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Chemical Composition and Fatty Acid Contents of Chestnuts Grown in Bursa Province, Turkey

SERKAN ÖZTÜRK*, MURAT ÇETIN† and MEHMET ÇETIN
Department of Chemistry, Faculty of Science and Arts,
Uludag University, Gorukle Campus, 16059 Bursa, Turkey
Fax: (90)(224)2941899; Tel: (90)(224)2941771
E-mail: serkanozturk@uludag.edu.tr

In this study, some chemical properties such as moisture, protein, starch, invert sugar, sucrose, fat and fatty acid contents of chestnut types grown in Atatürk Central Horticultural Research Institute, Yalova were determined. Chestnut fruits from seven cultivars were harvested in October and stored as required during analysis. The analysis resulted in some variations that were 51.18 to 54.74 % of moisture, 5.35 to 8.17 % of protein, 81.06 to 94.21 % of total carbohydrate, 52.92 to 75.25 % of starch, 10.66 to 28.84 % of total sugar, 0.10 to 2.53 % of invert sugar, 8.05 to 27.04 % of sucrose and 0.90 to 2.47 % of fat. After the analysis of fat compositions, chestnuts were found rich in unsaturated fatty acids of which linoleic acid was the highest and varied from 38.03 to 53.23 %. While oleic acid was the second highest unsaturated fatty acids varying from 20.02 to 36.64 %, palmitic acid was the highest among saturated fats and varied from 13.27 to 17.14 %.

Key Words: Chestnut, Chemical composition, Fatty acids, Capillary gas chromatography.

INTRODUCTION

Chestnuts are being cultivated in continents of Asia, Europe and America and also partially in South America[1]. Asia is leading in chestnut cultivation area of which is China which has very high potentials for chestnut cultivations. The second leading areas are located in Southern Europe and Mediterranean countries (France, Italy, Turkey and Spain). Chestnut production is important in continent of America especially in North America[2]. Some chestnut species such as *Castanea mollissima* Bl, *Castanea seguinii* Dode and *Castanea henryi* in China, *Castanea crenata* in Korea and Japan, *Castanea dentata* in America and *Castanea sativa* mill in the Mediterranean countries grow naturally[1]. Chestnut cultivation areas have been extending in Australia and New Zeeland.

Turkey located among the Mediterranean countries has suitable ecology for chestnuts and has high production potentials. Wild chestnuts, *Castanea sativa* Mill,

†Uludag University, Gemlik Asim Kocabiyik Vocational Higher School, Gemlik, Bursa, Turkey.

are grown naturally in humid forest areas of Black sea, Marmara sea and Aegean sea coasts in Anatolia[1,3]. Chestnut production in Turkey is *ca.* 5 % of the world production[4]. The chestnut fruits are consumed as baked (Kestane Kebabi) or processed in candy industries in Turkey.

Unlike walnuts and hazelnuts, chestnuts are rich in carbohydrate, starch and sugar but have low fat and protein contents[5]. Although all chestnut types do not posses the same chemical properties. There are different types of *Castanea sativa* mill grown in Mediterranean countries depending on countries and locations. Therefore, chemical properties of these types vary. The picture of a triple chestnut fruit is seen in the Fig. 1.

Fig. 1. Appearance of chestnuts

Chestnut storage period extension is very difficult due to its moisture and nutritional contents. It is essential to have no or minimum quality loss during storage periods regarding its sharp-shell colour and nutritional values[1]. Cold chamber storage is one of the best methods to store chestnuts as fresh. Chestnuts can also be stored after dehydration. Dehydrated chestnuts can store longer time period and advanced storage rooms are not required as compared to cold storage due to low moisture content suppressing enzymatic reactions leading to lower biologic activity. Westwood[6] reported that while the chestnuts with 10 % moisture stored as long as one year period, the chestnuts with 50 % moisture stored only 8 weeks both were at 4.5 °C.

