also caustic and corrosive. The lower the pH of the solution, the stronger the solution.

These chemicals are not used much in beekeeping. Hydrochloric acid (HCl) is used at a concentration of 10% for general cleaning. Phosphoric acid (H_3PO_4) and sulfuric acid (H_2SO_4) are used in wax processing at concentrations of 0.5% to 5%.

It should be noted that acid should always be poured into water during dilution, not water into acid**.**

Organic acids

Formic acid and oxalic acid are acaricides used against the bee parasite *Varroa destructor*. Acetic acid and sulfuric acid are used against wax moth larvae in honeycomb tanks. In addition, all of these acids have a disinfectant effect against some bacteria and fungi.
Peracetic acid is a good disinfectant for cleaning glass containers used in beekeeping.

Oxidizing agents

All substances that are separated from monatomic new oxygen have very good disinfecting effects. The disinfecting effect of oxygen increases in the presence of certain metals such as silver and magnesium.

The following can be used for disinfection in beekeeping practices:

- *Hydrogen peroxide (H_2O_2).*

It is stored as a solution in water. It is sold as 3%, 10% and 30% solutions. Hydrogen peroxide solutions age very quickly (Jeffrey, 1995).

- *Potassium permanganate (KMnO4).*

They are dark purple crystals that dissolve easily in water. Permanganate aqueous solution (0.3%) is effective against bacteria and viruses. It used to be used to disinfect hands.

Organic peroxides are quite expensive disinfectants. They are effective against bacterial spores. Another advantage is that they are environmentally friendly.

Dismozon (active ingredient magnesium monoperoxyphthalate) is effective against bacterial spores but is quite expensive for daily use in beekeeping practice.

- *Ethylene oxide*

It is a liquid with a low boiling point (11 ° C). Ethylene oxide in gaseous form disinfects the surface of objects very effectively. It is used in beekeeping and disinfection of equipment.

Halogens

The mechanism of action is based on the combination of the action of highly reactive halogen compounds and newly formed oxygen released in an alkaline environment.

Sodium hypochlorite (NaClO)

It has excellent bactericidal and virucidal properties. It is widely used. It is an effective component of many commercial preparations.

The solution must act for about 30 minutes to obtain a disinfectant effect. Mixing sodium hypochlorite with acids and acidic disinfectants is extremely dangerous and should not be done because gaseous hydrogen chloride, which is irritating and toxic to humans when inhaled, can be released.

Metals and their compounds

Some metals are significantly toxic to living cells. Metal ions pass into solution in insignificant amounts, but can still be very effective as disinfectants. For example, silver compounds can be used to disinfect drinking water. Bees tolerate colloidal silver and nanosilver better. Bees are unaffected by copper (Titěra, 2009).

Alcohols, ethers

Most commercial disinfectants are based on alcohols. Alcohols are most effective at about 70% solution. Concentrated alcohol (99% pure alcohol) and very diluted alcohol are not good disinfectants. Alcohols are broad-spectrum antimicrobial agents that damage microorganisms by disrupting their cell membranes and protein structures (Ewart & goats, 2001; Joklik, Willett, Amos, & Wilfert, 1992; Quinn & Markey, 2001).

Alcoholic preparations are not sufficient to destroy spores. They are known to be reasonably effective against some viruses. It has not yet been confirmed whether alcoholic solutions also destroy bee viruses and under what conditions.

Aldehydes

The disinfecting effect of aldehydes is based on chemical reduction and alkylation reactions that denaturate proteins and damage cells (Ewart & goats, 2001; Quinn & Markey, 2001).

Formaldehyde (HCHO)

Formaldehyde is a gas. In solution, in water up to 35% to 40% solution, it is known as formalin. In the past, it was widely used in health care and agriculture because it was effective and cheap. There are now very strict regulations governing its use due to its harmful effects on human health. In beekeeping, it can only be used to disinfect equipment that can be thoroughly rinsed with water several times. Wooden materials, honeycombs and beeswax should not be disinfected with formaldehyde because it leaves significant residues on the treatment surfaces and it is not possible to easily remove these residues. This disinfectant should not come into contact with bee products. (Ewart & goats, 2001; Öngen, 2009; Quinn & Markey, 2001; Titěra, 2009).

Glutaraldehyde ((CH2)3(CHO)2)

Glutaraldehyde is also one of the most effective disinfectants. Glutaraldehyde reliably destroys bacteria, viruses and spores after prolonged exposure. It is used as part of disinfection mixtures. Before use, it is diluted to a concentration of 2% and alkalized by adding 0.3% NaHCO3 (sodium bicarbonate). The solution can be used for several days. Glutaraldehyde 0.25%- 0.5% is used in spray form, for example in the preparation of STERILIUM (Ewart & goats, 2001; Greene & Cat, 1998; Öngen, 2009; Quinn & Markey, 2001).

Cyclic compounds

This group of disinfectants are effective by damaging enzymes and protoplasm. They are usually irritating to the skin and have a characteristic odor. Despite their superior disinfectant properties, they are not used much in beekeeping.

Phenol is one of the oldest known and most effective disinfectants. It is slightly soluble in water and very easily soluble in alcohol. A number called the phenol coefficient is a number that shows how many times more effective a product is than phenol. Phenol is a good disinfectant.

Surfactants, tensides, detergents, wetting agents

These are natural or synthetic substances such as soaps and detergents used in washing. They increase the wettability of the surfaces of the cleaned objects by reducing the surface tension of water. They are very helpful during disinfection because they dissolve oils.

Tensites from the group of quaternary ammonium compounds have particularly disinfecting effects.

Quaternary ammonium compounds are particularly effective on gram-positive bacteria and are ineffective on gram-negative bacteria. Their disinfectant effects are eliminated with soap.

Combined preparations

Disinfectants based on several active substances are appropriately combined and manufactured for commercial sale. Thus, preparations with lower concentrations can provide higher efficiency.

However, it should be remembered that combined preparations are not miraculous disinfectants.

Laboratory tests of products are carried out using comparative methods on selected strains of bacteria, fungi or viruses. However, among the microorganisms we combat in beekeeping, there are several highly resistant microorganisms, such as American foulbrood and its resistant spores.

These bacteria and their spores survive the effects of many disinfectants that are declared effective. Some products state that they are antiviral in their description, but this is only valid against the virus strains tested. We still know very little about the forms and conditions under which bee viruses survive. These viruses usually belong to the group called picornaviruses. For this reason, the laboratory of the beekeeping research institute is constantly developing and checking disinfection procedures specially designed for small and large bee operations.

Mistakes made during the disinfection process

* Wrong preparation selection
*Wrong preparation combination selection
*Using the wrong concentration
*Using the old solution
*Insufficient exposure time to disinfection
*Insufficient surface cleaning of the materials to be disinfected (Titěra, 2009).

SENSITIVITY OF PATHOGENEMIC MICROORGANISMS

Viruses

Viruses are very small infectious agents that have DNA or RNA packaged in a complex protein or structure envelope (Arda, 2000)

In 1971, David Baltimore made a classification based on the type of nucleic acid incorporated into the viron structure of viruses (Baltimore, 1971).

I. Double-stranded DNA viruses (Adenoviridae);

2. Single-stranded DNA viruses (Geminiviridae);

3. Double-stranded RNA viruses (Reoviridae);

4. Positive-specific single-stranded RNA viruses (Potyviridae);

5.Negative-specific single-stranded RNA viruses (Paramyxoviridae);

6. Reverse-transcribing RNA viruses (Retroviridae) (Baltimore, 1971)

They cannot reproduce on their own, but they can multiply in host cells. (Kabil & Onat, 2020).

About ten viruses that infect adult bees and young bees have been identified in terms of disease symptoms. Most bee viruses are small, single-stranded RNA viruses without a protein coat. These are called picorna viruses. These viruses are very resistant to disinfectants and it is very difficult to destroy them with alcohol. The basic method of disinfection in beekeeping is the mechanical cleaning of tools and equipment and then the use of oxidizing preparations (Titěra, 2009).

Bacteria

Bacteria are microscopic single-celled organisms. Most of them are beneficial to life, while a few are pathogenic.

Some of the bacteria are spore-forming, while others are non-spore-forming. All bacteria can be easily destroyed in their vegetative phase, that is, in their common form where they grow and divide.

Bacteria form spores against adverse environmental conditions. It is very difficult to destroy the spore forms of bacteria through disinfection procedures (Doron & Gorbach, 2008).

For example, the non-spore-forming *bacterium Leuconostoc mesenteroides* dies within half an hour at a temperature above 60 °C, while ten percent of the spores of one of the spore-forming bacteria, AFB (American foulbrood) (*Panibacillus larvae*), can survive for more than fifty hours at a temperature of 108 °C (Titěra, 2009).

