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Analysis of Sugar Composition in Nut Crops

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This study evaluated some fruit traits and kernel sugar components in nut crops (pistachio, walnut, hazelnut and almond) collected from different accessions of Turkey. Pistachio varieties had 0.44-0.64 g kernel weight and 49.4-59.4 % kernel percentage. Walnut genotypes had 5.80-7.20 g kernel weight and 45.0-46.4 % kernel percentage. Kernel weights and kernel percentages recorded for hazelnut (Tombul var.) and almond (E-1) were 0.98 and 1.14 g and 51.5 and 26.8 %, respectively. Kernel sugar components were detected by using HPLC. Pistachio kernels belonging to different varieties contained 1.13 (Ohadi)-5.04 (Siirt) g/100 g fructose, 1.01 (Siirt) - 4.25 (Kirmizi) g/100 g glucose, 2.58 (Uzun) - 4.74 (Buttum) g/100 g sucrose and 0.26 (Kirmizi) - 0.99 (Halebi) g/100 g maltose. Walnut genotypes contained 0.35-2.67 g/100 g fructose, 0.13-6.26 g/100 g glucose, 1.76-4.17 g/100 g sucrose and 0.23-0.74 g/100 g maltose. Sugar components of hazelnut and almond were 0.80 and 4.00 g/100 g fructose, 1.52 and 0.86 g/100 g glucose, 2.91 and 3.23 g/100 g sucrose, 0.91 and 1.08 g/100 g maltose, respectively. Amounts of sugar components and the mean sugars varied to varieties, genotypes and different accessions.

Key Words: Nut crops, Fruit traits, Sugar components, HPLC, Turkey.

INTRODUCTION

Nut crops are among the most leading fruits that contain valuable components. They not only provide an explicit flavour to various food products but also play major role for people nutrient and health. Comprehensive researches were performed on nutritional properties, quality values and the potential health effects of nuts[1-12]. Since preagricultural times, nuts have maked up a part of mankind's diet[13]. The most popular edible tree nuts

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contain almonds, Brazil nuts, cashews, hazelnuts, macadamias, pecans, pine nuts, pistachios and walnuts[5]. On account of the increasingly exhibited health benefits, nuts are considered fundamental to several dietary guidelines worldwide in present time[14,15]. Accordingly, they are valuable for in human diets. Containing both high amounts of protein, fat, mostly unsaturated fatty acids and provide dietary fibre, vitamins (*e.g.*, folic acid, niacin, vitamin E, vitamin B_6), minerals (*e.g.*, copper, magnesium, potassium, zinc) and many bio-active constituents such as antioxidants, phytosterols and other phytochemicals, nuts are nutrient dense foods[15-17].

Kernel quality analyses included kernel weight, moisture content, kernel oil quality and composition as well as sugar content and composition. Sugar composition is vital for good flavour and taste[2]. Protein, oil, sugar contents and other components of nut kernel influence its industrial use fruit genetic resources for modern breeding objectives should also be described in their nutritional values. The predominant sugar in fruits are sucrose, followed by glucose and fructose[18].

The sugar composition and amount vary to fruit species, cultivars, ecological conditions, technical and cultural practices affect the taste[19]. In connection with fruit taste, fructose is sweeter than sucrose and sucrose is sweeter than glucose[18]. In almonds, complex carbohydrates are widely utilized for weight reductions in human diets[5]. Sugar composition of almond kernel constitutes mainly sucrose and raffinose and lower amounts of fructose, glucose and galactose (reducing sugars)[20,21]. Studies on sugar composition in nuts are limited. This research aimed to determine and comparing sugar compositions of pistachio varieties (Siirt, Buttum, Ohadi, Halebi, Uzun), walnut genotypes (V-1, H-1, B,-1, D-1), hazelnut variety (Tombul) and almond genotype (E-1) collected from different accessions of Turkey.

