Comparison of roasting and boiling pre-treatments for cold pressed melon seed oil

Selçuk OK[1]
Emin YILMAZ[1*]

[1] Department of Food Engineering
Faculty of Engineering
Çanakkale Onsekiz Mart University
Çanakkale, Turkey

In this study, oils were produced from the melon seeds by cold press technique and physicochemical properties, compositions and sensorial properties of these oils, and physicochemical properties of the seeds and the press cakes were determined. In addition, the effects of the pre-treatments on the oil yield and on the properties of the seed, press cake and oil were compared with each other. It was observed that the contents of the melon seeds decreased significantly with the boiling pre-treatment. Press cakes were found to be rich in nutrition and they could be utilised in edible products. It was detected that oil yield obtained by the roasting pre-treatment was higher than that obtained by the boiling pre-treatment. Linoleic acid, b-sitosterol and a-tocopherol were determined as major fatty acid, sterol and tocopherol, respectively. It was observed that quantities of the phenolic compounds decreased significantly with boiling pre-treatment. Aromatic volatile compounds which have roasted/nutty and herbal/grassy/sour aroma descriptions were detected predominantly in roasted and boiled seed oils, respectively. According to the sensory analyses, melon seed oils were found to be low in the intensity of the sensory attributes. According to the consumer tests, it was observed that melon seed oils had intermediate scores and consumer satisfaction was moderate. In conclusion, it is thought that melon seeds could be used as a raw material for edible oil production.

Keywords: Melon seed, Cold press, Physico-chemical property, Composition, Aromatic volatile compound, Sensory property

INTRODUCTION

Melon (*Cucumis melo*) is an economically important species of *Cucurbitaceae* family which contains over 900 species of plants grown in tropics, subtropics and temperate regions. Melon is a plant with a short and thick taproot, 3-5 main offshoot spread on the soil, round or heart-shaped green leaves and yellow-coloured flowers. The fruit is generally round shaped, 6.5-11.43 cm in diameter, and 450-850 grams in weight. The fruit flesh is soft, juicy, sweet and fragrant, with colours ranging from yellow to orange. In the centre of the fruit flesh, there is a cavity filled with white seeds [1, 2, 3].

According to FAO statistics, in 2016, China was the biggest melon producer with 15,944,800 tons and it was followed by Turkey and Iran with 1,854,356 tons and 1,615,642 tons, respectively. Production quantity of Turkey corresponded to 5.95% of total melon production around the world in 2016 [4].

During the production of melon juice and melon syrup, huge amounts of rinds and seeds are generated as waste products. It was stated that melon rinds can be used as an adsorbent for the removal of heavy metals from the aqueous phase and as a nutrient source for enzyme production. It was also stated that melon seeds may be utilised as food additives, and animal and poultry feed. In

(*) CORRESPONDING AUTHOR:
Department of Food Engineering
Faculty of Engineering
Çanakkale Onsekiz Mart University
17020, Çanakkale, Turkey
Phone: +902862180018-2170
Fax: +902862180541
E-mail: eyilmaz@comu.edu.tr

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eastern and south-eastern regions of Turkey, melon seeds are consumed as a snack and these seeds are obtained from specific melon species that are specially cultivated for their seeds [5, 6, 7].
In a study, it was observed that melon seeds contained 25.0% protein, 25.0% oil, 23.3% fibre, and 2.4% ash [8]. In another study, the composition of melon seeds was determined as 17.2% protein, 13.9% oil, 41.6% fibre and 6.1% ash [9]. It can be said that melon seeds are nutritionally rich materials; therefore, it is important to valorise these huge amounts of waste product.
Cold pressing is an alternative technique for virgin oil production. This technique yields safe, sensorially acceptable and high-quality oils. Cold pressed oils are totally free from chemicals and other undesirable components and they retain all the naturally present bioactives [10, 11].
In recent years, there is a quest for new raw materials for oil production to meet increasing demands and produce new products for different applications. For this study, melon seeds, which were pre-treated by using roasting and boiling, were used for oil production by cold press technique and products were characterised completely. In addition, the effects of these pre-treatments on the oil yield and product properties were compared with each other. Physical properties and main components of the seeds and press cakes were also determined. Thus, possible usages of this new oil were evaluated.

EXPERIMENTAL PART

MATERIALS

Melon seeds (*Cucumis melo* var. Siirt) were purchased from a local market in Siirt, Turkey. It was known that the seeds were harvested the previous year (2017), and stored in dark and cool rooms in suitable plastic containers. All chemicals, solvents and standards were analytical or of chromatographic grade and purchased from Sigma (St. Louis, USA) and Merck Co. (Darmstadt, Germany).

ANALYSES OF THE MELON SEEDS

The seed dimensions (length, width and thickness) were measured with a digital caliper (Leo, Nikko Ltd., China). 1000-seed weights were calculated by weighing (Sartorius ED224S, Sartorius, Germany) of the randomly selected seeds several times. For the calculation of shell:seed ratios, whole seeds and seed shells were weighed and proportioned. Minolta colorimeter CR 400 (Osaka, Japan), AQUA Lab 4TE (Decagon Devices, USA) and OHAUS MB45 moisture analyser (Ohaus, Pine Brook, USA) were used to determine the colours, water activities and moisture contents of the melon seeds, respectively. Oil, protein and ash contents of the melon seeds were determined according to AOAC 920.39 [12], AOCS Aa 5-38 [13] and AOCS Ba 5a-49 [14], respectively.

COLD PRESSING OF THE MELON SEEDS

The roasting pre-treatment was applied to the seeds by roasting them at 150°C for 30 min in a conventional oven (Inoksan FPE 110, Bursa, Turkey). Before cold pressing, the seed moisture content was adjusted to 12% by water conditioning [10]. For boiling pre-treatment, seeds were soaked into the boiling water (99.8°C) for 30 min. Then, seeds were drained, and the seed moisture content was adjusted to 12% by drying at 105°C in a conventional oven (Inoksan FPE 110, Bursa, Turkey). The optimum moisture content of the seeds for cold pressing was determined to be 12% for the maximum oil yield and easiness of the operation.
A laboratory scale cold press machine (Koçmaksan, ESM 3710, İzmir, Turkey; single head, 2 hp, 1.5 kW power, 12 kg seed/h capacity) was used for the cold pressing of the melon seeds. The operating conditions were as follows; 18 rpm screw rotation speed, 12 mm exit die and 40°C oil exit temperature. After cold pressing of the seeds, oils were centrifuged (Sigma 2-16 K, Postfach, Germany) at 6797 × g and filtered to remove foreign materials. Then, oils were placed in amber-coloured glasses, flushed with nitrogen and stored in a fridge until further analyses.

