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Original Article

Chemical Compositions and Sugar Profiles of Consumed Chestnut Cultivars in the Marmara Region, Turkey

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Abstract

In this study, the chemical compositions and sugar profiles of seventeen local cultivars and two foreign chestnut hybrids, grown in the Marmara Region, Turkey, were examined. The results showed that chestnut hybrids and cultivars have 58.12-69.83 total carbohydrates, 10.59-22.38 total sugars, 2.41-3.41 invert sugar, 6.15-12.44 total protein, 2.09-4.36 ash and 0.87-2.61 total fat values (g 100 g^{-1} dry matter basis). It was determined that chestnut cultivars generally have over 50% water content and higher starch content (40.99-53.16 g 100 g^{-1}). The sucrose contents of the cultivars were higher than the other sugars. Sucrose, glucose and fructose contents were 10.77-21.66, 0.33-1.13, and 0.15-0.79, respectively (g 100 g^{-1} dry matter basis). These results stated that chestnuts have rich nutritive substances for human nutrition and health.

Keywords: *Castanea sativa*, glucose, fructose, nutritional composition, sucrose

Introduction

Turkey has one of the most important and largest productions of chestnut in the world. The naturally spreading chestnut species in Turkey is the European chestnut (*Castanea sativa* Mill.), and chestnut production utilizes native cultivars. Most chestnut production in Turkey is in the Marmara, Aegean and Black Sea Regions (Soylu *et al.*, 2009; Soylu and Mert, 2009). Chestnut can be consume fresh by roasting and boiling in Turkey, is used in making cakes and is widely used in the candy industry (Uylaser *et al.*, 2014).

Chestnuts have played an important role in human nutrition since ancient times. The term "bread tree" has been used in some places for chestnuts (Bounous *et al.*, 2000). Chestnuts contain high carbohydrates, protein and dietary fibre. In addition, chestnuts differ from other nuts for their low fat and salt content, which make them ideally suited for human nutrition and health (Mujić *et al.*, 2010). Carbohydrates are the relevant components in chestnut, especially starch, followed by sucrose. Together with sucrose, glucose, fructose and raffinose are present in significant amounts and may contribute to the identification of a specific chestnut cultivar (Bernárdez *et al.*, 2004; De la Montana Miguelez *et al.*, 2004; Barreira *et al.*, 2010; Warmund *et al.*, 2011; Suarez *et al.*, 2012). Due to the large proportion of moisture, sugar content, enzyme activity and pericarp characteristics, the shelf life of chestnuts is very limited (Correia *et al.*, 2009). According to several studies (De La Montana Miguelez *et al.*, 2004; Pereira-Lorenzo *et al.*, 2006; Ertan, 2007; Borges *et al.*, 2008; Silvanini *et al.*, 2014; Yang *et al.*, 2015; Poljak *et al.*, 2016), the chemical composition of chestnut fruits can be changed by cultivar (genotype), environmental factors (climatic conditions, soil characteristics and production practices) and altitude.

The aim of this study was to investigate the chemical composition and sugar profiles of grafted chestnut cultivars/genotypes that are commonly cultivated in the Marmara Region, Turkey.

Materials and Methods

Fruit samples

The seventeen native chestnut cultivars (cvs. 'Akkozak', 'Alimolla', 'Demirci', 'Dursun', 'Firdola', 'Hacıibiş', 'Hacıömer', 'Halilibrahim', 'İnegölkestanesi', 'İzmitli', 'Karamehmet', 'Korucu', 'Osmanoğlu', 'Öküzgözü', 'Sarıaşlama', 'Sarıkestane', and 'Tepeköysarısı') two foreign hybrids (cvs. 'Maraval' and 'Marigoule'), were collected from important place in term of growing chestnuts in the Marmara Region. The fruits were harvested from 25 to 40-year-old trees from the beginning of September until the end of October.

