NEW DEVELOPMENTS IN AGRICULTURAL PRODUCTION

EDITOR
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PREFACE

Agricultural mechanization, which plays a role in increasing productivity in agricultural production, is one of the essential inputs for the continuity of agriculture. These inputs contribute to the social, cultural and economic development of the population engaged in agriculture, as well as the modern way of agriculture in larger areas. New generation agriculture models are needed to meet the rapidly increasing needs of the society. In a sense, the economically sustainable development and development of countries on a local, regional and global scale can be achieved by revealing, developing, producing and applying new inventions and innovative differences. In the preparation of plans and programs in the agricultural sector, resources such as soil and water needed for agriculture and socio-economic factors such as investment potential, food chain economy and knowledge level are generally emphasized. In this process, it is vital to deliver information to the target audience in a faster and more efficient way to create an information society.

Allow these Technologies to be implemented and diffused. In increasing agricultural production, the selection and use of inputs such as water, fertilizer, seeds, plant protection and mechanization are as important as the use of work and machinery.

The power to ensure that these inputs are applied appropriately and economically. The developments in the field of mechanization in animal production, as in every field and every stage of plant production, have reached a promising level in using the agricultural potential of our country more effectively. In this book section, studies on new approaches and applications in agriculture production are included.

Best Regards

Assist Prof. Dr. Cihan DEMİR

CHAPTER 1

INVESTIGATION of GROWTH and GENETIC CHARACTERISTICS of *Arabibarbus grypus* (Heckel, 1843)

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INTRODUCTION

Fisheries are essential natural living resources that continuously contribute to the countries' economies. In addition to providing continuous support to the country's economy, the high level of animal protein contribution to human nutrition is also essential. Countries conscious of a balanced and healthy diet use sea and inland fishery products to meet their animal protein needs (Doğan, 2007).

The Euphrates and Tigris Rivers are critical natural resources in terms of fish diversity and fishing potential, and they create a great potential in terms of meeting the nutrient deficit (Oymak et al., 2009). Most fish living in the Tigris and Euphrates basins belong to the Cyprinidae/Cyprinus carpio (carp) family. As they are consumed as nutrition, many species of this family have economically importance (Parmaksız et al., 2016). The most preferred fish by the native population, because of its delicious meat, is *Arabibarbus grypus*.

Arabibarbus grypus is called Shabut-Sabot or Sore by the people living in the Euphrates-Tigris basin region. The body of this fish is quite long and close to cylindrical. Its nose is tiny, with a mouth and thick lips below the nose, and it has a transverse fold that continues further down. Its eye is relatively small, and the scales around it are 40. There are three simple lines on the ridge fin. The color of the hindquarters and lower sides is dark olive brown, and the abdomen is lighter with silvery reflections. The scales are darker and slightly mottled for some members, especially young ones. In addition, there are 40 scales on the lateral line.

Distributing in Turkey, Syria, Iran and Iraq, this species is an endemic fish species living in the Tigris and Euphrates river systems (Nikpei, 1996; Abdoli, 2000; Khodadadi et al., 2016). Endemic fish species are ecologically important and considered gene banks of an ecosystem (Khodadadi et al., 2016).

Although Oymak (2009) stated in his study that Shabut-Sabot fish is plentiful in the Euphrates River, but the population of this species has dramatically decreased recently. To provide the continuation of this species and to get the most out of existing stocks. it

is necessary to uncover the growth and genetic characteristics and to carry out studies on how to protect the species.

1. GROWTH CHARACTERISTICS

1. 1. Age Distribution in Atatürk Dam Lake

Arabibarbus grypus specimens (*n=243*) caught from Atatürk Dam Lake between 01.07.2004-31.06.2005 were between I and XIII years old. The age distribution according to age groups and sexes, and the population in general, the highest number of individuals were in the age groups III (21.40%), IV (22.22%), and V (19.75%). The number of individuals showed a decrease starting from the sixth age group. In the third age group, 2.88 % were female, 18.52 % were male; in the fourth age group, 6.17 % were female, 16.05 % were male, and in the fifth age group, there were 13.99 % female and 5.76 % male individuals.

63.37 % of the hunting population were between the ages of III-IV and V. 12.74% were younger than III, and 23.89 % were older than V. Among the specimens, III-IV and V. age groups were dominant, followed by the VI age group.

1.2. Height Distribution:

The lengths of Arabibarbus grypus specimens caught in Atatürk Dam Lake varied between 145–960 mm. In female individuals, the most petite size was 145 mm, and the largest was 960 mm. In male individuals, these values were 145 and 890 mm. The length of 69.13% of the Arabibarbus grypus population varied between 301 mm and 700 mm. 18.10% were smaller than 301 mm, and 12.75% were larger than 701 mm.

1.3. Weight Distribution:

The weight of Arabibarbus grypus specimens caught in Atatürk Dam Lake ranged from 40g to 11 000g. The lowest weight in female individuals was 40g, and the highest weight was 9 600g. In male individuals, these values were 40g and 11 000g. Considering the weight distribution, 47.31% of the fishing population varied between 250 g and 2 000g. 12.33% of the population was under 250 g, and 40.32% was over 2 000 g.

1.4. Sex ratio:

It was determined that 104 of the 243 *Arabibarbus grypus* specimens whose gonads were examined were female, and 139 were male. The rate of female individuals was 42.80%, while the rate of males was 57.20%. The female/male ratio in the general population was 0.75:1.

1.5. Breeding and breeding time:

The gonosomatic index values, egg diameter, and gonad development stages of Arabibarbus grypus were examined based on months. The ovarian development and egg maturation were at the highest level in May, spawning continued in June to start at the end of May, and they laid all eggs in July.

2. GENETIC CHARACTERISTICS

A. grypus is overfished by fishermen. Moreover, environmental factors like; the construction of dams, increase in the number of invasive species and the destruction of habitats affect *A. grypus* populations. They pose a significant risk to the future of this species. The reduction of individuals in their natural populations may lead to the disappearance of unique genotypes found nowhere else (Parmaksız, 2020). When genetic information is lost, it is almost impossible to recover (Parmaksız, 2020). Therefore, necessary measures should be taken to stop the hereditary loss and protect this species's future. For an effective protection program, first of all, reliable genetic data must be available. Genetic analysis of populations of a species is an effective tool for obtaining information in terms of conservation and management of the target species. (Ryman, 1991; Ward, 2000).

Molecular markers are a widely used technique for detecting genetic diversity and population structure (Englbrecht et al., 2000; Whitehead et al., 2003). Mitochondrial DNA markers can be used in genetic research for different species (Xia et al., 2016). Compared with nuclear DNA markers, mitochondrial DNA markers lead to a

preference for mtDNA markers due to their unique features for example, maternal inheritance and rapid evolution.

Sequence studies of mtDNA COI, cytb, and D-loop regions were conducted in sampling from different localities in the Euphrates and Tigris river systems. It partially determined the genetic structure. According to this; 3 haplotypes were calculated for the mtDNA COI region, five haplotypes for the cytb region, and three haplotypes for the mtDNA D-loop region, and the level of genetic diversity was determined to be relatively low (Parmaksız et al., 2017; Parmaksız and Şeker, 2018; Oymak and Parmaksız 2018). Genetic diversity indicates the strong adaptability and survival power of a population (Barrett and Schluter, 2008). The low genetic diversity of these fish will result in a reduced ability to adapt to the times and perhaps lead to extinction.

CONCLUSION

It is necessary to prevent fishing for this species, especially during the breeding season, and to prevent the destruction of the breeding areas of fish. In addition, it is necessary to construct gateways for fish on the dams built on the river, educate local fishers about fishing and hunting, raise awareness, and control the hunting ban application more strictly.

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CHAPTER 2

DETERMINING TOPOGRAPHIC CHARACTERISTICS of EPHEMERAL GULLY CHANNELS in MEDITERRANEAN REGION using an UNMANNED AERIAL VEHICLE

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INTRODUCTION

Topographic characteristics (Datta and Schack-Kirchner, 2010), which play a key role in the formation of gully channels, particularly in the initial phase, by affecting the runoff. Land slope, which is the most important primary topographic characteristic, is widely evaluated in erosion studies due to significant impact on the runoff energy and sediment transport (Sun et al., 2014). The slope shape (concave, convex, etc.) and aspect representing the land structure are other primary topographic characteristics that affect sediment transport by affecting the runoff accumulation and velocity (Arabameri et al., 2018). In addition, the combined topographic index (CTI) produced based on the DTM is used as a secondary topographic characteristic in the identification of risky areas where gully channels may occur in an agricultural basin (Bingner et al., 2010; Momm et al., 2013; Sheshukov et al., 2018).

Studies on gully erosion have increased considerably since the 1980s, especially since most of the soil losses in agricultural areas are caused by temporary gully erosion caused by heavy rains. While these studies focus on understanding the gully erosion process, on the other hand, they focus on the measures to be taken to reduce the soil losses caused by gully erosion. Therefore, fast and inexpensive sensitive data are needed for large areas where temporary gully erosion is effective.

For many years, one of the basic tools in obtaining topographic characteristics has been the digital elevation model. Digital terrain models (DTM) can be produced with an appropriate interpolation function in geographic information systems (GIS) and characteristics of the earth such as elevation, slope, aspect, drainage network, flow direction and runoff can easily be determined using the DTMs (Köse, 2006). Also the DEMs are indispensable elements of hydrological applications as well as usefull in generation of thematic maps such as soil, geology, land use (Algancı, 2010; Dindaroğlu et al., 2013; Bağdatlı et al., 2014).

Various sources such as satellite images and contour lines are used in the generation of DTMs (Patel et al., 2016). However, the accuracy of DEMs obtained from various satellite data is not sufficient

for precision agriculture studies (Arefi and Reinartz, 2011; Merryman and Caveats, 2016). The absolute vertical error based on a kinematic GPS-based ground control point (GCP) comparison of DSMs from optical and SAR sources was 6.6 m. The absolute vertical error according to the terrain GCP comparison was 8.5 m for Eurasia (Suwandana et al, 2012; De Oliveira, and Paradella, 2008). Although the accuracy of DSMs obtained from high-resolution satellites is higher, the accuracy is not yet below 1 m (Durand et al., 2013; Cam et al., 2013; Yılmaz et al., 2015).

The DTMs obtained using data collected from ground measurement methods (total station, GPS) more accurately reflect the real situation (Turker et al., 2004). In geodetic methods, sensitivity of the electronic meter, the accuracy of the station point, the point selection and measurement experience of an operator affect the accuracy of land measurements. The introduction of new electronic tachometers (Total Station) which is an electronic theodolite (transit) integrated with an electronic distance meter, and global positioning systems (GPS) improved the precision and accuracy of land information (Gopi, 2007).

The accuracy of a DEM is represented by spatial resolution and elevation (Muji and Tahar, 2017). Factors affecting the accuracy of a DTM are the accuracy of the ground control points (GCP), the frequency of the GCPs, the distribution of GCPs, the structure of the surface, the estimation method and the DTM surface. Negendran et al. 2018 states that 8-10 well-distributed ground control points are sufficient for submeter DTM accuracy. However, the aim determines the degree of accuracy, and the methods is chosen in accordance with the possibilities available and the expected accuracy (Aguilar et al., 2005). The quality or uncertainity of a DTM is determined with the degree of comparison of the estimated values in a DTM to the original elevation data (e.g., elevations read from topographic maps). Root mean square error (RMSE) is the most widely used measure to express the margin of error. The lower the RMSE value, the higher the accuracy of DTM (Weng, 2002). Montealegre et al. (2015) stated that

the increase in the spatial resolution of the DTM leads to a decrease in the mean square error of the interpolated surfaces.

Images obtained by unmanned aerial vehicles (UAV) have been used recently in the generation of DTMs. High quality DTMs that provide essential data for erosion studies are obtained more easily and low cost with UAVs (Uzar and Ozturk, 2019). Various factors such as the type of UAVs, camera resolution, shooting height and land topography are the important factors in resolution and accuracy of DTMs (Krsak et al., 2016).

In this study, digital terrain model was produced using the images from an unmanned aerial vehicle, and topographic characteristics (slope steepness, aspect and composite topographic index) and initial gully points of the ephemeral gully channels.

Material and Method

Description of the Study Area

The study was conducted in catchment of Topçu stream, Tarsus County, Mersin (Figure 1). The catcment is 3.9 ha and covers the north-south direction of the valley Topçu stream. The study area, with the dimensions of 220 m x 150 m, the elevation of 108 m to 126 m, was cropped by sesame crop. There was no tree and building. The slope of the study area varies between 0.7-99.5% and the average slope is 24.7%. Very steep (20-30%) and steep (>30) slopes are located on the eastern and western slopes of the valley, and especially steep slopes cover more area on the eastern slopes.

The soils in the catchment are shallow and very shallow with abundant stony gravels and formed over conglomerate parent material on steep slopes (12-20%). The soils were classified as Typic Haploxerept with vulnerable soil erosion especially gully erosion (Karakuş, 2019).

During the 2018-2019 period, sediment flow and temporary gully channels were formed three times due to heavy rains. These dates were December 20, 20018, January 10, 2019, and March 16, 2019, respectively as seen Figure 2. The first two rainstorms occurred when the soil was completely bare, while the third occurred just after seed

planting while the sunflower plants were still germinating. According to the assessment of the Mediterranean climate for many years (1929-2017), the annual total precipitation is 700 mm and the average annual temperature is 19.1 °C (MGM, 2019). Precipitation falls as heavy rain, at least a few times a year (Kuşvuran, 2011).

Figure.1 Location of study area

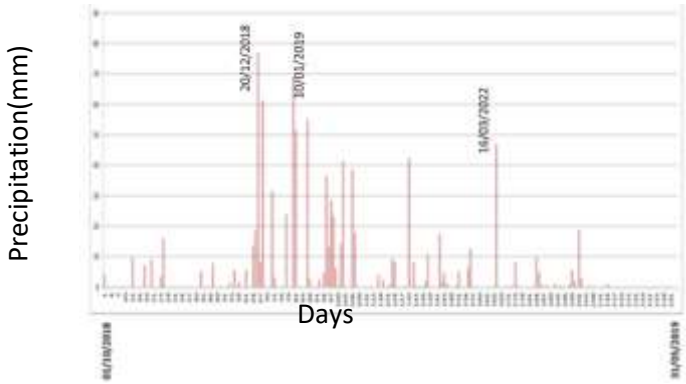

Figure 2. Daily rainfall of the study area in seson of 2018-2019 and dates of rainstorms

Data acquisition and Generation of Digital Terrain Model using UAV images

In 28 June 2018, 72 aerial photos along 4 lines from an altitude of 80 m with 80% (top) 60% (side) overlap, and 8 m s^{-1} speed to obtain digital elevation models for the Topçu creek micro-basin were taken by the CANON 160 digital camera, which was mounted to the Teknomer Multicopter UAV. Technical characteristics of the Multicopter and RGB camera used in image acquisition are presented in Table 1. The resolution of each photo was 5152 x 3864 Fourteen ground control points (GCP) were established before the flights to use for georeferencing. The GCPs were used for georeference benchmarks and the adjustment of the DTMs. The RMSE of GCP's was Tüm GCP'lerin rmse hatası 3,28 m'dir ve 5 m'lik hedef doğruluğu ile yeterince tutarlıdır. The spatial resolution (field of view, FOV) of the catchment of Topçu creek view was 1.88 cm. The calibration values of the camera (Canon 160) mounted on the UAV are given in Table 2.

Table 1 Technical characteristics of the multicopter

Specifications	**TEKNOMER Geo V2 Hexacopter**
Gimbal Stablization	3-axis
Weight (g)	3500
Autopilot Software	Mission Planner
Power	Elektrik (Li-Po Pil)
Body Size	72 cm
Motor	6 pieces
Max Speed km/h	80
Sensor	1/2.3 (CCD); 20 MPx
Lens	Focal Length; 5 – 40 mm (35 mm equivalent: 28 – 224 mm), Zoom; Optical 8x, ZoomPlus 16x, Digital Approx 4x; Maximum f / number; f / 3.2 - f / 6.9
Software	Pix4D

The DTMs from images acquired from UAV were produced using Pix4D software (Pix4D, 2017). The Pix4D software uses the binary approach, data objects are progressively distinguished among pairs of classes on all images uploaded for photogrammetric evaluation (Yilmaz et al., 2016). The accuracy of the geographical positioning of ground control points increases with this system (Pix4D, 2017).

Generating a Digital Elevation Model from Measurements

In this study, DTMs were also generated from elevation data obtained by GPS measurements. For this purpose, x, y, z coordinates were recorded using a kinematic sensitive geodetic GPS at approximately 2 m intervals (695 sites) in the Catchment of Topçu creek (Figure 3). The GPS is the most reliable data source for obtaining DEMs and can be carried by an operator or mounted on a vehicle in large areas (Ghilani and Wolf, 2008). The DEMs of the catchment were generated from the x, y, z coordinates using ArcGIS 10.4 software.

Determining Topographic Features

Both digital terrain model (DTM) produced from GPS measurements and aerial photographs taken by a multicopter type low-altitude unmanned aerial vehicle (UAV) were used to calculate the topographic characteristics of the study area and to estimate the initial points of gullies. Primary (slope, aspect) and secondary (CTI) topographic attributes generated from DTMs produced from images of

the UAV were obtained using ArcGIS 10.4 software (Zhang et al., 2014).

The CTI maps of the micro basin were generated from DTMs using both the GPS measurements and UAV images. The CTI was determined by the following equation (Moor et al., 1991):

CTI=Ln [A / tan ß],

In the equation; A represents the basin area per pixel and is derived from the cumulative flow data, and ß denotes the slope in radian.

Accuracy Assessment

In order to compare the accuracy of DTMs produced from UAV images, accuracy assessment of the DTMs was performed for 48 randomly selected check points (CPs) in study area were evaluated for vertical accuracy of DTM, slope (%), aspect and CTI values. The error of the root mean squares (RMS) term was used to test the accuracy of the DEMs. The equations of the RMSE are given below (Montealegre et al., 2015).

$$RMSE = \frac{\sqrt{\sum(Zi - Mi)^2}}{\mathrm{N}}$$

Where; Mi_i corresponds to the height value measured from the reference DEM and Zi corresponds to the height value measured from the DTMs derived UAV.

