İKSAD Publishing House

PEANUT GROWING, NUTRITIONAL CONTENT AND USAGE IN NUTRITION

CHAPTERS BOOK

Edited by

ASSOC. PROF. DR. ENVER KENDAL

PEANUT GROWING, NUTRITIONAL CONTENT AND USAGE IN NUTRITION

EDITOR

Assoc. Prof. Dr. Enver KENDAL

AUTHORS

Prof. Dr. Nevzat ARTIK
Assoc. Prof. Dr. Aybuke CEYHUN SEZGİN
Assoc. Prof. Dr. Enver KENDAL
Assoc. Prof. Dr. Seydi YIKMIŞ
Asst. Prof. Dr. Nazan TOKATLI DEMİROK
Dr. Halil BAKAL
Behiye İncisu AYDOĞDU
Melikenur TÜRKOL
İbrahim ÖZEL

İKSAD
Publishing House

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

It is responsibility of the author to abide by the publishing ethics rules.
Iksad Publications – 2022©

ISBN: 978-625-8377-33-0
Cover Design: Almaz TURSYNBAY
April / 2022
Ankara / Turkey
Size = 16x24 cm

CONTENT

PREFACE

Agriculture has kept its current status as the most critical and strategic sector since the creation of humanity and has always taken its place at the top of the strategic sector hierarchy. The reasons that make agriculture so critical; The main reasons are the geometrical increase in the world population, the rapid decrease in the world's agricultural areas, and the negative effects of the deteriorated environment on agriculture. For these reasons, some problems are expected in the coming years in terms of adequate and balanced nutrition, which is the basic vital requirement of the world population. These developments show that the agricultural sector will continue to increase its importance in the world.

In recent years, pandemics, droughts, climate change and wars have paved the way for discussion of countries' self-sufficiency. In order for a country to be self-sufficient, it depends on the development of the agricultural sector of that country. For the reasons mentioned above, it reminded us to use our natural resources much more effectively in order to strengthen our self-sufficiency. Today, the existence and size of agricultural lands alone is not enough to make maximum use of agricultural production. It is necessary to determine the products that can grow in the best way in these areas and to produce and evaluate these products with the best technology.

Peanut (*Arachis hypogaea* L.), which is produced in many countries of the world, has found wide use in human nutrition, animal husbandry and other branches of industry. Peanut, one of the leguminous plants, has attracted the attention of the world thanks to its rich nutrient content and low cost, and has formed an important part of the crop rotation systems in many regions and climatic conditions.

The aim of this study is to bring together the results of the studies of researchers working on peanuts, which is a product of increasing importance in the world, to develop solutions to problems related to peanuts, to shed light on the studies to be done on peanuts, to ensure that students benefit from the trainings given, to increase the interest in peanuts, to inform and enlighten all segments. Therefore, I would like to express my deepest gratitude to all the authors who contributed to the preparation of this book.

Sincerely Yours

Associate Prof. Dr. Enver KENDAL

FIRST CHAPTER

ANTIMICROBIAL PROPERTIES OF PEANUT SKIN

Nazan TOKATLI DEMİROK[1]
Behiye İncisu AYDOĞDU[2]
Seydi YIKMIŞ[3]
Melikenur TÜRKOL[4]

[1] Department of Nutrition and Dietetics, Health School, Tekirdag Namık Kemal University, ORCID: 0000-0003-1936-9337
[2] Department of Nutrition and Dietetics, Institute of Health Sciences, Tekirdag Namık Kemal University, ORCID: 0000-0001-6250-9628
[3] Department of Food Technology, Tekirdag Namık Kemal University, ORCID: 0000-0001-8694-0658
[4] Department of Medical Genetics, Institute of Health Sciences, Tekirdag Namık Kemal University, ORCID: 0000-0001-7354-9529

1. INTRODUCTION

Peanut, a legume herb, belongs to the Leguminosae family, the genus Arachis, and is a legume called Arachis hypogaea (Settaluri et al., 2012). It is thought that peanut spread from Central America to other parts of the 4uali (Settaluri et al., 2012).

Peanuts are an important source of flavonoids, fats and proteins 4uality mostly grown in the Mexico, Central America and South America (Stalker, 1997, FAO 2019).

Peanuts are used in many fields, including peanut butter, roasted peanuts, confectionery and peanut oil extraction (Zhao et al., 2012). Peanuts are seen as a valuable product, while peanut skins are considered a low value by-product (Sarnoski et al., 2012). The increase in peanut production, along with the increase in peanut by-products, has encouraged studies 4uality use of these products rich in bioactive compounds (Do Valle Calomeni et al., 2017).

Peanut skin, which is a part of peanut, is traditionally consumed in many parts of the 4uali without any side effects and is accepted as a GRAS product. 230-300 grams of 1 kg peanuts are peanut skins. Peanut skin is pink-red in color and has an astringent taste. It is known that peanut skin contains approximately 47.3% fiber. Peanut skin is rich in phenolics and potential health-promoting compounds (Collins and Post, 1981; Yu et al., 2005; Yu et al., 2010; Zhao et al., 2012). In this study, antimicrobial activities of peanut skin were investigated.

2. ANTIMICROBIAL PROPERTIES

Peanuts and by-products are well known sources of phenolic compounds (Alasalvar et al., 2015). Polyphenols have many basic roles in plant physiology; They are secondary metabolites produced by higher plants, potentially beneficial to human health, including antioxidant, anti-allergic, anti-inflammatory, anticancer, antihypertensive and antimicrobial agents (Daglia, 2012).

In order to prevent the growth of spoiling and pathogenic microorganisms, compounds such as sodium benzoate, nitrite, sodium meta bisulfate are added to foods and/or heat treatment is applied to foods (Aoki et al., 2010). With the increasing demand for natural and healthy foods, researchers have turned to researching new food additives. Peanut by-products are remarkable for their antioxidant and antimicrobial properties (Do Valle Calomeni et al., 2017).

There are limited in vitro studies on the antimicrobial properties of peanut skins. It is reported that phenolic compounds in peanut skin prevent the growth of pathogenic and spoilage microorganisms by multiple mechanisms (Lorenzo et al., 2018).

Peanut skin is known to be a rich source of oligomeric and polymeric procyanidins (Dudek et al., 2017). Peanut skin extract has been reported to contain high levels of A-type procyanidins (Levy et al., 2017). It has been stated that the use of probiotic bacteria and A-type proanthocyanidins together provides *Escherichia coli* inhibition by showing a synergistic effect, so that phenolic compounds can be used in functional food production (Polewski et al., 2016).

Makau et al. (2018), in their study in which they examined the antiviral activity of peanut skin, it was stated that extracts with higher polyphenol content exhibit higher antiviral activity, so that the active ingredients may be polyphenols. Peanut skin activity has been observed against both type A and type B viruses. It has been observed that the use of peanut skin extract together with anti-influenza drugs, increases the antiviral activity synergistically. It has been suggested that peanut skin extract could potentially be used in the development of new therapeutic alternatives in the management of influenza.

Bodoira et al., (2017), in their study using water and ethanol as extraction solvents, reported that the maximum concentration of total phenolics in peanut skin was obtained by using 60.5% ethanol as co-solvent at 220 °C extraction temperature and 7 g/min solvent flow. In that study, catechin, epicatechin, procyanidin and proanthocyanidin dimers were obtained.

Yu et al. (2010), in a study investigating the antimicrobial properties of peanut skins in cooked and raw ground meat; They determined that 0.4% or more peanut skin extract completely inhibited *Bacillus subtilis*, *Salmonella* Typhimurium, *Staphylococcus* aureus, *Streptococcus faecalis* and *Escherichia coli*.

In another study investigating the effect of peanut skin extract on meat products, it was reported that although there was not a very strong decrease in meat products, inhibition of *Bacillus subtilis*, *Salmonella* Typhimurium, *Staphylococcus aureus*, *Streptococcus faecalis* and *Escherichia coli* was observed in the microplate assay (Yu et al., 2010).

Antibacterial effect of phenolic extracts obtained from peanut skins and dry blanched peanuts on gram positive (*Bacillus cereus*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Geobacillus stearothermophilus*) and gram negative bacteria (*Pseudomonas aeruginosa*, *Pseudomonas fluorescens*, *Salmonella* Enteritidis, *Salmonella* Typhimurium, *Escherichia coli*) in the study examined; Gram-negative and gram-positive strains presented phenolic acid-rich extracts. It was determined that it showed the lowest minimum inhibitory capacity (MIC) and thus high antibacterial activity. Among them, the strongest inhibitory activity was observed against *G. Stearothermophilus*; *Listeria monocytogenes* was determined as the gram-positive bacteria with the highest resistance. (De Camargo et al., 2017).

Do Valle Calomeni et al. (2017), in the study they aimed to obtain a dried extract from peanut skin by using spray drying technology and apply it as a natural antioxidant and antimicrobial in foods; It was determined that the extract showed bacteriostatic activity against *Listeria monocytogenes* and both bactericidal and bacteriostatic activity against *Staphylococcus aureus*.

Martin et al. (2012), in the study conducted by; *Listeria monocytogenes* and *S.aureus* inhibition zone, MIC, and MBC values of methanol and ethanol extracts of peanut skins were investigated. The zone of inhibition for *S. Aureus* was 18 mm of methanol extract, 20 mm of extract; MIC value of both methanol and ethanol extract was found as 0.78 and MBC value as 1.56. Zone of inhibition for *Listeria monocytogenes* was 12.33 mm of methanol extract, 14 mm of ethanol extract; MIC and MBC values of both methanol and ethanol extract were found as 3.13.

Peng et al. (2015), determined that 0.5% peanut skin extract inhibited *Listeria monocytogenes*, *Lactobacillus casei*, and *Lactobacillus rhamnosus*. It has been suggested that bioactive components such as phenolic acids and flavonoids found in peanut skins may inhibit the colonization of pathogens by reducing the levels of flagellin and adhesin.

Sarnoski et al. (2012), studied *Saccharomyces cerevisiae, Zygosaccharomyces bailii,* and *Zygosaccharomyces bisporus* in apple juice to which they added proanthocyanidins obtained from peanut skins. In the research; They observed that for 3 yeast species, peanut skin extract prolonged lag phase growth at 1 mg/ml and inhibited yeast growth for 120 hours at 10 mg/ml. It was observed that fractions consisting mostly of A-type proanthocyanidin dimers, trimers and tetramers had the highest percentage of inhibition against the tested yeasts. However, considering the amount of concentrations that can inhibit yeast growth, it is thought to be high for use in the food and beverage industry.

3. CONCLUSION

It is reported that phenolic compounds in peanut skin regulate multiple mechanisms and prevent the development of pathogenic and spoilage microorganisms. Research has shown that peanut skin has 6uality6r activity against yeasts, viruses, Gram-negative and Gram-positive bacteria. However, more in vitro and in vivo studies are needed to better understand the antimicrobial potential of peanut skins.

REFERENCES

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

Aoki, K., Shen, J., & Saijo, T. (2010). Consumer reaction to information on food additives: evidence from an eating experiment and a field survey. *Journal of economic behavior & organization*, *73*(3), 433-438.

Bodoira, R., & Maestri, D. (2020). Phenolic compounds from nuts: extraction, chemical profiles, and bioactivity. *Journal of Agricultural and Food Chemistry*, *68*(4), 927-942.

Collins, J. L., & Post, A. R. (1981). Peanut hull flour as a potential source of dietary fiber. *Journal of food science*, *46*(2), 445-448.

Daglia, M. (2012). Polyphenols as antimicrobial agents. *Current opinion in biotechnology*, *23*(2), 174-181.

De Camargo, A. C., Regitano-d'Arce, M. A. B., Rasera, G. B., Canniatti-Brazaca, S. G., do Prado-Silva, L., Alvarenga, V. O., … & Shahidi, F. (2017). Phenolic acids and flavonoids of peanut by-products: Antioxidant capacity and antimicrobial effects. *Food Chemistry*, *237*, 538-544.

Do Valle Calomeni, A., de Souza, V. B., Tulini, F. L., Thomazini, M., Ostroschi, L. C., de Alencar, S. M., … & Favaro-Trindade, C. S. (2017). Characterization of antioxidant and antimicrobial properties of spray-dried extracts from peanut skins. *Food and bioproducts processing*, *105*, 215-223.

Dudek, M. K., Gliński, V. B., Davey, M. H., Sliva, D., Kaźmierski, S., & Gliński, J. A. (2017). Trimeric and tetrameric A-type procyanidins from peanut skins. *Journal of natural products*, *80*(2), 415-426.

F.A.O., World'stop peanut producing countries, Rome, 2019. www.fao.org/3/ca6030en/ca6030en.pdf.

Levy, J., Boyer, R. R., Neilson, A. P., O'Keefe, S. F., Chu, H. S. S., Williams, R. C., … & Goodrich, K. M. (2017). Evaluation of peanut skin and grape seed extracts to inhibit growth of foodborne pathogens. *Food Science & Nutrition*, *5*(6), 1130-1138.

Lorenzo, J. M., Munekata, P. E., Sant'Ana, A. S., Carvalho, R. B., Barba, F. J., Toldrá, F., … & Trindade, M. A. (2018). Main characteristics of peanut skin and its role 7uality preservation of meat products. *Trends in Food Science & Technology*, *77*, 1-10.

Makau, J. N., Watanabe, K., Mohammed, M. M., & Nishida, N. (2018). Antiviral activity of peanut (Arachis hypogaea L.) skin extract against human influenza viruses. *Journal of medicinal food*, *21*(8), 777-784.

Martin, J. G. P., Porto, E., Corrêa, C. B., Alencar, S. M., Gloria, E. M., Cabral, I. S. R., & Aquino, L. M. (2012). Antimicrobial potential and chemical composition of agro-industrial wastes. *J. Nat. Prod*, *5*, 27-36.

Peng, M., Bitsko, E., & Biswas, D. (2015). Functional properties of peanut fractions on the growth of probiotics and foodborne bacterial pathogens. *Journal of Food Science, 80*(3), M635-M641.

Polewski, M. A., Krueger, C. G., Reed, J. D., & Leyer, G. (2016). Ability of cranberry proanthocyanidins in combination with a probiotic formulation to inhibit in vitro invasion of gut epithelial cells by extra-intestinal pathogenic E. Coli. *Journal of functional foods*, *25*, 123-134.

Sarnoski, P. J., Boyer, R. R., & O'Keefe, S. F. (2012). Application of proanthocyanidins from peanut skins as a natural yeast inhibitory agent. *Journal of food science*, *77*(4), M242-M249.

Sarnoski, P. J., Johnson, J. V., Reed, K. A., Tanko, J. M., & O'Keefe, S. F. (2012). Separation and characterisation of proanthocyanidins in Virginia type peanut skins by LC–MSn. *Food Chemistry*, *131*(3), 927-939.

Settaluri, V. S., Kandala, C. V. K., Puppala, N., & Sundaram, J. (2012). Peanuts and their nutritional aspects—a review.

Stalker, H. T. (1997). Peanut (Arachis hypogaea L.). *Field crops research*, *53*(1-3), 205-217.

Yu, J., Ahmedna, M., & Goktepe, I. (2005). Effects of processing methods and extraction solvents on concentration and antioxidant activity of peanut skin phenolics. *Food chemistry*, *90*(1-2), 199-206.

Yu, J., Ahmedna, M., & Goktepe, I. (2010). Potential of peanut skin phenolic extract as antioxidative and antibacterial agent in cooked and raw ground beef. *International journal of food science & technology*, *45*(7), 1337-1344.

Zhao, X., Chen, J., & Du, F. (2012). Potential use of peanut by-products in food processing: a review. *Journal of food science and technology*, *49*(5), 521-529.

SECOND CHAPTER

COMPARISON OF IMPORTANT AGRICULTURAL AND QUALITY CHARACTERISTICS OF DIFFERENT MARKET TYPE PEANUTS (*Arachis hypogaea* L.)

Halil BAKAL[1]

[1] Dr, Cukurova University, Faculty of Agriculture, Department of Field Crops, Adana, TURKEY

1. INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a one-year-old plant from the legumes family and contains a high content of oil in its seeds. Peanut seeds, depending on the varieties, contain 50-55% oil and 18-26% protein (Islibe et al., 2008; Hassan & Ahmed, 2012). Peanut oil; due to its high content (80%) of unsaturated fatty acids (oleic and linoleic), it has superior properties than many vegetable oils in terms of healthy nutrition. The ratio of unsaturated fatty acids in peanut oil to saturated fatty acids (P/S) has been calculated as 4.6 (Arioglu, 2014). Tocopherol, which has abundant in peanut oil, is an antioxidant substance and prevents the oil from spoiling by oxidation and is preferred by oil manufacturers due to this feature (Onat, 2018). Peanut oil can be used as a liquid in food as well as margarine due to its superior properties. In addition, due to the peanut oil's durability feature; it is preferably used in the preparation of biscuits, cakes, candies and canned fish. Low 11ualityy peanut oils are also used as raw materials in the production of different products in the industry (Arioglu, 2014). Peanut seeds are the fourth most produced oilseed plant in the world after soy, rapeseed and cottonseed because of the high rate (50-55%) of oil it contains, and it has a very important place in the production of vegetable oilseed and crude oil. According to the values of 2018, world vegetable oil seed production is 554 million tons and 7.9% (43.9 million tons) of this is peanuts. In the same period, world vegetable crude oil production is 187 million tons, and 3% (5.6 million tons) of this is peanut oil (FAO, 2019). According to the values of 2019, 2.9 million tons of oilseeds are produced in our country, and 5.7% (164,200 tons) of this is peanuts.

Variety selection is one of the most effective factors on yield to be obtained from the unit area in peanut farming. Cultural methods, especially environmental factors, are effective on the growth and development of the peanut plant, and pod formation and maturity (Cox, 1979; Ketring et al., 1982). The effect of these mentioned factors varies according to the cultivars in different market types. Therefore, in peanut farming; selection of varieties according to planting times and regions is of great importance. Peanut varieties are divided into four types: Virginia (large pod-large seed), Runner (small pod-small seed), Spanish (small pod-small seed) and Valencia (small pod-medium seed), according to market types (according to pod and seed size), it is gathered under the main type (market type) (Arioglu, 2014). Growing times of the varieties included in this type differ according to the regions where they are grown and their planting times. In general, the varieties in the Virginia and Runner type mature late, while the varieties in the Spanish and Valencia type mature early. In addition, there are some differences in the usage areas of the varieties that fall into these types. In the world; Virginia type varieties with large pod and seeds feature are mostly used in roasted and salted snack peanuts, Runner and Spanish varieties with smaller pod and seed properties are used in vegetable oil industry and peanut butter production and Valencia type varieties are mostly used in boiled peanut production (Knauft et al., 1987).

In countries, where peanut farming is widely used today, varieties of different market types are preferred, taking into account the wishes of the industrialist. In the USA, the varieties that belong to the Runner type is preferred, while the varieties that belong to the Virginia type in the USA are preferred. In the USA, where modern peanut farming has made great progress, 75% of the produced peanuts are in Runner, 20% are in Virginia, 4% are in Spanish and 1% are in the Valencia type (Liao & Holbrook, 2007). In peanut farming in our country, varieties that are in the Virginia type, with large seeds and late maturing are used. However, it will be possible to produce varieties that are included in different market types in the future by diversifying their usage purposes. For this reason, determining the yield potentials and growing techniques of peanut varieties in different market types is of great importance for the future of peanut farming.

Peanuts, especially pod yield and some agricultural and quality characteristics; varies according to cultivated variety and environmental factors (especially high temperature) that are effective during growing. Cox (1979), Ketring et al. (1982) and Calıskan et al. (2008) stated that environmental factors are effective in the growth and development of peanut plants and yield and some agricultural characteristics. They stated that especially in the generative period, if the air temperature rises above 35^{o}C, ginefor and pod formation, internal yield and pod yield are affected negatively. Bakal & Arioglu, (2019); clarified this situation with a planting time study. Quality characteristics of peanuts, such as quality, yield and agricultural characteristics, vary greatly depending on the characteristics of the variety and growing conditions, especially environmental factors (Isleib et al., 2008). For this reason, in peanut farming, planting and harvesting times, especially the selection of varieties, are of great importance. The reactions of the varieties in different market types to these conditions are different.

The purpose of this study; to compare the yield potential, important agronomic and quality characteristics of some peanut varieties that are in different market types and have different growth characteristics, as the main product under the conditions of the Mediterranean region.

2. MATERIALS AND METHODS

2.1. Experimental Site and Materials

The study was carried out in 2017, 2018 and 2019 at the experimental area of Cukurova University in Adana, Turkey. Adana, Turkey situated to the south and has a Mediterranean climate. The station is located between 36°59l N, and 35°18[1] E at an altitude of 23 m above sea level. In this research, cultivars Halisbey, Georgia Green, Florispan and Georgia Red were used as material belonging to Virginia, Runner, Spanish and Valencia market types, respectively. The peanut varieties used as a plant material in these researches and their some characteristics were given in Table 1.

Table 1: Some characters of Virginia, Runner, Spanish and Valencia genotypes

Characters	**Virginia** (Halisbey)	**Runner** (G. Green)	**Spanish** (Florispan)	**Valencia** (G. Red)
Origin	Turkey	USA	Turkey	USA
Growing type	Semi-spreading	Spreading	Erect	Erect
Growing period (days)	150	130	120	110
Pod size	Large	Small	Very small	Medium to long
Seed size	Medium to large	Small	Small	Small to medium
Seed per pod	2	2	2	3-4
Testa color	Pink	Dark pink	Cream	Red

The soil in the experimental site is classified as clay loam texture. The soil tests in both years indicated a pH of 7.7 with high concentrations of K_2O and low concentrations of P_2O_5. In addition, the organic matter and nitrogen content of the soil was very low. The lime content was 21.8 % in the upper layers of the soil.

The average monthly air temperature during the research period (March-October) was varied between 15.2- 29.9°C in 2017, 16.8 and 29.7°C in 2018, whereas it was 13.8 and 29.6°C in 2019. The average air temperature was the higher during the research period in both years than long term average temperature. The total rainfall was 243.6 mm, 189.0 and 221.6 mm during the growing period in 2017, 2018 and 2019, respectively. The average relative humidity was ranged from 61.2% to 70.2% in 2018 and 57.6% to 68.8% in 2019. The differences between the years and long term for the climate data were not found very significant (Table 2).

