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CRITICAL EVALUVATION OF PROPERTIES OF TURKISH HAZELNUTS

TÜRK FINDIK ÇEŞİTLERİNİN ÖZELLİKLERİNİN KALİTE AÇISINDAN DEĞERLENDİRİLMESİ

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Özet

Dünyanın en büyük fındık üreticisi ve ihracatçısı olan Türkiye'nin yaklaşık 100 000 ton üretim fazlası bunulmaktadır. Fındık ve ürünlerinin kalitelerinin geliştirilmesi, yeni ürünlerle uygulama alanlarının genişletilmesi fındığa olan talebi artırabilir. Bu da ancak fındığın özelliklerinin ve işlemler sırasındaki davranışının iyi tanımlanmasıyla mümkün olabilir. Bu makalede, Türk fındık çeşitlerin fiziksel, kimyasal,
besin özellikleri kalite açısından değerlendirilmiştir.

Abstract

Turkiye is the biggest hazelnut producer and exporter in the world, but it has hazelnut surplus of about 100 000 tons/year. Improvement of quality of the hazelnut and its products may extend the market. New applications or products of the hazelnut may also increase demand. Further studies are necassary to understand properties of Turkish hazelnut varieties and their behavior during storage and processing. In the article, current knowledge about properties of hazelnut is critically reviewed.

Introduction

Wild species of hazelnut, genus *Corylus*, are distributed in nearly all parts of temperate zones of the northern hemisphere while the major producers are Turkiye, Italy, Spain, and USA (Ayfer et al., 1986). Economically important varieties in Turkiye are selected from *C. Avellana var. pontica* (common hazelnut), *C. maxima mill.* (the giant hazelnut), and *C. Colurna var. glandulifera.* (Turkish hazelnut) (Ayfer et al., 1986; Kasaplıgil, 1972). Turkiye produces 73% of the world hazelnut production (400,000-450,000 tons/year), and exports 83% of its production to get about 750 million US$ annually (Anonymous, 1995). Almost eight million people are involved into production and processing of Turkish hazelnut (Akdağ and Öztürk, 1993). Hazelnut cultivation in East Black Sea region of Turkey helps to prevent erosion in high slope, shallow fields under heavy rain (Ayfer, 1984; Baş, 1990; Pınar and Beyhan, 1991).

Hazelnuts are marketed in shell or as kernels. The kernels are consumed as natural, roasted, sliced, chopped, diced, flour, or as roasted paste. 80% of the hazelnut kernels is used in chocolate manufacture, 15% in confectionery, biscuit, and pastry manufacture, and the remaining 5 % is consumed without any further processing (Altundağ, 1989; Anonymous, 1995). They are used to provide a sweet, delicate, yet definite flavor in the food products such as dairy, bakery, confectionery products and muesli or are used to enhance flavor of chocolate, ice cream, desserts, snack bars and side dishes (Labell, 1983; Labell, 1992; Kinderlerer and Johnson, 1992). The principal flavor component of the hazelnut is filbertone which is formed during roasting (Buckholz et al., 1980; Jaunch et al., 1989). The unique flavor of roasted peanuts is preferred in the multi billion dollar peanut industry (Sanders et al., 1989). Contaminated hazelnuts are used in oil and cosmetic industry. Hazelnut shells are used for fuel and mulching, and are raw material of furfurel in dye industry. They are also used in making artificial wood, plywood, and linoleum (Woodroof, 1967).