Less are known about chemical properties of the Turkish chestnut. The reported researches have concentrated on total carbohydrates, starch, sugar, protein, fat and some minerals in mostly locally selected land races[7-9]. However, we were not able to find reports in fatty acid contents.

In this research, some chemical properties such as moisture, protein, starch, invert sugar, sucrose, fat and fatty acid contents of chestnut types grown in Atatürk Central Horticultural Research Institute, Yalova were determined.

EXPERIMENTAL

Seven chestnut cultivars grown at Atatürk Central Horticultural Research Institute, Yalova in Turkey were used as plant materials. Fresh chestnuts were harvested from seven different cultivars in October, 2007 and 2008 (Table-1). The samples were kept in polyethylene bags with holes at -10 ºC after harvest.

TABLE-1
PLANT COLLECTION NUMBERS AND CULTIVAR NAMES

Plant collection No.	Cultivar names
51205	Sariaslama Clone-2
52509	Sariaslama Clone-3
61316	Dursun Kestanesi
Maraval 74	*C. sativa x C. crenata* [Ref. 22]
52214	Haciomer
51112	Mahmutmolla
52104	Sari Kestane

Sample preparations: The shells and endosperm coats were removed before using blender to mesh edible parts as chestnut dough.

Determination of moisture: Moisture contents were determined following the AOAC 979.12 method[10]. Since about half of the sample fresh weights were due to moisture, gradual predehydration applications were needed. Therefore, the samples were firstly placed in a phosphorus pentoxide added desiccators and kept over night after vacuuming (predehydration). There after, samples and phosphorus pentoxide were removed from the desiccators, placed in vacuumed oven and dried about 3 h at 80 ºC and < 100 mmHg negative pressure until standard weighting. Differences between the fresh and dry weights were considered as moisture.

Determination of fat: Fat determinations of the samples were done according to DGF-Einheitsmethode: B-I 5(52) standard (Soxhlet extraction)[11]. Extracted fat samples were kept in N_2 atmosphere at 4 ºC in refrigerator environment.

Determination of protein: Protein contents of the chestnuts were determined according to the Kjeldahl method ASN 3317[12]. The FOSS 2006 Digester Unit D56 was used to burn the samples. During burning process, temperature was gradually increased up to 380 ºC and samples were kept a period of 1 h at that point. Distillation stages of the determinations were done using 2200 Kjeltec Auto Distillation system (FOSS TECATOR, Sweden). Determined Kjeldahl nitrogen multiplied by the 5.30 factor to determine protein content[8,13].

Determinations of invert sugar, total sugar and carbohydrates: Determinations of invert sugar, total sugar and carbohydrates were done by UV-Spectrophotometer (Shimadzu UV-1208 UV-Vis). Dinitrophenol method, absorbance values of red-brown solution formed by dinitrophenol and invert sugar depending on its concentrations at 600 nm wavelength[14] was used for all the readings from the spectrophotometer. Invert and total sugars were determined by absorbance values from directly

prepared solutions and by absorbance values read after inversion, respectively. Clarifications and inversions of the solutions were done according to Regnell[15]. Glucose solutions with varying concentrations (0.2-1.0 mg/mL) were prepared and their absorbance values were determined. Thereafter, the absorbance values plotted against the concentration values and the standard curve was drawn (Fig. 2). The factor (2.14) was determined using the standard curve and used to calculate the other reading results.