Table 2. The climate conditions during the 2017-2018-2019 growing period and long term (LT) average (1929-2019)

Months	Average Temperature (°C)				Precipitation (mm)				Relative Humidity (%)			
	2017	**2018**	**2019**	**L.T.**	**2017**	**2018**	**2019**	**L.T.**	**2017**	**2018**	**2019**	**L.T.**
March	15.2	16.8	13.8	13.4	65.2	38.2	93.0	65.1	62.8	71.6	69.0	65.2
April	18.5	20.1	17.0	17.5	63.2	33.0	61.4	51.1	60.7	61.2	67.0	60.1
May	21.8	24.4	24.1	21.7	44.4	25.6	2.6	47.1	68.8	62.8	57.6	63.2
June	26.2	26.4	27.1	25.6	19.4	27.0	13.8	20.5	69.1	70.2	68.7	70.2
July	30.4	29.1	28.4	28.2	0.0	0.0	28.0	6.2	64.4	69.8	68.8	67.5
August	29.9	29.7	29.6	28.7	0.0	0.0	0.0	5.5	67.5	68.8	68.0	68.5
September	27.8	27.9	27.3	26.1	11.2	1.2	0.0	17.6	66.1	63.6	62.1	65.4
October	22.2	22.9	24.2	21.6	40.2	64.0	22.8	42.4	54.1	58.6	61.6	60.3

3. METHOD

The seeds of different market types of peanuts genotypes were sown on 5 April 2017, 7 April 2018 and 6 April 2019 in sown with a 0.7 m spacing between rows and 0.15 m spacing between plants in a row. The seeds were sown by hand in four-row plots that were 5 m long (2.8 x 5.0 m =14.0 m^2). The experiment utilized a randomized complete block design with three replications for every years. The pre-sowing herbicide was applied to the soil and the plots were kept weed-free by hand weeding during the growing period. Before sowing the peanuts the plots were fertilized with 300 kg N, P_2O_5, K_2O ha^{-1} and an additional nitrogen dose of 200 kg ha^{-1} was side-dressed at the pegging stage. The plots received cultivar practices common for the area in which the experiments were conducted. All plots were irrigated with sprinkler irrigation approximately every 2 weeks, starting from the flowering stage. During the growing period, recommended pesticides and fungicides were applied at proper time intervals to control insects and diseases. The different market types of peanuts genotypes were harvested at the same time after they all reached harvest maturity. Two central rows in each plot were hand harvested 150 days after sowing seeds to determine yield and yield components. Pods were air-dried to reach a moisture content of 12% and agro morphology (number and weight of pods per plant, hundred pod and seed weight, shelling percentage, harvest maturity index property and pod yields per hectare were calculated from the samples obtained. Kernel yield per hectare was calculated as the ratio of shelling percentage x pod yield per hectare (Kurt et al., 2017). The harvested seeds were oven-dried at 40°C for 4 h in a ventilated oven until reaching a moisture content of about 5%, and were then ground with a Warring blender. Five grams of peanut seeds were extracted with petroleum ether for 6 h in a Soxhlet system, according to The American Oil Chemists Society (AOCS) method (AOCS, 1993). Protein content of groundnut seeds was determined using a micro-Kjeldahl digest procedure. Fatty acid profile was measured as fatty acid methyl esters using gas chromatograph (AOCS, 1990). Fatty acid composition by Gas Chromatography Analysis. Fatty acid methyl esters were prepared from seeds by alkaline trans methylation, and fatty acid composition was determined using an Agilent 7890 AGC equipped with a flame ionization detector and an auto sampler. Sample preparation, gas chromatography operation, and data collection followed the standard methods used by our lab routinely. Iodine values (IV) = [(% oleic acid x 0.8601) + (% linoleic acid x 1.7321)] and Oleic acid/Linoleic acid (O/L) ratio = [% oleic acid (18:1)/linoleic acid (18:2)] of the peanut oils were calculated using the equation given by Chowdhury et al. (2015).

The data were statistically and correlation analyzed by using JMP 8.1.0 package program with repeat years on randomized complete block design. The Least Significant Differences (LSD) test was used to compare the treatments at 0.01 level.

4. RESULTS

This study was carried out to determine the important agronomic and quality characteristics of peanut varieties with different market types. According to a three-year average, the data were statistically analyzed using repeated years randomized complete block design by using variety and year factors. The variance analysis of the findings obtained from the study was shown in Table 3. It can be seen in Table 3, variety and year factors were statistically significant for all the agronomic and quality traits. Interaction variety × years were also found to be statistically significant for all features except pod number, 100 seed weight, oil content, protein content, palmitic acid, stearic acid and oleic acid (Table 3).

Table 3. Variance analysis of agronomic and quality traits

	Mean Square			
	Variety	**Year**	**Variety x Year**	**CV**
DF	3	3	9	
Agronomic Traits				
Pod Number (no. plant^{-1})	1693.37**	24.368**	3.334	4.25
Pod Weight (g plant^{-1})	2478.15**	29.553**	13.809**	1.17
100 Pod Weight (g)	109911**	399.640**	46.240**	2.00
100 Seed Weight (g)	11527.9**	20.438**	2.818	1.47
Shelling Percentage (%)	351.412**	2.084**	4.847**	0.88
Harvest Maturity Index (%)	14.25**	2.089**	3.180**	0.92
Pod Yield (kg ha^{-1})	214382**	6219.91**	1501.76**	3.20
Kernel Yield (kg ha^{-1})	85791**	3725.23**	569.43**	2.52
Quality Traits				
Oil Content (%)	63.435**	0.362**	0.146	0.63
Protein Content (%)	14.708**	0.351**	0.224	1.84
Palmitic Acid (C16:0) (%)	12.310**	0.365**	0.089	3.26
Stearic Acid (C18:0) (%)	2.048**	0.069**	0.001	3.32
Oleic Acid (C18:1) (%)	343.652**	6.717**	0.318	1.19
Linoleic Acid (C18:2) (%)	215.064**	2.350**	0.308**	0.82
O/L Ration (%)	1.450**	0.022**	0.002**	1.70
Iodine Value	89.927**	0.190**	0.677**	0.31

**Significant differences are shown at $P < 0.01$, DF: Degree of Freedom, CV: Coefficient of Variation

4.1. Agronomic Traits

There was a statistically significant difference in pod number per plant (PN) among the different market type of peanut, variety, years and interaction in three years-average. As it can be seen Table 4, three-year average PN of different market type of peanut varieties were 52.4 pod number plant^{-1} in Runner type, 38.0 pod number plant^{-1} in Spanish type, 27.4 pod number plant^{-1} in Virginia type and 21.0 pod number plant^{-1} in Valencia type. Runner market type peanut varieties produce more pod than other market type of peanut varieties. It was determined to be at least Valencia type. There was a statistically significant difference in pod weight per plant (PW) among the different market type of peanut, variety, years and interaction in three years-average. As it can be seen pod weight per plant (PW) in Table 4, three-year average PW of different market type peanut varieties were Virginia type 88.8 g plant^{-1}, Runner type 69.9 g plant^{-1}, Spanish type 49.4 g plant^{-1} and Valencia type 61.3 g plant^{-1}. The PW values of different market type of peanuts were higher in Virginia type than other market type of peanut varieties.

The PN and PW values are important parameters affecting pod yield In peanut growing. As can be seen in the correlation analysis, it has been proved to have a considerable effect on pod yield values. This situation has been proven by previous studies (Zongo et al., 2017; Arioglu et al., 2018). In this study, The PN values were obtained higher in Runner type than other market type of peanut varieties. Since the Runner market type peanut developed spreading and produce more branches, it formed more pod than other market type of peanut varieties (Balota & Phipps, 2013; Kurt et al., 2016; Arioglu et al., 2018; Asık et al., 2018). On the other hand, The PW of different market type of peanuts was higher in Virginia type than other market type of peanut varieties. This is due to the fact that Virginia type peanuts have larger pod and higher seed weight than other market type of peanut varieties (Bakal & Arioglu, 2019). Similar results were found by some researchers (Canavar & Kaynak, 2008; Rahmianna et al., 2009; Kaba et al., 2014; Sarkees, 2015; Gulluoglu et al., 2016; Gulluoglu et al., 2017; Kumar et al., 2017; Arioglu et al., 2018).

Table 4. Agronomic characteristics of different market type peanut varieties in three-year average values

Agronomic Traits	Market Type				
	Virginia	**Runner**	**Spanish**	**Valencia**	**LSD**
Pod Number (no. plant^{-1})	27.4 c	52.4 a	38.0 b	21.0 d	2.53
Pod Weight (g plant^{-1})	88.8 a	69.9 b	49.4 d	61.3 c	1.98
100 Pod Weight (g)	354.6 a	132.6 c	135.2 c	281.8 b	7.77
100 Seed Weight (g)	135.9 a	64.6 c	57.0 d	94.3 b	2.21
Shelling Percentage (%)	64.09 d	78.54 a	72.35 b	67.66 c	1.07
Harvest Maturity Index (%)	55.75 c	56.78 b	56.50 b	58.70 a	0.90
Pod Yield (kg ha^{-1})	7522 a	5903 b	3852 d	5049 c	305.9
Kernel Yield (kg ha^{-1})	4819 a	4636 b	2786 d	3417 c	169.0

There was a statistically significant difference in 100 pod weight (HPW) and 100 seed weight (HSW) values among the different market type of peanut, variety, years and interaction in three years-average. As it can be seen Table 4, three-year average the HPW values of different market type of peanut varieties were Virginia type 354.6 g, Runner type 132.6 g, Spanish type 135.2 g and Valencia type 281.8 g. Depending on HPW, seed weights varied similarly. In this research, the results indicated that the highest HSW value was Virginia type (135.9 g) followed by Valencia type (94.3 g), Runner type (64.6 g) and Spanish type (57.0 g) (Table 4). The highest HPW and HSW values were determined to be from Virginia type peanuts than other market types.

The HPW and HSW vary depending on the market types of peanuts. In general, cultivars belonging to Virginia type tend to have larger and heavier seeds and pods; those belonging to Runner and Spanish types have smaller and lighter seeds and pods (Rao & Murty, 1994). In this study, it was determined that HPW and HSW values were higher Virginia type peanuts than other market types. These results were agreement with the findings of (Sharma et al., 2013; Wang et al., 2013; Sarkees et al., 2014; Gulluoglu et al., 2017; Arioglu et al., 2018; Asık et al., 2018).

The shelling percentage (SP) values of different market type peanuts were determined to be statistically significant in terms of variety, year and interaction in three-year average (Table 3). According to the three-year average, the highest SP (78.54%) was obtained from Runner type while the lowest SP (64.09%) was from Virginia type of peanut (Table 4). The highest SP values were determined to be from Runner type peanuts than other market types.

The SP values in Runner and Spanish type peanuts were determined to be greater than 70%. Since the pods of Runner and Spanish type peanuts were small and those market types were early, their SP values were higher compared to other market types. Arioglu (2014) reported that it affects SP in peanut varieties, vegetation period, maturity index and growing conditions. On the other hands, SP of peanut are influenced by several groups of factors including environmental factors, genetic factors and interaction of these factors (Isleib et al., 2008). In many studies, reported that Runner type of peanuts have higher SP than other market type of peanuts. These results were agreement with the findings of Halder & Panda (2014), Gulluoglu et al. (2017), Kumar et al. (2017), Zapata et al. (2017), Zuza et al. (2017), Arıoglu et al. (2018), Asık et al. (2018).

There was statistically significant differences in harvest maturity index (HMI) values between different market types of peanuts (Table 3). According to the three-year average values, the HMI in the peanut varieties varied between 55.75-58.70%. As can be seen from Table 4, the highest HMI was found in Valencia type (58.70%) and the lowest was in Virginia type (55.75%). As can be seen from these values, HMI values were found higher in early market types of peanuts.

The HMI of peanuts is determined according to the “Shell out” method. The HMI is a value that determines what percentage of the pods formed in a plant at harvest time reaches harvest maturity. Low or high of this value affects pod yield and quality. Therefore, when the harvest time approaches, it should be checked whether the crop grown in the field reaches harvest maturity considering the growing period (Bakal & Arıoglu, 2020). Arıoglu et al. (2018), in a study they conducted in the Cukurova region, reported that the HWI values in different market types varied between 55.0-68.2%, and this value was higher in early varieties (G.Red in Valencia market type peanut variety). The findings obtained in this study in terms of HMI values is supported by the findings of Tuncer (1985), Arslan (2005), Gulluoglu et al. (2016), Gulluoglu et al. (2017), Arıoglu et al. (2018).

There was a statistically significant difference in pod yield (PY) values among the different market type of peanut, variety, years and interaction in three years-average (Table 3). The PY values of peanut varieties varied between 3852-7522 kg ha^{-1}. The PY values were Virginia (7522 kg ha^{-1}), Runner (5903 kg ha^{-1}), Valencia (5049 kg ha^{-1}) and Spanish (3852 kg ha^{-1}) market type of peanut varieties, respectively. The differences between the different market types of peanut varieties for the kernel yield (KY) were statistically significant (Table 3). The KY values were Virginia (4819 kg ha^{-1}), Runner (4636 kg ha^{-1}), Valencia (3417 kg ha^{-1}) and Spanish (2786 kg ha^{-1}) market type of peanut varieties, respectively. The KY was obtained in the highest Virginia type and the lowest in Spanish type. Although the SP of varieties in the Runner and Spanish types were high, the KY was low due to the low PY (Table 4).

The PY obtained in peanuts were higher, since the pods and seeds in the Virginia market types was larger. Although the PN value was also effective on yield, the PW was more effective than the PN. Peanut PY is calculated by multiplying the plant number per unit area x pod weight per plant. In this research, the pod weight per plant of peanut varieties was higher in Virginia type than in other market types of peanuts (Table 4). Indeed, in this study, this situation emerged clearly. The aim of peanut farming is to obtain high pod yields and quality products. In order to achieve this, it is necessary to select the varieties with high yield potential and to make the necessary applications on time and in accordance with the technique during the growing period. In addition, environmental factors should be appropriate throughout the growing period. Otherwise, it is not possible to reach the expected high yield level and product quality. Cox (1979), Caliskan et al. (2008) and Arioglu et al. (2018) indicated that crop management practices such as cultivar selection, time of sowing and growing period of varieties may influence the growth, yield and seed quality of peanut. The PY values of the varieties according to the growing conditions are due to their different genetic factors and being affected by environmental factors differently. The findings obtained in this study was supported by the findings obtained from some studies (Arioglu & Isler, 1990b; Asubio et al., 2008; Canavar & Kaynak, 2008; Abouziena et al., 2009; Sarkees, 2015; Sogut et al., 2016). Peanut KY value is calculated by multiplying the PY x SP. For this reason, it Is not enough to only have high PY in order to have high KY. SP values should also be high. As can be seen from Table 4; since the Runner market type had a high the SP, while the PY difference between Virginia market type and Runner market type was 1618 kg ha^{-1}, the KY difference was 183 kg ha^{-1}. Indeed, in this study it emerged clear that KY changed depending on PY and SP. Similar findings have been reported on peanut by Laurence (1983), Naab et al. (2004), Caliskan et al. (2008), Canavar & Kaynak (2008), Abouziena et al. (2009), Gulluoglu et al. (2017) and Arioglu et al. (2018).

4.2. Correlation Between Agronomic Traits

Results of correlation analysis between all agronomic traits in all market types of peanut were showed in Table 5.

The PN showed significant and positive correlation with PW (r = 0.7157), SP (r = 0.7157) and PY (r = 0.7157) traits. On the other hands, it showed significant and negative correlation with HPW (r = -0.7887) and HSW (r = -0.6334) and non-significant correlation with HMI and KY. When the PN between and HWP and HSP correlation coefficient values were analyzed, it had been significant and positive. Because, as the PN increases, the PW increases, which affects the total PY positively. Since Runner market type of peanuts developed spreading and produce more branches, they form many pods. As it can be seen in Table 4, although PN values were the highest Runner market type, the seeds and pods were less heaver compared to other market types, since the seeds and pods are small. For this reasons, the correlation coefficient between PN and HWP and HSP were negative.

Table 5. Correlation analysis results between peanuts in all agronomic characteristics in different market types

	PN	PW	HPW	HSW	SP	HMI	PY
PW	0.7157**						
HPW	-0.7887**	0.6903**					
HSW	-0.6334**	0.8265**	0.9686**				
SP	0.8868**	0.4077	0.8972**	0.8345**			
HMI	-0.2565	0.3455	0.0068	-0.1581	0.6217**		
PY	0.7927**	0.9848**	0.6646**	0.8049**	0.8819**	0.3212	
KY	0.2414	0.9078**	0.3767	0.8466**	0.7269**	0.2956	0.9228**

PN: Pod Number (no. plant^{-1}); **PW**: Pod Weight (g plant^{-1}); **HPW**: 100 Pod Weight (g); **HSW**: 100 Seed Weight (g); **SP:** Shelling Percentage (%); **HMI**: Harvesting Maturity Index (%); **PY**: Pod Yield (kg ha^{-1}); **KY**: Kernel Yield (kg ha^{-1}), **Significant differences are shown at $P < 0.01$

The PW showed significant and positive correlation with HPW (r = 0. 6903), HSW (r = 0. 8265), SP (r = 0.7077), PY (r = 0.9848) and KY (r = 0.9078) traits. No significant correlation was found between the PW value and the HMI values. When the PW correlation coefficient values were analyzed, it was understood that PY and KY were very much affected by PW. If the peanuts are too heavy the pods and seeds, the yield from the unit area will be higher. Since Virginia market type peanuts were larger than other market types, the pod and kernel yield values of Virginia type peanuts were higher. With this study, this situation was clearly demonstrated.

The HPW and the HSW showed significant and positive correlation with all agronomic trails except with HMI. As it can be seen Table 5, the correlation coefficient between HPW and HSP were quite large value (r = 0.9686). Since the seeds were formed in the pods, the weight of the seeds increased as the pod size grows. When the HPW and the HSP correlation coefficient values were analyzed, it was understood that SP, PY and KY were very much affected by both. As HSP increased, SP increased as the seeds in the pods would increase seed weight. HPW also increased due to the increased in HSW. Therefore, PY and KY increased by being positively affected by these situations.

The SP showed significant and positive correlation with all agronomic traits. As it can be seen Table 5, the correlation between SP and HMI was significant and positive (r = 0.6217). The SP was an important quality parameter in peanuts. Seed formation of early varieties was faster than late varieties in peanuts. Since the seed development in the pod was more in early peanut varieties, SP increased. Therefore, the correlation between SP and HMI was significant and positive. The correlation between SP and PY (r = 0.8819) and KY (r = 0.7269) were significant and positive. Since KY was calculated by multiplying PY with SP, KY increased with increasing SP. In addition, as SP increases, peanut seed and pod weights increase. PY was positively affected by these situations.

4.3. Quality Traits

As it can be seen Table 6, three-year average oil content (OC) of different market type peanut varieties were Runner type 51.28%, Spanish type 50.54%, Virginia type 49.87% and Valencia type 45.38%. Depending on OC values, protein content (PC) values varied similarly. In this research, the results indicated that the highest PC value was Valencia type (26.41%) followed by Virginia type (25.52%), Spanish type (25.36%) and Runner type (23.35%) (Table 5).

The OC and the PC vary depending on the market types of peanuts, the genetic factors and environmental factors (Court et al., 1984; Lu et al., 1997; Sattayarak, 1997). In general, cultivars belonging to Runner type tend to have higher oil content than other market types of peanuts. Similar results were obtained when the data of the OC and PC in this study were analyzed. Many researcher reported that the oil content values of peanut varieties in different market types showed that they ranged from 42.0-53.8% in the Spanish type, 45.0-52.6% in the Virginia type, 41.2-53.6% in the Runner type and 43.0-

48.0% in the Valencia type (Savage & Keenan, 1994; Asubio et al., 2008; Calıskan et al., 2008; Onemlı, 2012; Wang et al., 2013; Gulluoglu et al., 2017; Arioglu et al., 2018). On the other hand, since the PC value and OC value are inversely correlated, protein values are generally higher in Valencia types (Court et al., 1984; Nagaraj et al., 1991).

Table 6. Quality characteristics of different market type peanut varieties in three-year average values

Quality Traits	Market Type				
	Virginia	**Runner**	**Spanish**	**Valencia**	**LSD**
Oil Content (%)	49.87 c	51.28 a	50.54 b	45.38 d	0.530
Protein Content (%)	25.52 b	23.38 c	25.36 b	26.41 a	0.796
Palmitic Acid (C16:0) (%)	10.04 d	11.25 c	12.68 a	12.22 b	0.171
Stearic Acid (C18:0) (%)	3.10 b	2.32 c	3.36 a	3.29 a	0.172
Oleic Acid (C18:1) (%)	51.97 a	47.01 b	37.46 d	42.68 c	0.911
Linoleic Acid (C18:2) (%)	27.20 d	31.20 c	38.68 a	34.60 b	0.466
O/L Ration (%)	1.91 a	1.50 b	0.97 d	1.23 c	0.041
Iodine Value	91.80 d	94.47 c	99.23 a	96.63 b	0.506

The differences between the market types of peanut varieties for the fatty acid values were statistically significant in three-year average (Table 3). The major saturated (palmitic and stearic acid) and unsaturated (oleic and linoleic acid) fatty acids in peanut oil composition values of different market type peanut varieties in three years average was given in Table 6. As it can be seen Table 6, three-year average palmitic acid percentage was 10.04% in Virginia type, 11.25% in Runner types, 12.68% in Spanish type and 12.22% in Valencia type, while the percentage of Stearic acid percentage was 3.10% in Virginia type, 2.32% in Runner types, 3.36% in Spanish type and 3.29% in Valencia type, respectively. It was determined that the total amount of saturated fatty acid was higher in Spanish and Valencia market type of peanuts than Virginia and Runner market type of peanuts. When the proportions of unsaturated fatty acids (oleic and linoleic acid) were examined, three-year average oleic acid percentage was 51.97% in Virginia type, 47.01% in Runner types, 37.46% in Spanish type and 42.68% in Valencia type, while the percentage of linoleic acid percentage was 27.20% in Virginia type, 31.20% in Runner types, 38.68% in Spanish type and 34.60% in Valencia type, respectively (Table 6). It was determined that the total amount of unsaturated fatty acid was higher in Virginia and Runner market type of peanuts than Spanish and Valencia market type of peanuts.