Critical Evaluation of Properties of Turkish Hazelnuts

Turkish hazelnut is classified as round hazelnuts (the length to width ratio of 1.00 ± 0.19), pointed hazelnuts (the length to width of 1.3 ± 0.1) and long hazelnuts (the length to width ratio over 1.4). The major Turkish hazelnut varieties, their domestic synonymous names and annual production rates are depicted in Table 1. Round hazelnuts such as Tombul, Palaz, Çakıldak, Foşa are medium in size and have the highest quality and taste. Pointed hazelnuts such as Sivri, Incekara are medium, or large in size, and are suitable for marketing in shell or as kernels. Texture, taste and other quality factors are moderate. Long hazelnuts such as Badem are undesirable in international trade, not only due to their shape but also their woody and dry texture and its low quality kernel. They have limited value only for fresh consumption in local markets (Ayfer et al., 1986). Physical properties of Turkish hazelnut varieties were reported by Ayfer et al., (1986) and Şahin et al., (1990). Tombul and Palaz have better physical characteristics (length to width ratio, % good kernels that is not decayed including shriveled kernels, doubles), sensory properties (taste, flavor, color) besides composition among Turkish varieties. They are followed by Kalınkara, Çakıldak, Kuş Fındığı, Sivri. Tombul is mostly produced in Giresun where best ecological conditions for hazelnut production exists (Şahin et al., 1990). The shell of Tombul is not attractive in color. The pellicle of its kernel is light brown, clean, and easy to remove. Many kernels lose their skins even during transportation and storage, so it is one of the best varieties for blanching. The kernel is white, and center hallow is small. It has kernel ratio of 50-52 %, and has low blanks and doubles percentages. It has tendency to alternate bearing unless good ecological conditions and orchard care exits. Shelling of Tombul is rather difficult because of its lopped shape, relatively thin and elastic, and completely filled shell. It is susceptible to illnesses, adverse weather conditions (Ayfer et al., 1986). Palaz is slightly compressed in shape, and is the second major variety of Turkiye, produced mainly in Ordu. It is easy to remove the pellicle of Palaz. It is susceptible to illnesses, adverse weather conditions (Ayfer et al., 1986). Kalınkara has high doubles 2-19 kernels/100g. Çakıldak is slightly bitter besides Incekara, Mincane while Acıfındık has bitter taste. Çakıldak, and Kuş Fındığı have high shriveled kernels above 8% besides Cavcava, Incekara, Kargalak, Mincane, Yuvarlak Badem (Şahin et al., 1990). Both Sivri and Incekara are not grown any more due to their pointed shape (Ayfer et al., 1986).

Kernel ratio (weight percentage of good kernels to weight of the unshelled hazelnuts), pellicle removal of hazelnut kernels are influenced from harvest time. Harvesting the hazelnuts from tree at the right time increases kernel ratio from 46 up to 58, increases pecille removal after roasting from 56% to 93%, and decreases shriveled hazelnuts from 9.5% to around 1% for Tombul compared to early harvest. Similar quality improvement is obtained with the Palaz and Çakıldak (Çakırmelikoğlu and Çalışkan, 1993). Çakıldak maturates about 2 weeks later than Tombul and Palaz. The best quality hazelnuts are obtained when the hazelnuts are harvested from ground which may bring about microbial activity related problems (Eke and Göktan, 1987; Çakırmelikoğlu and Çalışkan, 1993). Therefore, hazelnuts should be harvested with the help of plastic sheets when vines of the hazelnut are brown, and hazelnut clusters are falling from the tree by shaking the tree.

Pala et al., (1996) and Baş et al., (1986) reported oil, protein, vitamin and carbohydrate content, and mineral, amino acid, and fatty acid composition of Turkish hazelnut varieties. The major Turkish hazelnut varieties contain about 60-80% oil, and 15-19% protein. Composition of hazelnuts are influenced from harvest time. Protein content has tendency to decrease by around 2%, and oil content has tendency to increase up to 8% depending on harvest time for Tombul and Palaz. Oil and protein content of Çakıldak changes only by 2% depending on the harvest time (Çakırmelikoğlu and Çalışkan, 1993). Şahin et al., (1990) stated that Turkish hazelnut varieties except for Tombul and Palaz have different oils content between years. Moreover, oil content of the Turkish hazelnut varieties differs between locations. Parcerisa et al., (1993) stated that the hazelnuts from Spain are influenced strongly by environmental and growing conditions; but moisture, fat and unsaturated fatty acids do not change much among different varieties. Oleic acid provides oil the stability (Bonvehi and Coll, 1993a). Linoleic acid is the main cause of the chemical randification of the hazelnut, along with other factors such as the peroxidase activity, pro-oxidant components (Bonvehi and