Figure 1 - Melon seeds, melon seed oils and press cakes. (A: Roasted, B: Boiled)

Melon seeds, melon seed oils and press cakes are shown in Figure 1.
The following equation was used to calculate the cold press oil yields of the roasted and boiled melon seeds:

$$\text{Oil yield (\%)} = (A / B) \times 100$$

A = amount of oil obtained by cold pressing (g)
B = total oil content (g) of the seeds entering the cold press machine (calculated based on the crude oil content determined by the Soxhlet technique)

ANALYSES OF THE PRESS CAKES

Minolta colorimeter CR 400 (Osaka, Japan), AQUA Lab 4TE (Decagon Devices, USA) and OHAUS MB45 moisture analyser (Ohaus, Pine Brook, USA) were used to determine the colours, water activities and moisture contents of the press cakes, respectively. Oil, protein and ash contents of the press cakes were determined according to AOAC 920.39 [12], AOCS Aa 5-38 [13] and AOCS Ba 5a-49 [14], respectively.

PHYSICOCHEMICAL ANALYSES OF THE OILS

Specific gravities of the oils were measured by using oil pycnometers according to AOCS Cc 10c-95 [15]. Specific extinction values were measured by a spectrophotometer (Shimadzu UV-1800, Shimadzu Co., Japan) according to AOCS Ch 5-91 [16]. Abbe 5 refractometer (Bellingham and Stanley, UK) was used to determine refractive indices of the oils. Apparent viscosities were measured via Brookfield DV II+Pro Viscometer (Brookfield Eng. Lab., Inc., MA, USA) with LV-SC4-18 spindle and 50 rpm rotation at room temperature. Turbidities of the oils were measured by HACH 2100AN Turbidimeter (USA) at room temperature. Minolta colorimeter CR-400 (Osaka, Japan) was used to determine the colour values (L, a* and b*) of the oils.
Free fatty acidity values, peroxide values, *p*-anisidine values, iodine numbers, saponification numbers, unsaponifiable matters of the oils were determined according to AOCS Ca 5a-40 [14], AOCS Cd 8-53 [14], AOCS Cd 18-90 [14], AOCS Cd 1-25 [14], AOCS Cd 3-25 [16], TSE 894 [17], respectively.

THERMAL ANALYSES OF THE OILS

Thermal parameters of the oils were determined with the Differential Scanning Calorimeter (DSC) (Perkin-Elmer DSC 4000, USA). Melting and crystallisation properties of the oils were determined according to Dassanayake et al. [18]. 5–10 mg oil sample was weighed into an aluminium pan, sealed hermetically and analysed against the empty pan. The temperature program applied during the analyses was as follows; heating from 20°C to 110°C by 10°C/min rate, cooling from 110°C to -70°C by 10°C/min rate, waiting at that temperature for 3 min and heating from -70°C to 50°C by 5°C/min rate. Pyris 1 Manager Software of the instrument was used for the calculation of the thermal parameters of the oils.
Oxidative induction times (OIT) of the oils were determined according to Tan et al. [19]. 5–10 mg oil sample was weighed into an aluminium pan and analysed against the empty pan. The temperature program applied during the analyses was as follows; heating from 30°C to 150°C by 20°C/min rate with nitrogen (99.99%) and waiting at that temperature with oxygen (99.99%) for 30 min. Pyris 1 Manager Software of the instrument was used for the calculation of the OIT values (min) of the oils.

DETERMINATION OF THE FATTY ACID, STEROL AND TOCOPHEROL COMPOSITIONS OF THE OILS

Fatty acid compositions of the oils were determined according to David et al. [20]. First, fatty acid methyl esters were prepared. 100 mg oil sample was weighed into a test tube and dissolved with 10 ml hexane. Then, 100 µl 2 N methanolic KOH was added and the test tube was vortexed for 30 sec. Finally, this mixture was centrifuged at 6461 xg for 10 min (Sigma 2-16K, Sartorius, Germany) and clear phase was taken into a vial for injection. Fatty acid compositions of the oils were determined via Gas Chromatograph-FID (Agilent Technologies 7890B, Palo Alto, CA, USA) equipped with HP 88 capillary column (100 m 0.25 mm ID 0.2 µm film thickness, J&W Scientific Co, CA, USA). Conditions of the analysis were as follows; 1 µl injection volume, 1:50 injector split ratio, 2 ml/min flow rate, hydrogen as carrier gas, hydrogen (40 ml/min) and dry air (450 ml/min) as detector gasses, 250°C inlet temperature and 280°C detector temperature. The temperature program applied during the analysis was as follows; 120°C for 1 min, 175°C (10°C/min) for 10 min, 210°C (5°C/min) for 5 min and 230°C (5°C/min) for 5 min. Fatty acids were identified by using FAME standards mixture (37-components, C4-C24, Supelco, Bellefonte, PA, USA).
TSE EN ISO 12228 method [21] was used to determine the sterol compositions of the oils. First, unsaponifiable matters were obtained after the saponification procedure and then, sterol fractions were separated by using TLC. Sterol fractions were analysed via Gas Chromatograph-FID (Agilent Technologies 7890B, Palo Alto, CA, USA) equipped with DB5 capillary column (30 m 0.25 mm ID 0.1 µm film thickness, J&W Scientific Co, CA, USA). Conditions of the analysis were as follows; 1 µl injection volume, 1:100 injector split ratio, 0.8 ml/min flow rate, hydrogen as carrier gas, hydrogen (30 ml/min) and dry air (400 ml/min) as detector gasses, 290°C inlet temperature and 300°C detector temperature. The temperature program applied during the analysis was as follows; 60°C for 2 min, 220°C (40°C/min) for 1 min, 310°C (5°C/min) for 30 min.

Sterols were identified by using commercial standards. Sterols were quantified by using the peak area of α-cholestanol, which was added into the sample as an internal standard.
Tocopherol compositions of the oils were determined according to Grilo Camara et al. [22] with minor modifications. 200 µl of sample was diluted to 5 ml with dichloromethane and then transferred into a vial for injection. Tocopherol compositions of the oils were determined via Reverse-phase HPLC (Shimadzu Corporation, Kyoto, Japan) equipped with Inertsil ODS-3 column (250 mm 4.6 mm 5 µm, GL Sciences Inc., Japan) and RF-20A fluorescent detector. The methanol:water (97:3, v/v) mobile phase was eluted with an isocratic flow rate of 1.6 ml/min. The detector wavelengths were 290 nm for excitation and 330 nm for emission. Commercial standards were used for the identification and quantification of the tocopherols.