Results and Discussion

Digital Terrain Model of the Study Area

Vertical accuracy of the DSMs was assessed folowing the preprocessing steps. For this, the height information extracted from the 48 test points (CPs) (Figure 3) was compared with the information corresponding to the reference DTM (Figure 4). The RMSE value of DTM generated from UAV images was 1.63 m. Kerdsrilek (2008)

stated that filtering from preprocesses improves the image quality and increases the accuracy of DTM generation. Digital terrain models (DTM) were created by measuring ground altitude with a GPS. The results were considerably better than global DEMs such as SRTM_DEM, ASTER DEM, ALOS DEM and local DEM generated from HGK data (Algancı et al., 2018; Takaku et al., 218). Thus, DEMs are indispensable for many processes such as topographic features, flow analysis and slope stability (Skidmore, 2017).

The DTM, whose TIN model was obtained in ArcMap 10.4 software from the altitude and coordinate information obtained from the field measurements, had a resolution of approximately 1.3 x 1.3 m. The height of the catchment ranged 151.7 and 100.3 m. The results are in accordance with the previous reports stating that resolution and accuracy of the DTMs generated using UAV images were better compared to DTMs obtained by Light Detection and Ranging (LiDAR), and satellite (Yao et al., 2010; Gillin et al., 2015; Annis et al., 2020).

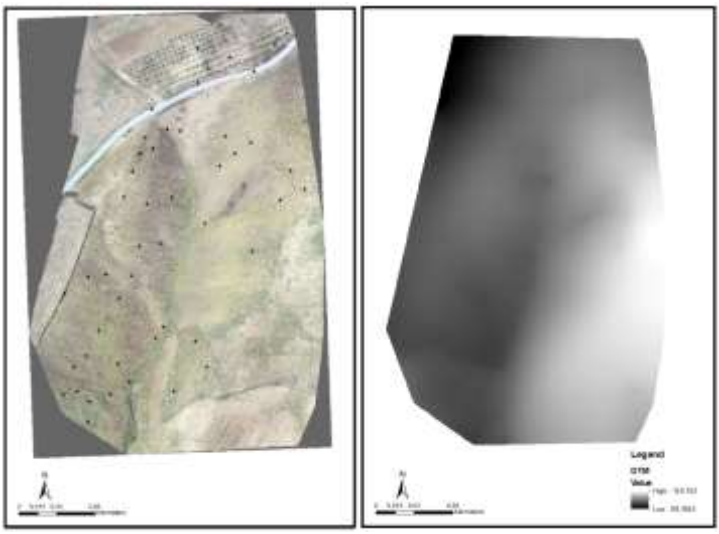

Figure 3. Orthomosaic map with validation sites and DEM produced using aerial photographs acquired by UAV

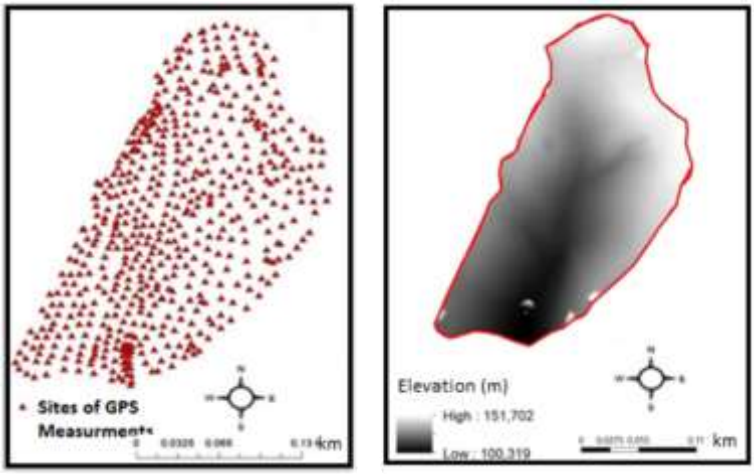

Figure 4. a) The locations of GPS measurements and b) DEM of the catchment of Topçu Creak

3.2 Topographic Characteristics of the Study Area

Spatial distribution of the slope groups obtained from the DTM, generated by kinematic GPS measurements is given in Figure 5. The slope of the test area varies between 0.7 and 99.5% and the mean slope is 24.6% (Table 2). The mean slope of the micro-catchment in DTMs generated from UAV images was 19.2%, which was very close to the mean slope generated from GPS measurements. The mean slope of a micro-basin produced from satellite images was considerably lower than that obtained from GPS measurements (Azami et al., 2017). Therefore, slope maps generated from UAV images provided better results than those produced from other sources.

Very steep (20-30%) and steep (> 30) slopes of the micro basin are located on the eastern and western slopes of the valley, and especially steep slopes cover more area on the eastern slopes. The slope map with high resolution generated from the UAV images is very similar to the slope map produced from GPS measurements.

Table 2. Slope values obtained from different sources

Data Source	Slope, %		
	Lowest	Highest	Mean
GPS measurment	0.72	99.5	24.6
UAV Image	0.0001	100	19.43

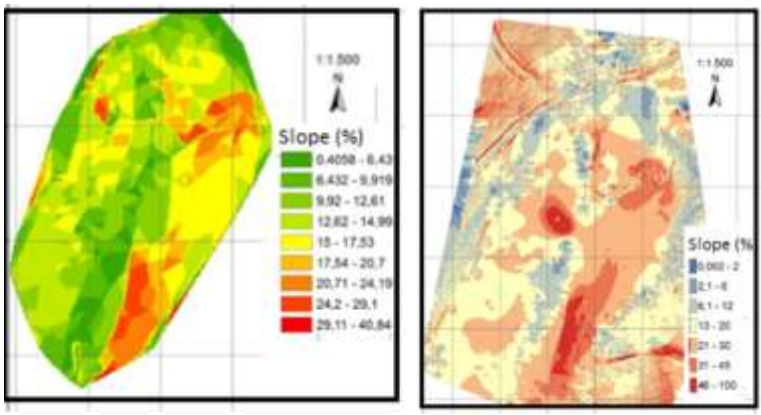

Figure 5. Slope maps generated from a) GPS measurements and b) DEM produced by UAV images

Aspect describes the orientation of the earth's surface with respect to the sun or the compass direction that the slope faces. The aspect map obtained by field measurements indicated that the general slope of the Topçu basin is in the north-south direction and the river network in the basin generally flows in the northeast-southwest direction. Therefore, the dominant aspect of the basin is in the east and west directions. The aspect maps generated from the UAV images are similar to the aspect map obtained from the topographic map (Figure 6). The slope aspect has significant influences on soil temperature, soil moisture, evaporation, vegetation and land use; thus, indirectly affects the soil erosion (Arabameri et al., 2018). Fang and Guo (2015) stated that the effect of sun-exposed south aspects (S, SE, SW) on the severity of gully erosion is more than the north aspects (N, NE, NW).

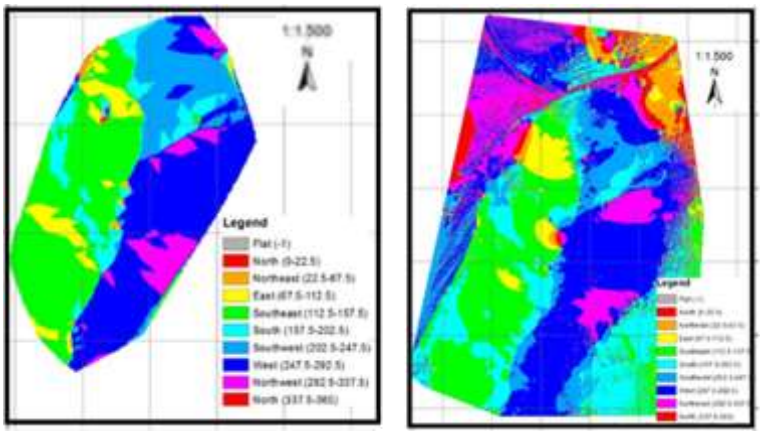

Figure 6. The aspect maps of micro catchemnt of Topcu creek generated from a) GPS measurements and b) DEM produced by UAV images

Compound topographic index (CTI) is one of the secondary topographic indices used to identify the areas with high potential for gully channel development. The strength of a CTI map to identify the gully develop location is affected by field and local topographic characteristics and DTM resolution (Momm et al., 2013).

The CTI maps generated from GPS measurements and UAV images were given in Figure 13. The CTI values generated from the GPS measurements of the micro-basin ranged between 0.38 and 14.32 and were very close to the CTI values produced from the UAV images (Table 4). The CTI values less than -1.0 indicate gully risk areas. The results included that the interval between the highest and lowest CTI values was narrower in maps produced using GPS measurements. The higher the CTI values indicates possible locations for gully initiation (Moore et al., 1991).

Threshold analyzes were performed for different values (20, 30 and 50) to estimate the gully initiation points. For this purpose, the initiation points of the gullies in the field were marked on high resolution orthophoto maps (Figure 7), and these points were compared with the results of the threshold analysis. The results of threshold analysis showed that CTI value of 30 provided more accurate estimation to the initiation points of the gullies. Parker et al. (2010)

stated that DTM resolution is important in predicting gully erosion, and resolutions less than 10 m decreased the prediction of gully erosion.

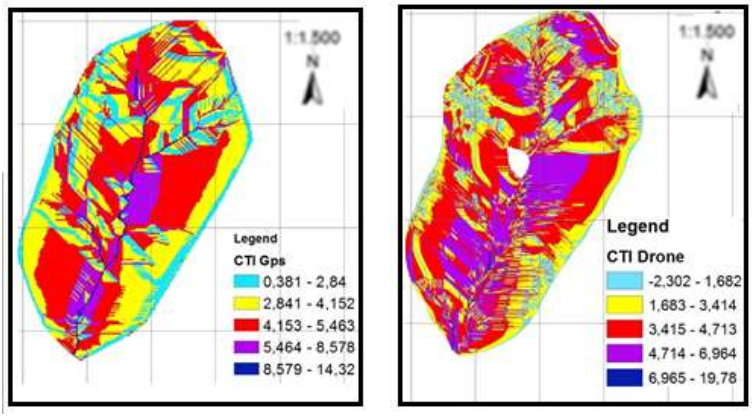

Figure 7. CTI maps generated from GPS measurements and UAV images

Table 3. Statistics of CTI values produced from GPS measurements and UAV images of Micro catchment of Topçu creek

Data Source	CTI		
	Lowest	Highest	Mean
GPS measurment	0.38	14.32	4.08
UAV Image	-2.30	19.78	3.64

Estimation of Channels and Initial Points of Ephemral Gully

Eighty one gully channels were formed in the Topçu creek microbasin (Figure 8). The total length of the gullies was 868.2 m and the total volume of gullies was 5.52 m^3. Average bulk density of soils in microbasin was 1.56 g cm^{-3}, therefore, the soil loss after heavy rains in January 2019 was estimated as 8.61 tons ha^{-1}. Kuşvuran et al. (2011) who reported that the soil losses by heavy rains (64.8 mm) in the Topçu micro catchment reached 49.9 tons ha and the average annual soil loss was 8.9 Mg ha^{-1}. The researchers stated that the highest daily precipitation in the basin (2000-2009) during the 10-year period (2000-2009) was 97.0 mm. Recent developments on geospatial data processing techniques improved the analysis of aerial photographs and DTMs in gully erosion studies (Martinez-Casasnovas, 2003), which

were mainly carried out on well-cut gullies with a depth of 1 to 10 m or higher. Accurate and fast methods are needed to assess the erosion caused by ephemeral gullies with a width of 0.5 to 1.0 m and a depth of 0.1 to 0.2 m in agricultural lands (Frankenberger et al., 2008). Ephemeral gully erosion is the main source of sediment transported from agricultural land however, it has often been ignored in conventional soil erosion assessments. Ephemeral gullies are easily filled with normal soil tillage operations, therefore, the difficulty in evaluating ephemeral gully erosion is related to the lack of well-defined channel morphology such as classical gullies and river channels. The width and depth of the ephemeral gullies are too small (+/- 0.5 m) to be determined by general topographic examination and mapping studies. The removal of ephemeral gullies by tillage operation makes difficult capturing the existing ephemeral gullies in croplands (Bennet and Wells, 2019).

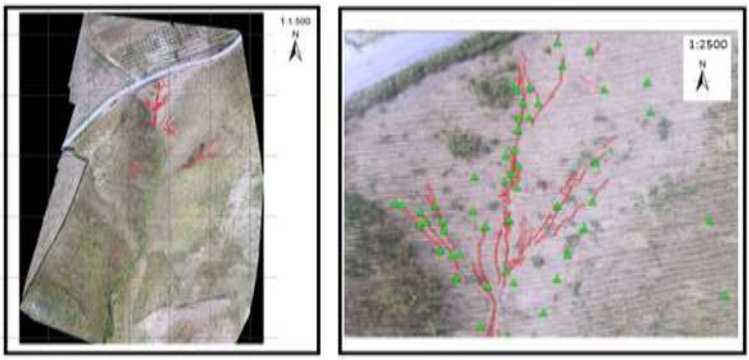

Figure 8. Gully channels and initial points captured by orthophoto generated by UAV Images

Conclusions

The results of the study revealed that the volumes of the channels that cause gully erosion can be successfully estimated in Pix4D software using DTMs produced from overlapped serial photographs taken from 30 m height by an UAV. The use of GIS software and developments in technologies enable to use the data obtained by UAV images more regularly and effectively. The DTMs generated using UAV images significantly reduce the problems related

to topographic map revision. In addition, the DTMs generated from UAV images decrease the cost and increase the accuracy of slope, aspect and relief maps. Comparison of the topographic features calculated from GPS measurements of the gully channels area showed that the gully volumes can successfully be estimated by Pix4D using the UAV images.

Some difficulties were encountered in volume calculations from produced DTMs due to weed and topography fluctuations in the slope area. Previous studies reported that corrections that cover topography and weeds will not increase the accuracy of the study. However, the production of DTMs in Pix4D software is time consuming. The DTMs should be generated in a short time with a reasonable cost in addition to be high accuracy. Better understanding of the subject depends on more advanced studies, different field studies, scientific and technological developments.

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CHAPTER 3

IMPACT of BIOCHAR AMENDMENT on SOME CHEMICAL PROPERTIES of a TYPIC FLUVENT SOIL

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1. INTRODUCTION

Biochar, a product produced thermochemical conversion of biomass into carbon rich and stable material, is extensively studied in various fields to determine the effects on environment. Soil amendment potential of biochar has attracted the attention of soil scientists to improve soil quality by increasing organic carbon content and enhancing sustainability of crop production (Joseph et al., 2010). The response of biochar application to soil has been assessed for various soils. Conflicting physical and chemical properties have been reported for biochar amended soils mainly due to the nature of the feedstock, pyrolysis conditions the amount of added biochar, and soil type (Saifullah et al. 2018; Gunal et al. 2018a and 2018b).

Soil salinity is one of the major constrains to agricultural production in all over the world; thus threatens the food and fiber needs of continuously increasing global population, which is expected to be over 9.8 billion marks in 2050 (United Nations, 2020). The most recent estimates for salinity (Hopmans et al., 2021; Tian et al., 2020) indicated that over one billion hectares of land have been affected by salinity and the problem is spreading at a rate of over two Mha per year (Singh, 2018). Thomas et al. (2013) stated that biochar could be used to alleviate negative impacts of soil salinity on plant growth either by reducing uptake of sodium ions or by facilitating exclusion of sodium ions or both in plants. In addition to reducing uptake of sodium ions, Usman et al. (2016) reported that biochar application to saline soil may improve plant growth by increasing potassium uptake of plants under salt stress. Similarly, Ali et al. (2017) who reviewed the studies on soil salinity and biochar application indicated that plant tolerance to salt stress in saline soils may be improved by increasing plant nutrient uptake and accumulation of nutrients in plants.

Southeastern region ranks 1st for pistachio production in Turkey with 96.8% of pistachio production covering more than 354500 ha pistachio orchards. Sanliurfa is Turkey's highest pistachio producing province more than 100000 ton per year (Anonymous, 2021). A pistachio fruit has two types of shells, which are a soft red outer shell and a very hard inner shell that protects the fruit. The soft outer skin

constitutes 18% of the fruit and approximately 13.000 tons of red skin is produced annually in Turkey as waste (Demiral et al., 2008). The hard inner shell constitutes approximately 45% of the fruit (Açıkalın et al., 2012). Therefore, pistachio waste produced only in Sanliurfa province is approximately 55,686 tons (BEPA 2018), which is used for heating or removed to dispose in the city landfills. In this study, the effects of biochar produced from slow pyrolysis of pistachio processing wastes and salinity on some of physical and chemical characteristics of a coarse textured soil were investigated.

2. Material and Methods Material

Surface (0 to 20 cm) soil (Typic Fluvent) was collected from Fırat River Bank in Şanliurfa, Turkey. The soil samples were passed through 4 mm sieve prior to mixing with biochar. Experimental soil had sandy loam particle size distribution and high calcium carbonate content (19.7%). Soil pH was 8.02 (slightly alkaline) and non-saline (0.4 dS m^{-1}) (Table 1).

Table 1. Characterization of experimental soil

pH	EC	Lime	Org. Mat.	P	K	Cu	Fe	Mn	Zn
	dSm^{-1}	%		mg kg^{-1}					
8.02	0.40	19.7	0.93	12	283.5	0.647	2.514	1.665	0.262
Clay	Silt	Sand	Soil Texture						
%									
13.6	16.0	70.4	Sandy Loam						

Biochar was produced by slow pyrolysis of pistachio processing wastes (maximum size 2 mm) at 500 °C in an ingeniously developed lab scale reactor. The feedstock was determined based on the abundance in the southeastern region of Turkey. The feedstock was subjected to slow pyrolysis process characterized by approximately 10 °C min^{-1} heating rate and long residence time. The pyrolysis continued at 500 °C until pyrolysis gas disappeared in the unit. The pyrolyzed materials were allowed to cool to room temperature for almost 4–6 hours.

Methods

The incubation study consisted of 4 biochar application rates × 5 salinity levels. All the treatments had three replications. The treatments were; 1) biochar application rates [(0, 0.25, 0.50 and 1.0% g/g), biochar application rates are equivalent to 5.625 t/ha (0.25%), 11.25 t/ha (0.5%) and 22.5 t/ha (1.0%)] and 2.) salinity levels were 0, 2.5, 5, 7.5 and 10 dS m^{-1}. The soils were thoroughly mixed with biochar and salt. The pots were with deionized water on a daily basis to keep soil moisture content close to field capacity.