Coll, 1993a). During initial stages of fruit formation linoleic acid is predominant, whereas oleic acid and antioxidant components becomes dominant as maturity increases (Bonvehi and Coll, 1993a). Rancidity produces off flavors and compounds with aromatic rings that are associated with possible carcinogenic effects (Baş et al., 1986; Fourie and Basson, 1989; Kinderlerer and Johnson, 1992; Garcia et al., 1994). Free radical above 2% also indicates start of deterioration (Radtke and Heiss, 1971). Çakırmelikoğlu and Çalışkan (1993) reported amount of free radicals in Tombul after 1 year storage under 15-20 ^oC and 70-75% relative humidity at 5% moisture content to increase from 0.28 to 0.40%. The increase was from 0.34 to 0.39% in Palaz and to 0.43% in Çakıldak under the same storage conditions. Therefore, it is recommended to use the varieties that are low in linoleic acid content and rich in antioxidant components such as tocopherol, and to eliminate light and oxygen from packages to increase the shelf life of the hazelnut products, and if possible, to reduce the preservation requirements (Kinderlerer and Johnson, 1992; Bonvehi and Coll, 1993a; Pershern et al., 1995).

Improper storage results in breakdown of sucrose to glucose and fructose due to invertase acitivity (Bonvehi and Coll, 1993b). Increased values of glucose and fructose in excess of 0.1 g/100 g from 0.05 g/100 g in fresh, mature hazelnuts indicates old or badly-stored nuts that are not suitable for further storage, and sucrose values below 2 g/100 g indicates spoilage. Hazelnut should contain 5% moisture and should be stored at 5-10 ^oC and 50-60 % relative humidity (Hadorn et al., 1977; Baş, 1990). It is possible to accomplish a given storage life by a combinations of temperature and relative humidity, and economical storage is a function of the relative costs of dehumidification, refrigeration, and insulation taken together with the risk of spoilage at high relative humidities and temperature (Ayfer, 1973a; Brundett, 1987). Relative humidity is more important factor than temperature for hazelnuts during storage (Ayfer et al., 1973a).

Glutamic acid, followed by arginine and aspartic acid are present in greatest concentrations in Turkish hazelnut varieties (Table 2). The order is glutamic acid, aspartic acid and then arginine in Chilean hazelnuts (Villareol et al., 1987). Cystine is only present in the variety Uzunmusa. Lysine is the only limiting amino acid in the Chilean hazelnuts (Villaroel et al., 1987). Lysine concentration is greater than the reference in the Turkish hazelnut varieties except for Palaz and Çakıldak. Digestibility of proteins from Turkish hazelnut variety is 82.91% (Anonymous, 1985) *(Revised at 15.10.2001).*

Among the nut species, the hazelnut plays a major role for human nutrition, because of its special nutritional composition of proteins, carbohydrates, fat, vitamins, and minerals (Woodroof, 1975). Essential fatty acids, minerals, vitamins B_1, B_2, B_6 and E improves the nutritional quality of the Turkish hazelnut varieties. Hazelnuts are excellent source of vitamin E, and vitamin B6 (Mehlenbacher, 1991; Pala et al., 1996). Hazelnuts are low in saturated fatty acid content (10%), even lower than olive oil (15%), and high in monounsaturated fatty acid (oleic acid) that has been associated with decreased indices of cardiovascular diseases as a result of decreased serum cholesterol levels and favorably modified lipoprotein profile in normal persons when consumed frequently (Mattson, 1989; Elvevol et al., 1990; Nicolosi et al, 1990; Sabate et al., 1993; Garcia et al., 1994; Alphan et al., 1996). They also contain essential polyunsaturated fatty acids, of which daily requirement (1g) is satisfied with 8 hazelnut kernels (Garcia et al., 1994). Villaroel et al., (1987) also suggest to use hazelnut as a complementary protein source for combination with legume-based foods since they are low in cystine and methionine.

Nut and kernels defects are serious problems in the hazelnut industry. They limit kernel ratio and quality, reducing returns to growers and increasing cost to the handlers. Poorly filled nuts and shriveled kernels are usually smaller than the normal size. Small kernels are most common when the crop load is heavy or trees are stressed during the period of rapid kernel growth. Black tips are found in varieties whose shells have weak sutures. Double kernels results from synchronous development and fertilization of both ovules (Mehlenbacher et al., 1993). Mehlenbacher et al., (1993) stated that among the all defects, the most serious is kernel molds that greatly shorten shelf life. The Turkish hazelnuts varieties are more susceptible to kernel molds than the other major hazelnut varieties. It starts in the field, increase during harvesting and malfunctioning drying operations, and continue accumulating during storage and shipment. If they are stored in warm and damp medium, fungi, particularly those of the genera *Penicillium, Aspergillus,* and *Eurotium* may quickly grow and cause spoilage (Kinderlerer and