AFB and EFB (European foulbrood), which are highly contagious bee diseases, are considered the main bacterial diseases of honey bees. Even in beekeeping facilities where these diseases are not present, attention should be paid to cleanliness and bacteria should be combated. Generally, bacteria can be destroyed with high temperatures, UV radiation and varying chemical disinfectants (Doron & Gorbach, 2008)

Freezing does not kill most bacteria, and extreme cold (-196°C) does not kill American foulbrood spores (Titěra, 2009).

Fungi

Fungi are larger organisms compared to bacteria, they are unicellular and multicellular and usually filamentous. Fungi have an irreplaceable role in nature and only some of them cause economic problems. In beekeeping, Nosema disease is caused by microsporidian parasites *Nosema apis* and *Nosema ceranae* (Ingemar Fries, 1993; Ingemar Fries, Feng, da Silva, Slemenda, & Pieniazek, 1996; Higes, Martín, & Meana, 2006). Again, the fungus *Ascosphaera apis* causes lime disease (Spiltoir, 1955).

Yeasts are also classified among fungi. Yeasts, molds and bacteria contaminate honey during processing in unclean environments. Most fungi, whether vegetative or spore-forming, are not as resistant to disinfectants as bacteria. High temperatures and most chemical disinfectants can destroy fungi.

Other disease agents

It is not only microorganisms that cause harm to bees. In addition to microorganisms, there are also more complex organisms. These are mites, Varroa jacopsoni, Acarapis woodi, Tropilaelaps and Aethina tumida. In order to reduce their parasitic effects, adults usually need to be destroyed, which is not called disinfection (Titĕra, 2009).

Preventive (prophylactic) disinfection

Cleaning and disinfection

The areas where beekeeping activities are carried out should be free of all kinds of dirt and grime. Because microorganisms can multiply in dirty environments. Cleaning is usually done mechanically. Concrete or tile floors should first be swept with a broom and then wiped with wet mops. When mopping, a detergent that dissolves dirt and oil well should be added to the water. Then, the washed surfaces should be wiped with a good disinfectant.

Rodent control

Environmental cleaning also includes combating harmful rodents. While mice are harmful to bees in winter, they damage honey, beeswax hives and frames in storage.

The most important reasons for combating rodents are;

*To prevent beekeeping products from being contaminated with microorganisms

*To prevent bee products from being contaminated with feces, urine and hair

Preventive measures

Beekeeping warehouses, honey extraction rooms and rooms where these products are stored should not provide an environment for rodents to live. Appropriate rodent control methods should be applied in these areas (Titěra, 2009).

Stations containing poisonous paste or granulated bait should be placed in every corner of the apiary and storage areas. These stations prevent any pet animal other than rodents from eating these baits and getting harmed. The baits in this station are checked from time to time and if the baits are consumed, bait is put in again. Classic rodent traps can also be used. The mice caught in the trap are taken and the trap is set again. Traps or sticky traps that are cruel to animals and do not kill them immediately should not be used (Mason & Littin, 2003).

Disinfection of beehives and frames

Beehives used to house bees should be made of materials that are easy and possible to clean and disinfect. The most commonly used material for beehives is wood, which is ideal for bees.

Disinfection is quite complicated due to the structure of wood; since living microorganisms can live in the pores of wood and it is difficult for chemicals to reach these pores. The hive should be completely disinfected before bee colonies are placed in the hives. In the disinfection of hives, utmost attention should be paid, especially to the bottom board (Bojanıć Rašovıć, 2021).

Disinfection of cover board and mating boxes

First, mechanical cleaning is done. The inner and outer surfaces of the boxes are thoroughly scraped with a steel scraper. A hot air gun can also be used to disinfect the mother boxes. The garbage resulting from the scraping should be destroyed by burning. Disinfection is done after the scraping process (Bojanıć Rašovıć, 2021).

Thermal disinfection

Burning

A propane-powered blowtorch can be used effectively for this purpose. Burning with flame is not sufficient for complete disinfection. For complete disinfection of the hive and other wooden materials, they must be burned until they turn brown. However, this is not sufficient to kill AFB spores. AFB spores can penetrate up to 3 mm deep into the wood structure.

Long-term heating

If we can keep beekeeping equipment in a room heated to 50-52 °C for at least 24 hours, we will clean the beehives, frames, combs and all other equipment from nosema and chalk disease spores.

Chemical Disinfection

All microorganisms, including pathogens, settle in the capillary openings in wood. AFB spores that settle there can survive in the microscopic cracks of the hives for a very long time. It is not possible to effectively disinfect wood with disinfectant solutions alone. Some of these disinfectant solutions are as follows.

Acid vapors

Formic acid, acetic acid, peroxyacetic acid and sulfuric acid vapors can be used to prophylactically disinfect beehives. However, these acids are quite expensive for disinfecting beehives.

Ethylene oxide

This disinfectant requires special and very expensive equipment. In addition, ethylene oxide forms an explosive mixture with air, which makes its use complicated. Therefore, it is very difficult to use this disinfectant in practice.

Instead of disinfecting and reusing old combs obtained as a result of beekeeping activities, it would be better to boil them and turn them into wax. If we are sure of the reliability of the combs we obtain, we can reuse them (Table 4.).

Table 4. Factors causing colony losses and how to use the remaining empty combs.

Causes of colony losses	***What to do with honeycombs?***
Starvation, queen loss, false queen, mice, birds	-Empty and clean honeycombs can be reused. -Very old honeycombs can be turned into candles.
Chemical spray poisoning	Except for fipronil and neonicotinoid poisoning, the pads can be reused.
Nosema	The honeycombs can be used after prolonged heating and disinfection.
Chalkbrood disease	Honeycombs with intense lime disease should be burned.
Honeycombs with viral diseases	Honeycombs can be processed into candles.
Honeycombs with *Varroa jacobsoni*	Empty honeycombs can be left for a week and used, or the honeycombs can be processed into wax..
Bacterially diseased (AFB, EFB) honeycombs	All honeycombs should be burned and destroyed.

(Titěra, 2009)

Disinfection of beeswax

Wax of unknown origin should never be used without disinfection. Melting the beeswax by exposing it to solar radiation also disinfects it.

If the beeswax is processed properly, none of these bacteria can survive. However, secondary contamination from the containers in which the wax is placed can occur.

Honeycombs known to come from bee colonies affected by AFB should definitely be destroyed without melting.

Heating the beeswax too long and too high causes its physical and chemical properties to change and reduces the quality of the basic comb made from this type of beeswax.

Disinfection of water source and waterers in the apiary

If we provide artificial water sources for bees in the apiary, the water containers and the boards placed on the water to prevent the bees from drowning should be changed and disinfected frequently. It should be ensured that the water is clean.

Disinfection of honey and beeswax processing equipment

Honey extraction rooms and beeswax factories must comply with all hygiene rules applied in food processing facilities.

These businesses must have a disinfection system to prevent the proliferation of pathogenic microorganisms.

Everything used after the daily work period must be washed, disinfected and dried.

After mechanical cleaning, containers must be disinfected using various disinfectants. Disinfectants must be changed frequently to prevent microorganisms from gaining resistance.

In order for disinfectants to show their effectiveness well, application instructions must be followed.

Disinfection of hands

Hands should be washed thoroughly with soap before disinfection. Because dirt is the carrier of microbes. The chemicals used in disinfection of hands should kill microbes in a very short time. Alcohol, hydrogen peroxide and peroxyacid-based preparations are fast-acting. Alcohol-based preparations can only be applied to dry hands, otherwise the alcohol will be diluted and its disinfecting effect will decrease.

Hands should be washed with drinking water with a sterile brush and soap for 5 minutes and dried with a sterile gauze. Then, they should be washed with 70% alcohol for 3 minutes, immersed in a disinfectant aqueous solution for 1 minute and dried with a sterile gauze (Organization, 2004; Pittet, 2008; Vesley, Lauer, & Hawley, 2000).

Disinfection of gloves and bee suit

Masks and beekeeping clothes that have been washed with bleach and hot water and dried in the sun do not cause disease for bees.

REFERENCES

Arda, M. (2000). *Bakteriyal İzolasyon, İdentifikasyon. Temel Mikrobiyoloji, 28. Bölüm. Medisan Yayın Serisi, No: 46, genişletilmiş 2. baskı*: Medisan Yayınevi, Ankara.

Baltimore, D. J. B. r. (1971). Expression of animal virus genomes. *Bacteriological reviews, 35*(3), 235-241.

Bojanıć Rašovıć, M. (2021). The most important methods of disinfection in beekeeping. *Agriculture Forestry/Poljoprivreda i Sumarstvo, 67*(3).