Biochar and Soil Analysis

Total C, N, H and S contents of biochar were determined by high temperature combustion using a Carlo Erba NA1500 NSC elemental analyzer. Organic matter content of soils was determined by dichromate oxidation using the modified Walkley Black method (Nelson and Sommers, 1996). Organic matter was converted to soil organic carbon content dividing by the conversion factor of 1.72. Soil pH and electrical conductivity (EC) were measured in a 1:2.5 soil/water mixtures (Thomas, 1996). Calcium carbonate content was determined by using calcimeter method as mentioned by Allison and Moodie (1965).

Statistical Analysis

The normality of data, which is the prerequisite for many of statistical analysis was tested prior to statistical evaluation. The data had normal distribution. The Levene's test was performed to confirm equality of variances of for soil properties between the replicated measurements. Two-way analysis of variance (ANOVA) technique was used to test the differences biochar rates and salinity levels. Duncan test (LSD at 0.05 level of probability) was used test to assess the significance of the differences among the means. Bonferroni correction was applied to adjust the significance level for the multiple comparisons. The results presented in the results and discussion section included the effects of biochar application rate and biochar rate x salinity level interaction on soil properties. Data for biochar application

rates are presented in Figures and two-way interactions for chemical properties and nutrients are given in Tables 1-2.

3. Results and Discussion

Soil and biochar properties

The characteristics of feedstock (pistachio processing waste) and the biochar are given in Table 1. The organic matter content of experimental soil was very low (0.90%). The biochar used in the incubation study contained 51.7% total carbon and 2.8% total nitrogen by mass. Carbon content of pistachio processing residue was increased from 39.6% to 51.7% in the pyrolysis process, while total nitrogen content of biochar material was only 0.2% higher than the feedstock. The analysis of feedstock and biochar material revealed that all sulphur in feedstock was removed during pyrolysis process. The pH of the pistachio residue was 7.5 and increased to 8.9 after pyrolysis (Table 2).

Table 2. Some of characteristics of pistachio residue and pistachio biochar

	Total C (%)	Total N (%)	C:N	Total H (%)	Total S (%)	pH
Pistachio Residue	39.6	2.6	15.5	4.5	16	7.5
Pistachio Residue Biochar	51.7	2.8	18.4	2.3	0	8.9

Effects of Biochar Application on Soil Properties

Soil organic matter content is one of the main indicators of soil quality (Andrews et al., 2004). The addition of biochar without salt significantly increased the soil organic matter content determined after 51-day incubation. Organic matter content in control was 0.93% and increased by 6.3, 9.2 and 12.6%, respectively, with the 0.25, 0.5 and 1.0% biochar treatments relative to the control (Figure 1). Similar to our results, Cooper et al. (2020) reported a significant increase in organic carbon content and pH of soils after 6 year of biochar application and agricultural use. In contrast to organic matter content, calcium carbonate content was significantly ($p<0.05$) decreased with the increase in biochar doses (Figure 1).

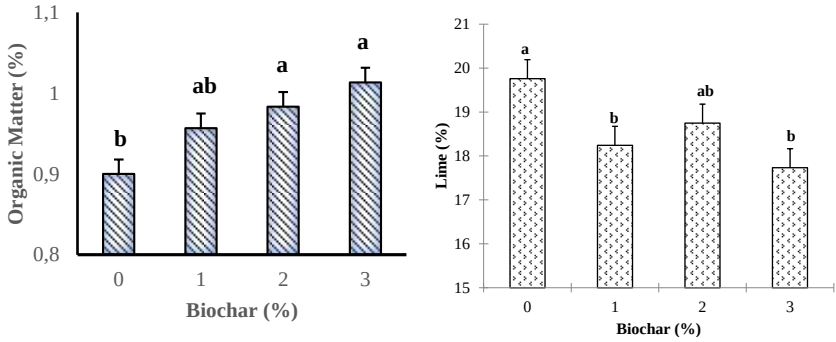

Figure 1. Effects of biochar doses on soil organic matter and calcium carbonate (lime) content of experimental soil

Soil pH is an important chemical property affecting the availability of nutrients in soil. The soil pH and EC values did not significantly differ with the addition of biochar. Biochar has potential in increasing soil pH in acidic soil due to the alkaline nature of biochar. However, the increasing levels of biochar slightly decreased soil pH, which was 8.51 in 0.25% biochar added to soil and decreased to 8.30 in 1.0% biochar added soil.

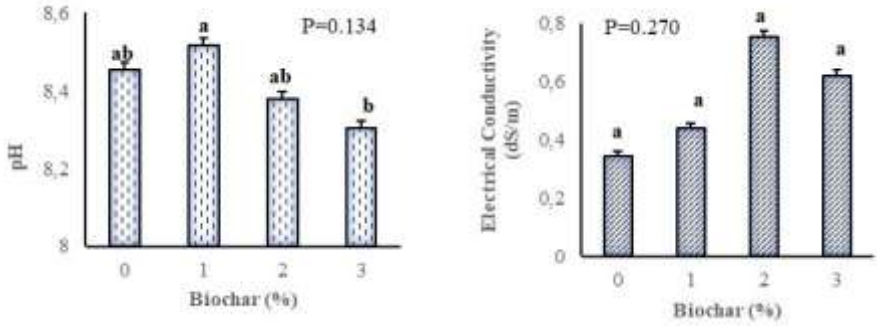

Figure 2. Effects of biochar doses on soil pH and electrical conductivity (dS/m)

Exchangeable potassium concentration of the experimental soil significantly increased with the increasing doses of biochar application (Figure 3). Potassium unlike nitrogen or sulfur volatilized during pyrolysis, is mostly retained and converted into highly soluble potassium containing salts (Karim et al., 2017). Therefore, potassium

content of biochar added soil increased by 26.8, 94.8 and 136.6% in 0.25, 0.5 and 1.0% biochar treatments compared to the control. The results reported by Angst and Sohi (2013) are in accordance with our results. The researchers recommended to use biochar as an alternative to conventional K fertilizers. In contrast to K, the biochar treatments had no significant effect on available P content of experimental soil (Table 4). The effects of biochar application on available P contents of soils is variable. Glaser and Lehr (2019) indicated that biochar produced at 600 °C and higher temperatures with an application rate of over 10 Mg ha^{-1} may significantly increase available P contents of agricultural soils depending on soil pH. The researchers stated that biochar application to acid and neutral soils increase the availability of soil P, while biochar addition to soil has no significant effect in alkaline soils.

Cation Exchange Capacity (CEC) of a soil indicates the potential of attraction, retention and exchange of cations such as calcium, potassium, ammonium. The CEC of a soil corresponds to the total negative charges available to adsorb cation in exchangeable form (Graber et al., 2017). Negative charges of a soil acts like a magnet, which attract and hold nutrients. Therefore, biochar addition to soil cause an increase in CEC of the soil depending on the CEC of soil and the biochar (Anonymous, 2022). The CEC of experimental soil significantly increased with the increasing doses of biochar application (Figure 3). The CEC of experimental soil was 12.13 me/100 g in control and increased to 13.45, 14.12 and 15.42 with the application of 0.25% (5.63 t ha^{-1}), 0.50% (11.25 t ha^{-1}) and 1% (22.5 t ha^{-1}) biochar. Similar to the increase in our experiment, Dominques et al. (2020) suggested to use alkaline and high-cation exchange capacity biochars to increase the CEC of highly weathered soils.

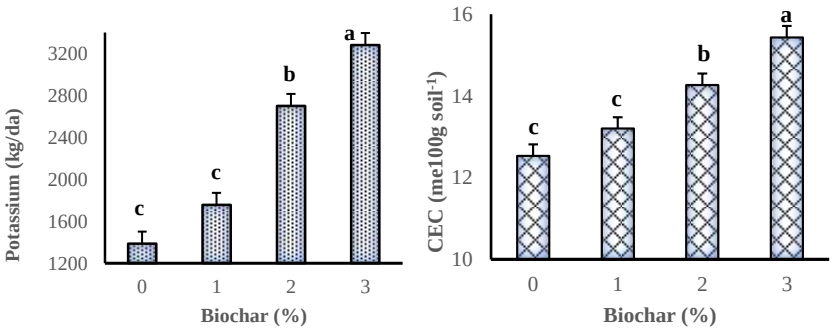

Figure 3. Effects of biochar doses on available potassium (kg/da) and cation exchange capacity of soils (me 100 soil^{-1}).

Significant increases in plant available Fe, Cu, Mn and Zn contents were recorded with the amount of biochar added (Tables 4). The increases in K, Fe, Cu, Mn and Zn contents with increasing doses of biochar are most likely due to the presence of these nutrients in the biochar. The findings are in accordance with Larid et al. (2010) who stated that biochar addition did not increase the P content of soil due to the low concentration of P in the biochar. The authors also attributed to the increases in Mehlich 3 extractable K, Ca, and Mn content with the increasing levels of nutrient rich biochar added to soil. The increase in the concentration of micronutrients compared to control has been reported by other researchers (Randolph et al., 2017).

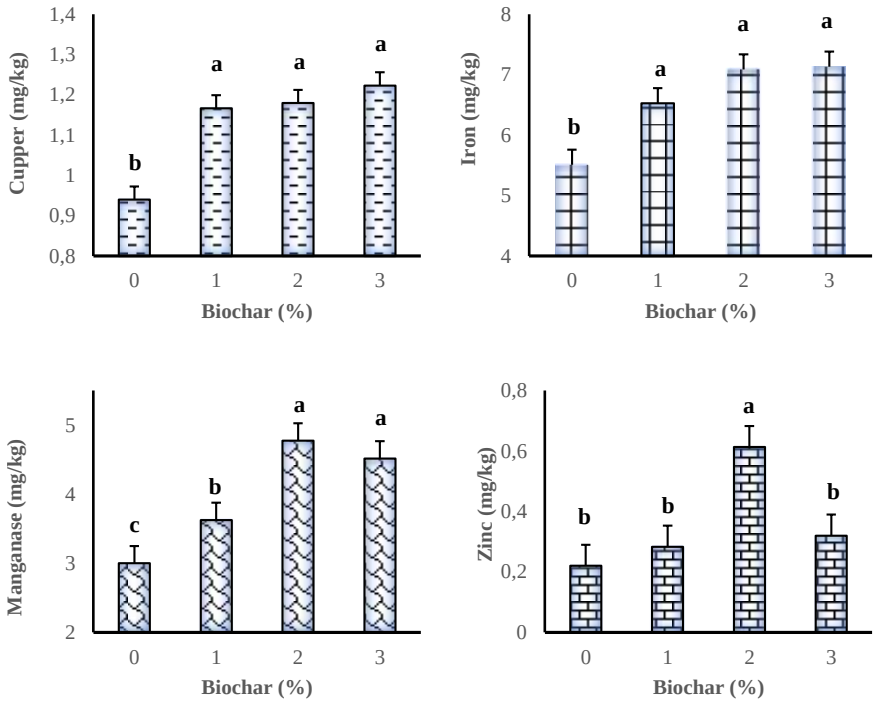

Figure 4. Effects of biochar doses on micronutrient concentrations (Cu, Fe, Mn and Zn) of experimental soil.

Effects of Salinity and Biochar x Salinity Interaction on Soil Properties

The effect of salt on EC and lime content of experimental soil was statistically significant ($p<0.05$), while it was not significant on pH value, organic matter content and CEC of the soil (Table 3). The effect of biochar x salt interaction on pH value, soil organic matter content and CEC was not significant (Table 3). The interaction of biochar x salt had only significant effect on lime content of soil. The highest lime content (19.8%) was recorded in control (B0xS0), while the lowest content (17.1 and 17.2%) was obtained in B0xS1 and B0xS2 treatments. Although the interaction of biochar and salt did have a significant effect on CEC value of the experimental soil, the highest CEC value (15.9 me 100g $soil^{-1}$) was recorded in B3xS3 treatment.

Similar to the CEC value, the highest organic matter content, pH and EC values were also determined in the B3xS3 treatment (Table 3).

Table 3. Variance analysis for some of chemical soil properties

Interactions	*pH*	*EC*	*Lime*	*Organic Matter*	*CEC*
		dS m^{-1}		%	me 100g $soil^{-1}$
B0xS0	8.5 ab	0.34 g	19.8 a	0.90 bc	12.5 gh
B0xS1	8.4 bcd	2.58 f	17.2 d	0.86 c	11.8 h
B0xS2	8.3 cd	4.72 de	17.1 d	0.90 bc	12.2 h
B0xS3	8.4 abc	8.92 ab	19.0 abc	0.89 bc	12.03 h
B1xS0	8.5 a	0.44 g	18.2 bcd	0.96 bc	13.2 fg
B1xS1	8.4 abc	2.49 f	18.4 bcd	0.97 bc	13.4 ef
B1xS2	8.2 cd	5.83 d	17.9 bcd	0.97 bc	13.6 def
B1xS3	8.4 abc	9.05 ab	17.9 bcd	0.96 bc	13.5 ef
B2xS0	8.4 abc	0.75 g	18.7 abc	0.98 bc	14.3 cde
B2xS1	8.3 cd	3.69 ef	19.1 ab	0.94 bc	13.5 ef
B2xS2	8.2 cd	6.36 cd	18.2 bcd	0.99 bc	14.5 bcd
B2xS3	8.3 cd	9.53 ab	18.0 bcd	0.97 bc	14.2 cde
B3xS0	8.3 bcd	0.62 g	17.7 cd	1.01 b	15.4 a
B3xS1	8.3 bcd	3.80 ef	18.4 bcd	1.01 b	15.3 ab
B3xS2	8.2 d	7.84 bc	17.9 bcd	0.98 bc	15.0 abc
B3xS3	8.3 cd	9.92 a	18.4 bcd	1.14 a	15.9 a
Biochar	0.134	0.270	0.045	0.012	0.001
Salt	0.094	0.001	0.024	0.500	0.241
Biochar x Salt	0.628	0.572	0.002	0.415	0.340

Salt addition to experimental soil had a significant effect on Cu, Fe, Mn and Zn concentration of the experimental soil. Except Fe concentrations, Cu, Mn and Zn concentrations of the experimental soil were higher in salt applications. The increase or decrease in nutrient concentrations of experimental soil in the biochar and salt interactions were not regular. The highest Mn concentration (10.12 mg kg^{-1}) was obtained in B3xS3 treatment, while the highest Cu concentration (1.46 mg kg^{-1}) was recorded in B1xS3 treatment. In contrast to Mn and Cu concentrations, the highest concentrations of Fe and Zn were obtained in more than one interactions.

Table 4. Variance analysis for some of macro and micro nutrients

Interactions	*K*	*P*	*Cu*	*Fe*	*Mn*	*Zn*
	kg da^{-1}			mg kg^{-1}		
B0xS0	1385.7 fg	4.8 abc	0.94 e	5.51 abc	3.00 h	0.22 d
B0xS1	1328.0 g	3.6 bc	1.38 abc	6.85 ab	5.73 def	0.57 abc
B0xS2	1396.3 fg	3.2 c	1.45 ab	3.22 d	6.07 cdef	**0.75 a**
B0xS3	1375.0 fg	3.7 bc	1.31 abcd	1.31 e	8.06 bc	0.63 ab
B1xS0	1756.3 efg	5.2 ab	1.17 d	6.53 abc	3.63 gh	0.28 cd
B1xS1	1796.0 efg	4.1 abc	1.36 abcd	**7.05 a**	7.07 cde	0.43 abcd
B1xS2	1875.0 ef	4.1 abc	1.41 abc	3.10 d	6.53 cdef	**0.78 a**
B1xS3	1829 efg	4.8 abc	**1.46 a**	5.09 bc	7.60 bcd	0.57 abc
B2xS0	2699.7 c	4.6 abc	1.18 d	**7.09 a**	4.78 fgh	0.61 abc
B2xS1	2184.7 de	4.6 abc	1.22 cd	6.25 abc	5.94 def	**0.74 a**
B2xS2	2588.0 cd	3.4 bc	1.38 abc	3.06 d	5.46 efg	0.49 abcd
B2xS3	1797.7 efg	5.2 ab	1.30 abcd	5.82 abc	9.44 ab	0.65 ab
B3xS0	3279.0 ab	**6.0 a**	1.22 cd	**7.13 a**	4.52 fgh	0.32 bcd
B3xS1	2822.0 bc	**5.7 a**	1.31 abcd	**7.25 a**	7.16 cde	0.47 abcd
B3xS2	**3438.0 a**	4.6 abc	1.26 bcd	4.80 c	7.06 cde	0.46 abcd
B3xS3	3218.0 ab	4.9 abc	1.28 abcd	5.74 abc	**10.12 a**	0.64 ab
Biochar	0.001	0.717	0.001	0.006	0.001	0.017
Salt	0.858	0.256	0.001	0.001	0.007	0.111
Biochar x Salt	0.049	0.803	0.013	0.003	0.273	0.067

BO: Control, B1:0.25%, B2:0.50%, B3:1.0% biochar; S0: Control, S1: 2.5 dS m^{-1}, S2: 5 dS m^{-1}, S3: 7.5 dS m^{-1}, S4: 10 dS m^{-1}.

4. Conclusions

The results of this incubation study clearly showed that addition of biochar that has high carbon content and surface area to coarse textured soil as in the experiment has a significant positive impact on soil organic matter content and cation exchange capacity of the soil. In addition, although biochar has not been considered as a fertilizer, application of nutrient rich biochar to nutrient deficient coarse textured soil significantly increased the potassium, iron, zinc, copper and manganese concentration of soil. Coarse-textured soils are considered to have low quality due to mainly low water and nutrient retention. Therefore, application of biochar to particularly coarse textured soils can be considered as a good strategy to improve soil quality.