EXPERIMENTAL

The material for present studies constituted kernels of four different fruit species collected from different accessions of Turkey (Siirt, Antep, Van, Hakkari, Bitlis, Denizli, Giresun and Elazig provinces). These are pistachio varieties (*Pistacia vera* L.) (Siirt, Buttum, Ohadi, Halebi, Uzun), walnut genotypes (*Juglans regia* L.) (V-1, H-1, B,-1, D-1), hazelnut variety (*Corylus avellana* L.) (Tombul) and almond genotype [*Prunus dulcis* (Mill.) D.A. Webb.] (E-1). The fruits were collected at harvest times, removed from their shells and then dried in a vacuum oven at 60 °C for 3 d for sugar analyses. In addition, main fruit characteristics such as nut weight, kernel weight, kernel percentage and shell thickness were also recorded in randomly chosen 30 fruits. For analysis of sugars (fructose, sucrose, glucose and maltose), the modified methods by Torije *et al.*[22] and Karkacier

et al.[23] were used. Kernel samples were applied by 2 g. The kernel samples were ground into powder in liquid nitrogen and then 40 mL of methanol was added. After the mixture was incubated on a magnetic stirrer at 65 °C for 0.5 h, it was centrifuged at 4 °C, 1300 rpm for 40 min. The supernatant was transferred in clean tube and made up to 50 mL with methanol. Subsequent to removing methanol by rotary evaporator, the residue was dissolved in 25 mL double distilled water. Extract was passed through Sep-Pak C_{18} cartridge. After 2.5 mL filtrate was mixed with 7.5 mL acetonitrile, it was filtrated by 0.45 μm membrane filter and injected into HPLC. The column was calibrated by using standards of fructose, sucrose, glucose and maltose. Kernel sugar components were expressed as g/100 g.

RESULTS AND DISCUSSION

In pistachio varieties, the mean values of nut weight, kernel weight, kernel percentage and shell thickness were recorded 0.74 (Halebi)-1.23 (Siirt) g, 0.44 (Buttum, Halebi)-0.65 (Siirt) g, 49.40 (Buttum)-59.40 (Halebi) % and 0.82 (Halebi)-1.13 (Kirmizi) mm, respectively. The mean values of nut weight, kernel weight, kernel percentage and shell thickness of walnut genotypes were 12.61 (H-1)-15.60 (B-1) g, 5.80 (H-1)-7.20 (B-1) g, 45.00 (V-1)-46.40 (D-1) % and 1.20 (V-1)-1.81 (B-1) mm, respectively. The mean values in Tombul and E-1 (almond genotype) were 3.10 and 4.24 g nut weight, 1.24 and 1.14 g kernel weight, 40.00 and 26.80 % kernel percentage and 1.26 and 2.45 mm shell thickness, respectively (Table-1).

On the other hand, contents of fructose, glucose, sucrose and maltose contents changed depending on species, varieties, genotypes and accessions. The main sugar was sucrose in the majority of pistachio varieties, followed by glucose, fructose and maltose. In walnut genotypes, main sugar was glucose in the majority and followed by sucrose, fructose and maltose. As for hazelnut, sucrose was main sugar, followed by glucose, maltose and fructose. The main sugar in almond kernel was fructose, followed by sucrose, maltose and glucose. Kernels of pistachio varieties contained 1.13 (Ohadi)-5.04 (Siirt) g/100 g fructose, 1.01 (Siirt)-4.25 (Kirmizi) g/100 g glucose, 2.58 (Uzun)-4.74 (Buttum) g/100 g sucrose and 0.26 (Kirmizi)-0.99 (Halebi) g/100 g maltose. Sugar contents of seeds of walnut varieties were 0.35 (D-1)-2.67 (H-1) g/100 g fructose, 0.13 (D-1)-6.26 (B-1) g/100 g glucose, 1.76 (D-1)-4.17 (V-1) g/100 g sucrose and 0.23 (D-1)-0.74 (B-1) g/100 g maltose. The sugar contents of Tombul and E-1 were 0.80 and 4.00 g/100 g fructose, 1.52 and 0.86 g/100 g glucose, 2.91 and 3.23 g/100 g sucrose, 0.91 and 1.08 g/100 g maltose, respectively (Table-1).