Determination of chemical compositions

The moisture content of the chestnuts was determined by the gravimetric method using a drying oven at 105±2 °C. Total ash content was measured according to AOAC (2000). The total nitrogen was analysed using the Kjeldahl method, and crude protein content was calculated using a nitrogen conversion factor of 5.30, which is specific for chestnut fruits (AOAC, 2000). Total fat was determined after extraction with ether for 16 h in a

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soxhlet device (AOAC, 2000). The dinitrophenol method was utilized in the analysis of total carbohydrates, total sugar and invert sugar (Ross, 1959) using the Beckman Du 530 model spectrophotometer. Starch quantity was calculated by multiplying the value obtained via subtracting the total sugars from the total carbohydrates by the coefficient 0.94.

Sugar Analysis

Extraction of sugar using and ultrasound bath

The fruit samples were carried to the laboratory, peeled, and stored at -20 °C until analysis. Approximately 10-15 g of frozen homogenized chestnut sample was directly weighed in a 100 ml volumetric flask, 70 ml deionized distilled water was added, and the dissolution was mixed with a magnetic blender for 30 minutes at 70 °C. Afterwards, the 100 ml dissolution was held in an ultrasound bath in 15 min at 50 °C and was centrifuged for 10 min at 3000 g. A millilitre of the dissolution was passed through a 0.45 μm filter GHP (Waters, Millford, MA, USA) prior to HPLC analysis.

Determination of sugars using high-performance liquid chromatography (HPLC)

Free sugar profiles were determined by high-performance liquid chromatography coupled to a refraction index detector (HPLC-RI). Acetonitrile/deionized water was used as the mobile phase at 80:20 (v/v), the flow rate was 2 ml/min, the column temperature was 35°C and the injection volume was 10 μl. The used NH2 column had a 4.6 mm diameter, was 250 mm long, and had a 5 μm particle size (250×4.6 mm ID). The results are expressed in g 100 g^{-1} of dried weight, calculated by an internal standard normalization of the chromatographic peak area. Sugar identification was made by comparing the relative retention times of sample peaks with standards.

Statistical analysis

Means and standard deviations of chestnut composition (except moisture content) were expressed on a dry weight basis due to the different moisture contents of the samples. Statistical comparisons of the mean values were performed using one-way analysis of variance (ANOVA), followed by Duncan's multiple range test ($p < 0.05$ confidence level) using Minitab 17.0 software. A principal component analysis (PCA) was also performed using Minitab 17.0 software.

Results and Discussion

Proximate analysis

The nutritional compositions of the nineteen chestnut cultivars are shown in Table 1. Moisture content of cultivars was determined between 46.52% and 59.47% and demonstrated significant differences among all cultivars ($p < 0.05$). The moisture content of chestnuts should not be less than 49% or over 60% in order to be able conserve them in a better way (Glushkova *et al.*, 2010). According to Pereira-Lorenzo *et al.* (2006), although high moisture content is very important for the fresh market, it causes mould problems during storage and delivery. The moisture content of chestnuts depends on fruit characteristics and ecological conditions such as soil type, summer rainfalls, altitudes and orchard locations (Borges *et al.*, 2008; Neri *et al.*, 2010).

Total carbohydrates varied significantly among cultivars ($p < 0.05$). Total carbohydrate amount of all cultivars ranged from 58.12 to 69.83 g 100 g^{-1} for cvs. 'Akkozak' and 'Demirci', respectively (Table 1). Our findings were lower than those obtained by other researchers. Chestnut fruits generally contain high rates of carbohydrates; the rate was 86.26 g 100 g^{-1} in American chestnuts (*C. dentata* Borkh.) (McCarthy and Meredith, 1988), 51.2 and 81.6 g 100 g^{-1} in Chinese chestnuts (Yang *et al.*, 2015), and 71.68-88.10 g 100 g^{-1} in European chestnuts (McCarthy and Meredith, 1988; Künsch *et al.*, 1999; Bounous, 1999; Bounous *et al.*, 2000; Ertürk *et al.*, 2006). This value changed nearly 16% in the different materials of the *C. sativa* species (Bounous *et al.*, 2000; Ertürk *et al.*, 2006). The accessions in the study also showed an approximately 12% variation in carbohydrate content in the highest and lowest cultivars.