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CHAPTER 4

VARICOCELE AND PATHOPHYSIOLOGICAL PROCESS

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INTRODUCTION

Varicocele is known as the enlargement above the physiological limits of the veins in the plexus pampiniformis, which has undertaken the task of venous drainage in the testis tissue (Kendirci et al., 2003). Varicocele, first described by Curling in 1843 (Nöske and Weidner, 1999), does not cause problems in some cases, but in some cases it can damage the testicular tissue and cause infertility (Mohammed and Chinegwundoh, 2009). It has been reported that a very high rate of varicocele is seen on the left side (90%) and localization on the right side is low (Grillo-López, 1971). It has been reported that a very high rate of varicocele is seen on the left side (90%) and localization on the right side is low (Grillo-López, 1971). It has been suggested that this difference is due to the fact that the left testicular vein is longer than the right side and enters the left renal vein perpendicularly (Agarwal et al., 2009). However, while it is claimed that varicocele usually occurs on the left side, there is also information that bilateral varicocele is seen in more than 50% (Amelar and Dubin, 1987).

While the rate of the male factor in infertility is between 50-60%, the role of varicocele alone in this rate is around 35% (Witt and Lipshultz, 1993). It has been reported that the rate of varicocele is 25% in infertile men with abnormal spermatology (Nieschlag et al., 1995). While the prevalence of varicocele is 0.92% between the ages of 2-10, it has been reported to be 11% between the ages of 11-19 (Akbay et al., 2000).

Patients with varicocele usually suffer from pain and testicular atrophy, especially scrotal swelling. Valsalva maneuver is at the forefront in diagnosis (Dubin and Amelar, 1970). Grading is done according to this examination. Varicocele detected with the Valsalva maneuver is called grade 1. Varicocele that can be detected but not visible without the Valsalva maneuver is called grade 2. Varicocele detected by direct inspection is called grade 3 (Dubin and Amelar, 1970). There is also a subclinical varicocele that cannot be palpated or seen with the naked eye, which can only be detected by imaging methods (de Los Reyes et al., 2017).

In order to understand the pathophysiology of varicocele, experimental varicocele models were considered and in this sense, a number of animals such as rats, dogs, rabbits and hamsters were used for experimental purposes. Among these animals, the rat took the first place (Marmar, 2001). Especially since varicocele pathology in humans is similar to rats, it was tried to clarify the etiology and pathophysiological situation by creating varicocele in the left renal vein in rats (Turner and Howards, 1994). Many experimental studies have been done. Although there are some modifications, the left varicocele model is generally created by partial ligation of the left renal vein. However, caution should be exercised in the narrowing process in experimental studies. Because excessive ligation can cause kidney necrosis.

VARICOCELE INDUCTION TECHNIQUE

First, general anesthesia is applied, and then sterility of the operation area is ensured. A midline incision is then made in the upper abdomen. When the inner abdominal region is reached, the abdominal contents are given to the right side and the left renal vein, inferior vena cava and left spermatic vein are detected. In particular, the part where the left spermatic vein enters the left renal vein is tried to be determined. The fat and connective tissue around the left renal vein are dissected and released. A ligature is placed under the renal vein to surround the renal vein and an angioket is placed parallel to the renal vein. Then, the left internal spermatic vein is ligated to enclose the renal vein angiokee with silk thread proximal to the point where it empties into the renal vein. The angioket is then removed. Expansion of the vessel within the ligation margin (the vessel diameter is reduced to approximately half of the original diameter) is ensured. After the procedure, the midline incision is closed with silk suture. In the group to be used as the sham group, all applications are almost the same. However, ligation is not performed on the left renal vein. The ligature is rotated to enclose only the left renal vein and removed without ligation (Turner, 2001).

Although many titles have been listed in the pathophysiology of varicocele, a clear result has still not been obtained. Among these listed; hyperthermia, apoptosis, oxidative stress, changes in testicular blood flow and venous pressure, hormonal disorders, renal-adrenal reflux, hypoxia, and acrosome reaction defect (Agarwal et al., 2009; Benoff et al., 2009; Hassanin et al., 2018).

PATHOPHYSIOLOGICAL PROCESS IN VARICOCELE

It is possible to list the theories in the pathophysiological process in varicocele under the following headings.

1-Hyperthermia

It is in the first place among the titles listed in the pathophysiology of varicocele. Thermoregulation in the testis is very important for a healthy spermatogenesis. There are two mechanisms in the regulation of scrotal temperature in the testis. One of them is the scrotum itself. The other is the heat exchange between arteries and veins in the plexus pampiniformis, which is in the spermatic cord. In this heat exchange system, the temperature of the spermatic artery blood entering the testis is cooled by the low temperature of the blood in the veins exiting the testis. While this is the normal mechanism, it is thought that this mechanism is impaired in varicocele (Dahl and Hendrick, 1959). Although this idea is controversial, it has been found that scrotal and intratesticular temperature increase in varicocele cases in both animals and humans. In addition, the most important finding that brings this idea to evidence is that the intratesticular temperature drops to a normal level after varicocelectomy (Kendirci et al., 2004). It has been reported that the scrotal temperature increase in varicocele is bilateral and decreases to normal levels after varicocelectomy (Mieusset et al., 1987).

Testicular temperature is approximately 2.5°C lower than body temperature under normal conditions. This heat is essential for the reproduction to continue in its normal course (Hassanin et al., 2018). However, it has been reported that the scrotal temperature is 2.6°C higher than the normal value in varicocele due to a number of reasons

such as venous reflux and stasis (Garolla et al., 2015). It has been emphasized that increasing temperature causes abnormal increases in reactive oxygen species (ROS) levels and reduces the efficiency of DNA polymerase enzyme, causing apoptosis (Witt and Lipshultz, 1993; Rao et al., 2015).

In studies, it has been determined that testicular temperature of patients with varicocele is higher than fertile individuals, and it has been emphasized that this situation increases the number of free radicals and impairs the spermatogenesis process (Xu et al., 2016). In another experimental study, a left varicocele was created by surgery and there were bilateral increases in testicular blood flow and intratesticular temperature after the study (Turner, 2001).

2-Apoptosis

Apoptosis, which is accepted as a physiological event, is important for many biological processes in humans and animals and has a regulatory role. For example, the role of apoptosis in spermatogenesis, which is the basis of male reproduction, cannot be denied. Studies have reported that spontaneous apoptosis occurs routinely in testis, and germ cell number and quality are regulated by apoptosis (Kerr et al., 1972). It is also believed that apoptosis has a significant protective role in the balance between germ cells and Sertoli cells (Said et al., 2004). It is thought that nitric oxide (NO) and endothelial nitric oxide synthase (eNOS) may have an effect on germ cell apoptosis in varicocele. As a matter of fact, while both NO and eNOS are not found in healthy cells, their detection in apoptotic germ cells has led to this idea (Zini et al., 1996). It has been suggested that there is a link between testicular temperature increase and germ cell apoptosis, and that germ cell apoptosis increases as testicular temperature increases (Socher et al., 1997).

In an experimental varicocele study, it was reported that 14 days after the varicocele was created, apoptosis detected in germ cells in the varicocele group doubled compared to the control group, and increased to maximum levels after 28 days. In the same study, it was observed that there was a decrease in apoptosis after varicocelectomy and the

mean apoptotic index decreased to the levels of the control group (Yılmaz, 2005).

Another study was conducted on 40 rats and it was reported that the mean apoptosis index of Leydig cells in the experimental group was significantly higher at 4 and 8 weeks. Based on the data obtained, it has been suggested that varicocele increases apoptosis and impairs Leydig cell function by suppressing the expression of steroidogenic acute regulatory (StAR) protein (Luo et al., 2011).

3-Oxidative stress

In addition to the decrease in antioxidant defense mechanisms in varicocele, the detection of some lipid peroxidation products such as ROS and malondialdehyde (MDA) at high levels suggests that oxidative stress plays an important role in varicocele (Cho et al., 2016). Various evidences have shown the association of varicocele with increased seminal ROS concentration (Yoon et al., 2010). The link between varicocele and oxidative stress has been demonstrated with higher ROS, NO, and lipid peroxidation products in infertile men with varicocele than in infertile men without varicocele (Sakamoto et al., 2008).

It has been reported that free oxygen radicals cause problems in sperm function (may impair sperm morphology and motility, cause DNA damage) as a result of lipid peroxidation of polysaturated fatty acids in the cytoplasm and plasma membrane of sperm (Agarwal et al., 2014; Akyol et al., 2001) .

4- Changes in testicular blood flow and venous pressure

It has been reported that testicular blood flow is impaired in increased venous pressure, which in turn affects spermatogenesis (Sweeney et al., 1995). Increased venous pressure affects oncotic and hydrostatic pressure within the testis. This situation may disrupt the appropriate environment for hormones and microvascular fluid exchange.

5-Renal-Adrenal Reflux

It has been reported that there is reflux (50%) into the left spermatic vein in varicocele and high levels of adrenal and renal-derived substances (adrenomedullin, cortisol, catecholamine) in the left spermatic vein (Ito et al., 1982). In a reported varicocele study, it was reported that the catecholamine level in veins with reflux was 3 times higher than in peripheral veins (Comhaire and Vermeulen, 1974).

6-Acrosome reaction defect

In varicocele, there is a problem in the acrosome reaction. As a matter of fact, abnormal acrosome reaction induction test was detected in men with varicocele at a rate of 48%, and it was reported that there was an improvement of 35% after treatment (Benoff et al., 1993).

7-Hypoxia

The presence of hypoxic tissue mediators was detected in the examination of the testicles in a reported experimental varicocele model (Oztürk et al., 2001). In another study, it was reported that the hypoxic state that developed after varicocele increased angiogenesis and induced some angiogenic factors such as hypoxia inducible factor-1 (HIF-1) and vascular endothelial growth factor (VEGF) (Wang et al., 1995).

8-Hormonal Dysfunction

It has been reported that varicocele reduces testosterone levels and there is a significant increase in these levels after varicocelectomy (Hudson et al., 1985; Tanrikut et al., 2011). It has also been reported to cause an increase in follicle stimulating hormone (FSH) levels and a decrease in inhibin B levels. However, varicocelectomy was found to improve both FSH and inhibin B levels (Kass et al., 1993; Ozden et al., 2008).

In another varicocele study, it was stated that intratesticular testosterone level decreased earlier than serum testosterone level. Since the adrenal gland also secretes a certain amount of testosterone, it may be logical for the serum testosterone level to drop later. Varicocele is likely to affect normal endocrine function and suppress secreted

testosterone by apoptosis in Leydig cells (Henriksén et al., 1995). In another varicocele study, it was determined that there was a decrease in the binding of human chorionic gonodotropin (hCG) to Leydig cells. From this point of view, the investigator attributed the decrease in intratesticular testosterone in varicocele to the disorder in its synthesis (Kazama, 1995).

Intratesticular testosterone levels are known to be regulated by Leydig cells in the testicles. There are some hypotheses explaining how varicocele may impair the function of Leydig cells. For example, hyperthermia in varicocele may inhibit some enzymes involved in the formation and secretion of hormones. Indeed, it is known that varicocele inhibits hydroxyprogesterone aldolase. This enzyme is responsible for the conversion of 17α-hydroxyprogesterone to testosterone. Therefore, since the related enzyme is inhibited, it is likely that the testosterone level will decrease in varicocele (Goldstein and Eid, 1989).

In the study, in which the effect of Silmarin on varicocele was investigated, 3 groups were formed and the study lasted 42 days. In the study, it was determined that the number of Leydig cells and testosterone levels decreased significantly in the varicocele group. It has been reported that varicocelectomy increases cell number and hormone levels (Moshtaghion et al., 2013).

In some studies, it has been reported that some hormones such as FSH, luteinizing hormone (LH), testosterone and estradiol are not affected by varicocele and remain within normal limits (Hudson et al., 1981; Schiff et al., 1976). There are also studies suggesting that testosterone levels do not change before and after varicocele repair (Hudson et al., 1985; Segenreich et al., 1986)

CONCLUSION

Although many theories (Hyperthermia, apoptosis, oxidative stress, venous pressure, hormonal dysfunction, etc.) regarding the pathophysiological process in varicocele, which has an important place in male infertility, have been proposed, no clarity has been obtained on this issue yet. In this sense, the results obtained from the studies

contribute to the process. However, studies continue to fully elucidate the event or events in the pathophysiological process that predisposes to the formation of varicocele. Because each study in this field will help to illuminate the pathophysiological process.

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CHAPTER 4

DILATATION OF PLEXUS PAMPINIFORMIS VEINS AND OXIDATIVE STRESS

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INTRODUCTION

Varcocele, known as abnormal enlargement of veins in the plexus pampiniformis, affects 15% of the general male population, 35% of men with primary infertility, and 81% of men with secondary infertility (Meacham et al., 1994; Gorelick and Goldstein, 1993). It has been reported that the prevalence is 48% in men over the age of 40 (Cayan et al., 1999). While there is information that varicocele usually occurs on the left side, it has been reported that more than 50% of men suffering from this condition have bilateral varicocele (Amelar and Dubin, 1987).

It is known that varicocele causes infertility by creating many problems such as progressive testicular damage, regression in testicular development, decrease in testicular volume and deterioration in spermatogenesis. In experimental varicocele studies, it has been reported that varicocele causes problems in Leydig cell function by increasing apoptosis and decreasing steroidogenic acute regulatory (StAR) protein expression, thus impairing testosterone production (Luo et al., 2011). It has been reported that 8-hydroxy-2-deoxyguanosine (8-OHdG) expression is higher in the seminiferous tubules of patients with varicocele (Ishikawa et al., 2007).

Experimental varicocele studies show different results. For example, some researchers claim that unilateral varicocele increases blood flow in both testicles (Turner et al., 1993). Another investigator, in his study in rats, also reported that unilateral varicocele had a bilateral effect, but blood flow returned to normal after varicocelectomy (Green et al., 1984; Hurt et al., 1986). The bilateral effect of unilateral varicocele has been attributed to neural or hormonal factors. However, in another study, it was determined that the blood flow in the right testis was still high despite the removal of the left testis in left varicocele. For this reason, it has been emphasized that why a bilateral effect occurs in unilateral varicocele cannot be explained by hormonal signals (Hurt et al., 1986).

In experimental studies on varicocele, it has been determined that oxidative stress products are at high levels in serum, seminal plasma and testicular tissues (Agarwal at al., 2005). It has been

emphasized that oxidative stress has an effective role in varicocele, especially based on the high levels of reactive oxygen species (ROS), nitric oxide (NO) and malondialdehyde (MDA) in varicocele groups and the detection of decreases in antioxidant defenses. Oxidative stress has been particularly emphasized in infertility due to varicocele (Witt and Lipshultz, 1993). Varicocele caused increased amounts of ROS formation in testicles and semen, peroxidation of sperm plasma membrane, DNA damage and apoptosis (Hendin et al., 1999).

Oxidative stress is the disruption of the balance between the reactive oxygen species that occur during the cellular metabolism in the body's biological systems and the antioxidants that try to eliminate them (Özcan et al., 2015). Superoxide radical, hydroxyl radical and hydrogen peroxide, known as reactive oxygen species, are formed by the reduction of oxygen during metabolic events (Navarro and Boveris, 2004). It is known that ROS occur both during physiological events and during pathological events in the body (Sarma et al., 2010). ROS at physiological levels are required for cellular activities (sperm capacitation, acrosome reaction and penetration, etc.). However, when they are produced at pathological levels above normal, they can cause harmful effects on reproduction and life by disrupting cellular functions and sperm functions (Çavdar et al., 1997; Saalu, 2010). Again, when ROS is produced in the body above physiological limits, problems occur in sperm parameters (it can disrupt sperm morphology, decrease sperm motility and decrease sperm count) (Aitken and Clarson, 1987; Alvarez et al., 1987).

Free radicals; they can damage the entire cellular process, especially lipids, nucleic acids and proteins. For example, problems occur in the cell membrane and in the functioning of enzymes. Neural transmission may be impaired. They also cause damage and mutations in DNA. It has been reported that ROS causes energy deprivation by disrupting the synthesis of proteins in energy metabolism pathways, transport and proton pumps (Agarwal et al., 2016).

Testicular tissue is susceptible to oxidative stress for two reasons: One of these reasons is the abundance of unsaturated fatty acids in the plasma membranes of cells. The other is the existence of

systems that produce low potential reactive oxygen species. It has been stated that increased temperature plays a role in inducing oxidative stress in the testis, and the connection between heat exposure and ROS formation has been confirmed in various studies (Hassanin et al., 2018; Lundy and Sabanegh, 2017).

It has been reported that cytoplasmic droplets that have not completed their epididymal maturation may also be a source of ROS, and the release of such distressed sperm may play a role in decreased sperm function in men with varicocele (Zini et al., 2000). In addition, abnormal spermatozoa resulting from impaired spermatogenesis may cause excessive production of ROS (Aitken et al., 1989). Leukocytes are another source of ROS in seminal plasma (Ochsendorf, 1999). Abnormal changes in the testicular microenvironment can increase ROS production and decrease antioxidant capacity, resulting in oxidative stress.

It has been suggested that oxidative stress may cause spermatozoal dysfunction in patients with varicocele (Agarwal et al., 2009). It has been suggested that infertile men with varicocele have high levels of spermatozoa with damaged DNA and this is caused by high levels of ROS production (Saleh et al., 2003; Smith et al., 2006). Varicocele reduces the activity of DNA polymerase, which is responsible for repairing sperm DNA damage. Increased ROS in varicocele causes infertility by increasing chromosome breaks and deterioration of acrosome integrity (Mostafa et al., 2012; Altunoluk et al., 2012).

When the sperm is exposed to high levels of ROS, oxidative injury begins first. Increasing levels of ROS then break down the inner and outer mitochondrial membrane. Finally, it activates cytochrome c proteins that activate caspases and initiates apoptosis (Dieamant at al, 2017; Tvrd á et al., 2011). It cannot be denied that it has effects on the pathogenesis of many diseases (Pisoschi and Pop, 2015).

In semen analyzes performed in men with varicocele, ROS was found at higher levels, while in men without varicocele, ROS was found at lower levels (Weese et al., 1993). Increased ROS concentration; It is found in 80% of men with infertile varicocele, 77%

of fertile men with varicocele, and 20% of fertile men without varicocele (Hendin et al., 1999). It has been suggested that increased ROS in varicocele causes increased DNA fragmentation, testicular tissue damage, deterioration of sperm profile, and biochemical changes (Zini et al., 2005; Kim and Goldstein, 2008; Ollero et al., 2001; Fischer et al., 2003).