Kernels of Siirt (Antep) variety had the highest fructose content (5.04 g/100 g), followed by Siirt (Siirt) (4.49 g/100 g), E-1 (4.00 g/100 g), Halebi (3.59 g/100 g) and H-1 (2.67 g/100 g), respectively.. Glucose content (6.26

g/100 g) of B-1 kernels was detected in the highest amount, followed by Kirmizi (4.25 g/100 g), H-1 (4.13 g/100 g), Halebi (3.96 g/100 g) and Buttum (3.94 g/100 g), respectively. Sucrose content (4.74 g/100 g) of Buttum kernels was determined at the highest level, followed by V-1 (4.17 g/100 g), H-1 (4.17 g/100 g), B-1 (3.93 g/100 g) and Halebi (3.68 g/100 g), respectively. With regards to maltose content, Alyanak and Sekerpare varieties had the lowest contents of maltose. E-1 and Halebi varieties had the highest levels of maltose with 1.08 g/100 g and 0.99 g/100 g (Table-1).

TABLE-1
SOME FRUIT PROPERTIES AND SUGAR COMPONENTS (AS g/100 g IN DRY WEIGHT) OF NUT CROPS FROM DIFFERENT ACCESSIONS OF TURKEY

Fruit	Variety	Accession	Nut weight (g)	Kernel weight (g)	Kernel percentage (%)	Shell thickness (mm)	Fructose (g/100 g)	Glucose (g/100 g)	Sucrose (g/100 g)	Maltose (g/100 g)
Pistachio	Siirt	Siirt	1.23	0.65	52.8	1.10	4.49	1.57	2.89	0.74
	Buttum	Siirt	0.89	0.44	49.4	1.12	1.65	3.94	4.74	0.96
	Kirmizi	Siirt	1.20	0.62	51.6	1.13	1.29	4.25	3.08	0.26
	Siirt	G. Antep	1.06	0.56	52.8	1.06	5.04	1.01	2.58	0.49
	Ohadi	G. Antep	1.10	0.64	58.1	1.08	1.13	3.14	3.56	0.78
	Halebi	G. Antep	0.74	0.44	59.4	0.82	3.59	3.96	3.68	0.99
	Uzun	G. Antep	1.00	0.50	50.0	0.99	1.97	2.36	2.97	0.92
	Mean		1.03	0.55	53.4	1.04	2.73	2.89	3.35	0.73
Walnut	V-1	Van	13.40	6.04	45.0	1.20	1.84	3.77	4.17	0.46
	H-1	Hakkari	12.61	5.80	45.9	1.36	2.67	4.13	4.17	0.61
	B-1	Bitlis	15.60	7.20	46.1	1.81	1.72	6.26	3.93	0.74
	D-1	Denizli	13.30	6.18	46.4	1.27	0.35	0.13	1.76	0.23
	Mean		13.72	6.30	45.8	1.41	1.64	3.57	3.50	0.51
Hazelnut	Tombul	Giresun	1.90	0.98	51.5	1.26	0.80	1.52	2.91	0.91
Almond	E-1	Elazig	4.24	1.14	26.8	2.45	4.00	0.86	3.23	1.08

There exist a limited knowledge regarding sugar contents of nut crops although they are consumed for appetizer and medicinal purposes. In the fruit species, composition of sugars influences the taste and it can vary to varieties, ecological conditions, technical and cultural practices[19]. Complex carbohydrates of nut crops are used for weight reductions in human diets[24,25]. Kernel sugar composition of nut crops can be affected by irrigation, harvest time and storage conditions[2,4,26].