The predominant component of dry matter is starch ranged from 37.82 to 53.16 g 100 g^{-1} with a mean value of 46.49 g 100 g^{-1} in the cultivars (Table 1). The highest starch content

Table 1. Proximate composition of the nineteen chestnut cultivars (mean ± SD)

Cultivar	Moisture (%)	Carbohydrates (g/100g^{-1})	Starch (g/100g^{-1})	Crude protein (g/100g^{-1})	Crude fat (g/100g^{-1})	Ash (g/100g^{-1})
'Akkozak'	53.63	58.12 ± 0.49 c	42.51 ± 1.79 efg	8.35 ± 0.38 efg	1.68 ± 0.05 cd	2.59 ± 0.01 def
'Alimolla'	55.11	68.37 ± 1.10 ab	53.16 ± 0.93 a	7.46 ± 1.17 hı	1.65 ± 0.76 cd	4.39 ± 0.43 a
'Demirci'	51.18	69.83 ± 3.20 a	52.90 ± 2.53 ab	7.93 ± 0.15 fgh	1.10 ± 0.41 g	3.09 ± 0.50 bcd
'Dursun'	51.43	62.19 ± 0.79 abc	45.45 ± 0.49 def	12.44 ± 0.30 a	1.05 ± 0.37 g	2.09 ±0.10 f
'Firdola'	54.83	63.54 ± 2.03 abc	43.42 ± 1.82 def	7.89 ± 0.27 ghı	1.04 ± 0.03 g	2.91 ± 0.06 bcd
'Hacıibiş'	49.25	68.88 ± 0.80 ab	51.45 ± 1.63 abc	6.55 ± 0.38 j	1.58 ± 0.03 de	2.66 ± 0.21 def
'Hacıömer'	57.48	65.69 ± 7.37 abc	49.11 ± 7.35 a-d	7.30 ± 0.35 hı	0.92 ± 0.11 h	2.74 ± 0.45 de
'Halilibrahim'	48.53	66.45 ± 1.71 ab	46.76 ± 1.97 c-f	7.96 ± 0.17 fgh	2.25 ± 0.30 b	2.96 ±0.21 bcd
'İnegölkestanesi'	53.96	65.99 ± 1.08 ab	40.99 ± 0.84 fg	7.23 ± 0.16 ı	1.71 ± 0.06 c	2.99 ± 0.43 bcd
'İzmitli'	47.97	63.60 ± 1.82 abc	46.12 ± 0.86 c-f	9.80 ± 0.41 d	1.32 ± 0.40 f	3.42 ± 0.41 bc
'Karamehmet'	49.95	64.36 ±0.18 abc	46.59 ± 0.70 c-f	8.23 ± 0.40 efg	1.73 ± 0.07 c	2.79 ± 0.20 cde
'Korucu'	54.71	63.57 ± 2.29 abc	47.38 ± 2.88 b-e	8.59 ± 0.08 ef	1.40 ± 0.17 f	3.05 ± 0.21 bcd
'Maraval'	50.71	65.26 ± 3.61 abc	46.22 ± 4.62 c-f	6.45 ± 0.18 j	1.15 ± 0.12 g	3.43 ± 0.30 bc
'Marigoule'	59.47	63.76 ± 10.66 abc	47.53 ± 4.51 b-e	8.88 ± 0.13 e	0.87 ± 0.07 h	3.56 ± 0.15 b
'Osmanoğlu'	55.78	66.03 ± 6.54 ab	45.35 ± 4.52 def	7.98 ± 0.28 fgh	2.61 ± 0.20 a	2.94 ± 0.85 bcd
'Öküzgözü'	58.05	65.53 ± 1.70 abc	46.20 ± 2.25 c-f	7.77 ± 0.19 hgı	1.54 ± 0.40 e	2.89 ± 0.17 cde
'Sarıaşlama'	58.52	67.13 ± 1.23 ab	46.15 ± 0.95 c-f	10.46 ± 0.24 c	1.50 ± 0.16 e	4.16 ± 0.21 a
'Sarıkestane'	48.10	67.50 ± 6.52 ab	48.23 ± 3.83 a-e	11.22 ± 0.19 b	1.58 ± 0.08 de	2.13 ± 0.21 f
'Tepeköysarısı'	46.52	60.97 ± 1.85 bc	37.82 ± 1.53 g	6.15 ± 0.09 j	0.93 ± 0.04 h	2.27 ± 0.09 ef