Boyd, R., & Hoeri, B. (1995). Sterilization and disinfection. *Basic Medical Microbiology. 5th ed. Boston, New York*, 93-103.

Doron, S., & Gorbach, S. L. (2008). Bacterial infections: overview. *International Encyclopedia of Public Health*, 273.

Erdogan, Y., Dodologlu, A., & Emsen, B. (2009). Some physiological characteristics of honeybee (Apis mellifera L.) housed in heated, fan wooden and insulated beehives.

Erdoğan, Y. (2019a). Comparison of colony performances of honeybee (Apis Mellifera L.) housed in hives made of different materials. *Italian Journal of Animal Science*.

Erdoğan, Y. (2019b). Determination of the effect of electric fence system on productivity and behaviour of honeybees housed in different beehive types (Apis mellifera L.). *Italian Journal of Animal Science*.

Erdoğan, Y., Turan, M. J. T. J. o. A.-F. S., & Technology. (2022). Physicochemical Properties of Honey Produced at Different Altitudes. *Turkish Journal of Agriculture-Food Science, 10*(4), 710-718.

Ewart, S., & goats. (2001). Disinfectants and control of environmental contamination. *Large Animal Internal Medicine: diseases of horses cattle, sheep*, 1371-1380.

Forbes, B. A., Sahm, D. F., & Weissfeld, A. S. (2007). *Diagnostic microbiology*: Mosby St Louis.

Fries, I. (1993). Nosema apis—a parasite in the honey bee colony. *Bee World, 74*(1), 5-19.

Fries, I., Feng, F., da Silva, A., Slemenda, S. B., & Pieniazek, N. J. (1996). Nosema ceranae n. sp.(Microspora, Nosematidae), morphological and molecular characterization of a microsporidian parasite of the Asian honey bee Apis cerana (Hymenoptera, Apidae). *European Journal of Protistology, 32*(3), 356-365.

Greene, C., & Cat. (1998). Chapter 94. Environmental Factors in Infectious Disease. *Infectious Diseases of the Dog*, 673-683.

Higes, M., Martín, R., & Meana, A. (2006). Nosema ceranae, a new microsporidian parasite in honeybees in Europe. *Journal of invertebrate pathology, 92*(2), 93-95.

Jeffrey, D. (1995). Chemicals used as disinfectants: active ingredients and enhancing additives. *Revue Scientifique et Technique-Office International des Epizooties, 14*, 57-57.

Joklik, W., Willett, H., Amos, D., & Wilfert, C. (1992). Sterilization and disinfection. *Zinsser microbiology*, 188-200.

Kabil, E., & Onat, A. (2020). Virüslerin özellikleri ve pandemi süreçlerinde (Covid-19) iklimlendirme sistem prametrelerinin değerlendirilmesi. *Termodinamik, 29,* 340.

Mason, G., & Littin, K. (2003). The humaneness of rodent pest control. *Animal welfare, 12*(1), 1-37.

Organization, W. H. (2004). *Laboratory biosafety manual*: World Health Organization.

Öngen, B. (2009). Laboratuvarlarda DAS Uygulamaları.

Pittet, D. (2008). Hand hygiene: it's all about when and how. *Infection Control Hospital Epidemiology, 29*(10), 957-959.

Quinn, P. J., & Markey, B. K. (2001). Disinfection and disease prevention in veterinary medicine. *Disinfection, sterilization, preservation, 5th ed. Philadelphia, PA: Lippincott Williams Wilkins*, 1069-1103.

Russell, A. D. J. T., Microbiology, W. s., & Infections, M. (2010). Microbial susceptibility and resistance to chemical and physical agents.

Spiltoir, C. F. (1955). Life cycle of Ascosphaera apis (Pericystis apis). *American Journal of Botany*, 501-508.

Titěra, D. (2009). *Hygiene in the Apiary:(a Manual for Hygienic Beekeeping)*: BRI.

Vesley, D., Lauer, J., & Hawley, R. (2000). Decontamination, sterilization, disinfection, and antisepsis. *Biological Safety: Principles Practices, 3rd ed. ASM Press, Washington, DC*, 383-402.

CHAPTER 7

CLIMATE CHANGE AND FOOD SECURITY

Ayşenur KELEŞ[1], Prof. Dr. Ümmügülsüm ERDOĞAN[2]

DOI: https://dx.doi.org/10.5281/zenodo.14544758

[1]Department of Organic Agriculture Management, Graduate Education Institute, Bayburt University, 69000 Bayburt, Türkiye; https://orcid.org/0009-0001-5808-2681
[2]Department of Food Engineering, Engineering Faculty, Bayburt University, 69000 Bayburt, Türkiye; gulsum25@gmail.com, https://orcid.org/0000-0002-0490-2285

1. Introduction

While increasing temperatures trigger the melting of glaciers, the sunlight reaching the earth also increases. This situation leads to a change in the climate and climatology worldwide and will cause great damage to the ecosystem in the future. The disruption of the natural balance increases the risk of extinction of many plant and animal species. In addition, water shortages will negatively affect agriculture and animal husbandry activities; this may result in drought, famine and other disasters.

On the other hand, the melting of polar glaciers and their mixing with the oceans causes sea levels to rise and the amount of water to increase. This situation brings to the agenda the possibility of the coastlines of coastal countries being submerged. The basis of all these changes is the increase in greenhouse gases in the atmosphere. The unexpected increase in these gases causes the world to warm up faster. These effects have led to the emergence of the process known as global warming. With global warming, climate events that affect all living things have begun to change. One of these effects is the food security problem caused by climate change. Food resources, while vital for life, are under threat due to droughts, floods and depletion of water resources caused by climate change. As a result, the availability, accessibility and reliability of food are gradually decreasing, which endangers human life.

The rapid increase in the world population has made this issue one of the priority agenda items of many countries. Research on climate change and food security reveals that if the current situation continues, these negative effects will continue to increase and may cause irreversible damage. Various steps have been taken, especially with the United Nations taking action on this issue. Many projects have been developed, new organizations have been established and policies have been created in order to reduce the effects of climate change and adapt to these changes.

Climate change leads to many phenomena that can negatively affect agricultural productivity at the local and regional scale. Climate extremes such as changes in rainfall patterns, increasing temperatures and more frequent droughts, changes in pest pressure and fluctuations in seasonal and daily temperature patterns can reduce food production by reducing productivity. In addition, they can restrict access to food and negatively affect food quality. Increases in the frequency and severity of extreme weather events can also lead to interruptions in food distribution.

2. Food and Food Security

Food is the basic components of vitamins and minerals that are necessary for the nutrition of living beings and for them to live a healthy life. It is extremely important for food to be of high quality and reliable for human health, and also to be free of all harmful chemicals. Food security can be defined as the process of protecting food from all kinds of dangers, from the production stage to the consumption stage. Safe food should always be accessible to people, have economic value, and be healthy and available in sufficient quantities to meet their needs. Environmental factors, especially the weakness of the soil, the decrease in water resources and climate change, play a critical role in terms of sustainability for safe food (Haspolat, 2015).

The increasing number of warnings about food security emphasizes the importance of food and food security even more. The increasing population increases the need for food, which reveals the necessity of ensuring food security. Otherwise, it will be difficult to access healthy and sufficient food in the coming years, which will lead to diseases and the risk of famine. The most important factor in ensuring food security is the human factor. In addition, elements such as water, soil and climate change are also vital for the sustainability of food. Today, four basic dimensions of food security are defined and the simultaneous provision of each of these dimensions is necessary to ensure food security.

Availability of food: The existence of sufficient food for all people at all times,

Accessibility of food: The supply of sufficient food at national or international levels, everyone's physical and economic access to available food at all times,

Utilization of food: Individuals' adequate energy and food intake, the body's best use of various nutrients, and sufficient for everyone,

Stability of access to food: Sustainable food management and production (FAO, 2008).

Agricultural production is largely affected by climate conditions. Although the temperature increases and increasing carbon dioxide levels experienced with climate change seem to have a positive effect on the quantity of agricultural products in some regions in the short term, these factors have the potential to lead to decreases in product quality and productivity in the long term (Akalın, 2014).

. The decrease in the amount of product is directly related to the emergence of a safe food deficit. Climate change leads to negative effects such as increasing or decreasing temperatures, decreasing soil fertility, delays in the harvest period of agricultural products, decreasing water resources, changes in precipitation patterns and drought. Such negative situations pose serious threats to productivity and sustainability in terms of agricultural activities and safe food. There is a strong connection between climate change and sustainable agricultural development. Production, consumption and agricultural development play an important role in providing safe food in a sustainable way. At the same time, the intensity of the factors causing climate change and the effects of climate change accordingly are among the main determinants of these phenomena. This situation also significantly affects sustainable agricultural development policies (Kulakoğlu, 2020).