DETERMINATION OF THE PHENOLIC COMPOSITIONS OF THE OILS

Phenolic compounds were extracted from the oil samples according to Vallverdú-Queralt et al. [23] with minor modifications. First of all, 3 g oil was dissolved with 3 ml hexane. Then, this mixture was loaded into a cartridge (CNWBOND Poly-Sery, GmbH, Germany) that was conditioned previously with 5 ml hexane and 5 ml methanol. Apolar compounds were removed with 5 ml hexane and, phenolic compounds were eluated with 10 ml methanol. Phenolic compounds were analysed by using Reverse-phase HPLC (Shimadzu Corporation, Kyoto, Japan) equipped with Zorbax Eclipse Plus C18 column (250 mm 4.6 mm 5 µm) and SPD-M20A diode array detector according to Moulehi et al. [24] with minor modifications. The mobile phase consisted of sulfuric acid:water (2:998, v:v) (A) and acetonitrile (B). The gradient program was as follows; 0. min 0% A, 0.1-18 min 80% A, 18-24 min 70% A, 24-30 min 67.5% A, 30-36 min 45% A, 36-40 min 0% A, 40-45 min 60% A, 45-47 min 80% A. Commercial standards were used for the identification and quantification of the phenolic compounds.

DETERMINATION OF THE AROMATIC VOLATILE COMPOUNDS IN THE OILS

Aromatic volatile compounds in the oils were analysed according to Krist et al. [25] with minor modifications. First, 5 ml oil, 1 g NaCl and 20 µl internal standards were placed into an amber coloured vial and then this mixture was vortexed for 1 min. The vial was kept in the water bath at 50°C for 15 min to collect the volatile in the headspace. Then, SPME fibre (2 cm, 50/30 µm DVB/Carboxen/PDMS, Supelco, Bellafonte) was immersed into the vial and the vial was kept in the water bath at 50°C for another 45 min. Finally, volatile compounds collected on the fibre were injected in the GC/MS (Agilent 6890HB/Agilent 5875C mass spectrometer; Agilent Technologies, Wilmington, DE, USA) equipped with HP5 MS column (30 m 0.25 mm, i.d. 0.25 µm film thickness, J&W Scientific, Folsom, CA, USA). Conditions of the analysis were as follows; 1:2 split ratio, 1.2 ml/min flow rate, helium as carrier gas. The temperature program applied during the analysis was as follows; waiting at 40°C for 1 min, heating to 200°C (4°C/min), heating to 230°C (7°C/min) and waiting at that temperature for 15 min. The working conditions of MS detector were as follows; 280°C capillary direct interface temperature, 70 eV ionization energy, 35-350 amu mass range, 4.45 scans/sec scanning rate. Wiley Registry of Mass Spectral Data and National Institute of Standards and Technology were used for the identification of compounds [26, 27]. Volatile compounds were quantified by using the peak area of 2-methyl-3-heptanone, which was added into the sample as an internal standard.

SENSORY ANALYSES OF THE OILS

Sensory descriptive analyses of the oils were accomplished according to Quantitative Descriptive Analysis (QDA) [14, 28, 29]. There were 7 female and 5 male volunteer panellists aged between 22 and 47 (24.25±7.31) and trained at least 15 hours on different days and sessions. Under the control of the panel leader, the panellists determined the sensory descriptive terms by using melon seed oils. There were 5 descriptive terms. Descriptive terms, their definitions and references used in these analyses are presented in Table I. A 10 cm line scale from 1 at the minimum intensity to 10 at the maximum intensity was used to quantify the sensory characteristics. Samples (around 50 ml each) were coded with 3-digit numbers and served in colourless glasses covered with metal lids to the panellists together with water, unsalted crackers, dry coffee and expectoration cups. The analyses were carried out in daylight at room temperature on different days and sessions. Fifteen minutes of break time was permitted to the panellists between the samples. Sensory analyses of the oils were replicated in randomised order. The subjects signed a consent form indicating the voluntary incorporation into the panel.

CONSUMER TEST

The sensory characteristics (appearance, smell/aroma, taste/flavour and general acceptance) of the oils were evaluated by 100 volunteer consumers (72 female, 28 male, aged between 20 and 47, 30.25±3.70) by using hedonic scale (1=Dislike extremely, 5=Like extremely). For this purpose, around 10 ml of each sample were coded with 3-digit numbers and served in colourless glasses covered with a metal lid to each consumer together with water, unsalted crackers and expectoration cups at room

Table I - Descriptive terms and references used in the sensory descriptive analyses of the melon seed oils

Descriptor	Definition	Reference
Turbidity	Clarity/turbidity	Min: Fully refined-winterized sunflower oil Max: 0.02% sodium dodecyl sulfate solution
Roasted	Flavour/aroma associated with baked foods/roasted nut	Min: Absent Max: Roasted nut
Zucchini	Flavour/aroma associated with raw zucchini	Min: Absent Max: Raw zucchini
Raw vegetable	Flavour/aroma associated with uncooked/raw vegetable	Min: Absent Max: Fresh green bean/green pepper
Oiliness	All oily taste and aroma	Min: Absent Max: Sunflower oil

temperature in daylight. The consumers took a break between the two samples as desired.

STATISTICAL ANALYSES

Cold pressing of the roasted and boiled melon seeds was replicated twice. For each sample, all analyses were carried out at least in triplicate (seed dimensions, colour, water activity, specific extinctions, turbidity, thermal properties) or duplicate (the rest of the analyses). Comparison of the roasting and boiling pre-treatments for seeds, oils and press cakes was accomplished by means of the One-way ANOVA and Tukey's test. Sensory evaluation data were compared by using non-parametric Kruskal-Wallis and Dunn's test. Minitab Ver. 16.1.1 [30] and SPSS [31] package software programs were used for statistical analyses. The level of confidence was determined for at least 95% in this study.

Table II - Physicochemical properties of the melon seeds

	Melon seed	
	Roasted	Boiled
Dimension (mm)		
Length	10.80 ± 1.39^a	10.28 ± 2.27^a
Width	4.37 ± 0.38^a	4.55 ± 0.50^a
Thickness	1.92 ± 0.22^a	2.02 ± 0.58^a
1000-seed weight (g)	3.57 ± 0.10^a	3.25 ± 0.04^b
Shell:seed ratio (%)	42.37 ± 1.84^a	41.16 ± 1.50^a
Colour		
L	65.57 ± 4.89^a	59.75 ± 4.55^a
a*	5.73 ± 1.15^a	7.24 ± 1.11^a
b*	24.80 ± 4.89^b	34.99 ± 3.22^a
Water activity (25°C)	0.38 ± 0.00^b	0.72 ± 0.00^a
Moisture content (%)	3.62 ± 0.01^b	34.52 ± 2.1^a
Crude oil content (%)	27.84 ± 0.17^a	24.37 ± 0.55^b
Crude protein content (%)	23.21 ± 0.51^a	19.85 ± 0.37^b
Ash content (%)	3.76 ± 0.02^a	3.28 ± 0.14^b
Oil yield (%)	64.89 ± 0.51^a	51.25 ± 0.44^b

Results are expressed as mean ± SE.
* Different superscript letters in the same line indicate significant differences ($p \leq 0.05$)