Different letters within the same column indicate significant differences (Duncan test, $p < 0.05$)

Table 2. Total sugar, invert sugar and sugar composition of the nineteen chestnut cultivars (mean ± SD)

Cultivar	Total sugar (g/100g^{-1})	Invert sugar (g/100g^{-1})	Sucrose (g/100g^{-1})	Glucose (g/100g^{-1})	Fructose (g/100g^{-1})
'Akkozak'	12.90 ± 1.42 hı	2.71 ± 0.11 cd	9.67 ± 0.77 o	0.42 ± 0.01 j	0.45 ± 0.00 f
'Alimolla'	11.82 ± 0.13 ıj	3.39 ± 0.06 a	10.78 ± 0.08 m	0.58 ± 0.00 fg	0.16 ± 0.00 k
'Demirci'	13.55 ± 0.53 cd	3.08 ± 0.16 abc	11.59 ± 0.04 k	0.43 ± 0.03 ıj	0.47 ± 0.03 ef
'Dursun'	13.84 ± 0.36 h	2.90 ± 0.03 a-d	10.39 ± 0.01 n	0.66 ± 0.00 de	0.28 ± 0.01 ıj
'Hacıibiş'	14.15 ± 1.08 h	3.28 ± 0.10 ab	13.05 ± 0.01 g	0.79 ± 0.01 c	0.37 ± 0.02 hg
'Hacıömer'	13.45 ± 0.72 hı	3.13 ± 0.47 abc	12.04 ± 0.03 j	0.55 ± 0.00 gh	0.57 ± 0.00 c
'Halilibrahim'	16.71 ± 0.47 def	2.98 ± 0.13 abc	13.03 ± 0.08 g	0.75 ± 0.04 c	0.37 ± 0.02 gh
'Firdola'	17.35 ± 0.34 def	2.77 ± 0.12 bd	15.79 ± 0.01 d	0.64 ± 0.02 ef	0.32 ± 0.01 hı
'İnegölkestanesi'	22.38 ± 0.30 a	2.62 ± 0.05 cd	16.39 ± 0.04 c	0.59 ± 0.04 fg	0.68 ± 0.04 b
'İzmitli'	14.54 ± 1.04 gh	2.94 ± 0.05 a-d	11.01 ± 0.15 l	0.77 ± 0.04 c	0.45 ± 0.01 f
'Karamehmet'	14.79 ± 0.56	2.97 ± 0.04 abc	12.45 ± 0.03 ı	0.72 ± 0.02 cd	0.29 ± 0.01 ıj
'Korucu'	13.17 ± 0.78 hı	3.02 ± 0.18 abc	9.63 ± 0.09 o	0.41 ± 0.01 j	0.41 ± 0.01 fg
'Maraval'	16.09 ± 1.30 fg	2.95 ± 0.29 a-d	12.69 ± 0.04 h	0.62 ± 0.00 efg	0.15 ± 0.01 k
'Marigoule'	17.03 ± 0.78 def	2.80 ± 0.68 bcd	14.10 ± 0.09 f	0.34 ± 0.02 k	0.23 ± 0.01 j
'Osmanoğlu'	19.49 ± 1.26 bc	2.79 ± 0.47 bcd	15.41 ± 0.06 e	1.13 ± 0.09 a	0.51 ± 0.04 de
'Öküzgözü'	16.38 ± 1.24 eg	2.95 ± 0.14 a-d	12.04 ± 0.13 j	0.49 ± 0.01 hı	0.54 ± 0.02 cd
'Sarıaşlama'	18.04 ± 1.75 cde	2.95 ± 0.06 a-d	16.63 ± 0.04 b	0.94 ± 0.04 b	0.80 ± 0.05 a
'Sarıkestane'	10.59 ± 2.17 j	3.41 ± 0.52 a	6.82± 0.10 p	0.40 ± 0.00 j	0.23 ± 0.00 j
'Tepeköysarısı'	20.74 ± 0.23 ab	2.41 ± 0.10 de	17.40 ± 0.07 a	1.00 ± 0.04 b	0.65 ± 0.02 b