The nutritive value of peanut oil is associated with its fatty acid composition, a major determining factor for oil quality. Unsaturated fatty acids make up 75-80% of the total fatty acids of peanut oil. For this reason, the nutritional value and oil quality of peanut oil is quite high. Various factors such as market types of peanuts, environmental factors (Brown et al. 1975; Sanders 1982), growing conditions and harvest time (Bakal and Arioglu, 2019) have been found to affect the fatty acid composition of peanut oil. Important factors influencing fatty acid composition are the variety and genetics factor (Gecgel et al., 2007). Similar results were obtained in many studies on fatty acids composition (Grosso & Guzman, 1995; Hinds, 1995; Onemlı, 2011; Chowdhury et al., 2015; Gulluoglu et al., 2017; Arioglu et al., 2018; Asık et al., 2018; Bakal & Arioglu, 2019).

As it can be seen in Table 3, the differences between the market types of peanut varieties for the O/L ratio and iodine value (IV) were statistically significant in three-year average. The O/L ratio and IV in peanut oil composition of different market type peanut varieties in three years average was given in Table 6. As it can be seen Table 5, three-year average O/L ratio was 1.91% in Virginia type, 1.50% in Runner types, 0.97% in Spanish type and 1.23% in Valencia type, respectively. The highest O/L ratio value was obtained from Virginia market type compared to other market types of peanut. As it can be seen IV in Table 6, the highest IV (99.23) was obtained from Spanish market type while the lowest IV (91.80) was from Virginia market type of peanut.

The ratio of oleic acid to linoleic acid (O/L ratio) and iodine values (IV) determine the nutritional quality, storability and shelf-life of peanut oil and its products. A high oleic to linoleic (O/L) acid ratio (>10:1) in peanut results an increased self-life (up to 10 times) and improved flavor when compared to a normal O/L ratio (1.5/1). In addition, the iodine value was used to determine the degree of unsaturated fatty acid and the stability of peanut oil. High O/L ratio and low IV value generally indicate good stability and long shelf-life (Young & Worthington, 1974; Chaiyadee et al., 2013; Chamberlin et al., 2014; Escobedo et al., 2015). These results were in agreement with the findings of How and Young (1983), Raheja et al. (1987), Hashim et al. (1993), Hinds (1995), Andersen & Gorbet (2002), Chaiyadee et al. (2013), Chamberline et al. (2014), Chowdhury et al. (2015), Gulluoglu et al. (2016), Arioglu et al. (2018) and Bakal & Arioglu, (2019) were indicated similar results.

4.4. Correlation between Quality Traits

Results of correlation analysis between all quality traits in all market types of peanut were showed in Table 7.

Table 7. Correlation analysis results between peanuts in all quality characteristics in different market types

	OC	PC	C16:0	C18:0	C18:1	C18:2	O/L
PC	-0.7177**						
C16:0	-0.2778	0.3308					
C18:0	-0.5110**	0.8577**	0.3685				
C18:1	0.1573	-0.3185	-0.9338**	-0.4189			
C18:2	-0.1566	0.3165	0.9419**	0.4264	-0.9943**		
O/L	0.1927	-0.2799	-0.9467**	-0.3596	0.9881**	-0.9917**	
IV	-0.1562	0.3103	0.9297**	0.4196	-0.9793**	0.9902**	-0.9837**

OC: Oil Content (%); **PC**: Protein Content (%); **C16:0**: Palmitic Acid; **C18.0**: Stearic Acid; **C18:1**: Oleic Acid; **C18:2**: Linoleic Acid; **O/L**: Oleic Acid/Linoleic Acid; **IV**: Iodine Value, **Significant differences are shown at $P < 0.01$

The OC showed significant and negative correlation with PC (r = -0.7177) and C18:0 (r = -0.5110) traits. On the other hands, it showed non-significant correlation with other fatty acids, O/L ration and IV. Peanuts have an important place among oilseed plants due to the high rate of oil (45-55%) in their seeds (Arioglu, 2014). In addition to its high oil content, it contains 18-26% protein. While the oil percentage was increased, the protein percentage was decreased. Many studies have found that there is a negative correlation between OC and PC (Tai and Young, 1974; Sepulveda and Pancholy, 1980; Wynne and Gregory, 1981).

The C16:0 showed significant and positive correlation with C18:2 (r = 0.9419) and IV (r = 0.9297) traits. But, it showed significant and negative correlation with C18:1 (r = -0.9338) and O/L value (r = -0.9297). When C16:0 correlation coefficient values were analyzed, it, an unsaturated fatty acid, caused an increase in C18:1 and IV and a decrease in C18:1 and O/L value. As it can be seen Table 7, The C18:1 showed significant and negative correlation with C18:2 (r = -0.9943) and IV (r = -0.9793) traits. In peanut oil, C18:1 and C18:2 fatty acids turn into one another depending on the temperature difference day and night. When night temperatures are low, C18:2 fatty acid is synthesized and the synthesized C18:2 fatty acid is converted to C18:1 fatty acid according to daytime temperatures. Therefore, there was an inverse correlation between C18:1 and C18:2. With this study, the accuracy of this result has been proved. On the other hands, it showed significant and positive correlation with O/L (r = 0.9881) traits. Since O/L and IV values were calculated by C18:1 and C18:2 ratio, C18:1 increased with increasing O/L value, on the contrary, IV value decreased. The same was actual in the relationship of correlation 18.2 with O/L and IV. While C18:2 showed significant and negative correlation with O/L ratio, it showed significant and positive correlation with IV.

5. CONCLUSION

As a result of this study, it has been determined that different types of market peanuts have important effects on the important agricultural and quality characteristics of peanut farming, which has an important place for the Mediterranean region. It was determined that the most suitable variety in the main crop peanut farming in Cukurova region was Virginia market type of peanut variety (Halisbey), which was superior in terms of many agronomic and quality characteristics. It was concluded that G.Green variety, which is included in the Runner market type, could be grown in the Cukurova region because of its high yield potential and on the other hand, the varieties in the other market types were weak in terms of yield and quality characteristics of peanut.

It was determined that the total saturated fatty acid was higher in Spanish and Valencia market types. On the other hand, the total unsaturated fatty acid was higher in Virginia and Runner market types. When the quality characteristics were investigate, it was revealed that Virginia market type given better results since it was higher in terms of pod yield. It was determined that the Runner market type was alternative to the Virginia type, and all the traits of Spanish and Valencia market type were far behind than other types.

REFERANCES

Abouziena, H. F. H., Sharma, S. D., & Singh, M. (2009). Impact of adjuvants on bentazon efficacy on selected broadleaf weeds. *Crop Protection*, *28*(12), 1081-1085.

Andersen, P. C., & Gorbet, D. W. (2002). Influence of year and planting date on fatty acid chemistry of high oleic acid and normal peanut genotypes. *Journal of Agricultural and Food Chemistry*, *50*(5), 1298-1305.

AOAC (1990). Official methods of analysis of the association of the official analysis chemists. Association of official analytical chemists (15th ed.). Washington, DC.

Arıoğlu, H. H., & Isler, N. (1990a). Çukurova Bölgesinde ana ürün olarak yetiştirilecek bazı Runner ve Virginia tipi yerfıstığı (*Arachis hypogaea* L.) çeşitleri üzerine bir araştırma. *ÇÜ ZF Dergisi*, *5*(3), 121-136.

Arioglu, H. H., & İşler, N. (1990b). Çukurova bölgesinde ana ürün olarak yetiştirilecek bazı Spanih ve Valencia tipi yerfıstığı (*Arachis hypogaea* L.) çeşitleri üzerine bir araştırma. *ÇÜ ZF Dergisi*, *5*(4), 95-110.

Arioglu, H., Bakal, H., Gulluoglu, L., Onat, B., & Kurt, C., (2018). The effect of harvesting dates on some agronomic and quality characteristics of peanut (*Arachis hypogaea* L.) varieties grown as a main crop in Mediterranean region (Turkey). *Turkish Journal of Field Crops*, *23*(1), 27-37.

Arioglu, H., (2014). The oil seed crops growing and breeding. *The publication of University of Cukurova, Faculty of Agriculture* No:A-70, 204 p. Adana-Turkey.

Arslan, M. (2005). Effects of haulm cutting time on haulm and pod yield of peanut. *Journal of Agronomy*. 4: 39-43.

Asık, F, F., Yıldız, R., & Arioglu, H. H. (2018). Osmaniye koşullarına uygun yeni yerfıstığı çeşitleri ile bunların önemli tarımsal ve kalite özelliklerinin belirlenmesi. *Tarim ve Doga Dergisi*, *21*(6), 825.

Asibuo, J. Y., Akromah, R., Safo-Kantanka, O., Adu-Dapaah, H. K., Ohemeng-Dapaah, S., & Agyeman, A. (2008). Chemical composition of groundnut, *Arachis hypogaea* (L) landraces. *African Journal of Biotechnology*, *7*(13): 2203-2208

Escobedo, R., Hernández-Luna, P., Joaquín-Torres, I. C., Ortiz-Moreno, A., & Robles-Ramírez, M. D. C. (2015). Physicochemical properties and fatty acid profile of eight peanut varieties grown in Mexico. *CyTA-Journal of Food*, *13*(2), 300-304.

Bakal, H., & Arioglu, H. (2019). The determination of fatty acids composition and oil quality factors of some peanut varieties having different market types at different harvesting times in main and double crop growing seasons in Mediterranean region. *Turkish Journal of Field Crops*, *24*(2), 221-229.

Balota, M., & Phipps, P. (2013). Comparison of Virginia and Runner-type peanut cultivars for development, disease, yield potential, and grade factors in eastern Virginia. *Peanut Science*, *40*(1), 15-23.

Brown, D. F., Cater, C. M., Mattil, K. F., & Darroch, J. O. (1975). Effect of variety, growing location and their interaction on the fatty acid composition of peanuts. *Journal of Food Science*, *40*(5), 1055-1060.

Caliskan, S., Caliskan, M. E., Erturk, E., Arslan, M., & Arioglu, H. (2008). Growth and development of Virginia type groundnut cultivars under Mediterranean conditions. *Acta Agriculturae Scandinavica Section B-Soil and Plant Science*, *58*(2), 105-113.

Canavar, Ö., & Kaynak, M. A. (2010). Growing degree day and sunshine radiation effects on peanut pod yield and growth. *African Journal of Biotechnology*, *9*(15), 2234-2241.

Chaiyadee, S., Jogloy, S., Songsri, P., Singkham, N., Vorasoot, N., Sawatsitang, P., ... & Patanothai, A. (2013). Soil moisture affects fatty acids and oil quality parameters in peanut. *Int. J. of Plant Production* 7(1), 81-96.

Chamberlin, K. D., Barkley, N. A., Tillman, B. L., Dillwith, J. W., Madden, R., Payton, M. E., & Bennett, R. S. (2014). A comparison of methods used to determine the oleic/linoleic acid ratio in cultivated peanut (Arachis hypogaea L.). *Agricultural Sciences*, 5(3):227-237.

Chowdhury, F. N., Hossain, D., Hosen, M., & Rahman, S. (2015). Comparative study on chemical composition of five varieties of groundnut (*Arachis hypogaea*). *World J. of Agricultural Science*, *11*(5), 247-254.

Court, W. A., Roy, R. C., & Hendel, J. G. (1984). Effect of harvest date on agronomic and chemical characteristics of Ontario peanuts. *Canadian journal of plant science*, *64*(3), 521-528.

Cox, F. R. (1979). Effect of temperature treatment on peanut vegetative and fruit growth. *Peanut Science*, *6*(1), 14-17.

FAO, 2019. Fao Statistical Databases. http://www.fao.org internet page

Gecgel, U., Demirci, M., Esendal, E., & Tasan, M. (2007). Fatty acid composition of the oil from developing seeds of different varieties of safflower (Carthamus tinctorius L.). *Journal of the American Oil Chemists' Society*, *84*(1), 47-54.

Grosso, N. R., Lamarque, A., Maestri, D. M., Zygadlo, J. A., & Guzman, C. A. (1995). Fatty acid variation of runner peanut (Arachis hypogaea L.) among geographic localities from Cordoba (Argentina). *Journal of the American Oil Chemists' Society*, *71*(5), 541-542.

Gulluoglu, L., Bakal, H., Onat, B., Kurt, C., & Arioglu, H. (2016). The effect of harvesting date on some agronomic and quality characteristics of peanut grown in the Mediterranean region of Turkey. *Turkish Journal of Field Crops*, *21*(2), 224-232.

Gulluoglu, L., Bakal, H., Onat, B., Kurt, C., & Arioglu, H. (2017). Comparison of agronomic and quality characteristics of some peanut (Arachis hypogaea L.) varieties grown as main and double crop in Mediterranean region. *Turkish Journal of Field Crops*, *22*(2), 166-177.

Halder, D., & Panda, R. K. (2014). Determination of appropriate sowing date and phosphorus fertilization strategy for peanut in Eastern India. *African Journal of Agricultural Research*, *9*(32), 2475-2487.

Hassan, F., & Ahmed, M. (2012). Oil and fatty acid composition of peanut cultivars grown in Pakistan. *Pakistan Journal of Botany*, *44*(2), 627-630.

Hashim, I. B., Koehler, P. E., Eitenmiller, R. R., & Kvien, C. K. (1993). Fatty acid composition and tocopherol content of drought stressed Florunner peanuts. *Peanut Science*, *20*(1), 21-24.

Hinds, M. J. (1995). Fatty acid composition of Caribbean-grown peanuts (*Arachis hypogaea* L.) at three maturity stages. *Food Chemistry*, *53*(1), 7-14.

How, J. S., & Young, C. T. (1983). Comparison of fatty acid content of imported peanuts. *Journal of the American Oil Chemists' Society*, *60*(5), 945-947.

Isleib, T. G., Tillman, B. L., Pattee, H. E., Sanders, T. H., Hendrix, K. W., & Dean, L. O. (2008). Genotype-by-environment interactions for seed composition traits of breeding lines in the uniform peanut performance test. *Peanut Science*, *35*(2), 130-138.

Kaba, J. S., Ofori, K., & Kumaga, F. K. (2014). Inter-Relationships of Yield and Components of Yield at Different Stages of Maturity in Three Groundnuts (*Arachis hypogaea* L) Varieties. *International J. of Life Science Research*, *2*(1), 43-48.

Ketring, D. L., Jordan, W. R., Smith, O. D., & Simpson, C. E. (1982). Genetic variability in root and shoot growth characteristics of peanut. *Peanut Science*, *9*(2), 68-72.

Knauft, W. R., Fehr, E. L., & Jessen, H. J. (1987). *Principles of cultivar development* (Vol. 1). New York: Macmillan.

Kumar, A., Kumar, M., & Virender, P. (2017). Effect of sowing time on growth, phenology and yield attribute of summer groundnut (*Arachis hypogaea* L.) in Allahabad. *Int. J. Curr. Microbiol. App. Sci*, *6*(4), 2357-2365.

Kurt, C., Bakal, H., Güllüoğlu, L., & Onat, B. (2016). Çukurova Bölgesinde İkinci Ürün Koşullarında Bazı Yerfıstığı Çeşitlerinin Önemli Agronomik ve Kalite Özelliklerinin Belirlenmesi. *SDU Journal of the Faculty of Agriculture, 11*(1), 112-119.

Kurt, C., Bakal, H., Gulluoglu, L., & Arioglu, H. (2017). The effect of twin row planting pattern and plant population on yield and yield components of peanut (*Arachis hypogaea* L.) at main crop planting in

Cukurova region of Turkey. *Turkish Journal of Field Crops*, *22*(1), 24-31.

Laurence, R. C. N. (1983). Effects of sowing date, spatial arrangement and population on yield and kernel weight of irrigated Virginia Bunch peanuts. *Australian Journal of Experimental Agriculture*, *23*(121), 178-180.

Liao, B., & Holbrook, C., (2007). *Groundnut*. Singh, R.J. (Ed.), Genetic Researches, Chrosome Engineering, and Crop Improvement, CRC Pres. New York, USA 4:51-87.

Lu, K. C., Yeh, M. S., Yang, K. H., & Lu, H. S. (1997). Effects of genotype, population density and harvest date on yield and quality of peanut. *Journal of Agrıcultural Research of Chına*, *46*, 116-131.

Naab, J. B., Singh, P., Boote, K. J., Jones, J. W., & Marfo, K. O. (2004). Using the CROPGRO-peanut model to quantify yield gaps of peanut in the Guinean Savanna Zone of Ghana. *Agronomy Journal*, *96*(5), 1231-1242.

Nagaraja, M. S., Parama, V. R., Siddaramappa, R., & Rajagopal, D. (1997). The effect of pesticides on dehydrogenase, phosphatase and urease activities in some selected soils of Karnataka. *J. Soil. Biol. Ecol*, *17*(1), 45-53.

Onat, B., (2018). The determination of Tocopherol composition of some peanut cultivars grown in main crop growing conditions in Cukurova Region. *Acta Biologica Turcica*, *31*(2), 62-68.

Onemli, F. (1995). *The improving early maturing peanut cultivars by progeny controlled single plant selection method* (Doctoral dissertation, Thesis PhD. University of Trakya, Institute of Natural Sciences, Department of Field Crops, Edirne, Turkey.

Onemli, F. (2012). Impact of climate change on oil fatty acid composition of peanut (*Arachis hypogaea* L.) in three market classes. *Chilean Journal of Agricultural Research*, *72*(4), 483.

Raheja, R. K., Batta, S. K., Ahuja, K. L., Labana, K. S., & Singh, M. (1987). Comparison of oil content and fatty acid composition of peanut genotypes differing in growth habit. *Plant Foods for Human Nutrition*, *37*(2), 103-108.

Rahmianna, A. A., Taufiq, A., & Yusnawan, E. (2009). Pod yield and kernel quality of peanut grown under two different irrigations and two harvest times. *Indonesian Journal of Agriculture*, *2*(2), 103-109.

Ramanatha, R. V., & Murty, U. R. (1994). Botany-morphology and anatomy. The Groundnut crop, a scientific basis for improvement. Chapter 3. 43-95 Edited by J. Smartt Department of Biology Southampton University, UK.

Sanders, T. H., Shubert, A.M., Pattee, H.E., (1982). Maturity methodology and postharvest physiology. *Peanut science and technology*. Pattee, H.E. and Young, C.T. (eds.) Yoakum: American Peanut Research and Education Society Inc. 625-627.

Sarkees, N. A. (2015). Effect of sowing dates on development, seed yield and quality of some peanut (*Arachis hypogaea* L.) genotypes. *Jordan J Agric Sci*, *11*(2), 67-380.

Sattayarak, S., & Laosuwan, P. (1997). Effects of harvesting dates on different characters and seed quality of peanut grown in Southern Thailand. In *12. Thailand National Peanut Meeting, Udon Thani (Thailand), 25-27 Oct 1994*.

Savage, G. P., & Keenan, J. I. (1994). The composition and nutritive value of groundnut kernels. In *The groundnut crop* (pp. 173-213). Springer, Dordrecht.

Sepulveda, R., & Pancholy, S. K. (1980). Oil, total protein, and amino acid composition of 80 peanut lines and cultivars. *Proceedings, American Peanut Research and Education Society, Inc.* 12(1), 59-68.

Sharma, P., Sardana, V., & Kandhola, S. S. (2013). Effect of sowing dates and harvesting dates on germination and seedling vigor of groundnut (*Arachis hypogaea*) cultivars. *Research Journal of Seed Sciences*, *6*(1), 1-15.

Sogut, T., Ozturk, F., & Kizil, S. (2016). Effect of sowing time on peanut (*Arachis hypogaea* L.) cultivars: II. Fatty acid composition. *Agriculture and Agricultural Science Procedia*, *10*, 76-82.

Tai, Y. P., & Young, C. T. (1975). Genetic studies of peanut proteins and oils. *Journal of the American Oil Chemists' Society*, *52*(9), 377-385.

Wang, Z., Xu, Z. H., Zheng, H., Zong, H. Y., & LI, L. (2013). Effect of peanut hull biochar on amelioration of typical orchard acidic soil in northern China. *Periodical of Ocean University of China*, *43*(8), 86-91.

Wynne, J. C., & Gregory, W. C. (1981). Peanut breeding. In *Advances in agronomy* (Vol. 34, pp. 39-72). Academic Press.

Young, C. T., Worthington, R. E., Hammons, R. O., Matlock, R. S., Waller, G. R., & Morrison, R. D. (1973). Fatty acid composition of Spanish peanut oils as influenced by planting location, soil moisture conditions, variety, and season. *Journal of the American Oil Chemists Society*, *51*(7), 312-315.

Zapata, N., Henriquez, L., & Finot, V. L. (2017). Caracterización y clasificación botánica de veintidos líneas de maní (Arachis hypogaea L.) Evaluadas en la Provincia de Nuble, Chile. *Chilean journal of agricultural & animal sciences*, *33*(3), 202-212.

Zuza, E. J., Muitia, A., Amane, M. I. V., Brandenburg, R. L., & Mondjana, A. M. (2017). Effect of harvesting time on groundnut yield and yield components in Northern Mozambique. *Journal of Postharvest Technology*, *5*(2), 55-63.

THIRD CHAPTER

BIOACTIVE PROPERTIES OF PEANUT; POLYPHENOLS

Seydi YIKMIŞ[1]
Nazan TOKATLI DEMİROK[2]
Melikenur TÜRKOL[3]
Behiye İncisu AYDOĞDU[4]

[1] Associate Professor, Department of Food Technology, Tekirdag Namık Kemal University, ORCID: 0000-0001-8694-0658
[2] Assistant Professor, Department of Nutrition and Dietetics, Health School, Tekirdag Namık Kemal University, ORCID: 0000-0003-1936-9337
[3] Master's degree Student, Department of Medical Genetics, Institute of Health Sciences, Tekirdag Namık Kemal University, ORCID: 0000-0001-7354-9529
[4] Master's degree Student, Department of Nutrition and Dietetics, Institute of Health Sciences, Tekirdag Namık Kemal University, ORCID: 0000-0001-6250-9628

1.INTRODUCTION

Among the nuts and oilseeds, peanuts are among the well-known sources of phenolic compounds (Alasalvar & Bolling, 2015). Peanuts were originally grown in South America; It is common in many tropical and subtropical regions of the world, especially in Asia, America, and Africa (Bertioli et al., 2011). Today, peanuts are consumed in almost all countries, thanks to their unique flavor and versatility in processing. According to the report of the United States Department of Agriculture, peanut production has increased. China leads the way in production, followed by India, Nigeria, and the United States, respectively (World Agricultural Production | USDA Foreign Agricultural Service, 2022).