RESULTS AND DISCUSSION

PHYSICOCHEMICAL PROPERTIES OF THE SEEDS

Physicochemical properties of the roasted and boiled melon seeds are presented in Table II. It is obvious that differences between the pre-treatments in terms of seed dimensions (length, width, thickness) are not statistically significant. In a study, length, width and thickness values of different type melon seeds were measured as 7.72-7.79 mm, 3.34-3.67 mm, 0.81-1.20 mm, respectively [32]. Our results are slightly different from this study, probably due to the differences in the melon species. 1000-seed weight and shell:seed ratio are important parameters to determine the value of oilseeds. It was observed that 1000-seed weight value of the boiled seeds was slightly lower than that of the roasted seeds. It is deemed that seed content leaked into the boiling water during boiling pre-treatments. As seen in Table II, oil, protein and ash contents of the boiled seeds were lower than those of the roasted seeds and these results support our explanation. It was detected that the shell:seed ratio was not affected by the pre-treatments. In a study, shell ratios of two different melon seeds were found as 27.19% and 30.16% [32]. Our results are different from this study, probably due to the differences in the melon species. It was observed that the roasted seeds had a lower yellowness (+b*) value than the boiled seeds did. These differences could be explained by the migration of some colour pigments into the boiling water or by the various reactions that take place by the effect of temperature during the pre-treatments. Water activity value and the moisture content of the seeds are important parameters to control possible microbial spoilage of seeds and the possible chemical degradation of oil in seeds [33]. The water activity value and moisture content of the boiled seeds were higher than those of the roasted seeds, as expected. To avoid possible deterioration, seeds were dried immediately after the boiling pre-treatment and kept dry until pressing.

As seen in Table II, differences between the pre-treatments in terms of oil, protein and ash contents of the seeds are statistically significant. It is thought that these substances leaked into the boiling water during

the boiling pre-treatment. In a study, the effects of heat treatments on the seed content were investigated and as a result of the boiling of the watermelon seeds, no significant change was observed in ash and fibre contents, while oil and protein contents decreased significantly [34]. Results in our study generally concur with this study. In our study, oil, protein and ash contents of the seeds were found as 27.84%, 23.21% and 3.76% for the roasted group and 24.37%, 19.85% and 3.28% for the boiled group, respectively. In a study, oil, protein and ash contents of the melon seeds were found as 25.0%, 25.0% and 2.4%, respectively [8]. In another study, the composition of the melon seeds was determined as 17.2% protein, 13.9% oil and 6.1% ash [9]. Compositions of the seeds in these studies are slightly different from the seeds in our study probably due to the species and cultivation differences.

Besides the many advantages, cold press technique has a significant disadvantage, which is low oil yield. In this study, roasting and boiling pre-treatments were compared with each other for both oil yield and oil properties. It was stated that the roasting process enhances the oil yield [33]. It was indicated that the boiling process softens the tissue of the seeds and increases permeability [34]. In this study, oil yield obtained by the roasting pre-treatment (64.89%) was higher than that obtained by the boiling pre-treatment (51.25%). Therefore, regardless of the oil properties, it can be said that the roasting pre-treatment may increase the oil yield during the cold pressing of the melon seeds.

PHYSICOCHEMICAL PROPERTIES OF THE PRESS CAKES

Physicochemical properties of the press cakes, obtained as a by-product of the cold pressing, are presented in Table III. The press cakes obtained from the roasted group had lower brightness (L) and higher redness values (+a*) than those obtained from the boiled group, probably due to the heat applications during pre-treatments. It was observed that press cakes obtained from the boiled group had a higher moisture content and water activity, but the differences in moisture content and water activity between the press cakes were not as high as the differences between the seeds (as seen in Tab. II). Because, moisture contents of the seeds were adjusted to a similar level (about 12%) by drying or tempering, before pressing. As seen in Table III, differences between the pre-treatments in terms of oil, protein and ash contents of the press cakes are statistically significant. It is thought that these differences could be the result of the cold press oil yield and migration of the seed content to the boiling water. Oil, protein and ash contents of the press cakes were found as 11.16%, 32.24% and 5.08% for the roasted group and 13.32%, 29.87% and 4.65% for the boiled group, respectively. In a study, it was determined that the fat-free melon seed flour contained 37.34% protein, 2.01% oil, 36.71% fibre and 7.27% ash [35]. Results in our study are slightly different from this study probably due to the differences in the melon species and oil extraction techniques. In the study of Siddeeg et al. [35] some functional properties of the fat-free melon seed flour were also detected. The compositional data and functional properties of the fat-free melon seed flour indicate that the press cakes, as similar by-products, could be used for edible applications. For instance, in a study, fat was replaced with the watermelon seed meal in chicken sausage preparation and it was observed that the addition of the watermelon seed meal reduced the fat content, decreased the weight loss during refrigeration and improved the overall acceptability of the product [36]. Therefore, it can be said that further studies are needed to valorise cold press cakes of melon seeds in edible products.

Table III - Physicochemical properties of the press cakes

	Press cake	
	Roasted	**Boiled**
Colour		
L	55.71 ± 2.82^{b}	63.22 ± 1.58^{a}
a*	8.47 ± 0.27^{a}	6.08 ± 0.21^{b}
b*	29.68 ± 0.42^{a}	27.88 ± 0.75^{a}
Water activity (25°C)	0.31 ± 0.00^{b}	0.37 ± 0.00^{a}
Moisture content (%)	5.68 ± 0.10^{b}	7.03 ± 0.01^{a}
Crude oil content (%)	11.16 ± 0.02^{b}	13.32 ± 0.33^{a}
Crude protein content (%)	32.24 ± 0.63^{a}	29.87 ± 0.25^{b}
Ash content (%)	5.08 ± 0.04^{a}	4.65 ± 0.01^{b}

Results are expressed as mean ± SE.
* Different superscript letters in the same line indicate significant differences ($p \leq 0.05$)

PHYSICOCHEMICAL PROPERTIES OF THE OILS

Physicochemical properties of the melon seed oils are presented in Table IV. Specific gravity and refractive index values depend on fatty acid compositions of the oils [33]. It was observed that these values were not affected by the pre-treatments, as expected, since the pre-treatments did not alter the fatty acid compositions of the oils. In a study, specific gravity and refractive index values of the seed oils of different melon cultivars were found between 0.912-0.954 and 1.471-1.483, respectively [37]. Our results concur with the literature. Specific extinction values at 232 nm and 270 nm are indicators of primary and secondary oxidation products, respectively [16]. According to the codex, for extra virgin olive oil, E232 and E270 values should be max 2.50 and 0.22, respectively [38]. Oil types are different, but production techniques are similar (cold pressing), and, therefore, these limit values could be suitable for comparison. Specific extinction values of melon seed oils were much higher