Different letters within the same column indicate significant differences (Duncan test, $p < 0.05$)

was observed in 'Alimolla' (53.16 g 100 g^{-1}), and this value was significantly higher than all the other cultivars. This was followed by 'Demirci' (52.90 g/100 g) and 'Hacıibiş' (51.45 g 100 g^{-1}). The lowest starch content was recorded in 'Tepeköysarısı' (37.82 g 100 g^{-1}), and it was significantly lower than all the other cultivars. The starch content reported in Chinese chestnuts ranged from 38.6 to 62.8% (Yang *et al*., 2015), from 38.6 to 47.9% in chestnut cultivars from Portugal (Borges *et al*., 2008), from 42.2 to 66.5% in chestnut cultivars from Spain (Pereira-Lorenzo *et al*., 2006), and from 40.85 to 56.32 g/100 g^{-1} in chestnut cultivars from Bulgaria (Glushkova *et al*., 2010).

Protein content varied significantly among cultivars ($p < 0.05$). The protein content of the chestnuts ranged from 6.15 (cv. 'Tepeköysarısı') to 12.44 g 100 g^{-1} (cv. 'Dursun'), which were slightly higher than a previous report (4.87-7.37 g 100 g^{-1}) (Ertürk *et al*. 2006). The protein content was reported to be between 3.43 and 13.28 g 100 g^{-1} in European chestnut cultivars and between 6.1% and 12.2% in Chinese chestnut cultivars (Ferreria-Cardoso *et al*., 1993; Pinnavaia *et al*., 1993; Brighenti *et al*., 1998; Bounous, 1999; Ertürk *et al*., 2006; Borges *et al*., 2008; Yang *et al*., 2015). Our results are similar to previous results.

Chestnuts differ from other nuts and have lower fat (2-5%) content. The crude fat content was significantly different among the cultivars ($p < 0.05$). The crude fat amount of all the cultivars ranged from 0.87 to 2.61 g 100 g^{-1} for cvs. 'Marigoule' and 'Osmanoğlu', respectively. The results are in accordance with those obtained by Ertürk *et al*. (2006) for *C. sativa* and hybrid cultivars, (Sacchetti and Pinnavaia, 2005) for Italian cultivars and De La Montana Miguelez *et al*. (2004) and Pereira-Lorenzo *et al*. (2006) for Spanish cultivars.

Ash content changed between 2.09 g 100 g^{-1} (cv. 'Dursun') and 4.39 g 100 g^{-1} (cv. 'Alimolla'), with an average of 3.00 g 100 g^{-1} (Table 1). The quantity of ash reported in chestnut ranged between 0.83 and 4.92 g 100 g^{-1} in various species and genotypes (Brighenti *et al*., 1998; Demiate *et al*., 2001; Sundriyal and Sundriyal, 2001; Ertürk *et al*., 2006; Pereira-Lorenzo *et al*., 2006; Bourges *et al*., 2008; Sacchetti *et al*., *2009*). Our results were similar to previous results.

Invert and total sugars varied significantly among the cultivars ($p < 0.05$). The invert sugar content of the cultivars ranged between 2.41 g 100 g^{-1} (cv. 'Tepeköysarısı') and 3.41 g 100 g^{-1} (cv. 'Sarıkestane'). These results are in accordance with Pinnavaia *et al*. (1993) for French cultivars (0.82 and 3.56 g 100 g^{-1}). Total sugar contents changed between 10.59 g 100 g^{-1} (cv. 'Sarıkestane') and 22.38 g 100 g^{-1} (cv. 'İnegölkestanesi') (Table 2). Within the range, the results of Pinnavaia *et al*. (1993), Bounous *et al*. (2000) and Ertürk *et al*. (2006) reported total sugar contents of 10.32-22.79 g 100 g^{-1}.