3. Definition and Formation of Global Warming

Short-wave radiation reaching our planet from the sun heats the world by converting light into heat. The earth reflects some of this radiation back into space as long-wave infrared rays. While a large portion of these long-wave infrared rays return to space, some are retained in the earth's atmosphere by greenhouse gases. These gases are called "greenhouse gases" because they preserve heat during the process of capturing and reflecting infrared rays in the atmosphere. This situation, which causes the earth to warm more than expected due to the increase in the amount of greenhouse gases in the atmosphere, is called the "greenhouse effect".

Global warming refers to the increase in the average surface temperature of the earth and climate changes that occur by increasing the natural greenhouse effect of greenhouse gases CO2, CH4, N2O, O3, CFCs and H2O released into the atmosphere as a result of human economic activities. The increase in greenhouse gas emissions has been clearly observed especially since the 1800s, that is, since the beginning of the industrial revolution (Dellal, 2008).

If we define global warming in another way, this phenomenon means that the temperature of the earth's atmosphere gradually increases with the increase in the concentration of greenhouse gases in our air. Greenhouse gases cannot transmit long-wave infrared rays and heat; this situation creates the greenhouse effect. The heat coming from the sun has short wavelengths and reaches the earth without being blocked by the atmosphere. However, when the earth cools and re-radiates this heat, the wavelengths become longer and some of it is retained by gases in the atmosphere. This increases the greenhouse effect and leads to global warming. The most fundamental reason for changes in climate is the greenhouse gases released by the burning of fossil fuels as a result of human activities and the decrease in the carbon retention capacity of the earth due to incorrect land use policies (Arı, 2010). While global warming refers to the systematic increase in temperatures worldwide, global climate change defines the changes in climate elements such as precipitation, humidity, air currents and drought as a result of this warming (Çepel, 2003). It manifests itself in various dimensions both in the world and in our country. These effects include changes in precipitation regimes and amounts, seasonal temperature increases, problems experienced in the photosynthesis and fertilization processes of plants, water shortages, exposure of plants to abiotic stress conditions and the infertility of agricultural lands (Traşçı, Erdoğan, 2021).

The focus of today's global climate change discussions is the production of greenhouse gases as a result of human activities. Increasing human activities in areas such as industry, transportation, agriculture and energy increase greenhouse gas emissions released into the atmosphere and strengthen the greenhouse effect. As a result, temperatures are increasing all over the world (Doğan and Tüzer, 2011)

4. Problems Caused by and Possible to Cause Global Warming

The world's climate system has entered warming and cooling cycles from time to time for millions of years and has experienced extraordinary conditions during this process. In addition to the known Ice Ages and subsequent periods, disasters such as volcanic eruptions have also occurred; the effects of these events have manifested themselves in climate changes lasting hundreds or even thousands of years.

If we list some of the events that have occurred and will occur due to global warming (Appenzerler and Dimick, 2004; Atalık, 2006):

□-The glaciers in the poles and high mountains continue to melt due to global warming. Globally, the average sea level rose by 19 cm between 1990 and 2010, the highest rate of increase in the last two thousand years.

□-Since the 1950s, the number of cold days and nights has decreased worldwide, while the number of hot days and nights has increased.

□-Inland, both the intensity and frequency of heavy precipitation events have increased.

□-Heat waves have occurred in large parts of Europe, Asia and Australia is increasing in both frequency and strength.

□-Greenland and Antarctic ice shields and islands are losing mass; glacier areas continue to shrink worldwide. At the same time, Antarctic sea ice and spring snow cover areas in the Northern Hemisphere have also decreased. As a result of global warming, the ozone layer in the atmosphere is thinning and depleting, which poses a danger to human health by causing the passage of ultraviolet rays.

□-With the warming of the atmosphere and the earth, the seas and oceans will also warm up and a decrease in the species living there will be observed.

□-Global warming will deepen the environmental pollution problem by causing the reserves and capacities of water basins to decrease.

□-Excessive heat and drought will lead to widespread erosion and desertification worldwide.

-Extreme cold and heat will cause mutations in the chromosome number and chromosome structure of living things, thus causing the genetic structures of living things to change.

-When the soil under the frozen glaciers in the Polar Regions begins to thaw as a result of global warming, they will release the greenhouse gases they have held for thousands of years into the atmosphere.

-Another event that global warming will cause is that the temperature differences between day and night will gradually decrease.

-It will trigger acid rain and many other natural disasters to occur one after another.

-Climate events: An increase in storms, showers, floods, precipitation, rain, drought, dust, etc. will be observed.

-There will be changes in the snow and precipitation regime all over the world.

-There will also be temperature fluctuations all over the world, and accordingly, there will be changes in the migration routes and life cycles of animals.

-In agricultural activities: There will be an increase in the need for irrigation, a decrease in yield, and changes in the product pattern and cycle.

-There will be a decrease and drying of underground water resources due to the decrease in precipitation.

-As a result of the increase in sea and river water temperatures; cold water creatures will face the danger of extinction.

-Sudden climate changes resulting from global warming will increase epidemics by making it difficult to maintain homeostasis in the body and decreasing resistance.

Biodiversity is under serious threat due to rapid climate change. In the next 100 years, an increase in average temperatures by 1-3.5 °C will cause mid-latitude ecosystems to shift 150-550 km further towards the poles. This will affect the geographical distribution and structures of ecosystems and change their responses to new conditions. Many species will face the danger of extinction because they cannot adapt to these new conditions quickly enough. The fact that changes occur in a very short period of time makes it impossible for living things to keep up with this speed. While living things can generally adapt to changes that occur in processes that last thousands or even millions of years, it is inevitable that changes experienced in short periods of centuries will cause species to disappear. The statement that "Global warming will eliminate a quarter of plant and animal species, that is, more than a million species, by 2050" reveals the seriousness of the current threats (Aksay et al. 2005).

5. The Effects of Climate Change on Safe Food and Soil

Agriculture plays an extremely important role in the supply of food, which is a vital need for humanity. Agricultural activities affected by natural conditions are one of the sectors most affected by global warming, which is seen as one of the biggest problems of our day (Traşcı, Edoğan, 2021). Soil is a natural resource that is critical in providing sufficient resources for food production, reducing the effects of climate change and supporting adaptation processes to climate conditions. It also forms the basis of many environmental processes such as the water cycle and purification processes. In this context, the United Nations (UN) declared 2015 as the International Year of Soils, drawing attention to the value of soil. The decrease in the rural population due to the urbanization trend leads to concentration in large cities as a result of migration; this situation causes a decrease in agricultural areas and therefore production. Sustainability of soil also directly supports food sustainability. The inefficiency of this natural resource that feeds people poses a serious threat to safe food (Ergene, 1993).

The agricultural effects of climate change are manifested in situations such as the extension of harvest seasons and the shifting of crop seasons. These changes have led to the shift of warm-weather crops to more northern regions (Hatık, 2015). However, not all crops may be able to adapt to these new conditions. Such a situation negatively affects the amount of crops, their yield and nutritional value, and increases food security risks. Since agricultural activities are based on nature, they are one of the areas most affected by climate change.

Greenhouse gas emissions, which are considered to be one of the important reasons for global warming, also have negative effects on agricultural production. When examined, fruit growing is one of the agricultural activities most affected by global warming. Perennial plants are more sensitive to sudden temperature changes. In recent years, unusual weather events have been observed during the winter dormancy, flowering, bud formation and fruit yield periods of fruit trees due to climate change. This situation not only affects fruit production and quality, but also negatively affects bees, which play a critical role in pollination. Climate change causes honeybees to lose their resistance to environmental factors, leading to the spread of diseases, bee deaths and losses (Şahin et al., 2015). Producing the food people consume is extremely important in terms of food security. The relationship between agriculture and climate change is also remarkable in that it covers 36% of the world's workforce. This rate varies between 40% and 50%, especially in Asian countries where the population is dense. Every year, 40% of food products are lost due to plant pests and diseases. This situation has serious consequences in poor regions dependent on agriculture, causing both yield and income loss (FAO, 2021). Increasing temperatures as a result of global climate change have a direct impact on insect development, reproduction, survival, population density and species spread. Studies support the fact that temperature has a higher effect on insects among environmental factors (Bale et al., 2002). Pests such as red palm weevil, fall weevil, fruit fly, desert locust and emerald ash borer cause their host ranges or distribution areas to expand (Gullino et al. 2022). It is predicted that global warming will increase the number of many soil-borne plant pathogens and especially negatively affect crop yield (Raza and Bebber, 2022). In addition, climate change increases the risk of exposure to new pests and pathogens by affecting the development of pathogenic microorganisms in agricultural and natural ecosystems, and is expected to have serious consequences on product productivity and yield in the future, leading to food insecurity (Ristaino et al., 2021; Gullino et al., 2022).