Table IV - Physicochemical properties of the melon seed oils

	Melon seed oil	
	Roasted	**Boiled**
Specific gravity (20°C)	0.92 ± 0.00[a]	0.92 ± 0.00[a]
Specific extinctions		
E232	3.77 ± 0.13[a]	3.72 ± 0.10[a]
E270	3.36 ± 0.08[a]	3.56 ± 0.16[a]
Refractive index (40°C)	1.47 ± 0.00[a]	1.47 ± 0.00[a]
Viscosity (25°C, cP)	51.40 ± 0.38[a]	51.35 ± 0.38[a]
Colour		
L	23.21 ± 0.09[a]	21.74 ± 0.08[b]
a*	-0.70 ± 0.02[a]	-0.21 ± 0.03[b]
b*	7.85 ± 0.10[a]	5.56 ± 0.16[b]
Turbidity (25°C, NTU)	5.17 ± 0.01[a]	0.92 ± 0.01[b]
Free fatty acidity (linoleic acid %)	0.43 ± 0.01[a]	0.44 ± 0.01[a]
Acid value (mg KOH/g oil)	0.86 ± 0.01[a]	0.88 ± 0.1[a]
Peroxide value (meq active O_2/kg oil)	14.17 ± 0.56[b]	17.07 ± 0.20[a]
p-Anisidine Value	4.15 ± 0.09[a]	1.69 ± 0.34[b]
Iodine value (g I_2/100 g oil)	88.38 ± 1.91[a]	87.91 ± 2.42[a]
Saponification value (mg KOH/g oil)	194.39 ± 1.45[a]	193.70 ± 0.83[a]
Unsaponifiable matter (%)	1.22 ± 0.10[a]	1.09 ± 0.09[a]

Results are expressed as mean ± SE.
* Different superscript letters in the same line indicate significant differences ($p \leq 0.05$)

than the limit values stated in the codex for extra virgin olive oil. It is thought that during the seed storage and the pre-treatments, oils in the seeds oxidised. It was observed that the viscosities of the oils were not affected by the pre-treatments. Viscosities of the roasted and boiled melon seed oils were determined as 51.40 and 51.35 cP, respectively.

Colour and turbidity are important appearance properties for the cold pressed oils. Roasted seed oil had higher brightness (L), greenness (-a*) and yellowness (+b*) values than boiled seed oil. It could be caused by Maillard products formed during roasting pre-treatment or migration of colour pigments to the boiling water during the boiling pre-treatment. In a study, the L, a*, b* values of the different melon seed oils were found between 48.29-91.78, (-)3.51-(-)5.21, 22.05-49.44, respectively [39]. It is clear that oils with different colours were obtained depending on the melon species. It was stated that turbidity values are higher in cold pressed oil, since they are not exposed to refining process [40]. It was observed that boiled seed oil had a lower turbidity value compared to the roasted one. Therefore, boiling pre-treatment could be suggested to overcome the turbidity problem in cold pressed oils. There isn't any data about the turbidity of cold pressed melon seed oil in literature for comparison. In a study, turbidity values of cold pressed citrus seed oils, which were exposed to different pre-treatments, were found between 8.00 and 34.25 NTU [40]. It is clear that oils in our study had lower turbidity values compared to the citrus seed oils, which were obtained by the same production technique (cold pressing). It can be concluded that oils in our study are more attractive than these cold pressed citrus seed oils in terms of turbidity.

Acid value and free fatty acidity are used for determination of non-esterified fatty acids generated by hydrolysis. Peroxide and *p*-anisidine values are measured to determine primary and secondary oxidation products, respectively [33]. It was observed that free fatty acidity and acid values were not affected by the pre-treatments. Most probably, hydrolysis of the boiled seed oil was prevented by drying the seeds right after the boiling pre-treatment. Acid values of both treatment groups were within acceptable limits according to the codex, which states that the acid value should be max 4.0 mg KOH/g oil for cold pressed oils [41]. As seen in Table IV, roasted seed oil had lower peroxide value and higher *p*-anisidine value than boiled seed oil. It is thought that primary oxidation products generated in the roasted seed oil decomposed into secondary oxidation products. Peroxide values of the oils were near limit values or slightly exceeded it according to the codex which states that the peroxide value should be max 15 meqO_2/kg oil for cold pressed oils [41]. It is thought that during the seed storage and the pre-treatments, oils presented in the seeds oxidised. Therefore, precautions must be taken to process the seeds without longer storage periods and without exposing to higher temperatures for a long-time during pre-treatments.

Saponification value and iodine number are used to determine the average molecular weight of fatty acids and the amount of unsaturated fatty acids in the oil and these values depend on the fatty acid compositions of oils [33]. As seen in Table IV, these values were not affected by the pre-treatments, as expected, since the pre-treatments did not alter the fatty acid compositions of the oils. In a study, iodine number and saponification value of the melon seed oil were determined as 126.7 g I_2/100 g and 207.2 mg KOH/g, respectively [42]. In another study, iodine number and saponification value of the seed oils of a different melon cultivar were found between 113.91-126.52 g I_2/100 g and 192.59-207.42 mg KOH/g, respectively [37]. Results in our study do not exactly match these previous studies probably due to the differences in melon cultivars.

There is no significant difference between the pre-treatments in terms of unsaponifiable matter. In a study, the unsaponifiable matter content of the melon seed oil was determined as 1.43% [42]. In another study, oils produced from the seeds of the melons that cultivated in two different regions, were found to contain 0.81% and 0.78% unsaponifiable matters [43]. Results in our study are slightly different from these previous studies, probably because of the differences in the melon species.

THERMAL PROPERTIES OF THE OILS

Melting and crystallisation parameters, and oxidative induction times of the melon seed oils are presented in Table V. Melting and crystallisation temperatures and enthalpies were not affected by the pre-treatments. It was stated that thermal properties of oils mostly depend on their fatty acid compositions [44]. Therefore, this result was quite expected because the pre-treatments did not alter the fatty acid compositions of the oils. As seen in Table V two different fractions were observed during melting and crystallisation. It was probably caused by the presence of triglycerides species with different melting ranges in the melon seed oil. It was stated that a higher melting temperature indicates a higher amount of saturated fatty acid contents [45]. The melting points of the oils were lower in this study, as expected, since unsaturated fatty acids were dominant in the melon seed oil. In a study, the thermal properties of the melon seed oil were determined, and it was observed that the first peak of melting was at around -40°C [8]. Results in our study concur with the literature.

Oxidative induction time (OIT) is defined as the time to the onset of the decompositions of oils with oxygen at a specific temperature. It is known that besides the major effect of the level of unsaturation in oils, the amount of other components with antioxidant activities also affect the oxidative induction times of oils [40]. It was observed that oxidative induction times of the melon seed oils were around 9 min at 150°C and were not affected by the pre-treatments, as expected, since the pre-treatments did not alter the fatty acid compositions of the oils. There is no data in the literature about oxidative induction time of the melon seed oil. In a study, oxidative induction times of cold pressed citrus seed oils at 130°C were found between 29.51-44.28 min [40]. Oxidative induction times of cold pressed citrus seed oils are much higher than oils in this study. This result was probably caused by the higher amount of polyunsaturated fatty acids in melon seed oil, differences in the amounts of the natural antioxidants present in the oils and the difference in the analysis temperature.