Sucrose is the main sugar in the chestnuts. Chestnut cultivars and hybrids showed heterogeneity with respect to their sugar contents. Significant differences ($p > 0.05$) were found among the cultivars for sucrose, glucose and fructose contents (Table 2). The sucrose, glucose and fructose contents of the cultivars were 6.82-17.40 g 100 g^{-1}, 0.34-1.13 g 100 g^{-1} and 0.15-0.80 g 100 g^{-1}, respectively. The 'Tepeköysarısı' cultivar showed the highest sucrose content (17.40 g 100 g^{-1}), while the 'Sarıkestane' cultivar had the lowest value (6.82 g 100 g^{-1}). Glucose and fructose were also present in lower quantities in the chestnut samples (Table 2)**.** Bernárdez *et al*. (2004) found slightly higher concentrations of sucrose (6.5 and 19.5 g 100 g^{-1}) and lower concentrations of glucose (0.00 and 0.27 g 100 g^{-1}) and fructose (0.04 and 0.31 g 100 g^{-1}) compared to our results. However, some researchers observed lower values (sucrose 3.11-9.99 g 100 g^{-1}, glucose 0.025-0.190 g 100 g^{-1}, and fructose 0.056-0.240 g 100 g^{-1}) (Suárez *et al*., 2012) or higher values (Barreira *et al*., 2010) (sucrose 9.56-22.05 g 100 g^{-1}, glucose 1.02-6.63 g 100 g^{-1}, and fructose 0.62-5.18 g 100 g^{-1}) than our findings.

Table 3 shows the coefficients of variation in the chemical parameters of the chestnut seeds from the different cultivars in order to verify the intravarietal homogeneity. Chestnuts from cvs. 'Marigoule' 'Sarıkestane', 'Osmanoğlu', 'Hacıömer', 'Alimolla' and 'Demirci' showed just one coefficient of variation higher than 15% in carbohydrates, total sugar, invert sugar, starch, crude protein and ash parameters. The

Table 3. Coefficients of variation [(SD/mean)*100] of main parameters analysed

Cultivar	Carbohydrates	Total sugar	Invert sugar	Starch	Crude protein	Crude fat	Ash	Sucrose	Glucose	Fructose
'Akkozak'	0.85	11.01	4.22	4.22	4.50	2.94	0.44	7.96	3.36	0.00
'Alimolla'	1.61	1.09	1.75	1.75	15.68	3.43	9.82	0.72	0.00	0.00
'Demirci'	4.58	3.90	5.19	4.79	1.89	1.93	16.24	0.35	6.58	6.02
'Dursun'	1.27	2.56	1.09	1.09	2.40	2.02	4.71	0.10	0.00	2.57
'Hacıbiş'	1.16	7.64	3.18	3.18	5.84	1.79	7.91	0.08	0.90	5.81
'Hacıömer'	11.21	5.34	14.96	14.96	4.82	3.08	16.55	0.25	0.00	0.00
'Halilibrahim'	2.57	2.83	4.21	4.21	2.09	0.63	6.98	0.61	4.75	5.81
'Firdola'	3.20	1.98	4.20	4.20	3.41	2.72	1.90	0.09	3.34	2.24
'İnegölkestanesi'	1.64	1.32	2.05	2.05	2.16	3.31	14.44	0.26	6.05	5.24
'İzmitli'	2.87	7.15	1.86	1.86	4.16	2.70	12.08	1.36	5.51	1.59
'Karamehmet'	0.28	3.81	1.49	1.49	4.81	4.09	7.19	0.22	2.97	2.48
'Korucu'	3.60	5.89	6.07	6.07	0.91	2.02	6.77	0.93	3.44	3.45
'Maraval'	5.54	8.07	9.99	9.99	2.76	1.85	8.62	0.28	0.00	9.43
'Marigoule'	16.72	4.57	24.39	9.50	1.51	8.13	4.16	0.65	6.33	3.14
'Osmanoğlu'	9.91	6.44	16.69	9.98	3.51	2.17	28.92	0.42	8.17	7.84
'Öküzgözü'	2.60	7.57	4.88	4.88	2.44	1.84	5.88	1.11	2.88	3.96
'Sarıaşlama'	1.83	9.67	2.06	2.06	2.26	0.94	5.08	0.25	4.51	6.23
'Sarıkestane'	9.66	20.51	15.12	16.77	1.67	5.37	9.89	1.47	0.00	0.00
'Tepeköysarısı'	3.03	1.09	4.04	4.04	1.45	4.56	3.96	0.40	3.56	3.29