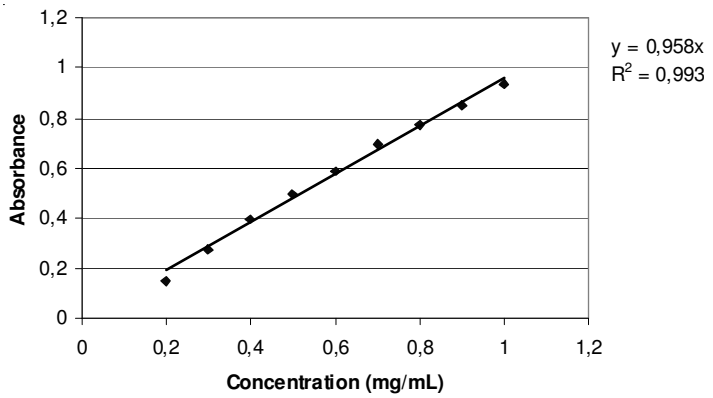

Fig. 2. Absorbance by concentrations standard curve

Determinations of sucrose quantity: Sucrose quantities of the samples were calculated by multiplication of the standard (0.95) and values determined after subtraction of the invert sugar values from the total sugar values read from UV spectrophotometer[16].

Determinations of starch quantity: Starch quantities of the samples were calculated by multiplication of the standard (0.94) and values determined after subtraction of the total sugar values from the total carbohydrate values read from UV spectrophotometer[16].

Preparations of fatty acid methyl esters: Fatty acid methyl esters were prepared by transesterification reaction of 1 % solutions with fatty acid and sulfuric acid in methanol[17].

Determination of fatty acids composition by capillary GC: We determined fatty acid composition by fatty acid methyl ester (FAME) analysis with a HP 6890 gas chromatograph equipped with an auto sampler, flame ionization detector and 60 m × 0.2 mm i.d. SP 2380 fused silica capillary column coated with 0.2 μm of stabilized poly-90 % biscyanopropyl/10 % cyanopropylphenyl siloxane (Supelco Inc., Bellefonte, PA, USA). Hydrogen was used as carrier gas at a flow rate of 0.8 mL/min. Temperatures of the injector and the detector were 280 and 300 °C, respectively. The oven was programmed at 120 °C initial temperature with a 2 min initial time. Thereafter, the temperature was gradually increased with a 10 °C/min increment up to 230 °C and held for 20 min. Total run time was 32 min. The samples

were analyzed in split mode (100:1) and FAME peaks were identified by comparison with retention times of standards. Fatty acid contents are given in relative percentages of the total GC areas[18].

RESULTS AND DISCUSSION

Moisture content: Moisture contents of the samples varied from 51.18 to 54.74 % (Table-2). The moisture range is narrow and is in the ranges of the reported results 52.33-61.36[19] and 48.37-59.35 % in Spanish cultivars[20]; 40.30-60.10 % in Portuguese cultivars[2]. In present studies, the moisture range is in between of these reported ranges.

TABLE-2
MOISTURE, FAT AND PROTEIN COMPOSITIONS OF THE CHESTNUT SAMPLES (g/100 g)

Sample No.	Moisture	Fat*	Protein*
52509	54.74 ± 2.30	0.90 ± 0.06	6.77 ± 0.02
51205	52.98 ± 1.94	1.14 ± 0.07	5.66 ± 0.00
61316	53.55 ± 0.88	1.34 ± 0.05	8.17 ± 0.05
52104	51.18 ± 2.32	1.43 ± 0.06	5.51 ± 0.16
52214	53.59 ± 0.81	2.47 ± 0.01	5.35 ± 0.07
51112	51.98 ± 1.13	1.60 ± 0.02	6.52 ± 0.09
Maraval 74	53.43 ± 1.87	1.00 ± 0.04	7.18 ± 0.00

*Amounts in dry matters.

Fat content: Fat contents of the analyzed chestnut fruits varied from 0.90 to 2.47 % (Table-2) that is similar to results of 1.26 to 2.98 % for the Spanish chestnut types grown in Galicia, Spain[20]. While in present work, the fat content results showed similarities with 1.02-1.76[19] and 0.90-1.70[13] % for the Portuguese type chestnut fat contents, Pereira-Lorenzo *et al.*[2] reported higher results (1.70 - 4.00 %) for Spanish types. Fat contents of the chestnuts grown in Sinop, Turkey were reported 0.66-3.08[8] and 0.49-2.01[9] % which are similar to present results.