In order to leave healthy and sustainable food to future generations, it is essential to increase production and increase productivity in our existing agricultural areas. For this, taking advantage of technological opportunities will have positive effects on the sustainability of safe food. Safe food starts with the quality of the soil. Therefore, it is extremely important for the seeds to be planted in the soil to be natural, especially in terms of food safety and human health. Selecting seeds suitable for soil type, using organic fertilizers and adopting methods that will increase productivity contribute to food sustainability.

CONCLUSION:

The rapid increase in the world population brings with it the necessity of ensuring sufficient and safe food production and consumption. It is of great importance for people to have access to safe food at the desired time and in sufficient quantities in order to sustain their lives. However, inadequate and unhealthy water and soil conditions pose serious threats to the sustainability of safe food. In addition, climate change negatively affects food security through global warming, disrupting the sustainability of food. Global warming stands out as a significant threat to food security, and this threat may increase even more in the future. The effects of climate change on agriculture and food production lead to changes in both production processes and consumption habits. Therefore, measures to be taken against global warming and adaptation strategies to be developed are of vital importance in terms of making food security sustainable. It is not only governments, but also the agricultural sector, scientists and individuals who must assume responsibility in this area.

It is a great necessity for the legislation developed in our country regarding food security and safety to be effectively implemented. Especially when the necessary measures are not taken in areas where problems are identified, significant problems may be experienced in the medium and long term in terms of access to sufficient, healthy and nutritious food due to factors such as population growth and global climate change. On the other hand, the reliability of international index data provided for food security and safety is also of great importance in terms of determining future strategies.

In order to ensure positive developments in food security, including food safety in our country and in the world, food security should be achieved with result-oriented strategies, in line with macro-level social and economic policies, and by taking into account changing climate conditions.It is necessary to act in accordance with the aims and tools of the policies.

REFERENCES

Akalın, M. (2014). İklim Değişikliğinin Tarım Üzerindeki Etkileri: Bu Etkileri Gidermeye Yönelik Uyum ve Azaltım Stratejileri. Hitit Üniversitesi Sosyal Bilimler Enstitüsü Dergisi. 7, 2, 361-363.

Akın, İ. (2021). Su, Toprak ve İklim Değişikliğinin Güvenli Gıdanın Sürdürülebilirliği Üzerine Etkileri ve Bazı Tespitler. Bitlis Eren Üniversitesi, Acil Durum ve Afet Yönetimi, Bitlis. Rahva Teknik ve Sosyal Araştırmalar Dergisi, 1, 1, 13-23.

Aksay, C.S., Ketenoğlu, O., Kurt, L. (2005). Küresel Isınma ve İklim Değişikliği. Selçuk Üniversitesi Fen Edebiyat Fakültesi Fen Bilimleri Dergisi. (25), 29-41.

Appenzerler, T. & Dimick, R. D. (2004). Dünya Alarm Veriyor. National Geographic.

Arı, İzzet. (2010) İklim Değişikliği ile Mücadele Emisyon Ticareti ve Türkiye Uygulaması-DPT Uzmanlık Tezleri, Ankara.

Atalık, A. (2006). Küresel Isınmanın Su Kaynakları ve Tarım Üzerine Etkileri. Bilim ve Ütopya, 139, 18-21

Bale, J.S., Masters, G.J., Hodkinson, I.D., Awmack, C., Bezemer, T.M., Brown,V.K., Butterfield, J., Buse, A., Coulson, J.C., Farrar, J., Good, J.E.G., Harrington, R., Hartley, S., Jones, T.H., Lindroth, R.L., Pres, M.C., Symrnioudis, I., Watt, A.D., Whittaker, J.B., 2002. Herbivory in global climate change research: direct effects of rising temperature on insect herbivores. Global Change Biology. 8: 1-16.

Çepel, N. (2003). Ekolojik Sorunlar ve Çözümleri, Tübitak Popular Bilim Kitapları, Ankara.

Dellal, İ. (2015). “İklim Değişikliğinin Tarım Sektörüne Ekonomik Yansımaları”, TMMOB Ziraat Mühendisliği Odası, Türkiye Ziraat Mühendisliği Vıı. Teknik Kongresi Bildiriler Kitabı-1. Ankara. 62-80.

Dinç, M. E., ve Sabancı, S. (2023). Batman Selinin Meteorolojik Analizi ve İklim Değişikliğinin Yağış Şartları Üzerindeki Etkileri. 2024 Conference On Climate Change, Sustainability And International Cooperation-Clıcs, 21-22 June, Düzce.

Ergene A. (1993). Toprak Biliminin Esasları. Atatürk Üniversitesi Yayınları. Erzurum.

FAO (Food and Agriculture Organization of the United Nations). (2008). Climate change, water and food security. https://www.fao.org/4/i2096e/i2096e.pdf

FAO (Food and Agriculture Organization of the United Nations). (2021). Scientific Review of the Impact of Climate Change on Plant Pests. www.fao.org/3/cb4769en/cb4769en.pdf

Gullino, M. L., Albajes, R., Al-Jboory, I., Angelotti, F., Chakraborty, S., Garrett, K. A., Hurley, B.P., Juroszek, P., Lopian, R., Makkouk, K., Pan, X., Pugliese, M., and Stephenson, T. (2022). Climate Change and Pathways Used by Pests as Challenges to Plant Health in Agriculture and Forestry. Sustainability, 14 (19), 12421.

Haspolat, N. A. (2015). Gıda Güvenliğinde Sürdürülebilir Gıda Sistemleri, Gıda, Tarım ve Hayvancılık Bakanlığı Avrupa Birliği ve Dış İlişkiler Genel Müdürlüğü AB Uzmanlık Tezi. Ankara.

Hatık, S. (2015). İklim Değişikliğinin Gıda Güvenliğine Etkileri; Türkiye, AB ve Uluslararası Örgütler (BM Kuruluşları) Nezdinde Atılan Adımlar, AB Uzmanlık Tezi, Ankara.

Kulakoğlu, Ö. (2020). Türkiye'de Tarımda Kendine Yeterlilik ve Gıda Güvencesi. Tekirdağ Namık Kemal Üniversitesi Yüksek Lisans Tezi.

Raza, M. M., and Bebber, D. P. (2022). Climate Change and Plant Pathogens. Current Opinion in Microbiology, 70, 102233.

Ristaino, J. B., Anderson, P. K., Bebber, D. P., Brauman, K. A., Cunniffe, N. J., Fedoroff, N. V., Finegold, C., Garrett, K. A., Gilligan, C. A., Jones, C.

M., and Martin, M. D. (2021). The Persistent Threat of Emerging Plant Disease Pandemics to Global Food Security. Proceedings of the National Academy of Sciences, 118 (23), 1-9.

Simmons A., Trends in The Tropospheric General Circulation From 1979 To (2022). Weather Clim Dynam, 777–809.

Şahin, M., Topal, E., Özsoy, N. (2015). İklim Değişikliğinin Meyvecilik ve Arıcılık Üzerine Etkileri. Ege Tarımsal Araştırma Enstitüsü, Meyvecilik Şubesi. Anadolu Doğa Bilimleri Dergisi 6(2), 147-154. İzmir.

Tıraşcı, S., Erdoğan, Ü. (2021). Küresel Isınmanın Tarım Üzerindeki Etkisi. Tarım, Gıda, Çevre ve Hayvan Bilimleri Dergisi, *2* (1), 16-33.

Türkeş, M., Arıkan, Y. (2006). Türkiye İklim Değişikliği Bülteni Cemre. https://silo.tips/download/rec-trkiye-klim-deiiklii-blteni

CHAPTER 8

CLAY MINERALS USED AS MYCOTOXIN BINDERS IN FEEDS

Lecturer PhD. Sadık ÇIVRACI[1]

DOI: https://dx.doi.org/10.5281/zenodo.14544768

-

[1]Bayburt University, Demirözü Vocational Schools, Veterinary Medicine Bayburt, Turkey. sadikcivraci@bayburt.edu.tr, Orcid ID: 0000-0002-0750-1823

INTRODUCTION

Toxigenic fungal species present significant threats to both human and animal health. These fungi are capable of producing numerous secondary metabolites, such as mycotoxins, which are toxic compounds with low molecular weights. These harmful substances negatively affect agricultural products, particularly cereals. As a result, they have detrimental effects on human health, animal productivity, and global trade (Wu, 2015).