It has been reported that seminal plasma is acidic as a result of increased ROS in varicocele. It has been emphasized that the decrease in pH also causes deterioration in antioxidant enzymes and decreases in sperm motility (Ghabili et al., 2009). Reported studies indicate that after varicocelectomy, antioxidant enzyme levels in seminal fluid increase and sperm quality improves (Richardson et al., 2008; Mostafa et al., 2001).

Studies on varicocele have shown that oxidative stress and antioxidant enzyme activity increase. The increase in antioxidant enzyme activity is considered as a response to balance the negative effects of free oxygen radicals (Ozbek et al., 2008). Superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPX) are three enzymatic antioxidants that protect cells from oxidative stress. The balance between the oxidant-antioxidant system allows beneficial oxidants to perform their normal cellular functions, while limiting the harmful effects of excessive oxidative stress (Ighodaro and Akinloye, 2018).

SOME STUDIES ON THE RELATIONSHIP BETWEEN VARICOCELE AND OXIDADIVE STRESS

In an experimental varicocele study investigating the relationship between varicocele and oxidative stress, apoptosis and increased ROS were shown in both testicles. In the related study, the protective role of Vit E was also emphasized (Çam, 1998). Another study focused on the effectiveness of melatonin. Researchers found that there was an increase in proapoptotic bax protein, decrease in antioxidant enzyme activity and increase in MDA levels in testis.

Sperm parameters and antioxidant status were evaluated in the study in which the effects of silymarin on varicocele-induced damage

were investigated. Three groups (Control, varicocele+simarin, varicocele) were formed in the study. 42 days after varicocele induction, silymarin was administered at a dose of 50 mg/kg for 6 weeks. In the study, testicular MDA level increased significantly in the varicocele group, while the total thiol content decreased significantly in the same group. While the applied silymarin decreased the MDA level, it increased the total thiol content (Moshtaghion et al., 2013).

In another study, the effect of royal jelly on varicocele was investigated. In the related study, MDA level, testicular antioxidant enzyme activity and spermatogenesis were evaluated. In the study, royal jelly was applied at a daily dose of 200 mg. Researchers found that lipid peroxidation increased significantly in varicocele testes. At the end of the study, they reported that varicocele has a negative effect on the male reproductive system and that royal jelly protects the testicles from the effects of oxidative stress that develops with varicocele (Asadi et al., 2019).

In the study in which the efficacy of testosterone and VitE in experimentally created varicocele was investigated, 42 rats were divided into 4 groups. In the study, the protective effects of testosterone and VitE on the damage caused by varicocele on testicular and sperm parameters were investigated. Researchers have determined that total antioxidant capacity (TAC), superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) levels, which decrease with varicocele, increase after testosterone and VitE application. They also observed that the increased MDA level after varicoel decreased with the administration of testosterone and VitE. In the same study, the researchers also found that VitE and testosterone significantly inhibited the increased RNA damage with varicocele in germinal cells. Finally, they suggested that VitE could partially inhibit varicocele-induced damage in Leydig and germinal cells by increasing the antioxidant content at enzymatic and non-enzymatic levels. They also reported that the testosterone they applied could compensate for the lack of physiological testosterone synthesis, resulting in improvements in spermatogenesis (Khosravanian et al., 2014).

Missassi et al (2017) created 3 groups in their experimental varicocele study that continued for 56 days in rats. Researchers have investigated the effect of chrysin on oxidative stress caused by varicocele. They reported that Chrysin administration prevents oxidative damage caused by varicocele by reducing MDA and sperm DNA fragmentation in testicles (Missassi et al., 2017).

The study investigating the effect of motilipermin on oxidative stress in varicocele was conducted on 60 rats. Motiliperm was administered in doses of 100 mg and 200 mg. It has been determined that both doses of Motiliperm treatment, especially the 200 mg dose, decrease the MDA level and ROS / reactive nitrogen species (RNS) ratio, and increase the glutathione (GSH) / oxidized glutathione (GSSG) ratio. Researchers have reported that motiliperm improves sperm parameters, increases left testicular weight and testosterone level (Soni et al., 2018).

In another study, the effects of berberine on many parameters such as oxidative stress, inflammation, sperm parameters, DNA integrity and chromatin condensation in experimental varicocele were investigated. In the study, it was determined that berberine significantly decreased testicular interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α) and NO levels, which increased after varicocele, and increased testosterone levels. In addition, it was observed that sperm chromatin condensation improved, DNA damage decreased and sperm viability increased with Berberine application. At the end of their studies, the researchers reported that berberine improved spermatogenesis by improving the antioxidant potential in the testis and reducing inflammatory reactions (Hassani-Bafrani et al., 2019).

In another study in which experimental varicocele was created, it was reported that sperm count, motility and normal morphology decreased significantly in the varicocele group, and there was a significant increase in sperm DNA damage. In the same study, it was reported that the levels of ROS and MDA were significantly higher in the left testicular tissues of the varicocele group, and the levels of CAT and GPX were low (Erfani et al., 2019).

In the study investigating the effects of Fumaria parviflora on varicocele-induced oxidative stress and testicular damage, 32 rats were divided into 4 groups. It was determined that mRNA and Bax density and MDA levels increased in the varicocele group. It has been stated that applied Fumaria parviflora increases SOD and GPX levels and decreases MDA levels. It was also reported that tubule diameter and Johnsen score improved after treatment. The researchers announced that they concluded that Fumaria parviflora can alleviate varicocele by reducing oxidative stress and testicular damage (Dolatkhah et al., 2020).

CONCLUSION

It is known how big the role of varicocele in male infertility is. Although it is known that the effective treatment in varicocele is varicocelectomy, it is seen that antioxidants are widely used. As a matter of fact, excessive formation of reactive oxygen species in varicocele has made the use of antioxidants widespread. It has been reported that with these antioxidants used, there is an improvement in sperm profile, decrease in DNA damage, and improvement in lipid peroxidation. However, more studies are needed to reveal the complex relationship between the antioxidant defense system and testicles and to achieve more success in treatment. Antioxidants can be used to delay harmful effects until surgery, the gold standard treatment for varicocele, can be performed. They can also be used as adjuvant therapy after varicocelectomy and as a supplement to the therapeutic strategy.

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CHAPTER 6

FARMERS' PERCEPTIONS ENGAGED IN ORGANIC FARMING TOWARDS THE PRODUCTION OF ORGANIC FOOD PRODUCTS

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INTRODUCTION

Organic farming, which means a sustainable agro-environmental system, is a production type that protects soil, ecosystem and the health of human. This system, which is a process of production that avoid the use of synthetic or inorganic agrochemicals, is based on local and renewable resources. Also, it uses natural nutrient sources such as compost and manure as well as methods of weed control and natural crop (Deepak and Senthil, 2018). Organic food products (OFP) can be identified as products cultivated organically without any use of chemical and synthetic fertilizers (Kaur and Bansal, 2019). Depending upon the production potential of these products and their consumption, markets regarding organic food and shops have also developed in recent years (Shireesha and Rao, 2018). Accordingly, it is important to evaluate the knowledge, the attitude, the perception and the awareness of farmers engaged in organic farming in order to increase their tendencies towards the production of OFP.

Turkey has a favourable position and an important advantages in organic agriculture in terms of factors such as the climate, the land, water resources, product varieties and the ratio of the population that works in agriculture.Organic agriculture, which started to develop in World in the 1930s, began through a small producer group in 1985 in Turkey (Turhan et al., 2017). The OFP range, which initially has traditional export products such as raisin and fig, expanded with the participation of hazelnut, apricot, cereal, oil seeds, some animal products and fresh fruits and vegetables in the following years. In Turkey, organic production was carried out 1,037 hectares land area by 313 producers in 1990. In 2021, it was carried out 351,919 hectares land area by 48,244 producers. The number of OFP were reached 252 in 2021 while the number of OFP were 8 in 1990 (TURKSTAT, 2021).

Northwest Turkey is a significant part of Turkey in terms of its potential in agricultural production and product diversity (TURKSTAT, 2021). Situated in the northwestern part of Turkey, Çanakkale province has lands on the Gallipoli Peninsula, which is connected to Eastern Thrace lands of the Balkan Peninsula by a isthmus and Biga Peninsula, which is an extension of Anatolia. In addition, it is Turkey's second

transcontinental city after İstanbul province, and the Dardanelles Strait separates the lands of this province in Europe and Asia. Çanakkale province has an area of 9,737 km^2 and located between 39°-30' and 40°-45'North latitudes and between 25°-35' and 27°-45' East longitudes(Niyaz and Demirbaş, 2020; Anonymous, 2021; TURKSTAT, 2021). This province, which has a significant position in terms of climatic conditions, the geographical location and the proximity to markets, also has a a strategic importance about organic agriculture. It offers favorable conditions for organic farming which is becoming more popular every day (Ilgar, 2017; Anonymous, 2021).In Çanakkale province, the land area used for organic farming are represented 11.7% of total organic agricultural land area in Turkey. In this province, a large number of OFP (mainly olives, fruit and grapes) are grown. In this province, organic production was carried out 729 hectares land area by 115 farmers in 2002. In 2021, it was carried out 30,112 hectares land area by 533 farmers and the number of OFP were 103 in the same year. In Çanakkale province, the number of farmers that make organic farming activity, the number of product produced and the amount of product have increased, especially in recent years. To that end, it is important to determine farmers' perceptions that make organic farming towards OFP production.

There are many studies on organic farming. The majority of these studies consist of studies about the dissemination of organic agriculture activity and organic products (Kenanoğlu and Karahan, 2002; Vaarst, 2010; Reganold and Wachter, 2016; Ilgar, 2017; Nguyen and Van, 2021), the demand of consumers for these products (Thompson, 1998; Chinnici et al., 2002; Pearson et al., 2007; Aertsens et al., 2009) and the comparison of traditional and organic products (Via and Nucifora, 2002; Bektaş and Miran, 2006; Karabaş and Gürler, 2011). Accordingly, the number of researches on farms producing OFP is limited in literature. In most of these studies, marketing opportunities of organic product were evaluated (Park, 2009; Ayla and Altıntaş, 2017; Korkmazyürek, 2020). In a study performed by Olgun et al. (2006), organic cherry production was evaluated economically. Çobanoğlu and Işın (2009) examined the criteria that are effective in

the orientation to the organic farming system of dried fig producers and their levels of influence. In a study performed in the Chittoor distrirct of Andhra Pradesh, awareness levels of farmers towards gren marketing were investigated (Cheema and Gowri Shankar, 2011). Uma and Rechanna (2018) stated that farmer's perception of organic farming and the issues linked with it. Considering the previous literature, the number of studies that evaluate the perception of farmers towards the production of OFP is quite limited. Hence, in the current study, it is aimed to define the perceptions of farmers engaged in organic farming in the northwestern part of Turkey towards the production of OFP. So far as author's knew, there has been no study performed in Turkey on existing subject. This difference of this study makes it unique and hence the current study is expected to fill the gap in the current literature. Furthermore, the results of the current research may contribute to decision-makers and policy makers in practices related to organic farming.

1. MATERIALS AND METHODS

1.1. Data Gathering and The Sample Size

The current study was conducted in the centre of Çanakkale province and in Gökçeada, Ayvacık, Ezine that is other districts of this province.In choice of this province, it was taken into account criteria such asbeing has a strategic position on organic farming (climatic conditions, geographical location and proximity to markets etc.) and being no study that is examined farmers' perceptions engaged in organic farming towards OFP production. In these districts selected as the research area, Most of farmers are engaged in organic farming. Therefore, they are the districts that best represent Çanakkale province (Figure 1).

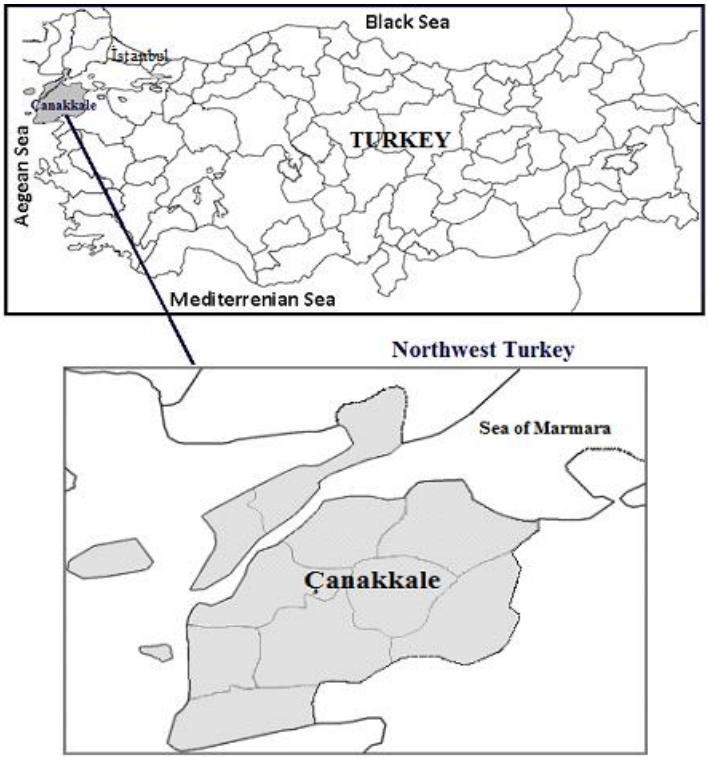

Figure 1: The Study Area

Surveys were conducted between April and September 2021. By face-to-face meetings, data were collected. The number of farmers that make organic farming in Çanakkale province central district, Gökçeada, Ayvacık and Ezine districts were obtained from the records of Directorate of Provincial Agriculture and Forestry. Total number of farmers that make organic farming in Çanakkale province central district (62 farmers), Gökçeada (190 farmers), Ayvacık (192 farmers) and Ezine (91 farmers) districts were determined as 533 (TURKSTAT, 2021; Anonymous, 2021). Çanakkale province central district had 10.9% of these farmers, and Gökçeada, Ayvacık and Ezine districts had 35.7%, 36.5% and 16.9% of them, respectively. The number of farmers in the survey to be conducted was defined by proportional sampling method (Newbold, 1995). It is as follows;

$$n=\frac{N*p*q}{(N-1)*\sigma^2p+p*q} \quad , \quad \sigma^2p=r/Z_{\frac{\alpha}{2}} \qquad [1]$$

where, the sampling sizeis n, N is the size ofpopulation (533), the variance ratio is σ^2p, the likelihood of the event occurring (0.5) is p, q is the probability of the examined situation not occurring (1-p), the acceptable margin of error(0.05) israndthe critical value for the normal distribution at $\alpha/2$ (e.g. for p=0.05, α= 0.05, the critical value is 1.96) is $Z_{\alpha/2}$.The sample size was calculated as 384 and it was proportionally distributed among farmers (Table 1).

Table 1: TheSampling Size

Province, country	Districts	Number of farmers	Percentage (%)
Çanakkale, Turkey	Çanakkale central	42	10.9
	Gökçeada	137	35.7
	Ezine	140	36.5
	Ayvacık	65	16.9
Total		384	100.0

Survey questions of this study were prepared taking into account earlier researches regarding OFP (Bektaş and Miran, 2006; Çobanoğlu and Işın, 2009; Davies et al., 1995; Chandrashekar, 2014; Deepak and Senthil, 2018; Yazar and Burucuoğlu, 2019; Mtimet et al., 2020).In the first stage regarding the questionnaire, it was included information regarding socio-economic features (gender, age, etc.) of farmers that produce OFP. The second section based on farmers' perceptions regarding the attributes of OFP (health, quality, price, etc.).

1.2. Data Analysis

Thedata analysis was performed in two stages. Firstly, descriptive statistics were used in order to determine farmers' socio-economic characteristics that make organic farming in Çanakkale province central district and its other districts. Secondly, factor and cluster analyses were used to determine farmers' perceptions that make organic farming towards the production of OFP. Before applying these analyses, a five-point likert type scale was applied in order to rank the importance of each attributes. With the help of this scale, farmers were

asked to rank the importance of each attributes a range from 1 (not important) to 5 (very important) (Krishna and Balasubramanian, 2018). In addition to factor and cluster analyses, a one-way variance analysis (ANOVA) test was performed in order to define difference between clusters. Levene's test was used to testing the homogeneity of variances. Also, post-hoc tests were performed for performing multiple comparisons in two or more sample populations. Welch's ANOVA test and Tamhane's T2 test for unequal variances (sig|<0.05) and Scheffe test for equal variances (sig|>0.05) were used (Ho, 2006). The external characterization of farmers clusters determined by cluster analysis was evaluated using socio-economic characteristics. Chi-square tests were used to controlling whether the defined clusters differ significantly compared to these variables. Statistical analyses was performed using SPSS programme (SPSS, 2008).

1.2.1. Factor Analysis

Factor analysis is one of the multivariate analysis techniques applied to provide data reduction, to determine variables taking into account common underlying dimensions and to analyze interrelationships among variables (Hair et al., 2014; Pandurangarao et al., 2017; Krishna and Balasubramanian, 2018). Therefore, it was used to determine farmers' perceptions towards the production of OFP. It was determined whether farmers' perceptions represented by 14 attributes could be grouped together to create a smaller number factors. Factors are interpreted with factor loadings. These loadings can be categorised using another rule of thumb as ±0.30 minimal, ±0.40 important, and ±0.50 practically significant (Hair et al., 2014). In this context, in the study, they were explicated for these loadings greater than ±0.40. The reliability of responses that is given to questions was measured by calculating Cronbach's alpha ($\alpha \geq 0.7$). To test the suitability related to this analysis of the data, Kaiser Meyer Olkin ($KMO \geq 0.6$) and Barlett's test of Spherincity statistics ($p < 0.01$) were used (Hair et al., 2014; Mtimet et al., 2020).