It has also been proven that phenolics and/or polyphenolics, which have beneficial effects on health through the prevention of cardiovascular diseases, diabetes, and obesity, have anticancer, anti-inflammatory, and antimicrobial effects (Lin et al.., 2016; Shahidi & Ambigaipalan, 2015). The increase in peanut production has also increased the peanut by-products formed as a result of their processing and made research on the use of these products, which are rich in bioactive components, encouraged. Especially processes such as drying and bleaching applied to peanuts increase the antioxidant and antimicrobial activities of the polyphenols in the peanut content (Chukwumah et al., 2009). In this study, the properties and health effects of polyphenols, which give peanuts bioactive properties, were investigated.

2. PEANUT

2.1. History of Peanuts

The peanut, named *Arachis hypogaea* L., is grown on sandy soils and is found in grasslands, open forest areas, and temporarily flooded areas (Bertioli et al., 2011). Peanuts, whose history dates back to the time of the ancient Peruvian Indicates, were a part of religious ceremonies at that time and were presented to the sun god. Peanuts are called ynchic by these societies. The civil war that started in America in the 1860s brought the modern history of peanuts, to begin with. George Washington, who developed more than 300 products derived from peanuts, has been described as the father of the peanut industry (Carver, 1925). In the 1890s, peanut butter was introduced by Doctor St. for people with weak teeth to consume as a soft protein source. Recommended by Louis. Having patented the peanut flour preparation process in 1895, Dr. Peanut flour was used by John Harvey Kellogg to serve the soldiers. In the early 1900s, John Mariana applied the oil-roasting process of in-shell peanuts, according to the "American Encyclopedia of Food and Drink," and the roasted peanuts were packaged in airtight bags. In 1928, Rosenfield J started its brand of peanut butter production process by licensing its peanut butter to Peter Pan peanut butter manufacturers. In this way, peanut butter became commercialized and popular in America, and peanut butter began to spread all over the world (Shahidi & Ambigaipalan, 2015).

2.2. Composition of Peanuts

Peanuts, which are rich in fiber, which is a complex carbohydrate, do not contain cholesterol. The crude protein value of peanut seeds is 22-30%, and thanks to the high protein content in its structure, it is preferred especially for vegetarian and vegan people to fill the protein deficit (Mutegi et al., 2013).

The presence of 50% oil in the structure of peanut, an oily seed, has caused peanuts to be described as an unhealthy food in previous years. However, recent studies have made it preferable to consume peanuts, as they illuminate the beneficial effects of peanuts on health (Toomer, 2017; Zhao et al., 2012).

The energy and nutrient composition of peanuts is given in Table 1 (United States Department of Agriculture (USDA), 2018).

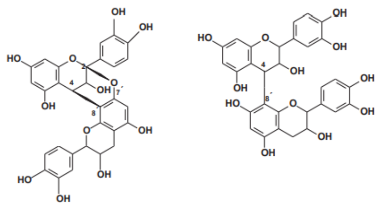
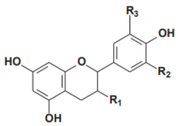
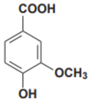
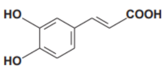
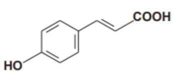
Table 1. Energy and nutrient composition of raw peanuts (100 g) (United States Department of Agriculture (USDA), 2018)

Energy and Nutrients	Quantity
Energy (kcal)	567
Protein (g)	25,8
Fat (g)	49,24
Carbs (g)	16,13
Cholesterol (mg)	-
Polyunsaturated fatty acid (g)	15,558
Monounsaturated fatty acid (g)	24,426
Saturated fatty acid (g)	6,279
Pulp (g)	8,5
Folate (µg)	240
Iron (mg)	4,58
Selenium (µg)	7,2
Phosphorus (mg)	376
Thiamine (mg)	0,64
Sodium (mg)	18
Vitamin B6 (mg)	0,348
Copper (mg)	1,144
Magnesium (mg)	168
Potassium (mg)	705
Riboflavin (mg)	0,135
Vitamin E (alpha-tocopherol)	8,33
Zinc (mg)	3,27
Calcium (mg)	92
Niacin (mg)	12,066

2.3. Phenolic Compounds in Peanut Shell

Peanuts usually consist of an outer shell containing two kernels. Each of these structures is surrounded by a thin, paper-like membrane known as the peanut shell. For the production of peanuts, shelled raw peanut kernels are obtained by the bleaching process. This process; is carried out by exposing the shelled raw peanut kernels to short-term, light dry heat treatment and mechanical abrasion. Peanut shells are also rich in bioactive components, polyphenols (Zhao et al., 2012).

Figure 1 shows the chemical structures of the main types of phenolic compounds in peanut shell extracts. It has been observed that the composition of peanuts changes depending on the extraction methods and solvents applied. It has been accepted that the chemical profiles and total phenol content of pistachio species, which vary according to the shell color, also differ (Attree et al., 2015; Chukwumah et al., 2009; Shem-Tov et al., 2011).

	**Proanthocyanidins** Peanut shell phenolics are mostly oligomeric proanthocyanidins. These refer to dimer and trimer polymerizations of flavanol (flavan-3ol) subunits (especially catechin or epicatechin) linked via carbon bonds between flavans. The most common proanthocyanidins found in peanut shells are homo-oligomeric catechin or epicatechin.
 **Flavanoller** — R_1 / R_2 / R_3 (Epi) Kateşin — OH / OH / H epigallokateşin — OH / OH / OH epikateşin gallat — GA / H / OH epigallokateşin gallat — GA / OH / OH	**Flavonoids** The most abundant monomeric flavonoids in peanuts; flavanols are catechin and epicatechin. They present two chiral centers (C2 and C3); so there can be four possible diastereoisomers. Two of these have the trans configuration (catechins) and the other two have the cis configuration (epicatechins).
 **anilik asit**  **Kafeik asit**  **Kumarik asit**	**Phenolic acids** They are minor components of peanut phenolic extracts. They can have a C6 C1 structure (hydroxybenzoic acid derivatives) or a C6 C3 structure (hydroxycinnamic acid derivatives). Vanillic, caffeic, and pcoumaric acids are common phenolic acids found in peanuts.

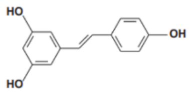
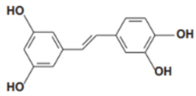
 **trans-Resveratrol**  **trans Piceatannol**	**Stilbene Derivatives** trans-Resveratrol and trans-piceatannol are the principal stilbenes (1,2-diphenylethylene) hydroxylated derivatives found in peanut shells. Resveratrol glucosides, coumaric and tartaric acid conjugates may be present as minor components.

Figure 1. Main types of phenolic compounds in a peanut shell

3.BIOACTIVE PROPERTIES OF PEANUT; POLYPHENOLS

Studies show that peanuts and peanut shells are rich in phenolic acids (Francisco & Resurreccion, 2008). In addition, studies indicate that peanuts contain high concentrations of polyphenolic antioxidants, especially p-coumaric acid, and this situation increases the antioxidant capacity of peanuts by 22% (Duncan et al., 2006). The antioxidant role of polyphenolic acids in roasted peanut shells has become clear as a result of studies (Lopes et al., 2011).

It is stated that flavonoids, which are found in all parts of the peanut plant and show bioactive properties, have a protective effect against cancer and reduce the risk of cardiovascular diseases through various mechanisms. Studies on the beneficial effects of bioactive compounds on health; focus on peanuts and peanut butter as the main source of flavonoids, and also says that the types of bioactive compounds found in peanuts are the same as the types of bioactive compounds found in green tea, black tea, apples, red wine, and soybeans (Duggan et al., 2002; Francisco & Resurreccion, 2008).

Ripe peanut shells contain rich sources of tannins, accounting for more than 50% of the dry weight. These tannins are called phenolic compounds (Hagerman & Butler, 2002). The rich tannin content in the peanut shell also acts as a plant protector by showing antifungal and antimicrobial effects (Davis et al., 2010). Polyphenols, which function as antioxidants, are easily absorbed from the intestinal wall and prevent cellular damage due to oxidative stress radicals (Gonçalves et al., 2017; Viapiana & Wesolowski, 2017).

The hydroxyl derivative p-coumaric acid, a polyphenolic compound found in the peanut shell, was between 8 mg/kg and 66 mg/kg in raw peanuts, while this value increased to 69 mg/kg as a result of roasting peanuts (Talcott et al., 2005).

4. CONCLUSION

Peanut, which is among oil seeds and nuts, gains a functional feature with the creation of various by-products. Proving the positive effects of bioactive compounds in peanuts on health has made them preferable. The high content of complex carbohydrates and amino acids in its structure makes peanuts attractive in terms of nutritional value. The presence of polyphenols rich in bioactive compounds, especially in peanut shells, increases the antioxidant capacity and helps in adopting protective approaches against diseases such as cardiovascular diseases and cancer. At the same time, it has been stated that peanuts can play a role in the prevention of chronic diseases such as obesity and diabetes, thanks to their unsaturated fatty acid content

REFERENCES

Alasalvar, C., & Bolling, B. W. (2015). Review of nut phytochemicals, fat-soluble bioactives, antioxidant components and health effects. *British Journal of Nutrition*, *113*(S2), S68–S78. https://doi.org/10.1017/S0007114514003729

Attree, R., Du, B., & Xu, B. (2015). Distribution of phenolic compounds in seed coat and cotyledon, and their contribution to antioxidant capacities of red and black seed coat peanuts (Arachis hypogaea L.). *Industrial Crops and Products*, *67*, 448–456. https://doi.org/10.1016/J.INDCROP.2015.01.080

Bertioli, D. J., Seijo, G., Freitas, F. O., Valls, J. F. M., Leal-Bertioli, S. C. M., & Moretzsohn, M. C. (2011). An overview of peanut and its wild relatives. *Plant Genetic Resources*, *9*(1), 134–149. https://doi.org/10.1017/S1479262110000444

Carver, G. W. (1925). How to grow the peanut and 105 ways of preparing it for human consumption. Içinde *Tuskegee Institute Experimental Station Bulletin* (C. 31, Sayı 31). https://www.nal.usda.gov/exhibits/ipd/carver/items/show/27

Chukwumah, Y., Walker, L. T., & Verghese, M. (2009). Peanut Skin Color: A Biomarker for Total Polyphenolic Content and Antioxidative Capacities of Peanut Cultivars. *International Journal of Molecular Sciences 2009, Vol. 10, Pages 4941-4952*, *10*(11), 4941–4952. https://doi.org/10.3390/IJMS10114941

Davis, J. P., Dean, L. L., Price, K. M., & Sanders, T. H. (2010). Roast effects on the hydrophilic and lipophilic antioxidant capacities of peanut flours, blanched peanut seed and peanut skins. *Food Chemistry*, *119*(2), 539–547. https://doi.org/10.1016/J.FOODCHEM.2009.06.057

Duggan, C., Gannon, J., & Allan Walker, W. (2002). Protective nutrients and functional foods for the gastrointestinal tract. *The American journal of clinical nutrition*, *75*(5), 789–808. https://doi.org/10.1093/AJCN/75.5.789

Duncan, C. E., Gorbet, D. W., & Talcott, S. T. (2006). Phytochemical content and antioxidant capacity of water-soluble isolates from peanuts (Arachis hypogaea L.). *Food Research International*, *39*(8), 898–904. https://doi.org/10.1016/J.FOODRES.2006.05.009

Francisco, M. L. D. L., & Resurreccion, A. V. A. (2008). Functional Components in Peanuts. *http://dx.doi.org/10.1080/10408390701640718*, *48*(8), 715–746. https://doi.org/10.1080/10408390701640718

Gonçalves, S., Moreira, E., Grosso, C., Andrade, P. B., Valentão, P., & Romano, A. (2017). Phenolic profile, antioxidant activity and enzyme inhibitory activities of extracts from aromatic plants used in

Mediterranean diet. *Journal of food science and technology*, *54*(1), 219–227. https://doi.org/10.1007/S13197-016-2453-Z

Hagerman, A. E., & Butler, L. G. (2002). Protein precipitation method for the quantitative determination of tannins. *Journal of Agricultural and Food Chemistry*, *26*(4), 809–812. https://doi.org/10.1021/JF60218A027

Lin, S. T., Tu, S. H., Yang, P. S., Hsu, S. P., Lee, W. H., Ho, C. T., Wu, C. H., Lai, Y. H., Chen, M. Y., & Chen, L. C. (2016). Apple Polyphenol Phloretin Inhibits Colorectal Cancer Cell Growth via Inhibition of the Type 2 Glucose Transporter and Activation of p53-Mediated Signaling. *Journal of Agricultural and Food Chemistry*, *64*(36), 6826–6837. https://doi.org/10.1021/ACS.JAFC.6B02861/SUPPL_FILE/JF6B02861_SI_001.PDF

Lopes, R. M., Da Silveira Agostini-Costa, T., Gimenes, M. A., & Silveira, D. (2011). Chemical composition and biological activities of Arachis species. *Journal of agricultural and food chemistry*, *59*(9), 4321–4330. https://doi.org/10.1021/JF104663Z

Mutegi, C., Wagacha, J., Christie, M., Kimani, J., & Karanja, L. (2013). Effect of storage conditions on quality and aflatoxin contamination of peanuts (Arachis hypogaea L.) . *International Journal of Agriscience* , *3*(10), 746–758. https://www.semanticscholar.org/paper/Effect-of-storage-conditions-on-quality-and-of-L.)-Mutegi-Wagacha/720ec7a53125ca6a73853cadfadb1b5967b5bd1f

Shahidi, F., & Ambigaipalan, P. (2015). Phenolics and polyphenolics in foods, beverages and spices: Antioxidant activity and health effects – A review. *Journal of Functional Foods*, *18*, 820–897. https://doi.org/10.1016/J.JFF.2015.06.018

Shem-Tov, Y., Badani, H., Segev, A., Hedvat, I., Galili, S., & Hovav, R. (2011). Determination of Total Polyphenol, Flavonoid and Anthocyanin Contents and Antioxidant Capacities of Skins From Peanut (Arachis Hypogaea) Lines With Different Skin Colors. *Journal of Food Biochemistry*, *36*(3), 301–308. https://doi.org/10.1111/J.1745-4514.2011.00539.X

Talcott, S. T., Duncan, C. E., Pozo-Insfran, D. Del, & Gorbet, D. W. (2005). Polyphenolic and antioxidant changes during storage of normal, mid, and high oleic acid peanuts. *Food Chemistry*, *1*(89), 77–84. https://doi.org/10.1016/J.FOODCHEM.2004.02.020

Toomer, O. T. (2017). Nutritional chemistry of the peanut (Arachis hypogaea). *Critical Reviews in Food Science and Nutrition*, *58*(17), 3042–3053. https://doi.org/10.1080/10408398.2017.1339015

United States Department of Agriculture (USDA). (2018). https://fdc.nal.usda.gov/

Viapiana, A., & Wesolowski, M. (2017). The Phenolic Contents and Antioxidant Activities of Infusions of Sambucus nigra L. *Plant foods* *for human nutrition (Dordrecht, Netherlands)*, *72*(1), 82–87. https://doi.org/10.1007/S11130-016-0594-X

World Agricultural Production | USDA Foreign Agricultural Service. (2022, Mart 9). https://www.fas.usda.gov/data/world-agricultural-production

Zhao, X., Chen, J., & Du, F. (2012). Potential use of peanut by-products in food processing: a review. *Journal of food science and technology*, *49*(5), 521. https://doi.org/10.1007/S13197-011-0449-2

FOURTH CHAPTER

DETERMINATION OF SUITABLE PEANUT CULTIVARS FOR ALTERNATIVE AFTERCROP IN SOUTHEASTERN ANATOLIA REGION

İbrahim ÖZEL[1]

Enver KENDAL[2]

[1] Master's Student, Mardin Artuklu University, Institute of Graduate Education, Department of Field Crops, ORCID: 0000-0001-6431-5915

[2] Assoc. Prof. Dr., Mardin Artuklu University, Kızıltepe Vocational School, Department of Plant and Animal Production, ORCID: 0000-0002-8812-8847

1. INTRODUCTION

Peanut research (*Arachis hypogaea* L.) has an important option in both the alternation cycle and second crop cultivation in the world, because, on the one hand, it preserves the soil characteristics with crop rotation, on the other hand, it allows two crops to be grown in one production season (Barbieri at al., 2017). Many different hoe crops are used in rotation or as a secondary crop in the world, one of which is peanuts. Recently, peanut maintains its importance as the preferred oilseed crop after cereals, sometimes as the main crop in rotation and sometimes as a second crop. As in the world, peanut cultivation, both as the main product and as a secondary product, has an important place in Turkey.

The total annual peanut production of world is nearly 49.0 million tons in around 25.0 million hectares of production area. The top five manufacturers of producer countries are respectively; it includes China, India, Nigeria, Sudan and the United States of America. On the other hand, Turkey is far behind in this ranking with 42.244 hectares production area, 164.186 tons production and 3.887 per hectare an average production (Anonymous 1, 2022).

Turkey has great potential in terms of Peanut cultivation and 90% amount of production grown in Mediterranean region mainly in Adana and Osmaniye provinces. Hatay, Kahramanmaraş, Antalya and partially Şırnak are other provinces where peanuts are grown, respectively (Anonymous 2). Some areas of Mardin province are similar to these provinces in terms of climate and soil conditions. In this province, corn and cotton plants, which are grain and hoe plants, are grown alternately. However, lately, increase in costs of cotton cultivation and the lack of workers have completely left its place to corn in second crop cultivation. However, alternative products that can alternate in the second crop product are being researched, since the corn plant both exploits the soil and needs a high amount of water and increases the cost of electricity due to the fact that irrigation is done with pressurized systems. Since good results were obtained in the second peanut cultivation, which was carried out under farmer conditions in 2020 in Mardin.

Multiple-cropping systems is obtaining a product from one or more plants during a growing season. Multiple-cropping systems for peanut have potential in the some places where a prolonged growing season exists (Li et al., 2022). Full-season of wheat production typically pushes peanut planting later than optimum, but a relay-intercrop (RI) system may allow peanut to be planted on-time while still harvesting wheat grain.

Southeastern Anatolia Region has a very long vegetation period for plant cultivation due to ecological factors. Due to this feature, two products, the main and the second product, can be easily grown during a crop growing season. In this region, usually wheat and barley are grown as the main products. As the second crop, mostly cotton and corn cultivation are preferred. However, recently, due to the increase in cotton production costs, it has almost completely left its place to corn cultivation. Since the corn plant weakens the soil very much and the water is limited in this region, alternative products to corn cultivation are also being researched. For this reason, peanuts are also among the searches for a second product in the same growing season after wheat or barley cultivation in Mardin. For this purpose, it was studied on the determination suitable of peanut varieties for the second product after wheat and barley cultivation in Mardin.

2. MATERIAL AND METHOD

As material, a total of 10 peanut cultivars (Aysehanım, Batem-Cihangir, Batem-5025, Çom, Efsane Florispan, Gazipaşa, Halisbey, Masal, NC-7) were used in the study in 2021 growing season in Küçükköy village of Mardin/Artuklu province. The climatic values of growing season and long term average showed in Table 1.

Table 1. The climatic values of growing season and long-term average.

Months	Temperature(°C)		Precipaticion(mm)		Humidity(%)	
	2021	Average	2021	Average	2021	Average
June	26.9	25.6	0	6.6	22.6	32
July	31.3	29.8	0	3.2	21.2	27.7
August	31	29.6	0	2.3	22.6	28.7
September	24.8	25.3	0	4	29	32.9
October	19.7	18.6	9.5	33.9	31.2	44.1
Total /Mean	26.7	25.8	9.5	50.0	25.3	33.1

www.tüik.gov.tr.

As can be seen in Table 1, the precipitation amount in 2021, when the experiment was carried out, was lower than the long period. In the average temperature, it is seen that the first three months are warmer than the long-term average, and it is cooler in September and October. When we look at the humidity values, it shows that the humidity rate in the growing season is lower than in the long years and the experiment was carried out in a dry season.

The trial was established as a second product. After the wheat was harvested, the soil was processed and made ready for planting, then the seed bed was prepared and the peanut planted. It was established as 3 replications according to the Random Blocks Trial Design, and a total of 10 peanut varieties were used in the study. The total trial area is 481 m2, parcel dimensions are 3 m x 2.8 m (8.4 m2); Each block consists of 10 plots and each plot consists of 4 rows of plants. The spacing between rows was 70 cm and the spacing between rows was 20 cm, 60 seeds were placed in each plot, and sowing was done by hand in the incisions made with a marker at a depth of 4-6 cm. In the experiment, the distance between the blocks was arranged as 2 m and the distance between the parcels in each block was 1 m, and 3.6 kg/da pure nitrogen and 9.2 kg/da pure phosphorus were applied by giving 20 kg of DAP (18-46-0) with planting.

Trial sowing was done on 07.06.2021 and 1 day after planting, irrigation was carried out for 6 hours with the sprintler irrigation methods. In the experiment, the first emergence was observed 11 days after the planting date. The second irrigation was carried out for 6 hours, 3 days after the first emergence. The first hoeing was done on 21.07.2021 and irrigation was carried out for 6 hours on 10.07.2021. The second hoeing was done on 17.08.2021 and three days later, irrigation was done again for 6 hours. After 1 week, 4-hour irrigation was performed again. Harvest was done on 17.11.2021, the plants were left to dry in the field for 2 days and then threshed on 19.11.2021.

In research, PH (plant height), NMB (number of main branches), NBP (number of pod per plant), SR (Shelling rate), GYP (grain yield pod of per plant), GYP (grain yield seed of per plant), GW (weight of 100 seeds), GY (grain yield of pod), GY (grain yield of seed) were examined.

The data analyzed respectively for each location and combined by using the JMP 5.0. Statistical software package(SAS, 2002) and the differences between means were compared using a least significant difference (LSD) test at the 0.05 probability level (Steel, 2001).

3. RESULTS AND DISCUSSION

The combined ANOVA revealed highly significant differences among the cultivars for all traits ($P < 0.01$, $P < 0.05$), as shown in Table 2.

Table 2. The MS of traits which examined in the study.

Sources	df	PH	NBP (ea/plant)	NMP (ea/plant)	SR (%)	GYP (pod)	GYP (seed)	GW(g) (100 seed)	GY (pod)	GY (seed)
Cultivar	9	39.21*	0.19*	81.12**	45.9**	548.6**	149.8**	515.19**	20841.6**	4651.7**
Rep.	2	13.7	0.03	11.24	0.09	13.23	3.07	8.5	119.3	145.16
Error	18	13.11	0.06	6.18	2.02	10.34	5.05	12.9	85.3	66.77
LSD(0.05)		6.21	0.43	4.263	2.441	5.517	3.855	6.164	15.85	14.02
CV(%)		6.3	5.07	6.82	3.44	3.45	5.79	4.07	2.35	5.05

**: Value significant at 0.01 probability level, * Value significant at 0.05 probability level

Moreover, Cultivars were found to be highly significant (P < 0.01) for NMP, SR, GYP(pod), GYP(seed), GW, GY(pod), GY(seed), while for PC PH, NMB were found significant (P < 0.05).