Table V - Thermal properties of the melon seed oils

		Melon seed oil	
		Roasted	**Boiled**
Melting	$Onset_m1$ (°C)	-39.67 ± 1.22[a]	-40.51 ± 0.02[a]
	T_m1 (°C)	-35.95 ± 0.67[a]	-36.11 ± 0.19[a]
	ΔH_m1 (J/g)	0.91 ± 0.26[a]	1.23 ± 0.09[a]
	$Onset_m2$ (°C)	-25.49 ± 1.14[a]	-26.84 ± 0.43[a]
	T_m2 (°C)	-18.72 ± 0.10[a]	-18.72 ± 0.15[a]
	ΔH_m2 (J/g)	5.75 ± 1.29[a]	5.96 ± 0.39[a]
Crystallization	$Onset_c1$ (°C)	4.05 ± 0.22[a]	4.37 ± 0.15[a]
	T_c1 (°C)	1.93 ± 0.19[a]	1.58 ± 0.29[a]
	ΔH_c1 (J/g)	-0.21 ± 0.08[a]	-0.38 ± 0.10[a]
	$Onset_c2$ (°C)	-7.58 ± 0.65[a]	-8.32 ± 0.27[a]
	T_c2 (°C)	-11.10 ± 0.57[a]	-11.55 ± 0.11[a]
	ΔH_c1 (J/g)	-2.53 ± 0.25[a]	-2.26 ± 0.67[a]
	OIT (150 °C, min)	9.28 ± 0.07[a]	9.09 ± 0.34[a]

Results are expressed as mean ± SE.
* Different superscript letters in the same line indicate significant differences ($p \leq 0.05$)

Table VI - Fatty acid, sterol and tocopherol compositions of the melon seed oils

	Melon seed oil	
	Roasted	**Boiled**
Fatty acids (%)		
Palmitic (C16:0)	8.40 ± 0.11[a]	8.42 ± 0.10[a]
Stearic (C18:0)	7.76 ± 0.07[a]	7.78 ± 0.12[a]
Oleic (C18:1 n-9)	28.06 ± 0.05[a]	28.09 ± 0.03[a]
Linoleic (C18:2 n-6)	52.02 ± 0.09[a]	52.04 ± 0.11[a]
Linolenic (C18:3 n-3)	3.69 ± 0.09[a]	3.62 ±0.05[a]
ΣSFA	16.16 ± 0.10[a]	16.20 ± 0.12[a]
ΣMUFA	28.06 ± 0.05[a]	28.09 ± 0.03[a]
ΣPUFA	55.71 ± 0.12[a]	55.66 ± 0.11[a]
Sterols (mg/100 g oil)		
β-Sitosterol	215.98 ± 0.13[a]	216.02 ± 0.09[a]
Stigmasterol	19.57 ± 0.05[a]	19.51 ± 0.06[a]
Campesterol	8.65 ± 0.03[a]	8.66 ± 0.06[a]
Brassicasterol	3.27 ± 0.07[a]	3.32 ± 0.05[a]
Cholesterol	0.82 ± 0.03[a]	0.85 ± 0.07[a]
Total	248.29 ± 0.31[a]	248.36 ± 0.30[a]
Tocopherols (mg/kg oil)		
α-Tocopherol	76.22 ± 1.36[a]	77.65 ± 1.2[a]
γ-Tocopherol	305.27 ± 5.27[a]	306.51 ± 5.70[a]
δ-Tocopherol	50.11 ± 1.36[a]	52.74 ± 2.47[a]
Total	431.60 ± 3.36[a]	436.90 ± 3.83[a]

Results are expressed as mean ± SE.
* Different superscript letters in the same line indicate significant differences ($p \leq 0.05$)

FATTY ACID, STEROL AND TOCOPHEROL COMPOSITIONS OF THE OILS

The physical properties, stabilities, and usage areas of the edible oils mostly depend on their fatty acid compositions; hence, determination of fatty acid compositions of oils is very important. As seen in Table VI, the fatty acid compositions of the oils were not affected by the pre-treatments. Melon seed oils were found to contain higher amounts of unsaturated fatty acids. Linoleic acid and oleic acid were major fatty acids with 52.02% and 28.06% for the roasted group, 52.04% and 28.09% for the boiled group, respectively. It was also observed that these oils are rich sources of the essential fatty acids, linoleic and linolenic acids. In a study, the major fatty acids of the melon seed oil were determined as linoleic and oleic acids with 62.5% and 22.7%, respectively [42]. In another study, the major fatty acids of the seed oils of a different melon cultivar were found as linoleic and oleic acids with 60.97%-68.63% and 15.24%-23.03%, respectively [37]. Results in this study mostly concur with literature.

Sterols decrease serum cholesterol level and have, in addition, anti-cancer, anti-inflammatory, anti-atherogenic and anti-oxidation activities [46]. As seen in Table VI, the sterol compositions of the oils were not affected by the pre-treatments. Total sterol contents of the roasted and boiled seed oils were found as 248.29 mg/100 g oil and 248.36 mg/100 g oil, respectively. b-Sitosterol was determined as major sterol with about 216 mg/100 g oil and followed by stigmasterol and campesterol. Cholesterol was also detected in the melon seed oils in a small quantity. In a study, the sterol composition of melon seed oil was determined and b-sitosterol and Δ5,24-stigmastadienol were found as major sterols with 206.42 mg/100g oil and 117.91 mg/100g oil, respectively [47]. In another study, the total sterol content of melon seed oil was found as 3272.9 mg/kg oil and b-sitosterol and stigmastanol were determined as major sterols with 2102.3 mg/kg oil and 1170.7 mg/kg oil, respectively [48]. There are some differences in sterol compositions between different studies probably due to differences in melon species.

Tocopherols are known as oil-soluble antioxidants and vitamins [33]. As seen in Table VI, the tocopherol compositions of the oils were not affected by the pre-treatments. Total tocopherol contents were 431.60 mg/kg oil and 436.90 mg/kg oil for roasted and boiled seed oils, respectively. g-Tocopherol was determined as major tocopherol with 305.27 mg/kg oil and 306.51 mg/kg oil for roasted and boiled seed oils, respectively. In a study, it was observed that melon seed oil contained 445.6 mg/kg total tocopherol and major tocopherol was g-tocopherol with 404.7 mg/kg [42]. In another study, total tocopherol content of melon seed oil was 269.17 mg/kg and g-tocopherol was determined as major tocopherol with 247.20 mg/kg [48]. Tocopherol compositions of the oils in this study concur with literature.