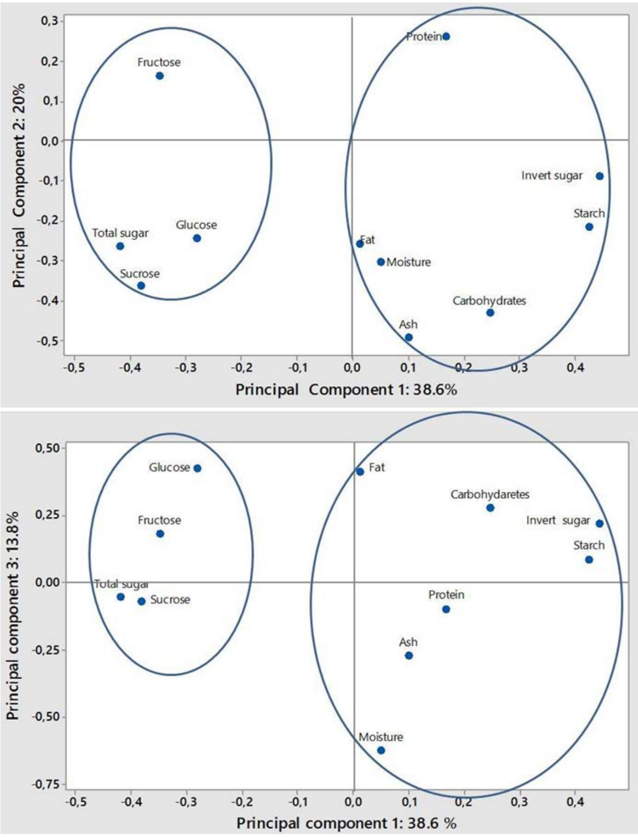

Fig. 1. Principal component analysis plot for nutritional parameters of the nineteen chestnut cultivars

coefficients of variation of the other chestnut cultivars were lower than 12%, distinguishing their homogeneity. PCA was applied to moisture, carbohydrates, total sugars, crude protein, crude fat, starch, invert sugars, ash, sucrose, fructose, glucose for the nineteen cultivars (Fig. 1). The results from the PCA showed that the first three principal components (PC1, PC2 and PC3) accounted for 72.4% of the variation (Fig. 1). PC1 explained 38.6% of the TV, and the parameters that correlated best with this PC were invert sugar (0.444), starch (0.425) and total sugar (-0.418). The parameters that best correlated with PC2 (that accounted for 20% of TV) were ash (-0.493), carbohydrates (-0.432) and sucrose (-0.364), and with PC3 (that accounted for 13.8% of TV), the parameters were moisture (-0.626), glucose (0.425) and crude fat (0.414). Two groups were defined according to the position of each sample. The total sugar, sucrose, glucose, fructose showed similar variation in relation to the PC1, whilst starch, protein, ash, moisture, invert sugar, carbohydrates, and crude fat showed an inverse variation.

Conclusions

The results obtained in this study do confirm that chestnuts are a rich source of carbohydrate and starch. In addition to sucrose, the predominant free sugars, glucose, and fructose also existed in our studied chestnuts. The results showed that, the chemical composition of studied cultivars varied depending on genetic structure and ecological conditions. Differences of nutritional value and other quality parameters among cultivars could be very useful in selecting cultivars for different purpose. For instance, 'Alimolla', 'Demirci' and 'Hacıbiş' cultivars are appropriate for flour production due to their high starch content. 'İnegölkestanesi', 'Tepeköysarısı' and 'Osmanoğlu' with high quantities of total sugar are more desirable for fresh consumption. The results of this study will be a benefit to producers, consumers, breeders and the processing industry.

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