Plant height: As can be seen from the table of the average values of plant height of the cultivars used in the study, varied between 52.5-62.1 cm (Table 3). Among the cultivars, the tallest cultivar with a height of 62.1 cm was the Batem-Cihangir, while the shortest cultivar with a height of 52.5 cm was observed to be the Masal variety used in the experiment. Plant height averages obtained in the study were higher than the averages obtained from Elinc and Erman, (2021), Kayantas (2015) results. The reasons why the plant heights obtained from this study are higher than the plant heights obtained from other studies; It is thought to be caused by reasons such as ecological factors, cultivars, planting time, amount of water and soil structure.

Table 3. The means of the traits of cultivars in 2021year

Cultivars	Plant height (cm)	Number branch of per plant(ea/plant)	Number of mature pods (ea/plant)	Shelling Ratio(%)
Aysehanım	60.9 ac	4.73 bd	38.9 ab	43.3 bc
Batem-Cihang.	62.1 a	5.20 a	41.4 ab	40.2 e
Batem-5025	61.0 ab	4.67 cd	32.4 de	43.7 bc
Çom	54.7 cd	5.13 ab	40.3 ab	40.4 de
Efsane	53.1 d	5.07 ac	34.6 cd	41.3 ce
Florispan	60.1 ac	5.07 ac	42.5 a	33.6 g
Gazipaşa	56.0 ad	5.13 ab	37.3 bc	47.1 a
Halisbey	54.9 bd	4.87 ad	27.3 f	37.0 f
Masal	52.5 d	4.60 d	40.0 ab	42.7 bd
NC-7	59.7 ac	4.53 d	29.7 ef	44.8 ab

PH (plant height), NMB (number branches of per plant), NFP (Number of mature pods (ea/plant)), SR (kernel rate),

Number of main branches: As can be seen from the table of the average values of main branches of the cultivars used in the study, varied between 4.53-5.20 count (Table 3). Among the cultivars, the number of branches in the plant was determined at the highest number with 5.20 at the Batem-Cihangir variety, while the least number with 4.53 at the NC-7 variety used in the study. Average number of branches per plant were found to be lower than the averages obtained by Elinc and Erman (2021), Caliskan et al. (1998) and Kayantaş (2015). These differences thought to be caused by reasons such as ecological factors, cultivars, planting time(second crop) and soil structure.

Number of fruits per plant; As can be seen from the table of the average values of NFP of the cultivars used in the study, varied between 27.3-42.5

count(Table 3). Among the cultivars, the number of branches in the plant was determined at the highest number with 42.5 at the Florispan variety, while the least number with 27.3 at the Halisbey variety used in the study. Average number of branches per plant were found to be higher than the averages obtained by Tunçtürk et al., (2005), lower than the averages obtained by Caliskan et al. (1998) and Kayantaş (2015), were foun to be similiar averages obtained by Elinc and Erman (2021), Cil et al. (2011) and Sogut at al.(2016). These differences thought to be caused by reasons such as ecological factors, irrigation, cultivars type, planting time(second crop) and soil structure.

Number of shelling rate; as can be seen from the table of the average values of shelling rate of the cultivars used in the study, varied between %33.6-47.1 (Table 3). Among the cultivars, the shelling rate was determined at the highest number with %47.1 at the Gazipaşa variety, while the least shelling rate with %27.3 at the Florispan variety used in the study. Average shelling rate were found to be lower than the averages obtained by Boydak at al. (2019), Kurt at al. (2016) and Oh at al.(2020). These differences thought to be caused by reasons such as ecological factors, irrigation, cultivars type, planting time(second crop) and soil structure.

Grain yield (pod) per plant: as can be seen from the table of the average values of grain yield (pod) per plant of the cultivars used in the study, varied between 71.7-120.0 (Table 4).

Table 4. The means of the traits of cultivars in 2021year.

Cultivars	Grain yield per plant (g)		100-seed weight (g)	Grain yield kg/ha^{-1}	
	pod	seed		pod	seed
Aysehanım	108.3 b	46.9 b	103.4 a	4534 c	1964 b
Batem-Cihangir	90.0 de	36.4 de	99.3 ab	3968 d	1595 c
Batem-5025	93.3 cd	40.6 c	80.7 c	2143 f	937 f
Çom	89.7 de	36.3 de	85.0 c	3609 e	1452 d
Efsane	97.5 c	40.0 cd	69.6 d	3901 d	1602 c
Florispan	71.7 g	25.1 f	96.4 b	3504 e	1255 e
Gazipaşa	81.0 f	37.9 ce	82.4 c	3577 e	1571 cd
Halisbey	91.0 de	34.1 e	68.1 d	4033 d	1455 d
Masal	120.0 a	51.3 a	96.6 b	5079 a	2143 a
NC-7	87.7 e	39.3 cd	102.5 ab	4906 b	2207 a

GYP (pod yield per plant), GYP (grain yield per plant), WS (weight of 100 seeds), GY (pod), GY (grain yield)

Among the cultivars, the grain yield(pod) per plant was determined at the highest number with 120.0 at the Gazipaşa variety, while the least grain yield(pod) per plant with 71.7 at the Florispan variety used in the study. Average grain yield(pod) per plant were found to be lower than the averages obtained by were found to be higher than averages obtained Kurt at al. (2016) and Onat at al. (2017). These differences thought to be caused by reasons such as ecological factors, irrigation, cultivars type, planting time(second crop) and soil structure.

Grain yield(seed) per plant: as can be seen from the table of the average values of grain yield(seed) per plant of the cultivars used in the study, varied between 25.1-51.3 g (Table 4). Among the cultivars, the grain yield(seed) per plant was determined at the highest number with 51.3 at the Masal variety, while the least grain yield(pod) per plant with 25.1 at the Florispan variety used in the study. Average grain yield(pod) per plant were found to be similiar averages obtained by Arıoğlu at al. (2018). These differences thought to be caused by reasons such as ecological factors, irrigation, cultivars type, planting time(second crop) and soil structure.

100 seed weight; as can be seen from the table of the average values of seed weight of the cultivars used in the study, varied between 68.1-103.4 g (Table 4). Among the cultivars, the seed weight was determined at the highest number with 103.4 g at the Ayşehanım variety, while the least number with 68.1 at the Halisbey variety used in the study. Average seed weight were found to be higher than the averages obtained by Oh at al., (2020), lower than the averages obtained by Arıoğlu et al. (2018) and Onat at al. (2017), were found to be similiar averages obtained by Elinc and Erman (2021) and Sogut at al.(2016). The differences thought to be caused by reasons such as ecological factors, irrigation, cultivars type, planting time(second crop) and soil structure.

Grain yield (pod): as can be seen from the table of the average values of grain yield (pod) of the cultivars used in the study, varied between 3504-5079 kg/ha^{-1} (Table 4). Among the cultivars, the grain yield(pod) was obtained from Masal (5079 kg/ha^{-1}) variety, while the least grain yield (pod) per plant was obtained from Florispan (3504 kg/ha^{-1}) variety used in the study. Average grain yield (pod) were found to be higher than the averages obtained by Kurt at al. (2016) Bonfim at al. (2020) and were found to be lower than the averages obtained by Onat at al. (2017), were found to be similiar averages obtained by Arıoğlu at al., (2018), Oh et al., (2020). These differences thought to be caused by reasons such as ecological factors, irrigation, cultivars type, planting time(second crop) and soil structure.

Grain yield (seed): as can be seen from the table of the average values of grain yield (seed) of the cultivars used in the study, varied between 937-2207 kg/ha^{-1} (Table 2). Among the cultivars, the grain yield (seed) was obtained from NC-7 (5079 kg/ha^{-1}) variety and there was not any differences with Masal variety, while the least grain yield(seed) per plant was obtained from Florispan (937 kg/ha^{-1}) variety used in the study. Average grain yield(seed) were found to be lower than the averages obtained by Bonfim at al. (2020), Onat at al. (2017), were found to be similiar averages obtained by Elinc and Erman (2021), Oh et al., (2020)and Sogut at al.(2016). These differences thought to be caused by reasons such as ecological factors, irrigation, cultivars type, planting time(second crop) and soil structure.

Genetic adaptation is the most important criterion for the successful production of any crop in a particular agroecological region. The results indicate that there are important results in terms of adaptation of peanut varieties to the plain conditions of Mardin province. It was observed that there were statistically significant differences between the cultivars in terms of both yield and yield components. The main factor in the formation of these differences can be explained by the ecological characteristics of the region, the reactions of the varieties used in the study and the effect of the planting period (second crop). Previously, by different researchers (Yolbaş, 2018) and Elinc and Erman (2021), it was determined that the peanuts grown in the region were suitable for the ecology of the region, and it was stated in the studies that there were significant differences depending on the applications and the adaptation of the cultivars. On the other hand; Elinc and Erman (2021) and Ijaz et al. (2021) pointed out that peanut is a species with wide adaptability that can be grown in arid and semi-arid ecology with or without irrigation, and they reported that significant yield and quality differences occur depending on the cultivars and planting dates. Haerani et al. (2020) reported that peanut genotypes developed different adaptation potentials against various biotic and abiotic stress factors, and accordingly, plant development and crop yield showed significant differences. Ramu et al. (2015) found that peanut genotypes with Alfalfa zinc finger 1 (Alfin1) gene activity had a higher level of tolerance to arid conditions, so they stated that gene activities were the determining factor on adaptation to the region.

4. CONCLUSIONS AND RECOMMENDATIONS

According to the results obtained from peanut grown as a second product after wheat in Mardin plain conditions; NC-7 and Masal cultivars showed high performance in terms of yield and yield traits, while Florispan cultivar performed poorly. Although it is grown as a second crop, more satisfactory results have been obtained than the results of many studies carried out under different conditions in terms of yield other traits. According to these results, it was concluded that it can be easily grow peanuts in Mardin plain conditions, NC-7 and Masal varieties can be recommended for cultivation. However, it would be beneficial to repeat the study for one more year for clearer recommendations.

REFERANCES

Anonymous 2. http://www.turktob.org.tr/dergi/makaleler/dergi7/30-33.pdf

Anonymus 1. 2022. https://www.atlasbig.com/en-us/countries-peanut-production

Arioglu, H., Bakal, H., Gulluoglu, L., Bihter, O., & Kurt C. (2018), "The effect of harvesting dates on some agronomic and quality characteristics of peanut (*Arachis hypogaea* L.) varieties grown as a main crop in Mediterranean region (Turkey)". Turkish Journal of Field Crops, 23(1), 27-37.

Barbieri, J. D., Dallacort, R., Faria, C. A., De Freitas, P. S., & De Carvalho, M. A. (2017), "Peanut cultivars submitted to irrigation levels and nitrogen adubation in tropical climate". Engenharia Agrícola, 37, 1126-1136.

Bonfim-Silva, E. M., Takenaka, P. Y., Nonato, J. J., Guimaraes, S. L., & da Silva, T. J. A. (2020), "Productive characteristics of peanut cultivars fertilized with wood ash". Australian Journal of Crop Science, 14(4), 691-696.

Boydak, Ç., Orhan, Kara., Arslan, R., Çil, A. N., Abdullah, Çil., Barut, H., & Irmak, S. (2019), "Farklı çinko ve demir dozlarının NC-7 Yer Fıstığı (*Arachis hypogaea* L.) çeşidinde verim ve verim ögeleri üzerine etkisi". Ziraat Fakültesi Dergisi, 14(2), 134-142.

Çalışkan, M.E., Mert, M., İşler, N., Çalışkan, S. (1998), "Agronomic and quality characteristics of some virginia type peanut genotypes (*Arachis hypogaea* L. subs. hypogaea var. hypogaea) and effects of these characters on yield formation as an alternate crop in Hatay district". Turkish Journal of Agriculture and Forestry, 24: 87-94.

Elinç, H., & Erman, M. (2021), "The research on the seed yield and some agricultural properties of Peanut cultivars cultivated as main product in Siirt ecological conditions". ISPEC Journal of Agricultural Sciences, 5(3), 598-607.

Haerani, H., Apan, A., Basnet, B. (2020), "The climate-induced alteration of future geographic distribution of aflatoxin in peanut crops and its adaptation options". Mitigation and Adaptation Strategies for Global Change, 25: 1149-1175.

Ijaz M, Nawaz A, Ul-Allah S, Sher A, Sattar A, Sarwar M, Hussain, I., Ur Rehman, A., Wahid, M.A., Ansari, M.J., Hessini, K. (2021), "Optimizing sowing date for peanut genotypes in arid and semi-arid subtropical regions". Plos One, 16(6): e0252393.

Kayantas, B. (2015), Determination of yield and yield components of some peanut varieties (*Arachis hypogaea* L.) in Bingol conditions. Bingol University, Graduate School of Natural and Applied Sciences, Master's Thesis.

Kurt, C., Bakal, H., Güllüoğlu, L., & Onat, B. (2016), "Determination of agronomic and quality characteristic of some peanut cultivars in the second crop conditions of the Cukurova Region". SDU Journal of the Faculty of Agriculture/ 11(1): 112-119.

Li, L., Zou, Y., Wang, Y., Chen, F., & Xing, G. (2022), "Effects of Corn Intercropping with Soybean/Peanut/Millet on the Biomass and yield of Corn under fertilizer Reduction". Agriculture, 12(2), 151.

Oh, E., Pae, S. B., Park, J. E., Kim, J. I., Kim, S., Lee, M. H., & Ha, T. J. (2020), "Effect of Harvest Time on Yield Components and Quality in' Heuksaeng', the Purple-Skin Peanut Variety". Korean Journal of Crop Science, 65(3), 248-254.

Onat, B., Bakal, H., Gulluoglu, L., & Arioglu, H. (2016), "The effects of row spacing and plant density on yield and yield components of peanut grown as a double crop in mediterranean environment in Turkey". Turkish Journal of Field Crops, 22(1), 71-80.

Ramu, V.S., Swetha, T.N., Sheela, S.H., Babitha, C.K., Rohini, S., Reddy, M.K., Tuteja, N., Reddy, C.P., Prasad, T.G., Udayakumar, M. (2015), "Simultaneous expression of regulatory genes associated with specific drought-adaptive traits improves drought adaptation in peanut". Plant Biotechnology Journal, 14(3): 10081020.

SAS, (2020), "Institute". JMP Statistics. Cary, NC, USA: SAS Institute, Inc., 707 p. 2002.

Sogut, T., Ozturk, F., & Kizil, S. (2016), "Effect of sowing time on peanut (*Arachis hypogaea* L.) cultivars: yield, yield components, oil and protein content". Scientific Papers-Series A, Agron. 2016b, 59, 415-420.

Steel, R.G.D and Torrie. J.H. (2001), "Principles and Procedures of Statistics: A Biometrical Approach". 2. ed. New York: McGraw-Hill Publ. Company, 1980.

Tunçtürk, M., Eryiğit, T., Arslan, B. (2005), "Determination of yield and yield components of some peanut cultivars grown in lake Van Basin". Journal of Çukurova University Faculty of Agriculture, 20(2): 109-116.

Yolbaş, M. (2018), The effect of different planting times on yield and yield components of peanut (*Arachis hypogaea* L.) in Siirt conditions. Siirt University, Graduate School of Natural and Applied Sciences, Master's Thesis, 23-45.

FIFTH CHAPTER

DETERMINATION OF SUITABLE PEANUT TYPES FOR AFTERCROP PRODUCT IN SOUTHEASTERN ANATOLIA REGION BY BIPLOT ANALYSIS MODEL

Enver KENDAL[1]
İbrahim ÖZEL[2]

[1] Assoc. Prof. Dr., Mardin Artuklu University, Kızıltepe Vocational School, Department of Plant and Animal Production, ORCID: 0000-0002-8812-8847
[2] Master's Student, Mardin Artuklu University, Institute of Graduate Education, Department of Field Crops, ORCID: 0000-0001-6431-5915

1. INTRODUCTION

As in all researches, many statistical models and programs are used to evaluate the data obtained from agricultural researches (Kendal, 2019). The important thing is to ensure that these statistical programs and models can be used easily by researchers and that researchers can easily reach the right results in a short way. Moreover, it is to discover and find statistical models that researchers can easily use and interpret, and to offer these models to the service of researchers by researching them (Yan, and Frégeau-Reid, 2018). For this reason, the subject of research always maintains its importance and up-to-datedness. Research, it is to obtain data within the scope of a scientific method in order to make progress on a particular subject, to resolve uncertainties and problems, and to analyze these data, to interpret them in a comprehensible way and to contribute to the source of the result for later researchers.

Constantly analyzing or interpreting the data obtained from the researches with the same methods hinders the development of researches. For this reason, especially the development of science leads to the development of some new analysis methods (Mahmoud et al., 2020). The use of developed new analysis methods in the evaluation and interpretation of research results increases the importance of research results. It is a fact that researchers have recently applied Bi-plot analysis technique a lot, especially in the evaluation of plant breeding and variety compatibility research results (Kuo et al., 2021; Oppong-Sekyere et al., 2019).

Bi-plot has attracted the attention of researchers with many evaluation models and is preferred to evaluate many research results (Nigam, 2008; Yan, and Frégeau-Reid, 2008) . Among these models, the GT (Genotype x Trait) biplot model is used the most. This model is also used as an alternative to the GGE (Genotype, Genotype x Environment) biplot to determine the trait profiles of genotypes(Yan, 2016). In a GT-biplot model, genotypes are analysed bi-directionally according to traits. One of them is designed to understand the differences of genotypes from each other according to traits, and the second is designed to understand the relations of genotypes with traits. In other words, genotypes can be evaluated in terms of a single trait as well as visually in terms of all traits.

In this study, yield and yield components of 10 Peanut (*Arachis hypogaea* L.) varieties, which were researched after wheat as the second product in the plains of Mardin province, were investigated by biplot technique. The main aim of this study; was to see 1) what kind of relationship (positive-negative) there is between genotypes and traits, 2) which traits are in the same sector with genotypes and the trait profiles of genotypes, 3) which genotypes are stable according to the average data obtained from the traits examined, 4) which genotypes are the most ideal according to the ideal center created according to the average data of the traits.

2. MATERIAL AND METHOD

As material, a total of 10 peanut cultivars (Aysehanım, Batem-Cihangir, Batem-5025, Çom, Efsane Florispan, Gazipaşa, Halisbey, Masal, NC-7) were used in the study in 2021 growing season in Küçükköy village of Mardin/Artuklu province. The climatic values of growing season and long term average showed in Table 1.

Table 1. The climatic values of growing season and long-term average.

Months	Temperature(°C)		Precipaticion(mm)		Humidity(%)	
	2021	Average	2021	Average	2021	Average
June	26.9	25.6	0	6.6	22.6	32
July	31.3	29.8	0	3.2	21.2	27.7
August	31	29.6	0	2.3	22.6	28.7
September	24.8	25.3	0	4	29	32.9
October	19.7	18.6	9.5	33.9	31.2	44.1
Total /Mean	26.7	25.8	9.5	50.0	25.3	33.1

www.tüik.gov.tr.

As can be seen in Table 1, the precipitation amount in 2021, when the experiment was carried out, was lower than the long period. In the average temperature, it is seen that the first three months are warmer than the long-term average, and it is cooler in September and October. When we look at the humidity values, it shows that the humidity rate in the growing season is lower than in the long years and the experiment was carried out in a dry season.

The trial was established as a second product. After the wheat was harvested, the soil was processed and made ready for planting, then the seed bed was prepared and the peanut planted. It was established as 3 replications according to the Random Blocks Trial Design, and a total of 10 peanut varieties were used in the study. The total trial area is 481 m2, parcel dimensions are 3 m x 2.8 m (8.4 m2); Each block consists of 10 plots and each plot consists of 4 rows of plants. The spacing between rows was 70 cm and the55paceng between rows was 20 cm, 60 seeds were placed in each plot, and sowing was done by hand in the incisions made with a marker at a depth of 4-6 cm. In the experiment, the distance between the blocks was arranged as 2 m and the distance between the parcels in each block was 1 m, and 3.6 kg/da pure nitrogen and 9.2 kg/da pure phosphorus were applied by giving 20 kg of DAP (18-46-0) with planting.

Trial sowing was done on 07.06.2021 and 1 day after planting, irrigation was carried out for 6 hours with the sprintler irrigation methods. In the experiment, the first emergence was observed 11 days after the planting date. The second irrigation was carried out for 6 hours, 3 days after the first emergence. The first hoeing was done on 21.07.2021 and irrigation was carried out for 6 hours on 10.07.2021. The second hoeing was done on 17.08.2021 and three days later, irrigation was done again for 6 hours. After 1 week, 4-hour irrigation was performed again. Harvest was done on 17.11.2021, the plants were left to dry in the field for 2 days and then threshed on 19.11.2021.

In research, PH (plant height), NMB (number of main branches), NBP (number of pod per plant), SR (Shelling rate), GYP (grain yield pod of per plant), GYP (grain yield seed of per plant), GW (weight of 100 seeds), GY (grain yield of pod), GY (grain yield of seed) were examined.

The data analyzed respectively for each location and combined by using the JMP 5.0. Statistical software package(SAS, 2002) and the differences between means were compared using a least significant difference (LSD) test at the 0.05 probability level (Steel, 2001).

3. RESULTS AND DISCUSSION

The results were analyzed with graphs in terms of the average data(Table 1) of cultivars and traits used in the study and the correlations among traits showed in Table 2.

Table 3. The means of the traits of cultivars in 2021year

Cultivars	PH (cm)	NMB (ea/plant)	NBP (ea/plant)	SR (%)	GY(ea/plant)		WG (100 seeds)	GY(kg/ha^{-1}))	
					pod	seed		pod	seed
Aysehanım	60.9	4.73	38.9	43.3	108.3	46.9	103.4	4534	1964
Batem-Cihang.	62.1	5.20	41.4	40.2	90.0	36.4	99.3	3968	1595
Batem-5025	61.0	4.67	32.4	43.7	93.3	40.6	80.7	2143	937
Çom	54.7	5.13	40.3	40.4	89.7	36.3	85.0	3609	1452
Efsane	53.1	5.07	34.6	41.3	97.5	40.0	69.6	3901	1602
Florispan	60.1	5.07	42.5	33.6	71.7	25.1	96.4	3504	1255
Gazipaşa	56.0	5.13	37.3	47.1	81.0	37.9	82.4	3577	1571
Halisbey	54.9	4.87	27.3	37.0	91.0	34.1	68.1	4033	1455
Masal	52.5	4.60	40.0	42.7	120.0	51.3	96.6	5079	2143
NC-7	59.7	4.53	29.7	44.8	87.7	39.3	102.5	4906	2207

PH (plant height), NMB (number of main branches), NBP (number of pod per plant), SR (Shelling rate), GYP (grain yield pod of per plant), GYP (grain yield seed of per plant), GW (weight of 100 seeds), GY (grain yield of pod), GY (grain yield of seed) were examined.