Global warming and climate change have a negative impact on food and feed safety. Changes in precipitation and temperature levels and atmospheric $C0_2$ concentration in the near future are interpreted to increase mycotoxin levels in agricultural products. This will significantly affect mycotoxin contamination in animal feed. Temperature, humidity, availability of water resources and insects are among the most important factors in the formation of fungi and mycotoxins in plants (Medina et al., 2017a; Medina et al., 2017b).

Mycotoxin contamination brings serious losses for the feed sector and livestock breeding. Fungi that form mycotoxins reproduce very rapidly in feeds when they find suitable conditions. Mycotoxin contamination can occur at every stage from production to consumption of feedstuffs, but fungal proliferation and toxin growth occur mostly during storage and placement. Consumption of feed contaminated with mycotoxins leads to health problems such as suppression of the immune system, organ damage and digestive system problems, negatively affecting the development and productivity levels of livestock. Advanced cases result in death. Destruction of contaminated feeds, decreases in the productivity levels of animals, treatment of sick animals cause great economic losses to producers and breeders. In addition, animal products to be obtained by animals consuming contaminated feeds also threaten human health (Marroquín-Cardona et al., 2014; Magnoli et al., 2019).

One of the most important methods to minimize the harmful effects of mycotoxins in animals is to prevent the absorption of these toxins in the digestive system of animals. Feed additives used for this purpose are adsorbents mixed with feed. Mycotoxin binders are classified as inorganic and organic. Clay and activated carbon are inorganic, yeast cell wall and micro ionized fibers are organic mycotoxin binders. The most preferred feed additives among mycotoxin binders are clay and alimunosilicates containing clay minerals. Clay minerals bind mycotoxins themselves and carry them throughout the digestive system without adverse effects on animals. At the same time, clay minerals have different positive effects on animals besides their adsorbent properties. There are differences between clay species in terms of their binding capacity (Binder, 2007; Slamova et al. 2011, Nadziakiewicza et al., 2019).

1. Important Mycotoxins in Feed

Mycotoxins are secondary metabolites of fungi that cause feed contamination (Marin et al., 2013). Approximately 300 fungal species are capable of producing mycotoxins. Especially Aspergillus, Penicillium, Fusarium, Alternaria and Claviceps genera are the most common mycotoxin producers in animal feed (Kabak et. al, 2006). More than 500 mycotoxins have been identified, but aflatoxins, fumonisins, ochratoxins, trichothecenes, zearalenone and patulin are the most important food safety concerns due to their frequent occurrence (Maguey-Gonzalez et al., 2024). The most frequently observed mycotoxins in feed are aflatoxins, fumonisins, zearalenone, trichothecenes and toxic metabolites of ochratoxin A produced by fungal species (Smith et al., 2016).

Aflatoxins are among the most common and toxic mycotoxins in animal feed. These toxins are generally produced by *Aspergillus flavus* and *Aspergillus parasiticus* and rarely *Aspergillus* nomius species also produce this toxin. Aflatoxin has 6 types as B1, B2, G1, G2, M1, M2 (Huang et. Al., 2010). Aflatoxins are hepatocarcinogenic and hepatotoxic (Moudgil et al., 2013). Aflatoxin poisoning causes acute, subacute and chronic poisoning (Benkerroum, 2020). Aflatoxin poisoning causes economic losses by weakening the immune system, loss of body weight, decrease in milk and reproductive efficiency and nutritional disorders in livestock. Aflatoxin B1 (AFB1) is one of the most potent liver toxins threatening animal health and is commonly found in contaminated feeds (Çelik, 2001). Furthermore, some of the AFB1 toxin consumed by animals such as cattle is converted to aflatoxicol in the rumen, while the rest is absorbed in the digestive tract and converted to aflatoxin M1 in the liver. Aflatoxin M1 is either excreted through bile and urine or passes into milk (Seid and Mama, 2019).

Fumocins are secondary metabolites produced by various species of Fusarium molds, mainly *Fusarium moniliforme*, which are found naturally in cereal grains and animal feeds worldwide. They are most commonly found in maize worldwide (Šegvić and Pepeljnjak, 2001). Fusarium toxins can cause species-specific organ damage and fatal diseases in animals. Fumomycin B1 (FB1) mycotoxin causes leukoencephalomalacia, also known as "moldy corn poisoning", in horses and pulmonary edema in pigs. It can also cause mild or severe toxicity to the kidney, liver and heart in chickens, ducks, cattle, sheep, sheep, rabbits, rats and mice. Long-term administration of high doses of FB1 in rats caused liver and bile duct tumors. In humans, frequent consumption of fumonisin-containing foods has been associated with esophageal cancer (Bucci and Howard, 1996; Szabó et al., 2018)

Zearalenone (ZEA) is a prevalent mycotoxin generated by certain Fusarium species found in various cereals and forages, such as wheat, maize, oats, barley, and soybeans (Fink-Gremmels and Malekinejad, 2007). This mycotoxin exhibits estrogenic properties, leading to both structural and functional alterations in reproductive organs, despite its non-steroidal nature. ZEA has been associated with reproductive issues, hormonal imbalances, and growth inhibition in animals. Among all species, pigs are the most vulnerable to ZEA exposure, displaying clinical symptoms like ovarian shrinkage, irregular estrous cycles, persistent corpus luteum, reduced fertility rates, and stillbirths (Zinedine et al., 2007; Zhang et al., 2018).

Deoxynivalenol (DON), also known as vomitoxin (Canady, et al., 2001), is a mycotoxin produced by fungi of the genus Fusarium in the trichothecenes group and is usually found in cereals such as wheat, barley and corn. Deoxynivalenol is one of the most important trichothecenes in food and feed, with a very high incidence worldwide.

It is not possible to completely eliminate the contamination of this mycotoxin due to environmental conditions such as temperature and humidity. Therefore, it becomes a permanent health problem for farm animals exposed to the toxin. The fact that cereal crops and feeds are often contaminated with DON causes animals to be frequently exposed to this toxin (Awad et al., 2010). DON causes weight loss, decreased growth performance and immunosuppression in animals by reducing feed intake. It can have different effects in different species such as poultry, cattle and pigs, but pigs are particularly sensitive to this toxin (Pestka, 2007).

Ochratoxins (OTA) are produced by some Aspergillus and Penicillium species. OTA is commonly found in many foods and beverages. OTA has been observed most frequently in cereal grains, but at lower levels in other foodstuffs of plant origin. OTA can also be found in tissues and products of animal origin, poultry, milk and dairy products. This suggests that this mycotoxin may pose a risk to human health as well as animal health (Duarte et al., 2011) . The most common ochratoxin is ochratoxin A (Ringot et al., 2006). Ochratoxin A is a compound with nephrotoxic, hepatotoxic, teratogenic and immunotoxic properties (Denli and Perez 2010). OTA poisoning causes ochratoxicosis and targets the kidneys. Studies on OTA in laboratory animals have shown that it is carcinogenic (Duarte et al., 2011). Ochratoxin A causes kidney damage, immunosuppression and reproductive disorders in animals (Battacone, et al. 2010). OTA has been identified as a potential carcinogen for humans (IARC. 1993). Epidemiologic studies have shown that OTA can cause different human nephropathies, including kidney cancer (Pfohl-Leszkowicz and Manderville, 2007).

2. Transmission Routes of Mycotoxins

Mold and toxin transmission pathways vary depending on the type of raw material, environmental factors and storage conditions (Binder et al., 2007).

The most common source of mold is field conditions. Fusarium species thrive during growth in the field, especially in cereals such as maize, wheat and barley. Improper agricultural practices can leave crops vulnerable to fungal infections. For example, mycotoxins such as deoxynivalenol (DON) and zearalenone (ZEN) produced by Fusarium graminearum can be transmitted in the field under high humidity and cool climatic conditions (Pestka, 2007).

This contamination process starts in the field and can be exacerbated by inadequate harvesting and drying processes. Products with high moisture content during harvest provide a favorable environment for the growth of fungi. Inadequate drying can accelerate the development of aflatoxins, especially those produced by Aspergillus flavus. These toxins are more prevalent in hot and humid climates and are particularly problematic in crops such as peanuts, maize and soy (Kensler et al., 2011).

Storage conditions are also one of the most important sources of mold. Poor ventilation, high humidity and temperature cause Aspergillus and Penicillium species to multiply during storage. Toxins such as ochratoxin A (OTA) are produced during storage processes and are often found in products such as cereals, coffee and grapes. It is critical to keep moisture levels below 13% to prevent fungal growth during storage (Fleurat-Lessard, 2017).