Johnson, 1992). Generally, oil seeds enhances growth of fungi especially that of *Aspergillus parasiticus* which produces aflatoxin B_1 (Reddy and Shetty, 1992). *Aspergillus flavus, A. parasiticus, A. tamarii, A. ochraceus, A. terreus, A. wentii* produce aflatoxins on the hazelnuts (Anonymous, 1978). Hazelnuts at 78-81% relative humidity and 20-30 ^{o}C are good substrate for production of aflatoxin and ergosterol (Sanchis et al., 1988). Peanuts infected with *A. flavus* is diverted to from edible market to oil stocks, and income of the producer is greatly reduced (Thai et al., 1990). Unroasted, roasted ground hazelnuts are more susceptible to aflatoxin contamination compared to roasted hazelnuts (Sanchis et al., 1988). When Unroasted hazelnut and roasted hazelnuts are stored at water activities between 0.24 and 0.38, they are not susceptible to mold growth and subsequent aflatoxin contamination. However, at water activities between 0.78 and 0.81, hazelnut becomes a good substrate for aflatoxin and ergosterol contamination (Sanchis et al., 1988). 8% of the 142 hazelnut samples, obtained from domestic market of Turkiye were found to be contain 2 to 100 ppb aflatoxin with a average of 34 ppb (Anonymous, 1978). Aflatoxin has been associated with carcinogenesis (Bullerman et al., 1984; Bullerman, 1986; Sanchis et al., 1988; Wilson and Abrason, 1992; Jones, 1993). Total aflatoxin limit (B1, B2, G1, and G2) for Germany were decreased from 10 ppb to 4 ppb while limit of aflatoxin B1 decreased from 4 ppb to 2 ppb (Majerus, 1989). Consumer demand and the world export market for commodities susceptible to aflatoxin contamination are seeking a goal of aflatoxin free products by the year 2000 (Paster et al., 1992). Preharvest sanitation and postharvest safe handling are essential to reduce molding of the kernels and related quality losses of discoloration, musty or sour odors, dry matter loss, chemical and nutritional changes, heating, caking, and mycotoxin formation in the stored food products (Topal and Aran, 1987; Sauer et al., 1992).

Postharvest damages to hazelnut kernels are also a major defect of the Turkish hazelnuts (Bozacı and Durmuşoğlu, 1988; Pınar and Beyhan, 1991; and Nalbant, 1991; Özdemir, 1996). Hidden-damage is one of the most quality reducing damage besides broken hazelnuts (kernels which lost at least 1/3 of its meat) and damaged hazelnuts (kernels with damage greater than 2 mm in diameter, and 1 mm in depth) (Özdemir, 1996). Most of the oil present in the hazelnut is in the outer layers of the cotyledons while it is very low in the inner cells of cotyledons which makes hazelnuts very sensitive to mechanical disturbance. Hidden-damage results from mechanical disturbance during cracking, drying, storage and transportation operations, and may cause misleading good appearance from the outside, but color is darker and appearance is oily inside, due to explosion of oil in the cotyledons. It may cover small area, appear in more than one places, or may be ring-shaped, cover the surface or reach 1-2 mm depth of the kernel (Ayfer, 1973b). Hidden-damage may promote lipid oxidation, causing rancidity and off-flavor development which reduces the shelf life. During the crop year of 1970, 20.8% of Tombul and 31.4% of Sivri were found to have hidden-damage after cracking (Ayfer, 1973b). Akçakoca hazelnuts (a mixture of Mincane, Karafındık, Foşa, and Çakıldak varieties) had 38% hidden-damage after cracking with the produce of 1995 (Özdemir and Özilgen, 1997).

Conclusion

Present knowledge about hazelnut is lacking sorption isotherms of Turkish hazelnut varieties and hazelnut products, and enzymatic activities in Turkish hazelnut varieties and products. Moreover, optimum methods and conditions for drying, storage, cracking, roasting and packaging should be determined for the Turkish hazelnut varieties to decrease nutritional losses and textural changes, to improve aroma, and extend shelf-life of the hazelnut and its products.