In the analysis, the two-dimensional PCA score constituted 63.68% of the total variation, while PC2 included 42.45% and PCI 21.24%, respectively. With the biplot technique, the relationship between GT (genotype x trait) were examined visually by different figures. The GT Bi-plot showed that, 1) what kind of relationship (positive-negative) there is between genotypes and traits, 2) which traits are in the same sector with genotypes and the trait profiles of genotypes, 3) which genotypes are stable according to the average data obtained from the traits examined, 4) which genotypes are the most ideal according to the ideal center created according to the average data of the traits. With these graphics, the cultivars used in the study were examined in terms of the examined traits.

Table 2. The correlations among traits which examined in the study.

	PH(cm)	NMP (ea/plant)	NBP (ea/plant)	SR (%)	GYP (pod)	GYP (seed)	GW (g/100 seed)	GY (pod (kg/ha)
NMP(ea/plant)	-0.062							
NBP(ea/plant)	0.1216	0.4723						
SR(%)	-0.0328	-0.3375	-0.1884					
GYP(pod)	-0.3414	-0.5276	0.0174	0.3398*				
GYP(seed)	-0.2569	-0.5726	-0.0308	0.6676	0.9246**			
GW(g/100 seed)	0.5608	-0.2853	0.4989	0.1204	0.1333	0.2029		
GY(pod(kg/ha)	-0.2754	-0.326	0.0365	0.1028	0.4788	0.4318	0.4546	
GY (seed/kg/ha)	-0.2004	-0.4368	0.0026	0.381	0.53	0.5868	0.5248	0.9518**

**: Value significant at 0.01 probability level, * Value significant at 0.05 probability level, PH (plant height), NMB (number of main branches), NBP (number of pod per plant), SR (Shelling rate), GYP (grain yield pod of per plant), GYP (grain yield seed of per plant), GW (weight of 100 seeds), GY (grain yield of pod), GY (grain yield of seed) were examined.

Sector analysis (Figure 1) shows how genotypes and traits are grouped by creating regions over the average data of traits (Fig. 1).

In Figure 1, each segment of the x curve starting from 0.0 in the positive direction and dividing the graph with thick curves towards the center of the graph is called a sector and continues as 1, 2, 3… to the right. Masal and NC-7 cultivars located in first sector(1) and correlated with GYP(pod), GYP(seed), GY(pod) and GY(seed); Ayşehanım located in sector 2 and correlated with WG/100 seed); Florispan, Batem-Cihangir and Çom cultivars located in sector 3 and correlated with NMB, PH and NPB traits; Gazipaşa, Batem-5025, Efsane and Halisbey, located in sector 4 and did not correlated with any traits, it means that these four cultivars have poor results in terms of traits. The Masal variety located in top of angle sector 1, Ayşehanım in sector 2, Florispan in sector 3 and Halisbey in sector 4. In particular, it proves that the varieties located at the corner of the triangle in each sector are more effective than other varieties and have good results in the sector. According to these results, the varieties should be preferred which located side of the yield and yield traits. On the other hand; it can be say that the cultivars used in the study which located in different sectors, it can be said that and these cultivars genetically far from each other, and they are genetically closer to each other if they are located in the same sector.

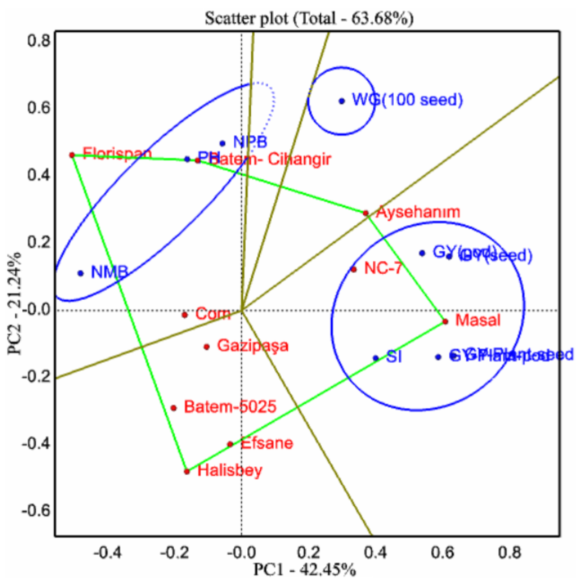


Figure 1. Sector analysis and grouping of circles based on the averages of traits

In addition, genotypes (Masal, Ayşehanım, Florispan and Halisbey) located in the center of the triangle in each sector mean that they are more dominant than other genotypes in the sector they are located. Kendal (2015)' sector biplot plot is called polygon and is highly based on original data. In addition, Letta et al. (2008)' reported that the results of the sector analysis can be easily recommended. Kizilgeçi et al., (2019) and Chinipardaz et al., (2016) reported that if the genotypes and environments are located in different sectors, there is a negative relationship if they are located in the same sector, a positive relationship if they are located in the same sector, and a mixed interaction if all of them are located in the same sector.

The scatter plot (Figure 2), show the relationships between genotypes and traits over the average data of the traits. It is possible to see two-way results in this figure. The first is the correlations between traits. In this graph, there is a high positive correlation (Gypod and Gyseed), when the angle of triangle between the vectors of the traits gets narrower. On the other hand, when the angle of triangle value is more than 90^0 degrees (SI and Gypod), then the relationship of these traits are weakens. Also there is a negative relationship (SI and NMB), when the angle of triangle value is more than 100^0 degrees. When we observe all the traits on the graph, we can see the correlations among traits. Therefore there is high correlations among SI, Gypod, Gyseed, GYPpod, GYPseed and between NPB,TH, while negative correlations between NMB and GY-Traits(SI, Gypod, Gyseed, GYPpod, GYPseed)(Table 2).

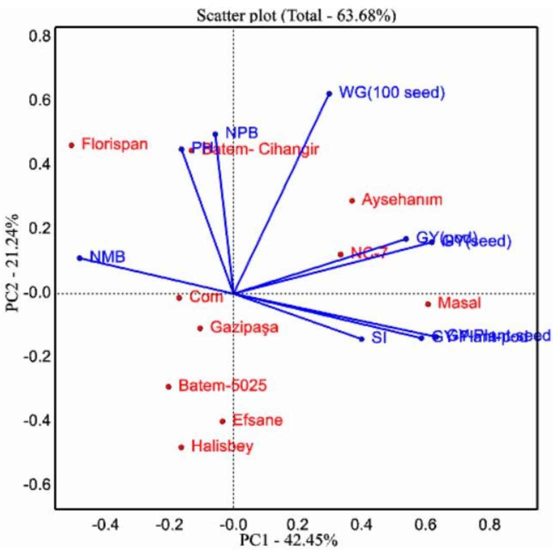


Figure 2. The figure show genotype-trait and relations between traits

Some researchers had same results like these results and Sanogo et al., (2019)’ reported that there is high correlations between pod yield and grain yield. The second is the relationship cultivars-traits. The cultivars located near of the traits, related with them, as Masal and NC-7 varieties which have good result based on value of average traits. On the other hand, Batem-Cihangir variety related with PH and NPB traits. Other traits (Masal, Ayşehanım, Florispan and Halisbey) did not correlated with any traits, because they were located independent area. In selection, the GT biplot technique makes it easy for us to visually interpret the relationships. It is possible to say that the longer the vectors showing the traits, the higher the special adaptive abilities (ie, in terms of specific properties), and the shorter the general adaptive abilities (i.e., most of the cultivars in terms of traits). Many researchers have stated in different studies that there is a positive relationship between the vectors of two features as the angle value (>0--<90^o) gets narrower, and a negative relationship as the angle value (90^o>-<180^o) increases (Mohammadi and Amri, 2011).

The Ranking biplot (Figure 3) method shows the stability of the cultivars and the most suitable cultivars over the average of all traits. This graph is usually explained by two curves (vertical and horizontal, indicated by arrows) that are created over the average of all traits. The horizontal curve shows the mean of the traits, and the vertical curve with the arrow shows the stability of the cultivars in terms of the mean of all traits. In this graph, it is seen that Ayşehanım and NC-7 located the center of stable, it mean that these two cultivars are most stable based on average of traits, while Masal and Cihangir-Batem are favorable cultivars in terms of the average of all traits, because these two cultivars proved to be quite far from the stable line. On the other hand; Efsane, Batem-5025, Gazipaşa, Florispan, Halisbey cultivars are unfavorable, because they are located under mean line of average traits.

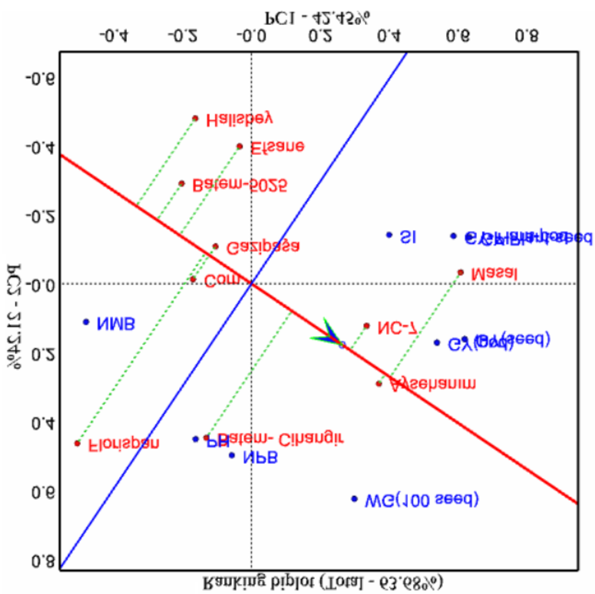


Figure 3. The figure show stability of cultivars based on mean of traits

Therefore, Ayşehanim, NC-7 and Masal varieties can be advise to Mardin plane conditions for cultivation. The researchers reported that this model is a good model to see and select visually stable cultivars in breeding studies and constitutes an exemplary model (Mohammadi and Amri, 2011; Mohammadi, 2019).

Comparison biplot (Figure 4) method determines the most suitable cultivars by positioning the cultivars according to the ideal center formed over the average of all the traits.

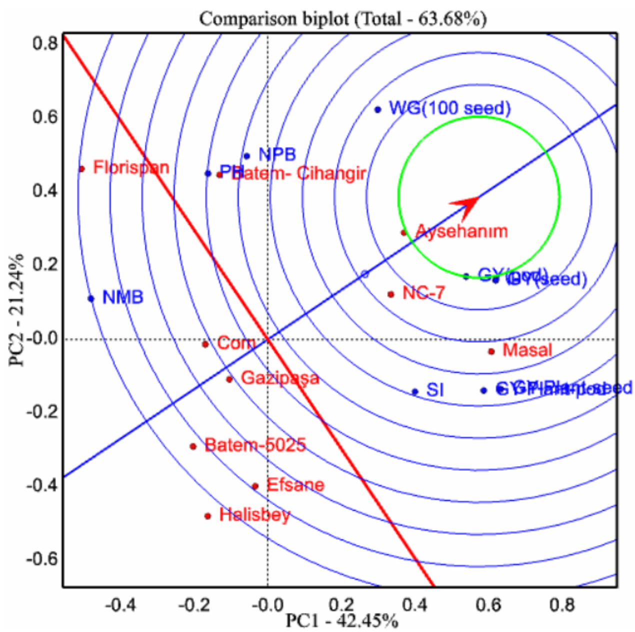


Figure 4. Evaluation of varieties according to ideal center

This graph generally creates a center (center indicated by the arrow) formed over the average of all traits. The horizontal curve shows the cultivars below and above the mean according to the mean of the traits. This graph shows that Ayşehanım are located at the center of ideal circle and NC-7 and Masal varieties located closest point to the ideal center circle and have the best results in terms of all traits. Some other genotypes (Batem-Cihangir) located above the mean line and therefore have good values in terms of the average of all traits, while some genotypes such as Efsane, Batem-5025, Gazipaşa, Florispan, Halisbey located below the mean line of traits, thus it means that they have bad results in terms of average of traits.

The Biplot method has shown to be a good method for investigating and evaluating both cultivars and traits. In this study, biplot method has exhibited that we can visually determine which traits are in the same group, which traits are in a positive or negative relationship, which cultivars are associated with which traits, which genotypes are stable, which genotypes can be preferred and which cultivars do not have good results. Kuo et al., (2021)' the genotype × trait (GT) biplots provide an easy way to visualize the correlation among traits and germplasm accessions. This is a good tool to help breeders rapidly choose the desired genotypes based on traits.

4. CONCLUSIONS AND RECOMMENDATIONS

The biplot analyses results indicated that the peanut grown as a second product after wheat in Mardin plain conditions; Ayşehanim and NC-7 cultivars showed high performance in terms of yield and yield traits, also they were quite stable among cultivars, while Florispan cultivar performed poorly. According to these results, it was concluded that it can be easily grow peanuts in Mardin plain conditions, Ayşehanım, NC-7 and Masal varieties can be recommended for cultivation. Moreover, the biplot technique has proven to be a very useful model for identifying visually stable, ideal and favourable varieties.

REFERANCES

Chinipardaz, A., Karimizadeh, R., Asghari, A., Chinipardaz, R., Sofalian, O., Ghaffari, A.(2016), "Application of GGE biplot analysis to evaluate grain yield stability of rainfed spring durum wheat genotypes and test locations by climatic factors in Iran". Crop Breeding Journal, Vol.6 no.2 (2016) pp.41-49.

Kendal, E.(2015), "Relationship between chlorophyll and other features in durum wheat (*Triticum turgidum* L.) using SPAD and biplot analyses". J. Agr. Sci. Tech. cilt.17 (2015) pp.1873-1886.

Kizilgeci, F., Albayrak, O. Yildirim, M.(2019), "Evaluation of thirteen durum wheat (*Triticium durum* Desf.) genotypes suitable for multiple environments using GGE biplot analysis". Fresenius Environmental Bulletin, Vol.28 no.9 (2019) pp.6873-6882.

Kendal, E. (2019), "Comparing durum wheat cultivars by genotype× yield× trait and genotype× trait biplot method". Chilean journal of agricultural research, 79(4), 512-522.

Kuo, H. I., Dai, H. Y., Wu, Y. P., & Tseng, Y. C. (2021), " Germplasm evaluation for agronomic traits and disease resistance under a two-season cropping system in Taiwan". Agriculture, 11(12), 1277.

Mahmoud, M. W., Hussein, E., Aboelkassem, K. M., & Ibrahim, H. E. (2020), "Graphical presentation of some peanut genotypes by comparing two patterns of biplot analysis". Journal of Plant Production, 11(8), 697-705.

Nigam, S.N.; Aruna, R.(2008), "Improving breeding efficiency for early maturity in peanut". Plant Breed. Rev. 2008, 30, 295–322.

Oppong-Sekyere, D., Yintii, B. B., & Akolgo, L. A. (2019), "Assessment of selected landrace and improved groundnut (*Arachis hypogaea* L.) genotypes under stressed and non-stressed conditions". Journal of Experimental Agriculture International, 40(1), 1-25.

Mohammadi, R. (2019), "Genotype by yield* trait biplot for genotype evaluation and trait profiles in durum wheat". Cereal Research Communications, Vol.47 no.3 (2019) pp.541-551.

Mohammadi, R., & Amri, A.(2011), "Graphic analysis of trait relations and genotype evaluation in durum wheat". Journal of Crop Improvement, Vol.25 no.6 (2011) pp.680-696.

Sanogo, O., Tongoona, P. B., Ofori, K., Offei, S. K., & Desmae, H. (2019), "Evaluation of yield and yield components of some groundnut genotypes under rainfed condition in Mali using biplot analysis". African Journal of Agricultural Research, 14(34), 1904-1912.

Letta, T., Egidio, M. G. D., Abinasa, M.(2008), "Analysis of multi-environment yield trials in durum wheat based on GGE-biplot". Journal of Food Agriculture and Environment, Vol.6 no.2 (2008) s.217.

Yan, W. and Frégeau-Reid, J. (2018), "Genotype by Yield* Trait (GYT) Biplot: a novel approach for genotype selection based on multiple traits". Sci Rep., 8:1-10.

Yan, W.K.(2016), "Analysis and handling of G × E in a practical breeding program". Crop Sci. 2016, 56, 2106–2118.

Yan, W.K., Frégeau-Reid, J.(2008), Breeding line selection based on multiple traits". Crop Sci. 2008, 48, 417–423.

CHAPTER SIX

CHEMICAL COMPOSITION, HEALTH EFFECTS, AND GASTRONOMIC PROPERTIES OF HAZELNUT

Aybuke CEYHUN SEZGİN[1]

Nevzat ARTIK[2]

[1] Assoc. Prof. Dr., Ankara Hacı Bayram Veli University, Faculty of Tourism, Department of Gastronomy and Culinary Arts, Gölbaşı/Ankara, ORCID: 0000-0003-1068-9940

[2] Prof. Dr., Ankara University, Faculty of Engineering, Department of Food Engineering, Gölbaşı/Ankara, ORCID: 0000-0001-5583-6719

1. INTRODUCTION

Hazelnut, which is the most widely grown hard-shelled fruit in the world after almond, is the name given to the genus Corylus and is included in the Betulaceae family of the Fagales order (Yaltırık, 1997; Toprak Mahsulleri Ofisi, 2018). All species in the genus Corylus have a monoic-dioic flower structure and are pollinated by the wind (Lagerstedt, 1975). The number of chromosomes in hazelnuts is 2n=2x=22, but 26 chromosomes have also been reported (Özbek, 1978). Morphological features of the plant, pomological features of the fruit, and husk features are used as distinguishing features in the classification of hazelnut species (Köksal, 2018).

The word hazelnut is derived from "Pont Exinus", which was the name of the Black Sea in Antiquity. The Greeks called the hazelnut "Karüa Pontica", that is, "Black Sea walnut" (Fındık Araştırma Enstitüsü Müdürlüğü, 2014; Tez, 2015). In 401 BC, Xenophon mentioned a small walnut grown in the region while he was passing through the Eastern Black Sea with the Greek army. This fruit was called "Karla Pontica" or "Nut Pontica", which means Pontic walnut (Zaman, 2004). Anatolia, which is the homeland of hazelnut and has the best quality hazelnut cultivars in the world, is the first place where hazelnut cultivation and trade are carried out in economic terms. It is known that hazelnut, which has existed in Anatolia for 5000 years, spread from the Black Sea to the Mediterranean, Middle East, and European countries. Of the approximately 4 million tons/year of hard-shelled fruit produced commercially in the world, 700 thousand tons are hazelnuts, and hazelnut production is carried out on an area of approximately 926 thousand hectares in the world. Turkey is the most important country with a share of 75-80% of world production. Hazelnut is a product that has an important place in the Turkish economy and brings the highest foreign exchange among plant products (Dölekoğlu, 2002; Alasalvar and Shahidi, 2009). Hazelnut planting areas in Turkey are located between latitudes 40-41° and longitudes 37-42°. The most suitable areas in terms of environmental conditions within these borders are the Black Sea coasts. Hazelnut cultivation is done 60 km inland from the Black Sea coast and up to 750 m altitudes (Özbek, 1978). Ordu, Giresun, and Trabzon provinces in the Eastern and Western Black Sea Regions of Turkey are the main provinces where hazelnut cultivation is carried out. Apart from these, hazelnut cultivation is also carried out in Kocaeli and Sakarya provinces (Sıray and Akçay, 2010; Duyar, 2015). Hazelnut is cultivated on an area of approximately 706,000 hectares, with an annual average production of 675,000 tons, by approximately 400,000 families and constitutes the direct or indirect economic livelihood of approximately 8,000,000 people. The gradual development of the hazelnut processing industry brings an important employment area (TMMOB Ziraat Mühendisleri Odası, 2018).

Hazelnuts can be planted in deep, fertile, well-drained soils with a pH between 6.0 and 7.5 in areas not exceeding 600 meters in height. Loamy-humus, clayey-sandy, and organic matter-rich soils are suitable soil types for its growth. In excessively humid areas, drainage should be done as trees cannot tolerate high soil moisture. The development of hazelnut trees is insufficient in hard and compacted soils and dry and calcareous soils (Köksal, 2018).

Hazelnut is grown in regions where the danger of frost is rare, the average winter temperature does not fall below -8°C, and the highest temperature in summer is 36-37°C. Hazelnuts are grown in regions with an average annual temperature of 13-16°C, 60% relative humidity in June and July, and annual rainfall between 750-1500 mm. Low winter temperatures are the most important factor limiting commercial hazelnut production in inland areas away from the sea. Early leafing cultivars are sensitive to frost damage in spring (Karagülmez and Usul, 2004; Gökçe, 2016). Hazelnuts harvested in August-September in our country are naturally dried under the sun. After drying (withering), the separation or threshing of the shells continues until October. While harvesting is done by gathering from the branch and the ground with labor, machine support is needed in the threshing (Babadoğan, 2009).

Turkish hazelnut varieties are classified into three different groups such as round, pointed, and long hazelnuts according to their size and shape (Köksal, 2006). Different hazelnut varieties such as *Tombul, Palaz, Çakıldak, Foşa, Mincane, Sivri, Kalınkara, İncekara, Allahverdi, Acı, Kan, Yassı Badem* and *Yuvarlak Badem* are grown in Turkey, where many hazelnut cultivars are grown (Özdemir and Akinci, 2004). However, in general, most of the production is made with hazelnut varieties such as *Tombul, Palaz, Çakıldak, Foşa, Mincane, Sivri, Kalınkara, Mincane,* and *Foşa* are planted in Trabzon, *Tombul* and *Sivri* in Giresun, *Tombul, Palaz* and *Çakıldak* in Ordu and Samsun, *Karafındık, Mincane, Çakıldak* and *Foşa* in Zonguldak, Sakarya and Bolu (Şimşek and Kara, 2017). Obtained from these hazelnut cultivars by breeding selections for many years, *Tombul* is the most important hazelnut variety in the world. *Tombul,* which has a very important role in Turkey, is mostly planted in Giresun and Ordu (Sıray and Akçay, 2010; Balık, 2015).