1.2.2. Cluster Analysis

Cluster analysis is a statistical method used in classification. Unlike other statistical classificationmethods, it makes no former assumptions on differences in a population. This analysis is the method of classification and an inductive technique. The coefficients of four factors that revealed farmers' perceptions towards the production of OFP obtained from factor analysis were used as clustering variables. In this context, two different types of this analysis methods were employed to define segments of farmers (Hair et al., 2014; Mtimet et al., 2020). In the first stage of this analysis, it was used a hierarchical clustering method. It puts the elements into clusters based on similarities among clusters (Kaufman and Rousseeuw, 2008). It was applied to define the number of clusters. Hierarchical clustering methods may be agglomerative or divisive. Agglomerative methods collect elements into clusters. Ward's method is agglomerative clustering. This method ensures that the variance between clusters is minimum by using the variance analysis approach. It based on a sum of squared errors that uses for Euclidean distance between observations (Cavlak, 2019; Mtimet et al., 2020). The purpose of using Ward's method was to identify farmers who belong to each group and to join their into clusters. Thus, the variance in clusters was minimized with this method. The groups in cluster analysis are determined according to the proximity or distance of data or observations to each other. Euclidean distances are the simplest method for calculating distances between objects in a multidimensional space. The squared Euclidean distance, which place progressively greater weight on objects that are further apart, uses more often than the simple Euclidean distance (Everitt et al., 2011; Cavlak, 2019; Mtimet et al., 2020). Thus, the squared Euclidean distance was applied as distance criterion in this study. In the second stage of this analysis, the K-means clustering method that is non-hierarchical cluster analysis was used. It is used when there are hypotheses or knowledge concerning the number of clusters in variables (Everitt et al., 2011; Cavlak, 2019; Mtimet et al., 2020).

2. RESULTS AND DISCUSSION

2.1. Farmers' Socio-Economic Features

Socio-economic features of farmers engaged in organic farming were determined using descriptive statistics. These results were summarized in Table 2. About 42.7% of farmers were aged between 30 and 41 years, and 8.9% of them were over 54 years old. The average age of farmers was 41.1 year.These results revealed that farmers were middle-aged, generally. The majority of farmers were primary school graduates (43.8%). Also, 12.5% of them had bachelor's degree. The average year of farmers' schooling was 7.8 year. These results revealed that most farmers (45.8%) engaged in organic farming had a secondary school graduates or high school graduates.The average household size of farmers was 2.97 person and 48.1% of them consist of 2 and less persons. These results showed that most farmerswas the part of the nuclear family structure. Organic farming experience of farmers was 7.6 year on average and 35.9% of them had between 5 and 9 years of experience in organic farming activity. Furthermore, it was determined that farmers had knowledge on organic agriculture and they mostly gained this information from their own experience and relatives. Therefore, the increase in experiences regarding farmers' organic farming activity may increase their perceptions towards the production of OFP.

Table 2: Farmers' Socio-Economic Characteristic

Characteristics	Frequency	%	Mean	**SD
Age (year)				
20-29	42	10.9	41.12	8.56
30-41	164	42.7		
42-53	144	37.5		
≥54	34	8.9		
Education level (year)				
Primary school	160	41.6	7.83	3.12
Secondary school	105	27.3		
High school	71	18.5		
Bachelor's degree	48	12.5		
Household size (person)				
≤2	185	48.1	2.97	1.16
3-5	145	37.8		
≥5	54	14.1		

Organic farming experience (year)				
≤4	82	21.4		
5-9	138	35.9	7.6	2.69
≥9	164	42.7		
*Average household income (€ year^{-1})				
≤€1702.6	114	29.7		
€1703-€3357.6	222	57.8	€2389.6	1018.7
≥€3358	48	12.5		
Agricultural land asset (decare)				
≤25	268	69.8		
26-50	65	16.9	20.0	21.04
≥50	51	13.3		

1 Euro=8.72 TRY (Turkish lira) in March 2021(average)-Low income (≤€1702.6), Medium income (€1703-€3357.6), High income (≥€3358);SD=Standart deviation*

The average an annual household income of farmers was €2389.6 and 57.8% of them had an annual income between €1703-€3357.6. In addition, 12.5% of them had an annual income of €3358 and above (Table 2). These findings showed that most farmers had middle and high income level. In this context, the increase in farmers' household income level may positive effect on their perceptions towards the production of OFP. The majority of farmers (69.8%) performed organic farming activities on 25 decares and smaller lands and the average land size of them was 20 decares (Table 2). These findings showed that the majority of organic farming activity in the research area were carried out on 25 decares and smaller lands. Accordingly, it may be said that the increase of land size is effective in the farmers' perceptions towards the production of OFP. The present results comply with the findings of previous studies. For instance, Feder et al. (1985) stated that large number of family members involved on-farm activities were enabled farmers to adopt a labor intensive technology. In a study performed in Nepal, it was indicated that farmers with large farm size were more likely to be adopters than small farmers as they were likely to be resource-rich (Kafle, 2011). Adesope et al. (2011) indicated that farmers who have been farming for a long time were usually old and less educated, and hence they were more reluctant to switch to organic farming. In a study conducted in Canada, it was stated that farmers with younger and educated allocated the lesser part of their cultivated lands to organic practice (Khaledi et

al., 2011). Singh et al. (2015) stated that the education plays a significant role in the adoption of organic farming. In a study performed in Pakistan, it was indicated that households with a larger number of family were more likely to adopt organic farming (Ullah et al., 2015). Issa and Hamm (2017) stated that there was a positive correlation between farmers' education level and their adoption of organic farming. In a study performed in India, it was suggested that the larger landholdings were positively associated with switching their farms to organic farming (Ghosh et al., 2019). Nandwani et al. (2021) indicated that middle-aged people were that make more organic farming. However, Nguyen and Nguyen (2020) reported that younger farmers were showing more interest in organic farming. The findings of the current study differ from the results of earlier study.

2.2. Cluster of Farmers That Make Organic Farming

To determine their perceptions towards the production of OFP, a total of 14 attributes were applied the factor analysis (Table 3). In current study, the feature that OFP are private-label products had the highest average and it was identified as the most important feature by farmers. These results revealed that this feature plays a significant role in increasing the promotion and the confidence of OFP produced by farmers. Accordingly, the increasing of farmers' awareness related to private-labels products can affect their perceptions towards the production of OFP. Furthermore, this attribute of OFP was followed by products with high nutritional value, products without preservations/additives, certificated products and products with less variety available, respectively. In this study, farmers were rating from 1 (very important) to 5 (not important at all) the significance of 14 attributes of OFP. These attributes were grouped among four factors, which defined 71.2% of the cumulative variance by factor analysis (Table 3). All attributes had factor loadings greater than 0.40. Conbach's alpha values varied between 0.64 and 0.84. All the factors had an Eigen values greater than one. Kaiser Meyer Olkin measure of sampling adequacy were 0.778 (KMO≥0.6) and Bartlett's test of sphericity was significant ($X^2_{(91)}$=2465.168, p=0.000). These findings

backed to use of factor analysis for attributes of OFP. Four factors determined applying factor analysis from 1 to 4 were named as health and safety, product information, quality and product value, and certification and labelling.

Table 3: Factor Analysis Results of OFP Attributes

Factors and attributes	M[a]	SD[b]	Factor[c] loading	Variance (%)	Eigenvalues	α[d]
Factor 1. Healthy and safety	3.84			20.26	3.67	0.79
Human health sensitive products	3.95	0.721	0.864			
Fresh and natural products	3.65	0.628	0.792			
Chemical-free products	3.58	0.692	0.783			
Products without preservations / additives	4.17	0.697	0.646			
Factor 2. Product information	4.07			19.21	2.62	0.76
Tastier products	3.75	0.696	0.823			
Products with high nutritional value	4.31	0.643	0.801			
Products with market guarantee	4.10	0.703	0.695			
Products with less variety available	4.12	0.714	0.592			
Factor 3. Quality and product value	3.92			17.97	2.24	0.84
Products with high profit margin	4.00	0.806	0.858			
Environment friendly products	3.67	0.611	0.829			
Products produced with regularly checking	4.10	0.662	0.756			
Factor 4. Certification and labelling	4.08			13.77	1.44	0.64
Certificated products	4.13	0.677	0.755			
Private-label products	4.43	0.501	0.752			
Standardized products	3.68	0.521	0.639			

[a]Mean(M), [b]Standard deviation(SD), [c]Varimax rotation with Kaiser Normalization, [d]Cronbach's alpha (α)

Factor 1, healthy and safety, emphasizes the importance of being healthy, quality, fresh and safe of OFP produced by farmers. Factor 2, product information, reflects farmers' knowledge concerning OFP. Factor 3, quality and product value, emphasizes the opinion of farmers about high profit margin of OFP, the positive impact for environment and the regular check of the product. Factor 4, certification and labelling, reflects farmers' knowledge about certificate, labelling and legal regulation related to OFP. Accordingly, it was found

that the most important factor perceived by farmers was certification and labeling. This factor was followed by product information, quality and product value and healthy and safety. After factor analysis, farmers were segmentation by using cluster analysis according to differences in their perception of OFP. This segmentation was based upon attributes corresponding to 4 factors of OFP perception obtained earlier. These attributes were human health sensitive products (Factor 1), tastier products (Factor 2), products with high profit margin (Factor 3) and certificated products (Factor 4). The correlation matrix determined using these factors showed that there were no significant correlations between four chosen attributes (Table 4).

Table 4: Correlations Matrix Between The Chosen Attributes

Attributes	Human health sensitive products	Tastier products	Products with high profit margin	Certificated products
Human health sensitive products	1	0.136**	0.041*	0.121*
Tastier products		1	0.166**	0.490**
Products with high profit margin			1	0.398**
Certificated products				1

**Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2- tailed)*

This result allowed proceeding with the cluster analysis. Hierarchical cluster analysis allowed the definition of 3 clusters of farmers. Based on dendrogram and agglomeration schedule, and final centers of the 3 obtained clusters, K-means cluster analysis was applied (Table 5). Also, it was found that there was differences in average values of perception attributes that exist between groups in one-way ANOVA analysis. The results of Levene's statistic applied to test the homogeneity of variances showed that the conjecture of equal variances of the 3 groups was refused for all attributes except for 5 variables (standardized products, products without preservations/additives, tastier products, products with less variety available, certificated products). Hence, Scheffe test used for equal variances (sig>0.05) was used in compare cluster means of these 5 variables. In addition, Welch's ANOVA test for the equality of means and Tamhane's T2 test for multiple comparison of

unequal variances (sig<0.05) was used. The results in Table 5 revealed that there show parallelism with between farmers' perceptions and their claimed behaviours towards OFP.Because, generally, farmers had positive attitudes towards the production of OFP.

Table 5: Farmers' OFP Perception Attributes According To Clusters

Factors/attributes	Farmers producing OFP							
	Cluster 1 (30.7%)		Cluster 2 (36.7%)		Cluster 3 (32.6%)		Univariate	
	M[1]	SD[2]	M	SD	M	SD	F	p
Healthy and safety	4.33		3.85		3.35			
Human health sensitive products	4.45[a]	0.533	4.16[b]	0.556	3.23[c]	0.424	228.854[d]	0.000
Fresh and natural products	4.06[a]	0.574	3.65[b]	0.597	3.26[c]	0.443	73.805[d]	0.000
Chemical-free products	4.15[a]	0.700	3.46[b]	0.580	3.18[c]	0.382	90.177[d]	0.000
Products without preservations/ additives	4.67[a]	0.472	4.13[b]	0.653	3.74[c]	0.621	74.673	0.000
Product information	4.39		3.85		4.02			
Tastier products	4.06[e]	0.670	3.50[f]	0.651	3.75[g]	0.656	23.477	0.000
Products with high nutritional value	4.47[a]	0.609	4.06[b]	0.630	4.45[a]	0.602	18.487[d]	0.000
Products with market guarantee	4.55[a]	0.516	3.86[b]	0.713	3.95[b]	0.646	52.431[d]	0.000
Products with less variety available	4.48[e]	0.610	3.99[f]	0.712	3.93[f]	0.686	24.733	0.000
Quality and product value	4.37		3.35		4.14			
Products with high profit margin	4.66[a]	0.527	3.26[b]	0.457	4.20[c]	0.660	272.243[d]	0.000
Environment friendly products	3.82[a]	0.517	3.13[b]	0.343	4.13[c]	0.457	218.761[d]	0.001
Products produced with regularly checking	4.63[e]	0.486	3.67[f]	0.514	4.10[g]	0.601	101.660	0.000
Certification and labelling	4.33		3.84		4.11			
Certificated products	4.59[e]	0.527	3.69[f]	0.536	4.19[g]	0.631	83.217	0.000
Private-label products	4.61[a]	0.490	4.12[b]	0.348	4.61[a]	0.490	64.426[d]	0.000
Standardized products	3.80[a]	0.532	3.70[a]	0.489	3.54[b]	0.517	7.803[d]	0.000

[1]Mean (M) and [2]Standard deviation (SD),[a,b,c] Tamhane's T2tests: mean value with the same superscript in the same row indicates a significant difference between the two groups at p<0.05(unequal variances), [d]Welch ANOVA F; [e,f,g]Scheffe tests:mean values with the same superscript in the same row indicates a significant difference between the two groups at p<0.05 (equal variances)

In this study, the cluster 1 was represented by 30.7% of farmers. About 67.3% of them had more than 29 years of age and 33.8% of them had organic farming experience less than 9 years (Table 6). Also, it was defined that there is a statistical difference between this cluster and other two clusters in terms of some attributes related to OFP. Thus, the sub-attributes of two factors (health and safety, and product information) that identified for OFP had the highest mean values

according to other two clusters. Two attributes (products without preservations/additives and human health sensitive products) that are perceived as rather important by farmers showed that they considered OFP as healthy, safe and quality products. These results revealed that farmers' tendencies towards the production of these products is high. In cluster 1, farmers' perceptions towards attributes regarding being human health sensitive products of OFP, being fresh and natural products of them and being chemical-free products of them were higher than those of farmers in cluster 2 and in cluster 3. The perception of OFP as high nutritional value and tastier products by farmers in this cluster is higher than those of farmers in cluster 2. However, this perception of farmers was the same as those of farmers in cluster 3. Nandwani et al. (2021) indicated that the prime attributes of organic products described by growers were taste, chemical freeness, freshness and nutrition. The current results comply with the results of the previous study. Similar results were explained by other studies in China (Zhang et al., 2018) and in Spain (Rodríguez-Bermúdez et al., 2020). High average values in product information factor revealed that farmers wanted to produce more product types. Although farmers perceived OFP as products with market guarantee, they stated that marketing channels for these products were insufficient. Accordinly, new strategies should be determined in order to cope with reasons such as the lack of diversity in OFP and the lack of marketing channels. Farmers in this cluster had the highest perception of OFP as products with high profit magrin. This situation can be explained as a result of the fact that most farmers continue their organic farming activities on 25 decares or smaller lands. Because, the majority of farmers (40.2%) obtained their high profit margin from lands of 25 decares or smaller. Shaban (2015) indicated that organic farming had high market demand. The current findings comply with the results of the previous study. About 36.1% of farmers had an average annual household income of €3357.6 and below (Table 6). The present results comply with the results of earlier studies. For instance, Singh et al. (2015) indicated that the creation of a group for organic farming and the training provided through this group play a significant role in the production and the dissemination of information among farmers. In a

study conducted in Pakistan, it was revealed that organic farming was adopted both to increase farmer's income and to preserve the environmental pollution (Ullah et al., 2015). In this cluster, farmers engaged in organic farming were the conscious of positive effects of these products on environmental protection. This result also supported the idea that OFP were perceived as healthier and better quality by farmers. In cluster 1, farmers' perceptions regarding the positive influence of OFP on environmental protection was higher than those of farmers in cluster 2 and less than those of farmers in cluster 3. The findings of this study are consistent with the results of Shaban (2015), which stated that farmers' awareness on health and environmental issues have a significant effect on their decision in order to switch to organic farming. The features related to high profit margin of OFP and their regular control were important criteria for farmers in determining the quality and the value of these products. In this cluster, farmers perceived OFP as certified, private-label and standardized products. They stated that these features were effective in increasing the reliability of these products. They perceived private-labels as a guarantee that these products are organic products. In cluster 1, farmers' perceptions regarding this attribute of OFP were higher than those of farmers in cluster 2. However, it was the same as those of farmers in cluster 3. Farmers' perceptions of OFP as standardized products were higher than those of farmers in cluster 3, but it was the same as those of farmers in cluster 2.

In this study, the cluster 2 was represented by 36.7% of farmers. This cluster was the largest one of all clusters. About 77% of farmers had more than 29 years of age and 33.1% of them had organic farming experience less than 9 years (Table 6). In this cluster, the ratio of farmers aged 29 and over was the highest compared to farmers in other clusters. Also, it was found that there was statistical differences between this cluster and other two clusters in terms of some attributes regarding OFP. In this cluster, like in cluster 1, farmers' perceptions towards health and safety factor of OFP and its sub-attributes were high. The perception of OFP as tastier products and products with high nutritional value by farmers in this cluster was less important than the

farmers in other clusters. Farmers stated that OFP did not have sufficient market guarantee. In this cluster, the quality and product value factor as well as its sub-attributes had the lowest mean values compared to other clusters. Accordingly, it can be said that the quality and product value factor of OFP are not very important for these farmers. In addition, high profit margin attribute of OFP for these farmers was not an important attribute in terms of the production of OFP compared to farmers in other clusters. This situation can be explained as a result of the fact that 62.4% of farmers have a high income group (€3357.6 and above) and 64.7% of them have 25 decares or above of agricultural land asset (Table 6). For farmers in this cluster, being certified and private-label products of OFP was not found to be important compared to farmers in other clusters. Therefore, it can be said that farmers do not take into account the fact that these products are certified and private-label products while defining the reliability of OFP.

In this study, the cluster 3 was represented by 32.6% of farmers. About 44.2% of farmers had less than 29 years of age and 33.1% of them had organic farming experience than 9 years (Table 6). In addition, the ratio of farmers aged 29 and below in this cluster was the highest. Also, it was found that there was statistical differences between this cluster and other two clusters in terms of some attributes regarding OFP. The sub-attributes of healthy and safety factor that identified for OFP in this cluster had the lowest mean values compared to other clusters. In this context, farmers in this cluster need more information on the production and control processes of OFP. For this reason, information and training meetings to be organized for farmers on the production and control processes of OFP can positively affect their perceptions about producing these products. Similarly to the cluster 2, attributes regarding being market guarantee of OFP and being less variety available were found relatively important by farmers. The perception that OFP had high profit margin by farmers in this cluster was higher than those of farmers in cluster 2. Because, 73.7% of farmers in this cluster had a high income group and 75.5% of them had 25 decares or more of land (Table 6). The ratios related to agricultural land asset and income group were the highest in this cluster according to other

clusters. The feature of being environmentally friendly products defined for OFP had the highest mean value compared to other clusters. In other words, these farmers were more aware of the positive effects of OFP on environmental protection compared to farmers in other clusters.