3. General Properties of Mycotoxin Binders

In animal nutrition, toxin binders are widely used feed additives to reduce the negative effects of mycotoxins in feeds. Toxin binders protect animal health and minimize production losses by neutralizing various mycotoxins such as aflatoxins, zearalenone, deoxynivalenol and fumonisin in feeds. Commonly used toxin binders include clay minerals, organic binders, yeast cell walls and enzymatic detoxification products (Avantaggiato et al., 2005). Organic binders are derived from cellular structures and yeast derivatives. Glucans and mannans in yeast cell walls interact with mycotoxins such as zearalenone and trichothecenes, reducing their bioavailability. Such organic binders improve the overall performance of animals by supporting gut health through their probiotic effects (Yiannikouris and Jouany, 2002). Enzymatic detoxification strategies also inactivate toxins by breaking down the biochemical structure of mycotoxins. For example, bacterial or fungal enzymes are used to reduce the toxic effects of fumonisins. These enzymes biodegrade mycotoxins in feed, minimizing the effects of the toxins on animals. Furthermore, the combination of various enzymes and binders can provide more effective protection against different mycotoxin species (Huwig et al., 2001).

4. Clay Minerals Used as Mycotoxin Binders

Clay minerals are natural substances with a high capacity to bind mycotoxins due to their physical and chemical structure. Aluminosilicate minerals, especially clays, constitute the largest class of mycotoxin binders (Whitlow, 2006).

Silicates are categorized based on their structural characteristics rather than their chemical makeup. Minerals that share similar chemical compositions can belong to different subclasses. The silicate subclasses include neosilicates (single tetrahedral structures), sorosilicates (double tetrahedral units), inosilicates (single and double chains), cyclosilicates (ring structures), phyllosilicates (layered sheets), and monosilicates (frameworks). Silicates examined for their adsorption capabilities typically fall under the phyllosilicate and monosilicate groups (Hashizume, 2022).

Some clay minerals in the group of phyllosilicates and tectosilicates are known for their toxin-binding properties and are used to reduce the impact of mycotoxins, especially in animal feed. The main clay minerals in the phyllosilicates group are bentonites, montmorillonites, smectites, kaolinites, illites and Hydrated Sodium Calcium Aluminosilicate (HSCAS). The group of tectosilicates includes zeolites (Lemke, 2000; Kolosova and Stroka, 2011).

Bentonites are classified as phyllosilicate clays with a layered crystalline structure and a variable composition. These clays are often referred to as smectites due to the prevalence of clay minerals in their makeup, with montmorillonite being the primary component. The ability of bentonite to adsorb substances is largely influenced by its montmorillonite content and the presence of exchangeable cations. Bentonite has demonstrated high efficacy in binding aflatoxins, neutralizing these toxins within the digestive system and preventing their absorption. Its layered structure allows bentonite to expand upon contact with water, facilitating the adsorption of mycotoxin molecules. This characteristic makes it particularly effective in binding polar toxins, such as aflatoxins (Mockovčiaková and Orolinova, 2009; Wang et al., 2020).

Montmorillonite, a significant clay mineral within the smectite group, is a dioctahedral member and constitutes the primary component of bentonite (Emmerich et al., 2009). Its structure is composed of layers arranged in a 2:1 ratio, with Si-O tetrahedral sheets and Al-O octahedral sheets (Brigatti et al., 2006). The substitution of Mg^{2+} for Al^{3+} in the octahedral layer or Al^{3+} for Si^{4+} in the tetrahedral layer results in a consistent negative charge within the montmorillonite layers (Melo et al., 2021). This negative charge allows AFB1 to interact with positively charged atoms in its carbonyl groups. Additionally, montmorillonite's negative charge, which helps stabilize metal cations located between its layers, gives it a high cation exchange capacity, enhancing its effectiveness in AFB1 adsorption. The mineral's layered structure also contributes to a large specific surface area, offering adsorption sites on its outer surface, edges, and interlayer spaces, thereby improving AFB1 binding efficiency (Zhang et al., 2021).

Zeolites are characterized by a limitless three-dimensional framework composed of SiO_4 and AlO_4 tetrahedrons interconnected through shared oxygen atoms. In this arrangement, the substitution of Si4+ with Al3+ generates a surplus negative charge, which is counterbalanced by cations from alkali and alkaline earth metals, such as sodium, calcium, or potassium. Zeolites feature an extensive internal surface area and a high cation exchange capacity, which enhance their efficiency in adsorbing polar molecules (Wright and Lozinska, 2011). Research indicates that natural zeolites, particularly clinoptilolite, are capable of binding mycotoxins, including aflatoxins (AFs) and fumonisins (FBs) (Yiannikouris and Jouany, 2002). By adsorbing ammonia and mycotoxins found in animal feeds, zeolites not only support improved animal health but also promote more sustainable and environmentally friendly production systems (Avantaggiato et al., 2005).

Hydrated sodium calcium aluminosilicate (HSCAS) is widely recognized as one of the most efficient adsorbents for aflatoxin binding (Kabak et al., 2006) and is commonly utilized as an anti-caking agent in animal feeds (Whitlow, 2006). This substance is a form of Ca-montmorillonite, either sourced from nature or produced through the heat processing of calcium clay. Its molecular structure features water molecules that are either attached to metal ions or incorporated into metal complexes. The absence of a positive charge in the aluminosilicate framework provides an ideal environment for attracting and adsorbing positively charged substances (Phillips, 1999).

However, there are important considerations when using clay minerals. For example, overuse of these minerals can also bind beneficial nutrients such as vitamins and minerals in feed and negatively affect the nutrient intake of animals. Therefore, it is crucial that the correct dosage is set and that the type of clay used is compatible with the feed content. Furthermore, the efficacy of clay minerals may vary depending on factors such as the pH level of the feed environment, the concentration of toxins and the properties of feed ingredients (Huwig et al., 2001).

CONCLUSION

Clay minerals have a very important place in order to reduce the threat of health risks posed by mycotoxins in feeds and food chain. Especially minerals such as bentonite, montmorillonite, zeolite, HSCAS play an effective role in binding and neutralizing mycotoxins with their high adsorption capacity, large surface areas and ion exchange properties. Toxin binding mechanisms of these minerals include processes such as adsorption, ion exchange and complex formation (Whitlow, 2006).

These minerals, which are effective against various types of toxins, offer a reliable and economical option as feed additives. However, the toxin binding efficiency of clay minerals may vary depending on the physical and chemical properties of the mineral, toxin type, feed ingredients and environmental factors. Therefore, specific tests and regulations for the use of minerals are important for both efficacy and safety (Huwig et al., 2001).

In the future, modification studies should be emphasized to make the use of clay minerals as mycotoxin binders more effective by utilizing advanced technology applications. In addition, the development of formulations that do not adversely affect the binding of toxins as well as the absorption of nutrients may increase the potential for the use of these minerals.

In conclusion, clay minerals are considered as an effective mechanism for controlling mycotoxins. However, the correct selection and application of these minerals is essential for successful control of mycotoxins.

REFERENCES

Avantaggiato, G., Solfrizzo, M., & Visconti, A. (2005). Recent advances on the use of adsorbent materials for detoxification of Fusarium mycotoxins. *Food additives and Contaminants*, *22*(4), 379-388.

Awad, W. A., Ghareeb, K., Böhm, J., & Zentek, J. (2010). Decontamination and detoxification strategies for the Fusarium mycotoxin deoxynivalenol in animal feed and the effectiveness of microbial biodegradation. *Food Additives and Contaminants*, *27*(4), 510-520.

Battacone, G., Nudda, A., & Pulina, G. (2010). Effects of ochratoxin A on livestock production. *Toxins*, *2*(7), 1796-1824.

Benkerroum, N. (2020). Chronic and acute toxicities of aflatoxins: Mechanisms of action. *International journal of environmental research and public health*, *17*(2), 423.

Binder, E. M. (2007). Managing the risk of mycotoxins in modern feed production. *Animal feed science and technology*, *133*(1-2), 149-166.

Brigatti, M. F., Galan, E., & Theng, B. K. G. (2006). Structures and mineralogy of clay minerals. *Developments in clay science*, *1*, 19-86.

Bucci, T. J., & Howard, P. C. (1996). Effect of fumonisin mycotoxins in animals. *Journal of Toxicology: Toxin Reviews*, *15*(3), 293-302.

Canady, R.A., Coker, R.D., Rgan, S.K., Krska, R., Kuiper-Goodman, T., Olsen, M., Pestka, J.J., Resnik, S., Schlatter, J., 2001. Deoxynivalenol. Safety Evaluation of Certain Mycotoxins in Food. *Fifty-Sixth Report of the Joint FAO/WHO Expert Committee on Food Additives. International Programme on Chemical Safety, World Health Organization, Geneva*, pp. 420-555.