According to the average data of the last 5 years, hazelnut production in the world was carried out on approximately 926 thousand hectares. Turkey is the leading hazelnut producer and exporter, which provides approximately 68% of the world's production (Köksal, 2019). Turkey is followed by Italy with 13%, the USA with 4% and Spain with 3%. Other producing countries are Azerbaijan, Georgia, Iran, China, Greece, and France (Contini et al., 2011; Enescu et al., 2016). In Turkey, 675,000 tons of hazelnuts were produced in 2017 and 515,000 tons in 2018. While 85% of the hazelnuts produced in

Turkey are exported, the rest is used for domestic consumption. A large part of the country's exports is dependent on certain countries and certain markets. These countries are the world's largest chocolate producers and markets, which are members of the European Union and located in Western Europe. In 2016, hazelnut exports were mostly made to Italy (23%) and Germany (22%). These countries were followed by France (10%), Canada (5%), and Poland (4%). Almost all of the exported products were processed hazelnut or kernel. With the export of 250 thousand tons of hazelnuts in the 2015/16 season, a foreign exchange inflow of $2,280 billion was provided to Turkey (Duyar, 2015; Gümrük ve Ticaret Bakanlığı, 2018; TMMOB Ziraat Mühendisleri Odası, 2018).

2. CHEMICAL COMPOSITION OF HAZELNUT

Hazelnut is a nutritious food due to its high content of lipid, protein, vitamins, and minerals. The edible inner part of the hazelnut constitutes an average of 50% of the fruit. In a study, the chemical composition of hazelnut kernels was determined as 2-6.5% moisture, 10-24% protein, 50-73% lipid, 1-3% cellulose, and 1-3.4% ash (Alasalvar et al., 2003). In another study, it was stated that the average composition of hazelnut was 62% lipid, 16% protein, 11% carbohydrate, and 4% moisture, and these values may vary according to the type of hazelnut (Tatar et al., 2013).

The protein content of hazelnut varies between 10-24% and digestibility between 73-83% depending on the cultivar, growing conditions, and ecological factors. The protein content of hazelnut is higher than egg and cereal and is almost equal to the amount of meat and legume. Protein quality is lower than egg and meat products. Hazelnut contains 10-22% carbohydrates. The total sugar in dry weight is 2.8-7.9%. Total carbohydrates are 90% sucrose, 6% stachyose, 3% raffinose, and 1% glucose, fructose, and myoinositol. Sucrose is associated with the flavor of hazelnut and is sometimes present in such a high amount that it can be felt by sensory analysis. Stachyose and raffinose do not have any effect on hazelnut flavor as they have a very low sweetness (Şimşek and Aslantaş, 1999).

The total amount of lipid in hazelnut varies between 50-73 grams per 100 grams. As fatty acids, oleic acid has the most, followed by linoleic, palmitic, stearic, and linolenic acids, respectively. Oleic acid lowers blood cholesterol levels and linoleic acid has an inhibitory effect on the constriction of the blood vessel (Garcia et al., 1994).

The most abundant organic acid in hazelnut is malic acid. Cellulosic compounds and pectin are 1-3% (Köksal et al., 2006). Hazelnut is a good source of vitamins and minerals. Hazelnut, which is rich in mineral substances

(Fe, Mg, Cu, Mn, K, P, Zn, and Ca), is a very important nutrient for bone development and health. In 100 grams of hazelnut, there is 0.69 mg of vitamin B, 31.4 mg of vitamin E, small amounts of vitamins A and C, 5.8 mg of iron, 160 mg of calcium, 2.2 mg of zinc, 655.3 mg of potassium, 2.1 mg sodium, 161.2 mg magnesium, 1.3 mg copper and 5.1 mg manganese. Due to these properties, hazelnut is food that relieves body and mental fatigue, gives energy, and protects cardiovascular health. The average chemical content of 100 grams of hazelnut is shown in Table 1.

Table 1. The Chemical composition of Hazelnut (100 g)

Components	**Average Value**
Water (g)	4.60
Protein (g)	14.10
Lipid (g)	63.50
Carbohydrate (g)	6.00
Total nitrogen (g)	2.66
Thiamine (vit. B_1) (mg)	0.43
Riboflavin (vit. B_2) (mg)	0.16
Vitamin B_6 (mg)	0.59
Vitamin E (mg)	24.98
Energy (kcal)	650.00

According to the analyzes measuring the chemical composition of hazelnut cultivars of Turkey, moisture levels were 3.41% (*Kan*) and 5.25% (*Cavcava*); ash levels were 1.87% (*Kalınkara*) and 2.72% (*Cavcava*); lipid levels were 56.07% (*Cavcava*) and 68.52% (*Kalınkara*); protein levels were determined between 11.73% (*Kalınkara*) and 20.84% (*Yuvarlak Badem*) (Table 2).

Table 2. Chemical Composition of Turkish Hazelnut Cultivars (Köksal and Artık, 2018)

Cultivars	Moisture (%)	Ash (%)	Lipid (%)	Protein (%)
Acı	4.09	2.22	63.41	16.63
Cavcava	5.25	2.72	56.07	20.83
Çakıldak	4.86	2.60	60.67	19.44
Foşa	4.46	2.25	59.50	15.75
İncekara	4.27	2.41	60.75	16.28
Kalınkara	4.14	1.87	68.52	11.73
Kan	3.41	2.13	63.05	16.98
Karafındık	3.49	1.90	67.75	15.58
Kargalak	4.39	2.37	59.57	15.23
Kuş	4.41	2.30	61.25	16.80
Mincane	4.71	2.43	57.95	19.96
Palaz	4.76	2.61	57.65	18.03
Sivri	4.78	2.30	63.89	18.73
Tombul	4.63	2.43	64.60	17.51
Uzunmusa	4.17	2.34	61.75	16.98
Yassı Badem	3.56	2.42	63.48	17.86
Yuvarlak Badem	4.61	2.46	58.35	20.84

Due to its high lipid content, hazelnut is also utilized for oil production. Depending on the cultivars, hazelnut lipid contains on average 5% palmitic acid, 2% stearic acid, 1% palmitoleic acid, 78% oleic acid, and 14% linoleic acid. Just like olive oil, hazelnut oil contains high levels of oleic acid, one of the monounsaturated fatty acids. Most of the fatty acids are oleic and linoleic acids. Oleic acid lowers the level of cholesterol in the blood, and linoleic acid has a preventive effect on narrowing the blood vessel.

Table 3. Lipid and Fatty Acid Composition of Turkish Hazelnut Cultivars (Köksal and Artık, 2018)

	Lipid (%)	Palmitic C16:0 (%)	Palmitoleic C16:1 (%)	Stearic C18:0 (%)	Oleic C18:1 (%)	Linoleic C18:2 (%)	Linolenic C18:3 (%)	Saturated (%)	Unsaturated (%)
Acı	63.41	-	-	-	-	-	-	-	-
Cavcava	56.07	5.869	0.215	2.365	78.83	12.65	0.069	8.234	91.76
Çakıldak	60.67	4.889	0.324	2.148	80.69	11.89	0.059	7.037	92.96
Foşa	59.50	5.615	0.372	1.695	79.03	13.21	0.074	7.310	92.68
İncekara	60.75	5.672	0.317	1.761	79.52	12.65	0.073	7.433	92.56
Kalınkara	68.52	5.714	0.415	2.415	79.49	11.89	0.067	8.129	91.87
Kan	63.05	5.723	0.315	2.295	81.79	9.82	0.053	8.018	91.98
Karafındık	67.75	5.624	0.278	2.365	78.85	12.79	0.058	7.989	92.01
Kargalak	59.57	4.886	0.421	0.863	81.02	12.74	0.067	5.749	94.25
Kuş	61.25	5.686	-	0.871	79.87	13.49	0.076	6.557	93.44
Mincane	57.95	5.019	0.376	1.896	82.79	9.89	0.029	6.915	93.08
Palaz	57.65	4.873	0.340	2.131	77.57	15.01	0.076	7.004	92.99
Sivri	63.89	4.715	0.415	2.485	79.24	13.15	-	7.200	92.80
Tombul	64.60	5.165	0.478	1.750	77.77	14.78	0.054	6.915	93.08
Uzunmusa	61.75	5.700	0.460	1.410	78.80	13.56	0.069	7.110	92.89
Yassi Badem	63.48	4.874	0.279	1.432	81.13	12.24	0.046	6.306	93.69
Yuvarlak Badem	58.35	5.660	0.360	0.872	74.23	18.73	-	6.532	93.45

When the saturated and unsaturated fatty acid levels of Turkish hazelnut cultivars are compared, the highest palmitic, palmitoleic, and stearic acid levels are found in *Cavcava* (5.869%), *Tombul* (0.478%), and *Sivri* (2.485%), respectively. The dominant fatty acids in hazelnut lipids are oleic and linoleic, and the richest varieties in terms of these acids are *Mincane* (82.79%) and *Yuvarlak Badem* (18.73%) but linolenic acid is at the lowest level in these cultivars. *Kuş* and *Palaz* cultivars are the richest (0.076%) cultivars in terms of linolenic acid. The level of unsaturated fatty acids in hazelnut cultivars is much higher than the level of saturated fatty acids. In addition, the amounts of arginine and leucine essential amino acids and glutamic acid and aspartic acid are the highest in Turkish hazelnut cultivars (Köksal and Now, 2018).

Aromatic components of hazelnut are the quality parameters for export. It was determined that raw hazelnut and hazelnut roasted at 135°C for 30 minutes contained a total of 20 and 29 aroma compounds, respectively. "Nonanal" took first place among the aromatic compounds in raw hazelnuts. The most detected aromatic compound in roasted hazelnuts was "2(3H)-furanone". Turkish hazelnut varieties *Acı* and *Kalınkara* are preferred both in the roasted hazelnut processing industry and in the world hazelnut trade due to their high level of aromatic compounds (Artık et al., 2021).

Plant sterols (phytosterols) are compounds that are structurally similar to cholesterol and belong to the group of desmethylsterols steroid alcohols. They are found in all living organisms except bacteria. Sterols have a cholesterol-lowering effect, and β-sitosterol inhibits intestinal absorption of the cholesterol during the digestion of lipids. Phytosterols also have anti-inflammatory, antibacterial, antifungal, anti-ulcerative, and antitumor activities (Yorulmaz et al., 2017).

The mean sterol content of Turkish hazelnut cultivars was determined as 1581.6 ± 265.1 mg/kg. While a low level (1297.7 mg/kg) of total sterol was detected in a commercial variety, *Tombul*, β-sitosterol, which is the main sterol of hazelnut lipid, was 82.8-86.7% in all varieties. This component was followed by campesterol, Δ-5-avenasterol, sitostanol and stigmasterol (Yorulmaz et al., 2009).

3. HEALTH BENEFITS OF HAZELNUT

Hazelnut is not only a functional food, it is a food that is high in calories due to its carbohydrate content, rich in protein, mineral substances, lipids, and fatty acids, and sufficient in vitamins B1, B2, B6, and E. It is important for human nutrition due to diabetic fibers, phytosterols, and its special composition of antioxidant phenolics. Hazelnut, which contains many bioactive substances, has beneficial effects on health and has high nutritional value (Crews et al., 2005; Kornsteiner et al., 2006; Alasalvar and Bolling, 2015). Due to these positive properties, it has been the subject of many scientific studies. Hard-shelled fruits such as hazelnut, walnut, and almond are among the foods recommended for the nutrition of employees, athletes, and weak people, as they are high in energy value and rich in vitamins and minerals (Ayaz, 2008). The Mediterranean diet is important for human health because it contains carbohydrates, especially starch that provides the balance between nutrient and energy ratio, proteins of animal and plant origin, the dominance of mono-chain unsaturated fatty acids, omega-3 fatty acids, low cholesterol intake, antioxidants, vitamins, provitamins, phenolic compounds, and dietary fibers. Hazelnut, which is a type of hard-shelled fruit in the Mediterranean diet, is the subject of many studies not only regarding the effects of its components on human health but also its functional properties. Hazelnut ranks first among other hard-shelled fruits in terms of nutritional value (Fidanza, 2002).

Hazelnut is important in a healthy diet. 100 gr hazelnut provides 600-650 calories of energy (Baysal, 1993; Richardson, 1997). Hazelnut contains 10-24% protein, and 100 g of hazelnut meets 22% of the daily protein requirement (Pala et al. 1996). 2.8-7.9% of the dry matter in hazelnut is total sugar (Mashev and Kabatrzhikov 1978, Botta et al., 1994). The total amount of lipid in hazelnuts varies between 50-73 gr/100 gr. Hazelnut has a fatty acid composition rich in mono and polyunsaturated fatty acids, which are important for health (Crews et al., 2005).

It is reported that the rate of heart disease is low in Mediterranean countries due to a MUFA (monounsaturated fatty acid) diet. It is stated that the addition of hazelnut which is rich in MUFA has beneficial effects on human health (Alphan et al. 1997, Durak et al. 1999, Fraser 2000, Mercanlıgil et al. 2007). It is found that hazelnut lipid contains the highest MUFA and lowest SFA (saturated fatty acids) among vegetable oils and other nut oils (Venkatachalam and Sathe 2006). Hazelnut lipid contains low levels of SFA, moderate levels of PUFA (polyunsaturated fatty acids), and high levels of MUFA. Consumption of high amounts of SFA increases low-density lipoprotein-cholesterol and decreases high-density lipoprotein-cholesterol concentrations. Therefore, it causes an increase in the risk of heart diseases and cancer types (Mensink, 1993; Willet, 1997). In particular, palmitic acid (16:0) is defined as the main component that increases serum cholesterol (Groff et al., 1995).

Hazelnut lipid supports health as it contains low saturated fatty acids (SFA) and high unsaturated fatty acids. The main fatty acids in hazelnut oil are oleic acid (C18:1, ω-9), a monounsaturated fatty acid with a ratio of 66-83%, followed by polyunsaturated fatty acid and also an essential fatty acid linoleic acid (C18:2, ω-6) with 8-25% (Krist et al., 2008). Oleic acid lowers the level of cholesterol in the blood, and linoleic acid has a preventive effect on narrowing the blood vessel. Another feature of hazelnut lipid is that it reduces the absorption of cholesterol in the intestine. It was reported that linoleic and linolenic acids in hazelnuts have a reducing effect on blood lipid and glyceride levels and hypertension (Garcia et al., 1994; Durak et al., 1999).

Hazelnut contains the most malic acid and trace amounts of galacturonic, succinic, levulinic, citric, acetic, and butyric acids as organic acids (Botta et al. 1994). Hazelnut is an important fruit in terms of amino acid content. Amino acids in 100 grams of hazelnut are histidine 0.33 g, isoleucine 0.91g, leucine 1.05g, lysine 0.45g, methionine 0.16g, cystine 0.22g, phenylalanine 0.60g, tyrosine 0.55g, threonine 0.47g, tryptophan 0.25g, and valine 1.03g, respectively. (Nuattrucci, 1996).

Consumption of 100 g of hazelnut meets 33% of vitamin B_1, 8% of vitamin B_2, 35% of vitamin B_6, 12% of niacin, and 12% of pantothenic acid in recommended daily intake (Richardson, 1997; Alphan et al., 1997). Hazelnut lipid is a very rich source of vitamin E, and it is reported that 25-30 g of hazelnut consumption meets 100% of the daily vitamin E requirement (Bada et al., 2004; Alasalvar et al., 2006). Vitamin E, which has antioxidant properties, prevents oxidation in the cell membrane. It prevents free oxygen, which causes free radical formation in the cell, from non-enzymatically oxidizing polyunsaturated fatty acids. The active form of vitamin E in hazelnut, α-tocopherol, is also revealed to reduce the risk of many diseases. These diseases are chronic diseases such as various heart diseases, type 2 diabetes, hypertension, and cancer. In addition, the protective effects of α-tocopherol against Alzheimer's disease were proven (Gunstone and Harwood, 2007). Antioxidants from foods play an important role in the prevention of cancer, and inflammatory and cardiovascular diseases (Kornsteiner et al., 2006).

It is determined that 50 g hazelnut consumption per day can provide approximately 6% B, 9% Co, 19% Fe, 9% Ni, and 16% Zn intake. Se, Cu, and Cr levels in 50 g hazelnut are found to be higher than daily intake. It has been determined that these elements are in doses that are not toxic to human health. It is reported that hazelnut is an important source of microelement for human nutrition and health. Among the mineral substances found in hazelnut, selenium is one of the main minerals important for human health. Se amount of *Tombul* cultivar was determined as 60 µg/100 g (Alasalvar et al., 2003). Selenium binds with proteins to make selenoproteins, which are important antioxidant enzymes. The antioxidant properties of selenoproteins help prevent cellular damage by free radicals, which are by-products of oxygen metabolism, and the progression of chronic diseases such as cancer and heart disease. Other selenoproteins help regulate thyroid function and play a role in the proper functioning of the immune system. Selenium deficiency can cause heart disease, hypothyroidism, and a weakened immune system. Selenium deficiency does not usually cause disease; however, it may cause the body more susceptible to other nutritional, biochemical, or infectious diseases (Kim et al., 2014).

Copper, an essential mineral, is one of the important substances found in hazelnuts. Copper plays an important role in hematopoiesis (production of blood cells), and diets low in copper have adverse effects on lipid, glucose tolerance, and blood pressure. Magnesium in hazelnuts plays a role in maintaining the calcium-potassium balance. The decrease in magnesium levels is associated with dysrhythmias, myocardial infarction, and hypertension. It was found that after 7 days of regular hazelnut consumption in individuals with and without the habit of consuming hazelnut, serum Na, Cl, and Ca values decreased significantly, and the total iron-binding capacity increased significantly (Köksal, 2018).

Various antioxidants such as phenolic and hydroxycinnamic acids (gallic acid, caffeic acid, protocatechuic acid, vanillic acid p-coumaric acid, ferulic acid, sinapic acid) were detected in hazelnut. It was reported that hazelnut contains flavonoids such as catechin, quercetin, myricetin, and kaempferol; vitamin E (ὰ-tocopherol), one of the antioxidant vitamins (Shahidi et al., 2007; Contini et al., 2008; John and Shahidi, 2010).

As can be seen in every food product, there are biological, chemical, and microbiological risks that limit hazelnut production. Fungal contamination and aflatoxins produced by fungi are the leading microbiological risks. One of the most important factors that reduce the shelf life of hazelnuts is fungi. *Aspergillus* and *Penicillium* species are widely seen in the natural microflora of hazelnut. *A. flavus, A. parasiticus, A. fumigatus, A. candidus, A. niger, A. ochraceus, A. tamarii, A. terreus, A. wentii, P. brevicompactum, P. verrucosum, P. jensenii, P. griseofulvu* and *P. rugulosum* are more prone to producing mycotoxins as a result of secondary metabolism activities by developing during and after harvest if appropriate humidity and temperature are available (Abdel Hafez and Saber 1993).

4. HAZELNUT IN THE FIELD OF GASTRONOMY

Hazelnut, which is known as a holy fruit in every field from history books to religious books, from legends to folk songs in folk culture, was known since 2838 BC and mentioned in mythologies. It is known that the nutritional value of wild hazelnut, which was consumed by people in ancient times, is high. The hazelnut branch was considered a symbol of peace by the ancient Greeks and Turks. The fruit, shell, and leaf of the hazelnut were seen as an indispensable source of healing for many diseases, according to the medical scholars of ancient times. The Arabs believed that a person with a hazelnut branch in his hand could be protected from all evil. Since hazelnuts are considered sacred in British and French culture, it has become a tradition to have hazelnuts on Christmas tables and to decorate the tables with hazelnut branches. The Italians, on the other hand, blessed the hazelnut by giving the names of their saints (Köksal, 2018).

Hazelnut is very important not only in social life and economy but also in terms of the fat, protein, vitamin, and mineral composition for human and animal nutrition. After harvest, hazelnut is separated from its hard shell by various techniques, and hazelnut kernel is used in different fields in the industry. Worldwide, 70% of hazelnut are processed for chocolate, 15% for cakes and confectionery, 10% for snacks, and 5% for other uses. While 80% of hazelnut are used in the chocolate industry (chopped, sliced, ground) in the production of biscuits, confectionery, desserts, cakes, and ice cream, hazelnuts that are not sold in the domestic market or exported are processed for hazelnut oil. Hazelnut is generally consumed as a snack in Turkey (Özdemir et al., 1998; Akgün et al., 2005). In addition, the pulp remaining after the extraction of oil is used as animal feed due to its high protein content (38-45%). While hazelnut shell is used as a raw material in various industries (chipboard, linoleum flooring, plastic, paint, varnish oil, etc.), hazelnut leaves are recycled as natural fertilizers in hazelnut plantations or other agricultural areas (Yavuz, 2013). While the hazelnut plant is used as a landscape plant in parks and gardens, its shell is used as an ornamental and its oil is used as auxiliary raw material in food, medicine, cosmetics, health, and other industries (Kırca et al., 2018).

Although Turkey is the largest hazelnut producer in the world, hazelnut consumption in Turkey is quite low. The annual average amount of hazelnut consumed in Turkey is around 80 thousand tons. In other words, 11-12% of the hazelnuts produced today are consumed in the domestic market. The annual consumption amount per person is 500-600 grams. Many factors such as insufficient purchasing power of the people, limited use of hazelnut, and abundance of substitute products such as peanut, almond, and walnut are among the reasons for low consumption.

In addition to being a good antioxidant, there is a high amount of protein in the hazelnut pulp remaining after the oil is removed, and hazelnut protein is effective in food processes and food product formulations. With properties such as oil and water absorption, emulsification, and foaming capacity, hazelnut protein is functional in food processes (Tatar et al., 2013).

Hazelnut may be consumed either unroasted and with its skin or roasted and without its skin. It may be added to many food products, especially in chocolate production, confectionery, biscuits, and pastry products as flavor and aroma ingredients. Hazelnuts that are surplus to needs or that are not preferred because they are not suitable in terms of shape and size are processed for hazelnut oil (Koyuncu and Kılıç, 2018). If the hazelnut is roasted at the appropriate temperature and time, it will be delicious. This process also performs tasks such as providing color, taste, smell, and texture to the product, increasing the digestibility of proteins, reducing toxins, breaking down enzymes, improving microbiological quality, and prolonging the shelf life under appropriate storage conditions (Matsui et al., 1998, Pfnuer et al., 1999, Langourieux et al., 2000; Özdemir et al., 2001).