Protein content: Protein contents of the analyzed chestnut fruits varied from 5.35 to 8.17 % (Table-2) that is similar to results of 4.50-9.60[2] and 4.88-10.87[9] %. De La Montana *et al.*[20] reported no less than 6 % protein content that is also similar to in present studies. Üstün *et al.*[8] reported a protein content range that its minimum protein content was 3.43 % slightly lower than present minimum results and the maximum amounts are the same 8.27 and 8.17, respectively. On the other hand, Ferreira-Cardoso *et al.*[13] reported a protein content range that its maximum protein content was 12.00 higher than present maximum results and the minimum amounts are close to 5.40 and 5.35, respectively.

Starch content: Starch contents of the chestnut samples varied from 52.92 to 75.25 % (Table-3). These values are higher than what Üstün *et al.*[8] reported 29.88-63.66 %. De La Montana *et al.*[20] reported slightly higher minimum and maximum values (56.70-81.70 %). Ferreira-Cardoso *et al.*[13] and Ertürk *et al.*[9] reported shorter ranges, 54.90-64.90 and 54.45-69.70 %, respectively. Pereira-Lorenzo *et al.*[2] reported slightly lower minimum and maximum values 42.20-66.50 %.

TABLE-3
SUGAR AND CARBOHYDRATE COMPOSITIONS OF
THE CHESTNUT SAMPLES (g/100 g)

Sample No.	Invert sugar	Total sugar	Total carbohydrate	Sucrose	Starch
52509	2.19	10.66	88.84	8.05	73.49
51205	2.53	15.31	94.21	12.14	74.17
61316	0.67	12.65	92.70	11.38	75.25
52104	1.86	15.73	87.88	13.18	67.82
52214	0.74	15.48	81.06	14.00	61.65
51112	0.38	28.84	85.14	27.04	52.92
Maraval 74	0.10	11.20	81.36	10.55	65.95

Invert sugar content: Invert sugar (glucose + fructose) amount was found between 0.10-2.53 % (Table-3). The present results are generally higher than the results of De La Montana *et al.*[20] who separately found glucose and fructose and reported results of the sum as 0.08-0.57 %. Ertürk *et al.*[9] reported lower invert sugar amount (0.08-1.25 %) than that of present results.

Sucrose content: Sucrose amount varied from 8.05-27.04 % (Table-3) that is similar to work of De La Montana *et al.*[20] and Ertürk *et al.*[9] reported 6.55-19.50 and 8.86-21.28 %, respectively.

Total carbohydrate and total sugar contents: Total carbohydrates and total sugar found in present chestnut samples were 81.06-94.21 and 10.66-28.84 %, respectively (Table-3). Ertürk *et al.*[9] reported similar results for total carbohydrates and total sugar 75.32-86.31 and 10.32-22.79 %, respectively.

Fatty acid content: Fatty acid compositions of the fatty acids found in the chestnut samples are given in the Table-4. As it seen in the table, fatty acids found richer in unsaturated fatty acids contents. Among the unsaturated fatty acids, linoleic acid was the highest (C18:2, 38.03-53.23 %), oleic acid was the second highest (C18:1, 20.02-36.64 %) and followed by linolenic acid (C18:3, 4.85-9.38 %). Among the saturated fatty acids, palmitic acid was the highest (C16:0, 13.27-17.14 %). Amount of the stearic acid percentage was found very low (C18:0, 0.71-1.28 %). The other fatty acids were found lower than 1 % (Table-4). Ferreira-Cardoso *et al.*[13] reported palmitic acid as 17.10-22.20 %, oleic acid 18.50-29.70 %, linoleic acid 46.90-58.20 % and linolenic acid 4.90-9.00 % in Portuguese chestnuts. The results of Ferreira-Cardoso *et al.*[13] for linoleic acid and linolenic acid are similar, oleic acid is lower, palmitic acid is higher as compared to present results. Danish Institute for Food and Veterinary Research[21] determined the fatty acid amount as 37.70 % of linoleic acid, 38.50 % of oleic acid, 4.20 % of linolenic acid, 16.70 % of palmitic acid and 1.00 % of stearic acid and reported to Danish Food Composition Databank[21]. These reported values are similar to present results of fatty acid compositions.