Celik, S. (2001). Biochemical and histological effects of aflatoxins which are liver carcinogens and treatment options. *Journal of Uludag University Veterinary Faculty*, *20*(3), 131-136.

Denli, M., & Perez, J. F. (2010). Ochratoxins in feed, a risk for animal and human health: control strategies. *Toxins*, *2*(5), 1065-1077.

Duarte, S. C., Lino, C. M., & Pena, A. (2011). Ochratoxin A in feed of food-producing animals: An undesirable mycotoxin with health and performance effects. *Veterinary microbiology*, *154*(1-2), 1-13.

Emmerich, K., Wolters, F., Kahr, G., & Lagaly, G. (2009). Clay profiling: the classification of montmorillonites. *Clays and Clay Minerals*, *57*(1), 104-114.

Fink-Gremmels, J.; Malekinejad, H. (2007). Clinical effects and biochemical mechanisms associated with exposure to the mycoestrogen zearalenone. *Anim. Feed. Sci. Technol.* 2007, *137*, 326-341.

Fleurat-Lessard, F. (2017). Integrated management of the risks of stored grain spoilage by seedborne fungi and contamination by storage mould mycotoxins-An update. *Journal of Stored Products Research*, *71*, 22-40.

Hashizume, H. (2022). Silicate Minerals. In *Natural Mineral Materials* (pp. 1-68). Tokyo: Springer Japan.

Huang, B., Han, Z., Cai, Z., Wu, Y., & Ren, Y. (2010). Simultaneous determination of aflatoxins B1, B2, G1, G2, M1 and M2 in peanuts and their derivative products by ultra-high-performance liquid chromatography-tandem mass spectrometry. *Analytica chimica acta*, *662*(1), 62-68.

Huwig, A., Freimund, S., Käppeli, O., & Dutler, H. (2001). Mycotoxin detoxication of animal feed by different adsorbents. *Toxicology letters*, *122*(2), 179-188.

IARC (International Agency for Research on Cancer). (1993). IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Some Naturally Occurring Substances: Food Items and Constituents, Heterocyclic Aromatic Amines and Mycotoxins. *Ochratoxin A. Vol*, *56*, 489-521.

Kabak, B., Dobson, A. D., & Var, I. I. L. (2006). Strategies to prevent mycotoxin contamination of food and animal feed: a review. *Critical reviews in food science and nutrition*, *46*(8), 593-619.

Kensler, T. W., Roebuck, B. D., Wogan, G. N., & Groopman, J. D. (2011). Aflatoxin: a 50-year odyssey of mechanistic and translational toxicology. *Toxicological sciences*, *120*(suppl_1), S28-S48.

Kolosova, A., & Stroka, J. (2011). Substances for reduction of the contamination of feed by mycotoxins: A review. *World Mycotoxin Journal*, *4*(3), 225-256.

Lemke, S. L. (2000). *Investigation of clay-based strategies for the protection of animals from the toxic effects of selected mycotoxins*. Texas A&M University.

Magnoli, A. P., Poloni, V. L., & Cavaglieri, L. (2019). Impact of mycotoxin contamination in the animal feed industry. *Current Opinion in Food Science*, *29*, 99-108.

Maguey-Gonzalez, J. A., Latorre, J. D., Laverty, L., Castellanos-Huerta, I., Shehata, A. A., Eisenreich, W., & Tellez-Isaias, G. (2024). Advances in Anti-Mycotoxins. In *Alternatives to Antibiotics against Pathogens in Poultry* (pp. 235-255). Springer, Cham.

Marin, S., Ramos, A. J., Cano-Sancho, G., & Sanchis, V. (2013). Mycotoxins: Occurrence, toxicology, and exposure assessment. *Food and chemical toxicology*, *60*, 218-237.

Medina, Á., González-Jartín, J. M., & Sainz, M. J. (2017)a. Impact of global warming on mycotoxins. Current Opinion in Food Science, 18, 76-81.

Medina, A., Akbar, A., Baazeem, A., Rodriguez, A., & Magan, N. (2017)b. Climate change, food security and mycotoxins: Do we know enough?. *Fungal biology reviews*, *31*(3), 143-154.

Melo, V. F., Salata, R., Abate, G., Azevedo, A. C., & Kummer, L. (2021). Characterization and manipulation of montmorillonite properties towards technological and environmental applications. *Revista Brasileira de Ciência do Solo*, *45*, e0200149.

Mockovčiaková, A., & Orolinova, Z. (2009). Adsorption properties of modified bentonite clay. *Cheminé Technologija*, *1*(50), 47-50.

Moudgil, V., Redhu, D., Dhanda, S., & Singh, J. (2013). A review of molecular mechanisms in the development of hepatocellular carcinoma by aflatoxin and hepatitis B and C viruses. *Journal of Environmental Pathology, Toxicology and Oncology*, *32*(2).

Nadziakiewicza, M., Kehoe, S., & Micek, P. (2019). Physico-chemical properties of clay minerals and their use as a health promoting feed additive. *Animals*, *9*(10), 714.

Pestka, J. J. (2007). Deoxynivalenol: Toxicity, mechanisms and animal health risks. *Animal feed science and technology*, *137*(3-4), 283-298.

Pfohl-Leszkowicz, A., & Manderville, R. A. (2007). Ochratoxin A: An overview on toxicity and carcinogenicity in animals and humans. *Molecular nutrition & food research*, *51*(1), 61-99.

Phillips, T. D. (1999). Dietary clay in the chemoprevention of aflatoxin-induced disease. *Toxicological sciences: an official journal of the Society of Toxicology*, *52*(suppl_1), 118-126.

Ringot, D., Chango, A., Schneider, Y. J., & Larondelle, Y. (2006). Toxicokinetics and toxicodynamics of ochratoxin A, an update. *Chemico-biological interactions*, *159*(1), 18-46.

Šegvić, M., & Pepeljnjak, S. (2001). Fumonisins and their effects on animal health. *Veterinarski arhiv*, *71*(5), 299-323.

Seid, A., & Mama, A. (2019). Aflatoxicosis and occurrence of aflatoxin M1 (AFM1) in milk and dairy products: a review. *Austin Journal of Veterinary Science & Animal Husbandry*, *1*(1), 1-12.

Slamova, R., Trckova, M., Vondruskova, H., Zraly, Z., & Pavlik, I. (2011). Clay minerals in animal nutrition. *Applied Clay Science*, *51*(4), 395-398.

Smith, M. C., Madec, S., Coton, E., & Hymery, N. (2016). Natural co-occurrence of mycotoxins in foods and feeds and their in vitro combined toxicological effects. *Toxins*, *8*(4), 94.

Szabó, A., Szabó-Fodor, J., Kachlek, M., Mézes, M., Balogh, K., Glávits, R., Ali, O., Zeebone, Y. Y., & Kovács, M. (2018). Dose and Exposure Time-Dependent Renal and Hepatic Effects of Intraperitoneally Administered Fumonisin B_1 in Rats. *Toxins*, *10*(11), 465.

Wang, M., Hearon, S. E., & Phillips, T. D. (2020). A high capacity bentonite clay for the sorption of aflatoxins. *Food Additives & Contaminants: Part A*, *37*(2), 332-341.

Whitlow, L. W. (2006, March). Evaluation of mycotoxin binders. In *Proceedings of the 4th Mid-Atlantic Nutrition Conference* (pp. 132-143).

Wright, P. A., & Lozinska, M. (2011). Structural Chemistry and Properties of zeolites. *Zeolites and ordered porous solids*, 1.

Wu, F. (2015). Global impacts of aflatoxin in maize: trade and human health. *World Mycotoxin Journal*, *8*(2), 137-142.

Yiannikouris, A., & Jouany, J. P. (2002). Mycotoxins in feeds and their fate in animals: a review. *Animal Research*, *51*(2), 81-99.

Zhang, G. L., Feng, Y. L., Song, J. L., & Zhou, X. S. (2018). Zearalenone: a mycotoxin with different toxic effect in domestic and laboratory animals' granulosa cells. *Frontiers in genetics*, *9*, 667.

Zhang, Q., Zhang, Y., Liu, S., Wu, Y., Zhou, Q., Zhang, Y., Zheng, X., Han, Y., Xie, C., Liu, N., (2021). Adsorption of deoxynivalenol by pillared montmorillonite. Food Chem. 343, 128391.

Zinedine, A., Soriano, J. M., Moltó, J. C., & Manes, J. (2007). Review on the toxicity, occurrence, metabolism, detoxification, regulations and intake of zearalenone: an oestrogenic mycotoxin. *Food and chemical toxicology*, *45*(1), 1-18.

İKSAD
Publishing House

ISBN: 978-625-378-064-7