In Turkey, hazelnut is preferred as salted and roasted snacks after they are separated from their hard shells, or they are presented to the market in different types of products such as roasted hazelnut, sliced hazelnut, chopped hazelnut, hazelnut flour, hazelnut puree, or hazelnut paste. These products are used in desserts with milk, fruit or vegetable, *aşure*, cakes, biscuits, pastries, ice cream, candies, chocolates, nougat, dragee, and *helva* production; as a sauce in products such as chicken, fish, vegetables, noodles, and pasta; in cocktails and canapes; paste which are spread on bread at breakfast; cheese pastes, syrup production, bread production by adding wheat and rye flour, and yogurt as a flavoring agent (Gökçe, 2016; Marzocchi et al., 2017).

The relationship between food preferences that form the nutritional habits of societies and culinary cultures is based on the production and consumption of plant and animal products in the geography where people live. The elements that make up the food culture are related to the interaction of people with ecology and the diversity of the physical and cultural geography they live together. Culinary cultures based on agriculture and animal products differ according to geographical regions, rituals, ceremonies, and social structure throughout historical development. Hazelnut is planted in 71.3% of the agricultural lands due to its suitability for geographical conditions in Giresun, one of the mountainous provinces of the Eastern Black Sea Region. Hazelnut is both an economic income for the local people and a part of the local cuisine. Hazelnut is used not only in bakery products such as cakes, desserts, and cookies but also in various dishes and appetizers in Giresun cuisine (Ayyıldız & Ceyhun-Sezgin, 2022) investigated that hazelnuts are used in desserts such as *sütlaç*, *kadayıf,* and *fındıklı burma*, as well as in regional soups, *çiğ köfte*, meatballs, hamburgers, and even in pasta, special salads, and pizza.

The hazelnuts *Tombul fındık*, *Sivri fındık*, and *Kalınkara fındık* of the Giresun region, which is defined by hazelnut cultivation in Turkey, have been protected and registered as geographical indications. A geographical indication, which expresses the name of a local product, is a sign that indicates a product that is identified with the area, region, or country of origin in terms of its distinctive quality, reputation, or other characteristics. A geographical indication is a system applied to identify unique products produced in a particular area or region and to highlight the related product. Turkey is a country that stands out with its wide agricultural lands, biological diversity, climatic conditions, geopolitical location, cultural and human sources, and agricultural product diversity. Many products unique to Turkey are named after the geographical regions they originate from. Products mentioned in this way are subject to the geographical indication protection process. The registration of these geographically indicated products contributes to the country economically, politically, and touristically (Artık et al., 2022). *Giresun Tombul Fındığı* in 2001, *Giresun Sivri Fındığı* in 2019 and *Giresun Kalınkara Fındığı* in 2020 were registered by the Turkish Patent and Trademark Office by taking geographical indications. In addition, Giresun Tombul Hazelnut, whose application was made to the European Commission in 2018, was registered in terms of geographical indication in 2022 with the name of origin (Turkish Patent and Trademark Office, 2022).

Within the scope of the “Home of Turkey” campaign, Turkish hazelnuts are promoted. The “Home: Turkey” campaign which was launched to raise awareness about Turkey's cultural and historical heritage, social and daily life aims to create strong, sustainable, sincere, convincing, and comprehensive ways of communication with tourists from all over the world. This campaign was established by the Ministry of Culture and Tourism of the Republic of Turkey in April 2014. This is a brand image campaign that tries to identify Turkey with various concepts because it promotes Turkey’s all values under several concepts such as “Home of Hospitality” and “Home of Civilization”, emphasizes Turkey’s geographical and cultural diversity, and celebrates that Turkey has hosted countless identities, cultures, and civilizations throughout history. Many items (Home of Troy, House of Santa Claus, House of Turkish Coffee, House of Virgin Mary, House of Cappadocia, etc.) that started with the phrase “Home of” in the campaign were featured in various visuals and videos. In this way, all cultural elements that are thought to represent Turkey are gathered under one title (www.tanitma.gov.tr).

Within the scope of the "Home of Turkey" campaign, the Turkish flag and Turkey as the homeland of the hazelnut were emphasized in the "Home of Hazelnut" promotional poster. In addition, the promotional poster contains information about the health benefits of hazelnut. The slogan “Discover Turkey, Home of hazelnut” draws attention to the poster (Ceyhun-Sezgin and Çetin, 2019).

Home of Hazelnut

In the lower-left part of the poster, information is given about the health benefits of hazelnuts. The poster contains the following words: "*Back in the old days, it was believed that the sweet-tasting fruit of the hazel would make one wiser. While that sort of benefit is yet to be discovered, modern science shows that hazelnut is an edible miracle for the heart. This fiber-rich food is also known to reduce the risk of heart disease, lower cholesterol and boost one's energy. Do your heart a favor and eat a handful of hazelnuts every day. Discover Turkey home of hazelnut. Be our guest"*. The slogan "Discover Turkey, Home of Hazelnut" draws attention (www.tanitma.gov.tr).

5. CONCLUSION

Anatolia, the homeland of hazelnut, has the best quality hazelnut cultivars in the world. Our country, which is economically developed in hazelnut cultivation and trade, is the leading producer and exporter providing approximately 75% of the world's hazelnut production. In the Eastern and Western Black Sea Regions, Ordu, Giresun, and Trabzon provinces are the main provinces where hazelnut cultivation is carried out. Hazelnut, which is from the *Betulaceae* family, is a nutritious food thanks to the lipid, protein, vitamin, and mineral substances. Hazelnut, which contains many bioactive substances, is beneficial for health and has high nutritional value. Hazelnut is among the foods recommended in human nutrition not only because of its high energy value but also because of its vitamin and mineral content. After being harvested, the hazelnut, which is separated from its hard shell by various techniques, is processed to be used in different fields in the industry. Hazelnut, which is consumed as chocolate, cake, dessert, confectionery, and snack in the world, has also gained an important place in local cuisines. In addition to bakery products, it is also used in the production of various dishes and appetizers. In local restaurants, it is used in recipes in regional soups, *çiğ köfte*, meatballs, hamburgers, pasta, special salads, and pizzas, as well as desserts such as *sütlaç*, *kadayıf,* and *fındıklı burma*. In this study, the gastronomic properties of hazelnut were revealed, and its chemical composition and health effects were detailed.

REFERENCES

Abdel-Hafez, A. I. I., & Saber, S. M. (1993). Mycoflora and mycotoxin of hazelnut (*Corylus avellana* L.) and walnut (*Juglans regia* L.) seeds in Egypt. *Zentralblatt für Mikrobiologie*, *148*(2), 137-147.

Akgün, A., Yazıcı, F., Dervişoğlu, M. (2005). Fındığın Önemi ve Aflatoksin Problemi. II. Ulusal Mikotoksin Sempozyumu Bildiriler Kitabı, 23-24 Mayıs, 111s.

Alasalvar, C., & Bolling, B. W. (2015). Review of nut phytochemicals, fat-soluble bioactives, antioxidant components, and health effects. *British Journal of Nutrition*, *113*(2), 68-78.

Alasalvar, C., & Shahidi, F. (2009). Tree Nuts: Composition phytochemicals and health effects. Taylor & Francis Group Boca Raton London New York: CRC Press.

Alasalvar, C., Karamać, M., Amarowicz, R., & Shahidi, F. (2006). Antioxidant and antiradical activities in extracts of hazelnut kernel (*Corylus avellana* L.) and hazelnut green leafy cover. *Journal of Agricultural and Food Chemistry*, *54*(13), 4826-4832.

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

Alphan, E., Pala, M., Açkurt, F., & Yılmaz, T. (1996). Nutritional composition of hazelnuts and their effects on glucose and lipid metabolism. In *IV International Symposium on Hazelnut 445*(305-310).

Artık, N. (2004). Türk Fındıklarının Fenolik Bileşik Dağılımı ve Kavurma Prosesinde Değişimi. Ankara Üniversitesi Bilimsel Araştırma Projeleri Kesin Raporu, 1-64, Ankara.

Artık, N., Akan, S., Okay, Y., Durmaz, N., & Köksal, A. İ. (2021). Volatile aroma component of natural and roasted hazelnut varieties using solid-phase microextraction gas chromatography/mass spectrometry. *Acta Scientiarum Polonorum-Hortorum Cultus*, *20*(5), 85-96.

Artık, N., Şanlıer, N., Ceyhun-Sezgin, A. (2022). Coğrafi İşaretleme Sistemleri. Gıda Güvenliği ve Mevzuatı Kitabı İçinde. ISBN: 978-605-9440-88, Genişletilmiş 4. Baskı, Detay Anatolia Akademik Yayıncılık Ltd. Şti. Ankara.

Ayaz, A. (2008). Yağlı Tohumların Beslenmemizdeki Yeri. *Sağlık Bakanlığı Yayın*, No: 727, Ankara.

Ayyıldız, S., Ceyhun-Sezgin, A. (2022). Giresun Restoran Mutfaklarında Fındığın Kullanımı. *Journal of Black Sea Studies*, *16*(32): 591-614.

Babadoğan, G., (2009). Fındık ve Fındık Mamulleri, T.C. Başbakanlık Dış Ticaret Müsteşarlığı İhracatı Geliştirme Etüd Merkezi. Ankara.

Bada, J. C., León-Camacho, M., Prieto, M., & Alonso, L. (2004). Characterization of oils of hazelnuts from Asturias, Spain. *European Journal of Lipid Science and Technology*, *106*(5), 294-300.

Balık, H., Balık, S. K., & Ahmet, O. K. A. Y. (2015). Yeni Fındık Çeşitleri (Okay 28 ve Giresun Melezi). *Harran Tarım ve Gıda Bilimleri Dergisi*, *19*(2), 104-109.

Baysal, A. (1993). Genel Beslenme (8. Baskı). *Hatipoğlu Kitabevi*, *194*, Ankara.

Botta, R., Gianotti, C., Richardson, D., Suwanagul, A., & Sanz, C. L. (1992). Hazelnut variety organic acids, sugars, and total lipid fatty acids. In *III International Congress on Hazelnut, 351*:693-699.

Ceyhun-Sezgin, A., Çetin, K. (2019). Türk Turizm İmajında Yer Alan Geleneksel Lezzetler. Sosyal, Beşeri ve İdari Bilimlerde Akademik Çalışmalar-2019/2. (Editör: Prof. Dr. Zafer Gölen, Prof. Dr. Hasan Babacan) Basım sayısı:1, sayfa sayısı:1263, Bölüm Sayfaları:962-995, IVPE Yayınevi.

Contini, M., Baccelloni, S., Massantini, R., & Anelli, G. (2008). Extraction of natural antioxidants from hazelnut (*Corylus avellana* L.) shell and skin wastes by long maceration at room temperature. *Food Chemistry*, *110*(3), 659-669.

Contini, M., Frangipane, M. T., & Massantini, R. (2011). Antioxidants in hazelnuts (*Corylus avellana* L.). In *Nuts and Seeds in Health and Disease Prevention* (pp. 611-625). Academic Press.

Crews, C., Hough, P., Godward, J., Brereton, P., Lees, M., Guiet, S., & Winkelmann, W. (2005). Study of the main constituents of some authentic hazelnut oils. *Journal of Agricultural and Food Chemistry*, *53*(12), 4843-4852.

Dölekoğlu, T. (2002). Türkiye'de Fındık. Tarımsal Ekonomi Araştırma Enstitüsü, Ankara.

Durak, İ. (1999). Hazelnut supplementation enhances plasma antioxidant potential and lowers plasma cholesterol levels. *Clin. Chem. Acta*, *284*, 113-115.

Duyar, Ö. (2015). Fındık İstasyonu'ndan Fındık Araştırma Enstitüsüne, Geçmişten Günümüze Giresun (Ed: Bekdemir, Ü. & Fatsa, M.), Giresun İl Özel İdaresi Kültür Serisi-4, İstanbul.

Enescu, C. M., Durrant, T. H., de Rigo, D., & Caudullo, G. (2016). *Corylus avellana* in Europe: distribution, habitat, usage, and threats. *European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg*, 86-87.

Fidanza, F. (2002). Tree nuts in the Mediterranean diet context. In *II Conferencia sobre Salud y Frutos Secos-Fundación Nucis. Barcelona*.

Fındık Araştırma Enstitüsü, (2018) Gıda olarak Fındığın değeri, https://arastirma.tarim.gov.tr/fındık/Sayfalar/Detay.aspx?SayfaId=29 (17.04.2018)

Fındık Araştırma Enstitüsü Müdürlüğü, (2014). Fındığın Tarihçesi, https://arastirma. tarim. gov.tr/findik/ Sayfalar/ Detay.aspx? SayfaId=26

Fraser, G. E. (1999). Nut consumption, lipids, and risk of a coronary event. *Clinical Cardiology*, *22*(3), 11-15.

Garcia, J. M., Agar, I. T., & Streif, J. (1994). Lipid characteristics of kernels from different hazelnut varieties. *Turkish Journal of Agriculture and Forestry, 18,* 199-202.

Gökçe, N. (2016). Meyveler, Gıda Coğrafyası (Editör: Aktaş, S.G.), Anadolu Üniversitesi Yayını, syf.1-246. Eskişehir.

Groff, J. L., Gropper, S. S., Hunt, S. M. 1995. Lipids. In: Groff JL, Gropper SS, Hunt SM, editors. Advanced nutrition and human metabolism. Minneapolis, MN: West Publishing Co. pp 113–146.

Gunstone, F. D., & Harwood, J. L. (2007). Occurrence and characterization of oils and fats. In *The lipid handbook with CD-ROM* (pp. 51-156). CRC press.

Gümrük ve Ticaret Bakanlığı, (2018). 2017 Yılı Fındık Raporu, Ankara.

Şimşek, M., & Kara, A. (2017). Production potential and development opportunities of hazelnut (*Corylus avellana* L.) in Turkey. In *VIII International Scientific Agriculture Symposium," Agrosym 2017", Jahorina, Bosnia and Herzegovina, October 2017. Book of Proceedings* (pp. 847-852). Faculty of Agriculture, University of East Sarajevo.

John, J. A., & Shahidi, F. (2010). Phenolic compounds and antioxidant activity of Brazil nut (Bertholletia excelsa). *Journal of Functional Foods*, *2*(3), 196-209.

Karagulmez, K., & Usul, M. (2004). Fındığın Genel Durumu Sorunları ve Çözüm Önerileri, 3. *Milli Fındık Şurası, Giresun,* 170-177.

Kırca, L., Tuba, B. A. K., Kırca, S., & Karadeniz, T. (2018). Fındığın Kullanım Alanları ve İnsan Sağlığına Etkileri. BAHÇE 47 (Özel Sayı 2: Uluslararası Tarım Kongresi (UTAK 2018)): 292-299.

Kim, Y., Kim, D. C., Cho, E. S., Ko, S. O., Kwon, W. Y., Suh, G. J., & Shin, H. K. (2014). Antioxidant and anti-inflammatory effects of selenium in oral buccal mucosa and small intestinal mucosa during intestinal ischemia-reperfusion injury. *Journal of Inflammation*, *11*(1), 1-8.

Kornsteiner, M., Wagner, K. H., & Elmadfa, I. (2006). Tocopherols and total phenolics in 10 different nut types. *Food Chemistry*, *98*(2), 381-387.

Koyuncu, A., & Kılıç, T. (2018). Fındık ve Fındık Yağının İnsan Beslenmesindeki Önemi. *Ordu'da Gıda Güvenliği*, *12*, 47-49.

Köksal A. İ., Artık, N., Şimşek, A. Güneş, N. (2006). Nutrient composition of hazelnut (*Corylus avellana L.*) varieties cultivated in Turkey, Food Chemistry, *99*(3), 509-515.

Köksal, A.İ. (2018). Türk Fındık Çeşitleri, ISBN: 978-975-8991-37-2, Ankara.

Köksal, A.İ. (2019). Turkish Hazelnut Cultivars. Hazelnut Promotion Group, Ankara.

Köksal, A.İ., Artık, N. (2018). Fındık Çeşitlerinin Kimyasal Bileşimi. Türk Fındık Çeşitleri Kitabı içinde, ISBN: 978-975-8991-37-2, Ankara.

Lagerstedt, H. B. (1975). Filberts. p:456-489. In: J.Janick and J.N.Moore (eds.) Advances in fruit Breeding Purdue University Press, Indiana.

Langourieux, S., Perren, R., & Escher, F. (2000). Influence of processing parameters on the aroma of dry-roasted hazelnuts. *Frontiers of flavor science. Garching, Germany: Deutsche Forschungsanstalt für Lebensmittelchemie. p*, 527-535.

Marzocchi, S., Pasini, F., Verardo, V., Ciemniewska-Żytkiewicz, H., Caboni, M. F., & Romani, S. (2017). Effects of different roasting conditions on physical-chemical properties of Polish hazelnuts (*Corylus avellana* L. var. Kataloński). *LWT*, *77*, 440-448.

Mashev, N. P., & Kabartzhıkov, L. G. (1978). Chemical composition and nutritive value of hazelnuts kernels. *Food Science and Technology Abstract*, *10*(1), 154.

Matsui, T., Guth, H., & Grosch, W. (1998). A comparative study of potent odorants in peanut, hazelnut, and pumpkin seed oils on the basis of aroma extract dilution analysis (AEDA) and gas chromatography-olfactometry of headspace samples (GCOH). *Lipid/Fett*, *100*(2), 51-56.

Mensink, R. P. (1993). Effects of the individual saturated fatty acids on serum lipids and lipoprotein concentrations. *The American Journal of Clinical Nutrition*, *57*(5), 711-714.

Mercanlıgil, S. M., Arslan, P., Alasalvar, C., Okut, E., Akgül, E., Pınar, A., & Shahidi, F. (2007). Effects of hazelnut-enriched diet on plasma cholesterol and lipoprotein profiles in hypercholesterolemic adult men. *European Journal of Clinical Nutrition*, *61*(2), 212-220.

Ozdemir, F., & Akıncı, I. (2004). Physical and nutritional properties of four major commercial Turkish hazelnut varieties. *Journal of Food Engineering*, *63*(3), 341-347.

Özbek, S. (1978). Özel Meyvecilik. Çukurova Üniversitesi Ziraat Fakültesi Yayınları No: 128.

Özdemir, F., Topuz, A., Doğan, Ü., & Karkacıer, M. (1998). Fındık Çeşitlerinin Bazı Fiziksel ve Kimyasal Özellikleri, *Gıda*, *23*(1): 37-41.

Özdemir, M., Seyhan, F. G., Bakan, A. K., Ilter, S., Özay, G., & Devres, O. (2001). Analysis of internal browning of roasted hazelnuts. *Food Chemistry*, *73*(2), 191-196.

Pala, M., Ackurt, F., Loker, M., Yildiz, M., & Omeroglu, S. (1996). Fındık Çeşitlerinin Bileşimi ve Beslenme Fizyolojisi Bakımından Değerlendirmesi. *Turk J Agric Forest*, *20*, 43-48.

Pfnuer, P., Matsui, T., Grosch, W., Guth, H., Hofmann, T., & Schieberle, P. (1999). Development of a stable isotope dilution assay for the quantification of 5-methyl-(E)-2-heptane-4-one: Application to hazelnut oils and hazelnuts. *Journal of Agricultural and Food Chemistry*, *47*(5), 2044-2047.

Richardson, D. G. (1996). The health benefits of eating hazelnuts: Implications for blood lipid profiles, coronary heart disease, and cancer risks. In *IV International Symposium on Hazelnut 445* (pp. 295-300).

Shahidi, F., Alasalvar, C., & Liyana-Pathirana, C. M. (2007). Antioxidant phytochemicals in hazelnut kernel (*Corylus avellana* L.) and hazelnut byproducts. *Journal of Agricultural and Food Chemistry*, *55*(4), 1212-1220.

Sıray, E., Akçay, Y. (2010). Giresun İli Merkez İlçede Fındık Yetiştiren İşletmelerin Ekonomik Analizi, Üretim ve Pazarlama Sorunlarının Belirlenmesi Üzerine Bir Arastırma. *Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi*, *2010*(1), 43-56.

Şimşek, A., & Aslantaş, R. (1999). Fındığın Bileşimi ve Insan Beslenmesi Açısından Önemi. *Gıda*, *24*(3):209-216.

Tatar, F., Tunç, M. T., & Kahyaoglu, T. (2015). Turkish Tombul hazelnut (*Corylus avellana* L.) protein concentrates functional and rheological properties. *Journal of Food Science and Technology*, *52*(2), 1024-1031.

Tez, Z. (2015). Lezzetin Tarihi, Geçmişten Bugüne Yiyecek, İçecek ve Keyif Vericiler, Hayykitap, syf.1-366, İstanbul.

TMMOB Ziraat Mühendisleri Odası, (2018). Fındık Raporu, https://www.zmo.org.tr/genel/bizden_detay.php?kod=30070&tipi=

Toprak Mahsulleri Ofisi, (2019). 2018 yılı Fındık Sektör Raporu, Ankara.

Türk Patent ve Marka Kurumu, (2022). Coğrafi İşaretler Portalı, https://ci.turkpatent.gov.tr/

Yaltırık, F. (1997). Orman ve Park Ağaçlarımız (İğne yapraklılar), Atlas Dergisi, Nisan Eki, İstanbul.

Yavuz, G.G. (2013). Tarımsal Ekonomi Ve Politika Geliştirme Enstitüsü TEPGE, Durum ve Tahmin Fındık 2012/2013, Ankara.

Yorulmaz, A., Velioglu, Y. S., Tekin, A., Simsek, A., Drover, J. C., & Ates, J. (2009). Phytosterols in 17 Turkish hazelnuts (*Corylus avellana* L.) cultivars. *European Journal of Lipid Science and Technology*, *111*(4), 402-408.

Yorulmaz, A., Koç, M., & Bircan, C. (2017). Farklı ısıtma tekniklerinin fındık ve kanola yağının sterol bileşimine etkisi. *Gıda*, *42*(2), 145-154.

Venkatachalam, M., & Sathe, S. K. (2006). Chemical composition of selected edible nut seeds. *Journal of Agricultural and Food Chemistry*, *54*(13), 4705-4714.

Willett, W. C. (1997). Specific fatty acids and risks of breast and prostate cancer: dietary intake. *The American Journal of Clinical Nutrition*, *66*(6), 1557-1563.

Zaman, M. (2004). Türkiye'de Fındık Bahçelerinin Coğrafi Dağılışı ve Üretimi. *Doğu Coğrafya Dergisi, 9*(11):49-92.

İKSAD
Publishing House

ISBN: 978-625-8377-33-0