PHENOLIC COMPOSITIONS OF THE OILS

Phenolic compounds are vegetative secondary metabolites with one or more hydroxyl groups on the aromatic benzene ring. It was stated that these compounds have curative effects on various diseases such as chronic degenerative diseases (cataract, central, neurodegenerative diseases and diabetes), cardiovascular diseases and cancer. In addition, they have antioxidant activities and are associated with a characteristic bitter taste in some foods [40, 49, 50]. Phenolic compositions of the oils are presented in Table VII. Six types of phenolic compounds were detected in the melon seed oil. It was observed that the quantities of the phenolic compounds decreased significantly as a result of the boiling pre-treatment and the amount of gallic acid and catechin became too low to be detected. It is thought that during boiling pre-treatments, phenolic compounds leaked into the boiling water. Rutin, *p*-coumaric acid and naringenin were found as major phenolic compounds. In a study, the phenolic composition of the melon seed oil was determined and amentoflavone was found as major flavonoid with 32.80 mg/kg, whereas gallic acid was determined as major phenolic acid with 7.26 mg/kg [47]. In addition, various phenolic compounds such as rosmaniric acid, naringenin, and caffeic acid were also detected in melon seed oil. In another study, the presence of phenolic compounds such as gallic acid, catechin, caffeic acid, *p*-coumaric acid, salicylic acid, quercetin and epicatechin were investigated and these compounds were not detected in the oil [48]. Results in our study are slightly different from these previous studies, probably due to the differences in the melon species.

Table VII - Phenolic compositions of the melon seed oils

Phenolic compound (mg/kg oil)	Melon seed oil	
	Roasted	Boiled
Gallic acid	5.56 ± 0.13	Nd†
Catechin	3.38 ± 0.16	Nd
Rutin	13.05 ± 0.17[a]	2.55 ± 0.09[b]
Eriocitrin	7.91 ± 0.12[a]	1.66 ± 0.10[b]
p-Coumaric acid	12.12 ± 0.21[a]	4.10 ± 0.12[b]
Naringenin	11.74 ± 0.14[a]	4.30 ± 0.15[b]
Total	53.76 ± 0.16[a]	12.61 ± 0.11[b]

Results are expressed as mean ± SE.
* Different superscript letters in the same line indicate significant differences ($p \leq 0.05$).
†Nd: not detected

AROMATIC VOLATILE COMPOUNDS IN THE OILS

Aromatic volatile compounds in the melon seed oils are presented in Table VIII. Twenty-two and fifteen aromatic volatile compounds were detected in roasted and boiled melon seed oils, respectively. Only thirteen of these aromatic compounds were detected in both oils, but, differences between the pre-treatments in terms of the amounts of these compounds were determined as statistically significant. Therefore, it can be said that the aroma of the oils was significantly affected by the pre-treatments. In roasted seed oil, various pyrazine derivatives, which have aroma descriptions such as roasted and nutty, were detected predominantly. In boiled seed oil, volatile compounds such as hexanal, hexanoic acid, which have aroma descriptions such as herbal, grassy and sour, were detected predominantly. It is thought that dominant volatile compounds in both oils formed during the pre-treatments. In addition, dominant volatile compounds in both oils concur with the descriptive terms determined by the sensory panel.

There is no data in the literature about the volatile composition of the melon seed oil. In a study, aromatic compounds were analysed in various melon species and it was stated that various nonanal derivatives are effective in the formation of the melon aroma. In

Table VIII - Aromatic volatile compounds in the melon seed oils

	RI	Volatile compound (µg/kg oil)	Aroma definition	Melon seed oil	
				Roasted	Boiled
1	602	Acetic acid	Vinegar, sour	190.95 ± 0.10^{b}	203.85 ± 0.10^{a}
2	612	Ethyl acetate	Fruity, sweet	103.58 ± 0.09	Nd†
3	664	Cyclobutanol	-	69.94 ± 0.06^{b}	137.50 ± 0.09^{a}
4	698	Pentanal	Fermented, wine	48.81 ± 0.05	Nd
5	740	Propanoic acid	Acidic, vinegar	113.50 ± 0.08	Nd
6	795	2,3-butanediol	Fruity	96.30 ± 0.13^{b}	162.00 ± 0.06^{a}
7	799	Hexanal	Vegetable, grassy	201.52 ± 0.17^{b}	596.49 ± 0.09^{a}
8	832	Cyclotrisiloxane, hexamethyl	-	166.29 ± 0.11^{b}	1067.46 ± 0.32^{a}
9	846	Ethyl 2-methylbutyrate	Fruity, sweet	255.29 ± 0.14	Nd
10	867	1-hexanol	Fruity	273.96 ± 0.17	Nd
11	889	2-heptanone	Creamy, waxy	78.75 ± 0.07	Nd
12	902	Heptanal	Vegetable	Nd	83.37 ± 0.07
13	914	2,5-dimethyl pyrazine	Roasted, nutty	1096.58 ± 0.19^{a}	577.48 ± 0.15^{b}
14	938	Alpha pinene	Pine odor, menthol	97.44 ± 0.04	Nd
15	954	Benzaldehyde	Almond, nutty	198.85 ± 0.13^{b}	304.58 ± 0.27^{a}
16	1002	2-ethyl-5-methyl pyrazine	Roasted, nutty	43.89 ± 0.05	Nd
17	1005	Trimethyl-pyrazine	Nutty	136.88 ± 0.08	Nd
18	1006	Hexanoic acid	Cheesy, sour, fruity	286.30 ± 0.17^{b}	1096.50 ± 0.28^{a}
19	1010	Cyclotetrasiloxane, octamethyl	-	Nd	1141.44 ± 0.24
20	1034	Benzyl alcohol	Flower aroma	38.49 ± 0.06^{b}	239.86 ± 0.16^{a}
21	1080	Pyrazine, 3-ethyl-2,5-dimethyl	Roasted, nutty	203.50 ± 0.06^{a}	83.77 ± 0.08^{b}
22	1103	Nonanal	Melon and cucumber aroma	20.48 ± 0.07^{b}	190.06 ± 0.09^{a}
23	1107	Phenylethyl alcohol	Sweet, flower aroma	15.25 ± 0.05^{b}	68.78 ± 0.04^{a}
24	1112	Benzeneethanamine	-	142.29 ± 0.16^{a}	94.43 ± 0.06^{b}
		Total		3878,84 ± 2.56^{b}	6047,57 ± 2.27^{a}

Results are expressed as mean ± SE.
* Different superscript letters in the same line indicate significant differences ($p \leq 0.05$).
†Nd: not detected

addition, acetate esters were detected in higher amounts in all melon species [51]. In our study, nonanal and ethyl acetate were detected in certain proportions, but these compounds were not predominant in the oils. This result was also supported by the fact that the melon aroma was not described by the sensory panel.