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Table 1
Turkish Hazelnut Varieties (Classified According to Shape), Their Synonymous Names and Annual Production Rates According to Grown Provinces (Data are gathered from Ayfer et al.,1986 and Anonymous, 1995)

Type	Variety	Synonymous names	Production (Tons/year)[a]				
			Giresun	Ordu	Trabzon	Akcakoca	Total
Round	Tombul	Mehmet Arif[b], Giresun Yağlisi[c], Yağlı Fındık[c]	80,807	31,030	13,460	2,463	127,760
	Palaz			43,324			43,324
	Mincane	Sarıfındık[c], Sarıyağlı[c], Sırafındık[b]		1,260	26,092	30,224	57,576
	Foşa	Yomra[b]			2,336	18,149	30,485
	Cakıldak	Delisava[c], Gökfındık[b]		31,124		11,037	42,161
	Kalınkara		1,484				1,484
	Karafındık	Karayağlı[b]					NA[e]
	Cavcava						NA
	Uzunmusa	Oskara Yağlısı[b,c], Enişte Fındığı[b]					NA
	Kan						NA
	Kargalak						NA
Pointed	Sivri	Giresun Sivrisi	7,644		1,891		9,536
	Incekara			2,520		49,532	52,052
Long	Yuvarlak Badem	Değirmendere[d]					NA
	Yassı Badem	Değirmendere[d]					NA
		Total	89935	117760	67300	120750	

[a] Production rates in 1995.
[b] Western Black Sea region.
[c] Eastern Black Sea region.
[d] Marmara region.
[e] NA: Not available.

Table 2

Amino Acid Composition[a] of the Major Turkish Hazelnut Cultivars (Data are gathered from Ayfer et al., 1986) *(Revised at 15.10.2001).*

	Variety								
Amino acid	**Tombul**	**Palaz**	**Mincane**	**Foşa**	**Çakıldak**	**Kalınkara**	**Cavcava**	**Uzunmusa**	**Sivri**
Essential									
Lysine	491.2	277.2	479.5	487.5	269.0	431.6	574.5	373.2	532.0
Isoleucine	720.1	516.8	369.6	621.8	488.9	670.1	606.5	529.0	438.0
Leucine	1,336.6	891.2	925.3	1,142.2	923.3	1292.9	1244.8	1003.3	929.6
Threonine	503.9	356.5	515.8	485.7	420.5	505.5	486.8	461.9	436.8
Valine	914.7	876.9	646.4	846.4	850.4	860.5	545.1	660.0	702.7
Methionine	255.2	144.7	179.6	234.0	120.6	244.1	171.5	164.4	202.9
Cystine	-	-		-	-	-	-	213.5	-
Methi.+Cyst.	255.2	144.7	179.6	234.0	120.6	244.1	171.5	377.9	202.9
Phenylalanine	798.7	570.6	746.6	724.7	614.3	731.5	691.9	419.4	635.3
Tyrosine	703.9	401.4	459.1	668.2	446.5	609.7	460.6	440.9	433.7
Pheyl.+Tyro.	1,502.6	972.0	1,205.7	1,392.9	1,060.8	1,340.2	1,151.5	859.3	1,069.0
Tryptophan	-	-	-	-	-	-	-	-	-
Non-essentials									
Histidine	454.4	648.5	441.8	429.6	774.3	421.0	355.2	363.0	337.7
Arginine	2,404.6	1,061.5	2,175.0	2,152.4	1,730.3	2,117.2	2,095.8	1,730.3	1,929.8
Aspartic acid	1,679.4	1,315.6	1,648.4	1,678.5	1,387.9	1,527.9	1,533.0	1,433.8	1,452.1
Serine	784.8	459.3	731.1	782.8	487.2	708.0	702.3	602.6	614.2
Glutamic acid	3,646.0	2,426.9	3,956.9	3,248.2	2,725.2	3,649.1	3,750.1	3,111.6	3,395.9
Proline	543.3	643.1	709.1	572.9	510.0	576.1	547.4	487.4	518.7
Glycine	691.6	441.9	782.7	665.0	483.6	672.2	743.9	629.2	681.8
Alanine	807.6	581.9	799.9	864.0	600.5	779.6	732.9	616.9	662.3

[a] mg/ 100g (d.b.).