Sugar composition of almond kernel have been reported as mainly sucrose and raffinose and lower amounts of fructose, glucose and galactose[20,21,27] and it has vital value for good flavour and taste[2]. Almond kernel contains 20.4 % carbohydrate and sugar 3 % and the main sugar is

sucrose[28]. Indian almond (*Prunus amygdalus*) contains 2.80 % carbohydrate[29]. Kader[28] reported that total sugar content in almond kernel is 3 % and the main sugar is sucrose. According to Saura-Calixto *et al.*[30], total sugar content of almond kernel is 5.5 %. Balta *et al.*[31] established selections harvested in late August and early September averagely contained 2.19-2.31 g/100 g sucrose, 0.68-0.92 g/100 g maltose, 2.09-1.82 g/100 g glucose and 4.08-3.41 g/100 g fructose and also sugar contents of selections did not differ by harvest season statistically. Barbera *et al.*[32] recorded that Ferragnes and Tuono kernels contain 3.47 and 3.19 % of total sugar, respectively. Aslantas[33] determined total sugar content between 2.64 % (Ke-170) and 4.17 % (Ke-130) for promising almond genotypes selected from Kemaliye (Erzincan, Turkey). Schirra *et al.*[34] determined as 3.9 % sugar content of Texas almond cultivar in Italy. Ellis *et al.*[35] detected 30.1-26.0 µg/mg galactose and 147.6-157.7 µg/mg glucose in seeds and skins of raw almonds, respectively. Kazantzis *et al.*[4] recorded that sucrose content varies from 70.4 to 85.3 % at early and late harvest of Ferragnes cultivar, depending on storage conditions as shelled kernels and in-shelled almonds.

The predominant sugar of the hydrolyzed sample in dried pistachio nuts is glucose[36]. Arzani *et al.*[37] recorded that Kalleh-Ghoochi variety (*Pistacia vera* L.) contained 3 % sucrose and 2 % glucose. Crane and Al-Shalan[38] reported that the predominant sugar in pistachio kernel was sucrose, followed in decreasing order by glucose, fructose and inositol and total sugars reached a peak of 43.3 % of dry weight early in the development of the kernel, but then decreased to 7 % at nut maturity.

Botta *et al.*[39] reported of kernels of several hazelnut cultivars and selections from Oregon and Italy averagely contain around 4 % total sugar (dry weight) ranging from 2.8 to 5.6 %, sucrose accounts for 90 % of total sugars and glucose, fructose and myo-inositol are present in low amounts (50-400 µg/g).

Walnut kernels contain 3-4 % sugar[40]. Reporting that kernel sugar contents in walnut vary by year, Mitrovic *et al.*[40] recorded that sugar contents of walnut varieties and selections (Dorka, Ceinovo, Ibar, Vujan, Ovcar, G-139, G-251 and G-286) ranged 2.59 % to 3.53 and they are averagely 2.93 %.

In this study, walnut genotypes from Van, Hakkari and Bitlis accessions located in eastern Turkey contained higher fructose, sucrose, glucose and maltose than that of Denizli located in western Turkey. While the total amount of four sugar components in walnuts from eastern Turkey were 8-10 g/100 g, it was about only 2 % for walnut genotype from western Turkey. This finding indicates that sugar content of walnut increases in areas with cold climate. Sugar data for hazelnut was in harmony with those reported by Botta *et al.*[39]. Although sugar compositional data for almond

was in agrement with those of Balta *et al.*[41], it had higher values than reported by many studies. In addition, some pistachio varieties had higher sugar contents than other studies and also the main sugar was glucose for some pistachio varieties. Nutritional improvement of nut crops through breeding efforts will gain more importance for more healtful life style[8,12,42-44]. This study indicated that kernel sugar composition of nut crops changed based on species, variety, genotype and accession was affected by different ecological conditions. Therefore, findings might contribute to nutritional improvement efforts of nut crops.

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