Table 6: Socio-Economic Definitions of Three Clusters

Characteristics[a]	Cluster 1	Cluster 2	Cluster 3	X^2
Age <29 years old	32.7%	23.1%	44.2%	6.65**
Average household income <€3357.6	36.1%	37.6%	26.3%	9.65*
Organic farming experience > 9 year	33.8%	33.1%	31.1%	6.57*
Agricultural land asset ≤ 25	40.2%	35.3%	24.5%	7.11*
Total				

[a]Only statistically significant variables are included in this table. Other socio-economic variables related to farmers' producing OFP were tested. However, they were not statistically significant.
,: indicate mean differences of clusters at 5% and 10% ($p<0.05$ and $p<0.10$) significance levels, respectively.*

CONCLUSION AND POLICY IMPLICATIONS

In Çanakkale province that is study area, the production of OFP has come into prominence in recent years as an alternative food product in terms of its importance in healthy nutrition. However, the production of these products has shown a slow growth in spite of the available production potential in the study area. In the study area, farmers with higher education and income were more interest in producing OFP. Generally, farmers agreed that OFP are important for health. This result confirmed that they are more conscious about health. Less than half of farmers had the lack of trust and knowledge about the production of OFP. Hence, it is rather significant to inform farmers about the certification process and production of these products. Also, it is important to improve of the product quality and increase of the marketing margin in favour of farmers in the production OFP. In the study area, farmers defined OFP as products human health sensitive, fresh and natural, chemical-free and without preservations/additives. Due to these attributes of OFP, farmers prefer to produce these products. Farmers in cluster 1 had the most aware of the benefit obtained from the production of OFP. For this reason, these farmers may play a significant role in the production of OFP and in the development of organic markets. In this context, information meetings

that will take place for farmers about OFP's production and control processes can help increase their perception of these products.

The current study contributes to the literature by determining farmers' perceptions engaged in organic farming towards the production of OFP. These results have ensured some policy recommendations.

- Although Turkey has favorable conditions and a great potential in terms of the production of OFP, it shows a slow growth trend in organic farming. This situation is a major problem in terms of production potential for farmers who engaged in organic farming activities in rural areas regionally. For this reason, agricultural policy measures (cheap input support, market guarantee, income support, credit facilities, etc.) should be taken to encourage farmers to adopt and expand organic farming in suitable ecological regions.
- This study results revealed the desire of farmers to produce more OFP and the inadequacy of marketing channels for these products. Hence, it is a significant for farmers to determine priority products for target markets, to carry out support activities covering issues related to production planning and different marketing channels.
- Infrastructure works towards the development of the internal market for these products and activities to raise awareness of farmers are important. For this reason, local marketing companies should be supported and the education of farmers and their awareness should be given importance.
- It is also very important to create a healthy database on organic farming so that farmers can have more information on the production and control processes of organic farming.Therefore, farmers should be aware of organic farming by extension services and training meetings both to increase their income and to change their perceptions about new agriculture techniques.
- Non-governmental organizations, extension services and development agencies can play a significant role in ensuring information on certification and standards for OFP.

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CHAPTER 7

HALAL FOOD MARKET WITH STATISTICS IN THE WORLD AND THE POTENTIAL OF TURKEY IN THE MARKET

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INTRODUCTION

One of the important factors affecting the purchasing behavior of consumers in the food sector is religious factors (Güzel and Kartal, 2017). Food and nutritional needs of people vary according to cultures and beliefs. (Akbulut *et al.* 2019). Products consumed by Muslim consumers are called halal products. Halal, in another sense, means a product that is permitted and legally harmless. (Riaz, 2007). The concept of halal food is included in the documents of the International The Codex Alimentarius Commission as "allowed foods and necessities in accordance with Islamic rules". It is also defined as "the product that is not in direct contact with any food produced outside of these situations, which are prepared, processed, transported and stored in places and devices free from these elements, which do not contain any prohibited elements according to Islamic rules" (GIMDES, 2022).

It is observed that the halal food market in the world and in Turkey develops rapidly every year. Due to the increase in consumers' awareness of healthy nutrition, the demand for halal food is increasing in the world and in Turkey. (Güneş and Yetim, 2020). For this reason, halal food is a sector with a large market potential globally, preferred by non-Muslims as well as Muslims. (Aslan and Aslan, 2019). The halal food sector constitutes approximately 20% of the global food sector. According to the results of the market research, the global halal food market is expected to reach 2 trillion dollars (Ali *et al.*, 2021) by 2023 and 2.55 trillion dollars by 2024 (Felton, 2017).

Increasing awareness and popularity of the Muslim population is one of the main reasons for the rapid growth of halal food among non-Muslims (Amalia *et al.*, 2020; Bashir *et al.*, 2019). Non-Muslim consumers also prefer halal products because they find them more hygienic, healthy and reliable (Öztürk *et al.*, 2015).

Muslim consumers have become more conscious with the effect of developing technology and globalization and have begun to question whether what they eat is halal. This situation plays an important role in the orientation of food businesses to halal food production (Akbulut *et al.*, 2019). For this reason, food producers in the world have focused on exporting halal food, especially to Muslim countries.

Islam is the second largest religion in the world after Christianity. According to data from Pew Research Company, the proportion of the Muslim population is expected to rise from 23,12% in 2010 to 29,7% in 2050. Studies show that the religion of Islam is growing faster than other religions.

The fact that the Muslim population in the world will grow rapidly according to future projections means a lot for marketers. In this context, the range of halal products is expanding day by day. Along with the rapid growth of the Muslim population, the Muslim consumers' desire to meet their food needs in accordance with their own religious beliefs and cultures is an indication that the halal food market will gradually grow. While the revenue from the halal food market was 7.5 trillion dollars in 2018, it is estimated to reach 20.43 trillion dollars in 2027 (Statista, 2022). In the halal sector, besides food, the cosmetics, pharmaceuticals, clothing, financial services and tourism sectors are other important sectors among Muslim consumers.

Demand for halal food products is as much in Muslim countries as there is interest especially in European countries (Lever and Miele, 2012; Bonne and Verbeke, 2008). Halal food practices are more common in countries where people of multicultural and different faiths live, such as Malaysia, Indonesia, Singapore and Thailand (Aslan and Aslan, 2018).

With the increase in foreign trade of halal food, certification has gained importance in food exchange between Muslim and non-Muslim countries. Halal certificate; It is a document issued by a well-known and competent institution in order to undertake that the manufacturer produces in accordance with the halal standards determined by this institution and shows that the products are safe, clean and suitable for consumption in Islamic terms (Batu, 2012; Noordin *et al.*, 2009). It is known that halal food certificate was started to be given in Malaysia for the first time in the world in 1971 (Yener, 2015).

The concept of halal food for consumers; While it is not very important for those living within the borders of Türkiye, it is important for Muslim consumers living abroad. In addition, in recent years, it is seen that hotels and businesses with halal certification are preferred by

Muslim consumers in tourism. In particular, halal certificates for products have been requested from companies exporting to Islamic countries. Due to these needs, the Turkish Standards Institute (TSE) in Turkey has completed its work on the "Halal Food" certificate and has started to certify in this field. In order to ensure unity and increase reliability in practices in halal food certification, the draft law for the establishment of the Halal Accreditation Authority (HAK) by the Ministry of Economy was adopted by The Grand National Assembly of Türkiye (TBMM) on 01 November 2017 and entered into force. HAK is the only institution authorized to provide halal accreditation services in Turkey.

The Muslim population, which has a population of approximately two billion in the world, is an important market in foreign trade. The rapidly growing Muslim population's demand for halal food products is also increasing day by day. However, the Muslim population's need for halal food is mostly met by non-Muslim countries.

Halal food certificate is not necessary for foods in Turkey. This situation creates a negative situation for food producers to reach the desired level in the halal food market in the foreign market. For this reason, it is necessary to take its place in the market through the leading enterprises in the sector by making use of the opportunities that our country has in the food sector.

There are studies on the halal food sector in our country (Torlak, 2012; Tekle *et al*., 2013; Derin and Türk, 2016; Güzel and Kartal, 2017; Tatlı *et al*., 2017; Ünalan, 2017; Akbulut *et.al*., 2019; Güneş and Yetim, 2020; Atasever and Alışanlı, 2020; Türker, 2020; Madenci *et al*., 2020) and in the world (Aziz and Chok, 2013; Mohayidin and Kamarulzaman, 2014; Haque *et al*., 2015; Fithriana and Annissa, 2018; Zulaipa *et al*., 2019; Bashır *et al.*, 2019; Hosseini *et al*., 2019; Ab Talib *et al*., 2020; Shahzad *et al*., 2020; Iranmanesh *et al*., 2021) about consumers and the sector. However, there is also a need for studies that look at the halal food market from a broad perspective and reveal the situation in the world in recent years.

1. PURPOSE AND METHOD

The aim of this study is to examine the situation of the Muslim population and halal food market in the world with statistics by country. In addition, for this purpose, Turkey's situation in the market has been revealed and some suggestions have been introduced.

The main material of the study consists of the data of The Statistical, Economic and Social Research and Training Centre for Islamic Countries (SESRIC) in the statistics of Islamic countries, the data of STATISTA and Halal Accreditation Agency (HAK) institutions in statistics on halal food, as well as the results obtained from previous research on the subject. The collected data were arranged in tables and figures by making percentage.

2. RESULTS

2.1. Muslim Population in the World

In the ranking of religions believed by the world population, Islam is an important religion that ranks second after Christianity. Studies show that the Muslim population will approach the Christian population, which is currently the largest group, between 2010 and 2050, and may exceed it in the following years (Table 1). Compared to other religious groups, Muslims are noted as the fastest growing religious group (Lipka and Hackett, 2017). This situation shows that the demand for halal food will also increase.

Table 1: Distribution of World Population by Religions

Religions	2010 Population	2010 %	2050* Population	2050* %	Change 2010-2050
Christians	2.168.330.000	31,44	2.918.070.000	31,35	749.740.000
Muslims	1.599.700.000	23,20	2.761.480.000	29,67	1.161.780.000
Faithless	1.131.150.000	16,41	1.230.340.000	13,22	99.190.000
Hindu	1.032.210.000	14,97	1.384.360.000	14,87	352.140.000
Buddhist	487.760.000	7,07	486.270.000	5,23	1.490.000
Local Religions	404.690.000	5,87	449.140.000	4,83	44.450.000
Other Religions	58.150.000	0,84	61.450.000	0,66	3.300.000
Jewry	13.860.000	0,20	16.090.000	0,17	2.230.000
Total	6.895.850.000	100,00	9.307.190.000	100,0	2.411.340.000

Source:The Future of Wold Religions Population Projections, 2010-2050
PEW Research Center,2022

The distribution of the Muslim population by continent is given in Table 2. Asia-Pasific ranks first with 59,2% in the projection between 2010-2030 in the distribution of the world's Muslim population by continent. In other continents, the Muslim population is estimated to be 20,1% in the Middle East and North Africa, 17,6% in Sub-Saharan Africa, 2,7% in Europe and 0,5% in the Americas. Sub-Saharan Africa is seen as the continent with the largest increase in Muslim population, with an increase of 2,6% between 2010 and 2030.

Table 2: Current and Projected Muslim Population by Region

Regions	2010		2030	
	Estimated Muslim Population	Estimated Global Share of Total Muslim Population	Projected Muslim Population	Projected Global Share of Total Muslim Population
Asia-Pasific	1.005.507.000	62,1	1.295.625.000	59,2
Middle East and North Africa	321.869.000	19,9	439.453.000	20,1
Sub-Saharan Africa	242.544.000	15,0	385.939.000	17,6
Europe	44.138.000	2,7	58.209.000	2,7
Americas	5.256.000	0,3	10.927.000	0,5
Total	1.619.314.000	100	2.190.154.000	100,00

Source: PEW Research Center, 2011

Muslim countries have formed unity within the Organization of Islamic Cooperation (OIC) since 2007 in order to provide solidarity and protect their rights and interests. This organization aimed to implement common standards in Islamic countries in halal food standards with the establishment of the Islamic Countries Standards and Metrology Institute (SMIIC) in 2010 (Şentürk, 2011). Turkey has been a member of the OIC since its establishment. There are 57 countries that are members of the OIC. 2022 yılı verilerine göre İİT'ye üye ülkelerin nüfus dağılımda Indonesia ranks first with a population of 279.134.505 people and a share of 14,12% (Table 3). Pakistan (11,61%) and Nigeria (10,97%) are the other most populated countries. Considering the population growth rate between 2018-2022, Uganda has the highest growth rate with 13,35%, while Turkey has the lowest rate with 3,91%.

Table 3: Populations of The Member Countries of The Islamic Cooperation Organization

Countries	2018	2019	2020	2021	2022	Change (%)	OIC (%)
Indonesia	267.670.549	270.625.567	273.523.621	276.361.788	279.134.505	4,28	14,12
Pakistan	212.228.288	216.565.317	220.892.331	225.199.929	229.488.996	8,13	11,61
Nigeria	195.874.685	200.963.603	206.139.587	211.400.704	216.746.933	10,65	10,97
Bangladesh	161.376.713	163.046.173	164.689.383	166.303.494	167.885.680	4,03	8,49
Egypt	98.423.602	100.388.076	102.334.403	104.258.327	106.156.692	7,86	5,37
Iran	81.800.204	82.913.893	83.992.953	85.028.760	86.022.843	5,16	4,35
Turkey	82.340.090	83.429.607	84.339.067	85.042.736	85.561.976	3,91	433
Uganda	42.729.032	44.269.587	45.741.000	47.123.533	48.432.873	13,35	2,45
Sudan	41.801.532	42.813.237	43.849.269	44.909.351	45.992.018	10,02	2,33
Algeria	42.228.415	43.053.054	43.851.043	44.616.626	45.350.141	7,39	2,29
Iraq	38.433.604	39.309.789	40.222.503	41.179.351	42.164.963	9,71	2,13
Afghanistan	37.171.922	38.041.757	38.928.341	39.835.428	40.754.385	9,64	2,07
Morocco	36.029.089	36.471.766	36.910.558	37.344.787	37.772.757	4,84	1,91
Saudi Arabia	33.702.757	34.268.529	34.813.867	35.340.680	35.844.913	6,36	1,81
Uzbekistan	32.476.232	32.981.715	33.469.199	33.935.765	34.382.077	5,87	1,74
Malaysia	31.528.033	31.949.789	32.365.998	32.776.195	33.181.079	5,24	1,68
Others	402.332.042	411.750.864	421.467.365	431.508.057	441.854.130	9,82	22,35
Total	1.838.146.789	1.872.842.323	1.907.530.488	1.942.165.511	1.976.726.961	7,54	100,00

Source: www.sesric.org. 2022

2.2. Evaluation of the World Halal Food Market with Statistics

2.2.1. Halal Food Market in the World

Today, the market value of halal food is approximately 2.4 trillion dollars, and it is estimated to reach 2.6 trillion dollars in 2023 (Figure 1). Increasing awareness among Muslim consumers increases the demand for halal certified products in the global market. In addition, women's participation in business life has increased the demand for packaged food. This situation has revealed the need to assure whether the food is halal or not (Khan and Azam, 2016). Halal food is preferred not only by Muslims but also by many non-Muslim consumers who see these products as healthy, safe, high quality and hygienic (Güneş and Yetim 2020). It has been observed that 90% of Buddhists and Hindus, 75% of Muslims, and 16% of Jews living in America obey religious prohibitions on food. It is estimated that the halal product market has 1.5 billion consumers. In other words, one out of every four consumers worldwide uses halal products (Bonne and Verbeke, 2008).

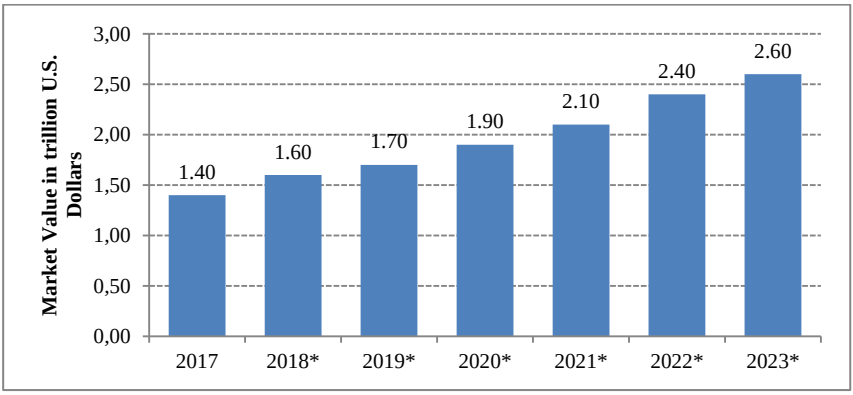

Figure 1: Market Value of Halal Foods Worldwide from 2017 to 2023
Source: www.statista.com. 2022

16% of the food market in the world is categorized as halal food and this rate is expected to increase to 30-40% in the future (Aslan, 2016). It is observed that there has been an increase in the estimated values of halal food market revenues between 2018 and 2027. In parallel with the increasing Muslim population, halal food market income is also increasing. According to Figure 2, it is seen that the highest increase will occur between 2025 and 2026 with 209.7 million dollars (12.7%).

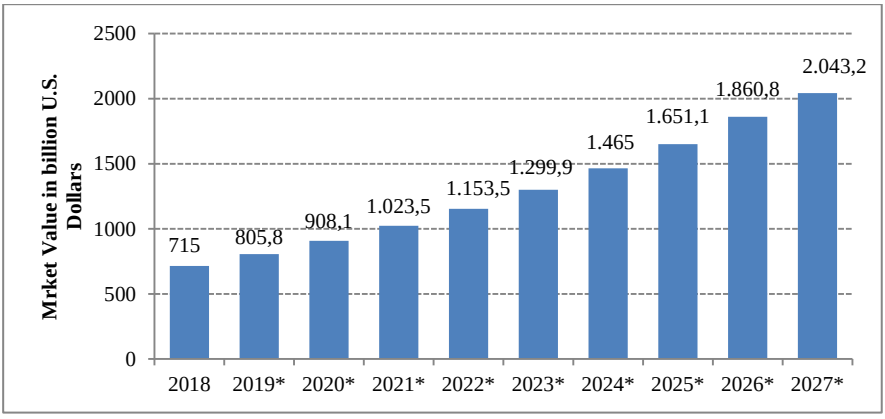

Figure 2: Forecast Market Revenue of Halal Food Woldwide from 2018 to 2027
Source: www.statista.com. 2022

The products traded in the world halal food sector are given in Figure 3 as three groups: confectionery, bakery products and processed food and beverages. Between 2014-2024, "processed food and beverages" is the group that generates the highest income in the halal food sector. While bakery products are the second highest income generating group, confectionery is the lowest income group. In 2024, it is expected to generate revenue of 1.750 million dollars in the processed food and beverages group in the halal food sector.