TABLE-4
FATTY ACID COMPOSITIONS (%) OF THE CHESTNUT SAMPLES

Fatty acids	Samples						
	52104	52509	Maraval 74	51112	61316	52214	51205
C 14:0 Myristic acid	0.21	0.00	0.49	0.17	0.44	0.20	0.15
C16:0 Palmitic acid	13.44	13.27	14.67	17.06	14.55	17.14	13.59
C16:1 Palmitoleic acid	0.92	0.96	0.81	1.21	1.20	0.74	0.73
C17:0 Heptadecanoic acid	0.12	0.26	0.25	0.16	0.17	0.20	0.37
C17:1 *cis*-10-Heptadecenoic acid	0.29	0.19	0.00	0.26	0.26	0.13	0.17
C18:0 Stearic acid	0.71	1.28	1.20	0.96	0.96	1.10	0.87
C18:1 Oleic acid	29.96	20.02	23.04	25.83	31.54	36.64	28.65
C18:2 Linoleic acid	47.36	53.23	52.71	47.25	41.26	38.03	48.44
C18:3 linolenic acid	6.28	9.38	5.75	6.03	8.52	4.85	5.96
C20:0 arachidic acid	0.35	0.61	0.49	0.45	0.56	0.51	0.54
C21:0 Henicosanoic acid	0.10	0.30	0.00	0.20	0.00	0.12	0.12
C22:0 Behenic acid	0.26	0.46	0.59	0.41	0.54	0.33	0.31
Total	100.00	99.96	100.00	99.99	100.00	99.99	99.90

Chromatogram of fatty acid methyl esters for the chestnut sample 61316 is given in the Fig. 3. Values of the fatty acid were calculated based on their peak areas.

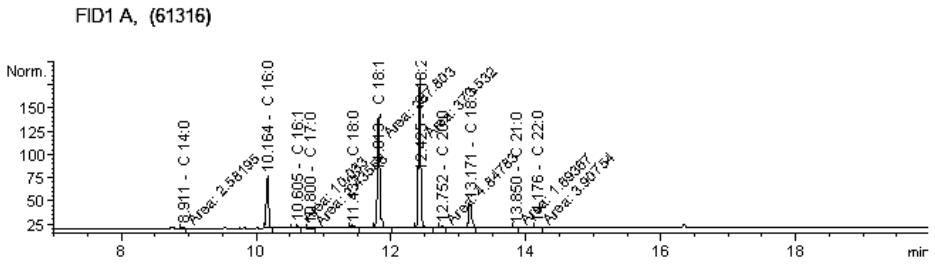

Fig. 3. GC chromatogram of the chestnut sample 61316

Conclusion

In this research, some chemical properties such as moisture, protein, starch, invert sugar, sucrose, fat and fatty acid contents of chestnut types grown in Atatürk Central Horticultural Research Institute, Yalova were determined. The fatty acid contents of chestnut types is the first report on chestnut cultivars that grown in Turkey. Moisture, protein, fat and fatty acid contents were determined in chestnut types that harvested in 2007; invert sugar, total sugar, sucrose and starch contents were determined in the same chestnut types that harvested in 2008. Chestnut samples in the 2007 showed some spoils. Therefore, analysis of invert sugar, total sugar, sucrose and starch were done in the 2008. In general, it is found that moisture contents and carbohydrates are higher; protein and fat values are lower in the chestnuts grown in Bursa province, Turkey. Starch, as for all chestnuts, occupies the highest

portion of the carbohydrates. Although protein and fatty acid contents are low, being rich in the unsaturated fatty acid percentage among the fatty acids makes chestnuts a valuable food in human diet.

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