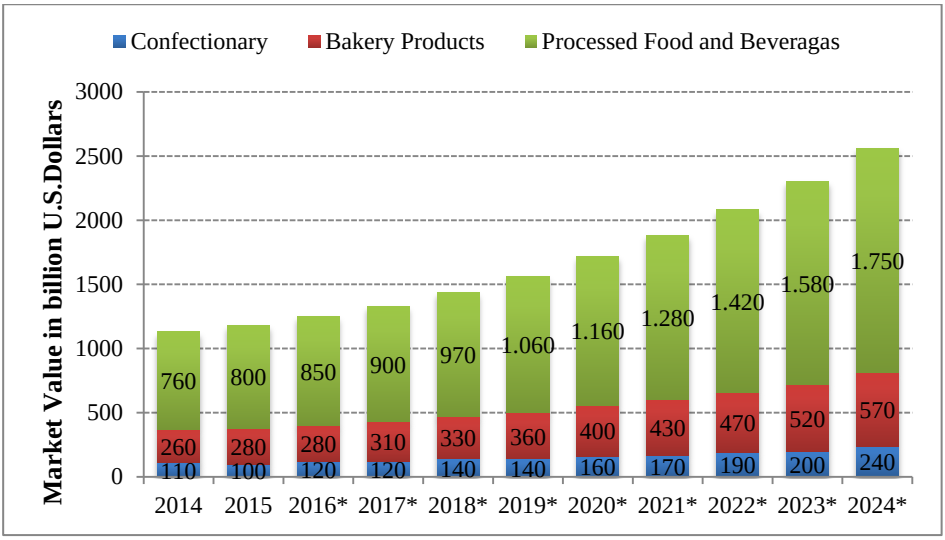

Figure 3: Forecast Halal Food Revenue Woldwide from 2014 to 2024. by Category. Source: www.statista.com. 2022

The index scores of the leading halal food markets in the world are given in Figure 4. While Maleysa (209,80) ranks first in the index score ranking, Singapore (125,20), United Arab Emirates (104,40), Indonesia (71,50) and Turkey (70,70) are the other countries with higher index scores. Malaysia is shown as the country that has made great progress in the field of halal certification and provides the best service. In Malaysia, both private institutions and state-sponsored organizations carry out many studies in the halal field (Doğaner and Fidan, 2021). This is the reason why Malaysia is important in the world market.

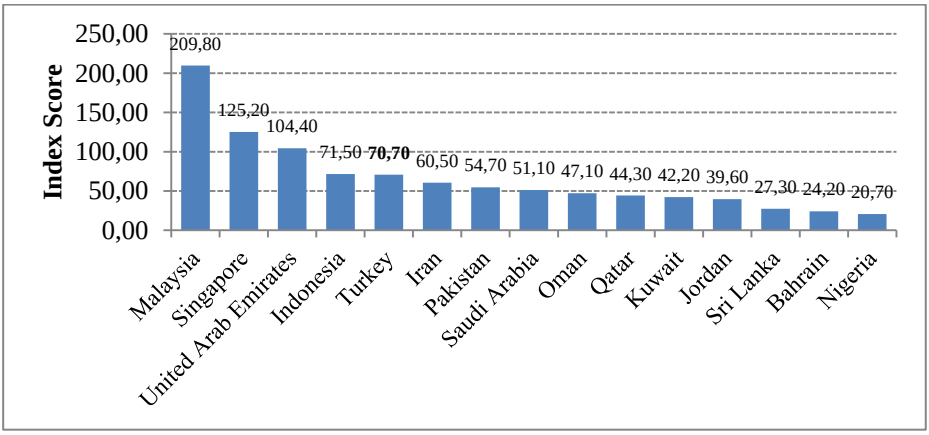

Figure 4: Index Score of The Leading Halal Food Markets Worldwide in 2020
Source: www.statista.com. 2022

2.2.2. Halal Food Market Foreign Trade in the World

The five countries that import the most halal food from the member countries of the Organization of Islamic Cooperation are given in Figure 5. Saudi Arabia is the country that imports the most halal food with 21.54 billion dollars. Malaysia, United Arab Emirates, Indonesia and Egpt are other important importing countries. Today, the awareness of reaching healthy and clean food also increases the demand for halal food. For this reason, the demand for halal food is increasing in countries other than Muslim countries. In some developed countries such as America, Canada and Europe where Muslims are a minority, the search for halal food has been increasing recently (Şahingöz and Onur, 2017).

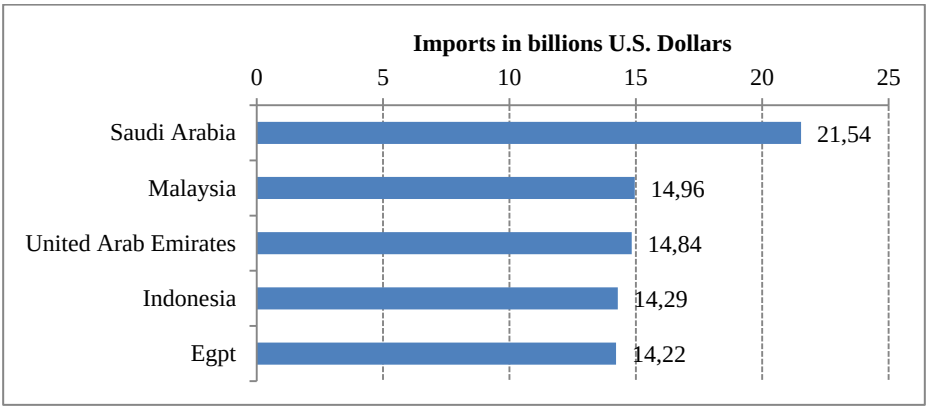

Figure 5: Leading Importers of Halal Foods to in 2015. by Organization of Islamic Cooperation Country
Source: www.statista.com. 2022

The value of the halal food market in the global market continues to grow every year. The incresing Muslim population is accelerating the growth of this market. However, it is seen that Muslim consumers have limited access to halal food. The halal food demand of consumers in Islamic countries is mostly met by non-Muslim countries. When the countries that export the most halal food are examined in Figure 6, although Brazil is not an Islamic country, it ranks first with 16.2 billion dollars.

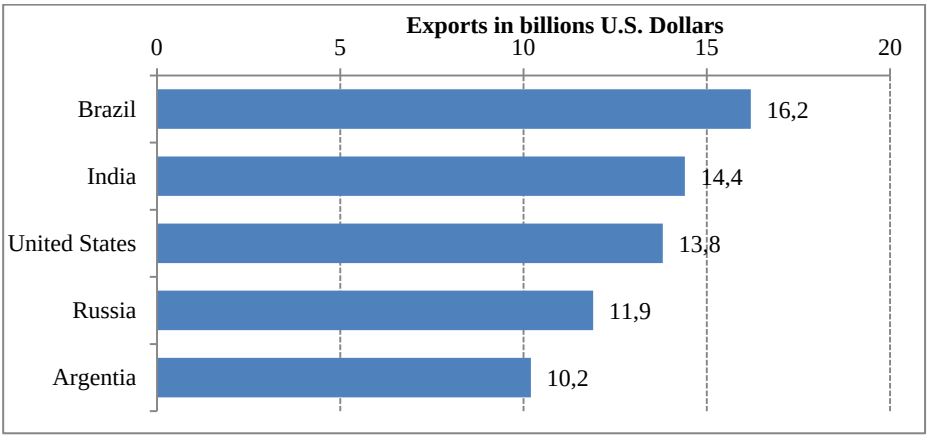

Figure 6: Leading Exporters of Halal Foods Organization of Islamic Cooperation Countries in 2019 Source: www.statista.com. 2022

The projection of food and beverage expenditures of Muslim consumers in the world between 2018 and 2024 is given in Figure 7. It is seen that food and beverage expenditures, which were 1.13 trillion dollars in 2018, increased to 1.17 trillion dollars in 2019. It is expected to increase to 1.38 trillion dollars in 2024. The increase in the expenditures of Muslim consumers in the food and beverage sector also affects the halal food sector.

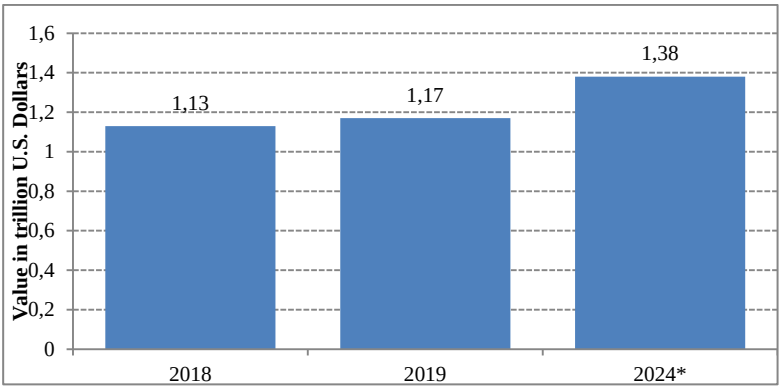

Figure 7: Muslim Consumer Expenditure on Food and Beverages Woldwide from 2018 to 2024. Source: www.statista.com. 2022

In Figure 8, the leading countries in food and beverage expenditures of Muslim consumers are given. Indonesia is the 144 billion dollar leading country. Other important countries are Bangladesh (107 billion dollars), Egypt (95 billion dollars), Nigeria (83 billion dollars) and Pakistan (82 billion dollars).

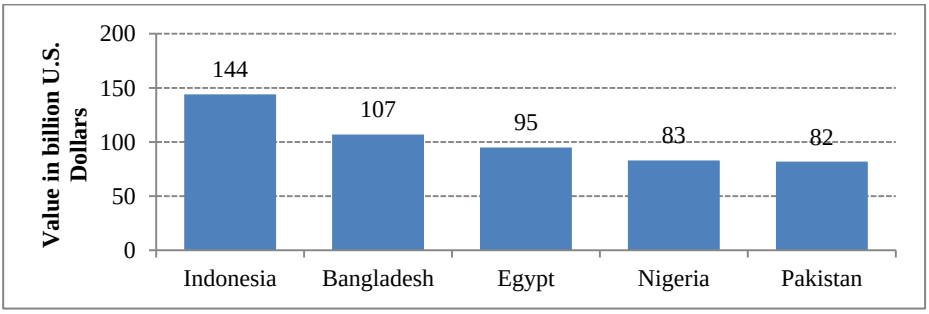

Figure 8: Muslim Consumer Expenditure on Food and Beverages Woldwide in 2019. by Leading Country. Source: www.statista.com. 2022.

2.2.3. Halal Food Market by Continent in the World

In terms of the number of halal conformity assessment organizations by continent in the world, the Asian continent has the largest number with 50 organizations. The Americas and Oceania are in the second place with 28 organizations, while the European continent is in the third place with 14 organizations (Table 4).

In Canada on the American continent, halal foods have been certified by the Food Inspection Agency since 2016. The number of certification establishments is effective in this. Brazil ranks first in poultry meat exports in halal food. Half of poultry meat exports are halal certified. There has been an increase in the Muslim population in the USA and around the world in recent years. This situation has led to the development of halal food trade in the USA. In the USA, halal certification is free of charge, except for a few states. For this reason, the number of organizations that issue halal food conformity certificates is high.

The country with the highest number of halal food conformity certificates in the Asian continent is the United Arab Emirates (UAE). The fact that food products consumed in the UAE have to comply with halal standards is the most effective factor in the high number of establishments. Halal certification is not obligation in India, which is not a member of the OIC. India mostly exports meat and meat products to Gulf countries and Muslim countries. Pakistan is a member of OIC, but halal certification is not obligation for the country.

In the European continent, Germany has the highest number of organizations that issue halal food conformity certificates. Muslims constitute the largest immigrant group in Germany. The biggest item in the halal food market is meat and meat products.

In the African continent, Egypt is the country with the highest number of establishments with a 90% Muslim population. While Brazil, India, Sudan and Paraguay are the leading countries in importing live animals and meat to Egypt, Egypt is the largest export market for US bovine offal.

Since 1970, in the Oceania continent, Australia has been exporting carcass meat and live animals to more than 40 countries,

including Egypt, Indonesia, Malaysia and Saudi Arabia, with 26 establishments.

Table 4: Number of Muslim Population and Halal Food Certification İnstitutions By Continent

Regions/Countries	Total Population	Muslim Population (%)	Number of halal conformity assessment establishment
Americas			
Canada	37.694.085	3,2	10
Brezil	211.715.973	0,01	2
Arjantina	45.479.118	0,8	2
A.B.D.	332.639.102	0,9	14
Asia			
Uzbekistan	30.565.411	93	1
Afghanistan	37.940.837	99,7	-
Azerbaijan	10.205.810	96,9	4
United Arab Emirates	9.701.315	76	31
Indonesia	267.026.366	87,2	-
India	1.326.093.247	14,2	7
Philippines	109.180.815	5,6	-
Pakistan	233.500.636	96,4	7
Saudi Arabia	34.173.498	99	-
Europe			
Bosnia and Herzegovina	3.263.000	50,7	1
Germany	80.159.662	5,1	13
Sub-Saharan Africa			
Nigeria	214.028.302	53,5	2
Egypt	104.124.440	90	3
Sudan	43.120.843	95	-
Oceania			
Australia	25.466.459	2,6	26
New Zeland	4.925.477	1,3	2

Source: www.hak.gov.tr, 2022.

2.3. Turkey's Potential in Halal Food Market

Due to its large Muslim population, Turkey has not needed a domestic halal food certificate until today. However, with the introduction of imported products into the market over time, customers' doubts about whether the products are halal or not have increased and they demanded approval.

In order to meet the demands for the approval of the halalness of the products produced, initially regional service societies, associations and foundations were established (Özbay and Cebeci, 2019).

The first institution to initiate the halal certification process in Turkey is the Turkish Standards Institute (TSE). A Turkish Standard has been established on the subject of combining the standards of the practices of TSE, the International Standardization Organization (ISO) and the European Standards Committee.

Today, the only institution authorized to provide halal accreditation services in our country is the Halal Accreditation Agency (HAK). The institution that has the authority to issue halal certificates is accredited by being audited by HAK. (HAK, 2022). HAK meets the need for accreditation, which is especially needed in the international area.

Although the concept of halal food in Turkey is not a very important issue for consumers, it is one of the first considerations for Muslim consumers living abroad. It is expected that Muslims, which is the fastest growing religion in the world, will exceed half of the world's population by 2070. Therefore, halal food is extremely important for companies.

Halal food has gained importance in international trade in recent years. This situation has caused the exporting companies working in the sector to search for the halal certificate.

It provides confidence for especially Muslim consumers who buy Halal certified products at domestic and abroad.

The fact that the halal certificate is not compulsory for the food produced in Turkey has caused its share in the foreign market to be quite low. Considering the increasing Muslim population in the world, there is a need to encourage relevant food companies and to accelerate investments in this direction.

Not only Muslim consumers but also non-Muslim consumers have started to prefer halal food because they find it more hygienic and safe. Despite the fact that our country is a Muslim country, it is an important handicap for our country that its share in the foreign market

is low and that the countries that have a say in the market are progressing rapidly. For this reason, we need to turn our advantage of being a Muslim country in this market into an opportunity as soon as possible. It is not difficult for our country, which has the potential to produce halal food, to be among the countries that have a say in the world market.

CONCLUSION

Food is an important and indispensable factor in the sustainability of human life. Governments have to meet the nutritional needs of their populations. In the nutrition of societies, their religious beliefs are also important along with their food needs. Because the religious beliefs of consumers also effect food consumption. For this reason, preference can be made in food consumption according to accepted products in religious belief. With globalization, food products can be marketed from different countries. In addition, people can travel to different countries for various reasons. When people go abroad or in their own country, they may experience anxiety in food consumption or problems in reaching the product due to their religious beliefs. This situation has increased the concern of Muslim consumers whether the food they consume is halal or not. The concern of Muslim consumers is halal tourism, halal cosmetics, etc. affected the sectors and caused the expansion of this field.

Consumers who prefer halal products around the world may have doubts about trusting more products and certificates. In particular, a lack of confidence may increase when Muslim consumers use food products from non-Muslim countries. Because there are different certification practices between countries on halal food.

The fact that there is no detailed information about the product content on the labels on the food products can create suspicion in the consumer. It shows that non-Muslim countries are in the majority in countries that have a say in world halal food trade. This situation can create trust concerns among Muslim consumers.

It is seen that the leading countries in the halal food market made their investments in very early years. Developed countries see the

increasing Muslim population as an important opportunity for the halal food market. They continue to rapidly increase their investments in this field.

As a result, the halal food market is growing with the growing Muslim population. However, it is seen that the sensitivity of halal food certificate is low in Turkey. In this rapidly growing sector in the world market, Turkey needs to position themselves as a country without delay. In order to have a say in the world halal food market, it is necessary to focus on being a brand in products and certificates. Especially, the Ministry of Culture and Tourism needs to create worldwide awareness of halal food products produced in our country through promotional activities. In order for Turkey to get the market share it deserves in the growing and developing halal food market, the relevant institutions should provide the necessary support and incentives to the investors in the food sector. Turkey, as a geographical location, has a strategic importance in the marketing of products in terms of logistics and commercial relations in the world. For this reason, as a country in the halal food market, we need to increase our investments in the market as soon as possible, evaluate the opportunities and have a say in the market.

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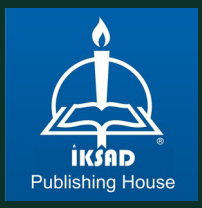

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