SENSORY PROPERTIES AND CONSUMER PREFERENCES OF THE OILS

The results of the sensory descriptive analyses of the melon seed oils are presented in Table IX. Five descriptors, which are turbidity, roasted, zucchini, raw vegetable and oiliness, were determined for melon seed oils. The oiliness term was defined and selected by the panel to observe how cold pressed oil resembles refined oil in terms of just an oily/fatty flavour. It is clear that differences between the pre-treatments in terms of roasted, zucchini and raw vegetable terms are statistically significant. While roasted aroma was higher in the roasted seed oil, zucchini and raw vegetable aroma were higher in the boiled seed oil. It is obvious that the aroma and flavour of the oils were affected by the pre-treatments significantly. These results also concur with the results of the aromatic volatile analyses (Tab. VIII). Aromatic volatile compounds, which have aroma descriptions such as melon, cucumber and fruity, determined by the aromatic volatile analyses could not be detected by the sensory panel. It is thought that the aroma compounds with roasted and raw vegetable aroma definitions, which were detected in high scores in the oils, suppressed the other aroma compounds.

Table IX - Sensory descriptive properties of the melon seed oils

	Melon seed oil	
	Roasted	Boiled
Turbidity	8.11 ± 0.99^{a}	8.44 ± 0.68^{a}
Roasted	7.33 ± 1.63^{a}	1.22 ± 0.78^{b}
Zucchini	1.77 ± 0.63^{b}	4.22 ± 0.63^{a}
Raw vegetable	1.67 ± 0.67^{b}	4.22 ± 0.63^{a}
Oiliness	9.44 ± 0.68^{a}	9.55 ± 0.49^{a}

Results are expressed as mean ± SD.
* Different superscript letters in the same line indicate significant differences ($p \leq 0.05$).

There is no data in the literature on the sensory properties of melon seed oils. In a study, olive oils were collected from different regions of Turkey and physicochemical and sensory properties of these oils were determined. 14 sensory descriptors were determined for these oils; 3 for appearance, 4 for aroma, 5 for flavour and 2 for mouthfeel. Olive aroma, grassy aroma and throat catching were determined in

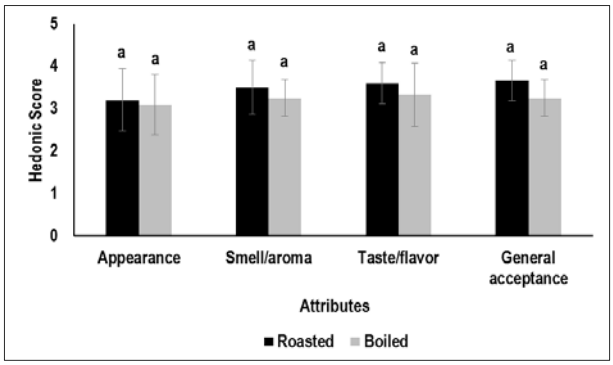

Figure 2 - The consumer hedonic scores of the cold pressed melon seed oils (1 = dislike extremely, 5 = like extremely; n = 100)

higher scores [52]. It can be said that melon seed oil is quite weak in the intensities of the sensory properties compared to this commercially important oil.

Results of the consumer tests are presented in Figure 2. It is clear that consumer preferences were not affected significantly by the pre-treatments. Hedonic scores of the consumer test are slightly above 3.00 score (the neutrality point) in the 5-point scale. Therefore, it could be said that consumer satisfaction was moderate. It is thought that the lack of a very distinct aroma and flavour in the oils caused the consumer scores to be closer to the neutral value. There is no data on the consumer preferences on the melon seed oils. In a study, the consumer test was applied to the cold pressed grapefruit seed oil treated with different adsorbent soils after cold pressing. It was observed that these oils were not appreciated by consumers in terms of taste and flavour because of their bitter taste and throat catching sense [40]. Oils in our study were quite weak in the intensities of the sensory properties, but they did not have any distinct and unattractive aroma and/or flavour as in the case of grapefruit seed oil and this situation affected the consumers' preferences positively.

CONCLUSION

In this study, melon seeds, which were exposed to two different pre-treatments, were utilised in oil production by means of the cold press technique. As a result of this study, significant information has been provided to the literature on these seeds, cold pressed oils and press cakes. It was observed that cold pressed melon seed oils were rich in unsaturated fatty acids, essential fatty acids, sterols and tocopherols. Aromatic volatile compounds with roasted/nutty and herbal/grassy /sour aroma descriptions, most probably formed during the pre-treatments, were detected predominantly in roasted and boiled melon seed oils, respectively. Dominant aromatic compounds in both oils were also defined by the sensory panel. According to the consumer test, melon seed oils had intermediate scores and consumer satisfaction was moderate. Therefore, it is deemed that these oils could be preferred by consumers. Press cakes, obtained as a by-product, were found to be nutritionally rich materials, and it is deemed that they could be valorised in edible products. Consequently, melon seeds could be utilised in edible, safe and nutritionally rich cold press oil production.

BIBLIOGRAPHY

[1] A.A. Mariod, M.E.S. Mirghani, I. Hussein, Unconventional Oilseeds and Oil Sources. Academic Press, London (2017)

[2] MEGEP, Kavun Yetiştiriciliği. MEGEP, T.C. Milli Eğitim Bakanlığı, Ankara (2011). Retrieved from http://www.megep.meb.gov.tr/?page=moduller

[3] H.S. Paris, Y. Tadmor, A.A. Schaffer, Cucurbitaceae melons, squash, cucumber. In: B. Thomas, B.G. Murray, D.J. Murphy (Eds.), Encyclopaedia of Applied Plant Sciences (Volume 3). Academic Press, Oxford, 209-217 (2017)

[4] FAO, FAOSTAT (2018). Retrieved from http://www.fao.org/faostat/en/#data

[5] C. Lucas-Torres, A. Lorente, B. Cabanas, A. Moreno, Microwave heating for the catalytic conversion of melon rind waste into biofuel precursors. Journal of Cleaner Production, 138, 59-69 (2016)

[6] A.A. Shetty, R. Rana, T. Buckseth, S.P. Preetham, Waste utilization in cucurbits: a review. Waste and Biomass Valorization, 3, 363-368 (2012)

[7] R.Y. Yıldırım, Fırat'tan Volga'ya Medeniyetler Köprüsü. Adıyaman Üniversitesi Yayınları, Adıyaman, Turkey (2015)

[8] N.A.M. Yanty, O.M. Lai, A. Osman, K. Long, H.M. Ghazali, Physicochemical properties of cucumis melo var. inodorus (honeydew melon) seed and seed oil. Journal of Food Lipids, 15, 42-55 (2008)

[9] D.R. Morais, E.M. Rotta, S.C. Sargi, E.G. Bonafe, R.M. Suzuki, N.E. Souza, M. Matsushita, J.V. Visentainer, Proximate composition, mineral contents and fatty acid composition of the different parts and dried peels of tropical fruits cultivated in Brazil. Journal of the Brazilian Chemical Society, 28, 308-318 (2017)

[10] B. Aydeniz, O. Güneşer, E. Yılmaz, Physico-chemical, sensory and aromatic properties of cold press produced safflower oil. Journal of the American Oil Chemists' Society, 91, 99-110 (2014)

[11] B. Aydeniz Güneşer, E. Yılmaz, S. Ok, Cold pressed versus refined winterized corn oils:

quality, composition and aroma. Grasas Y Aceites, 68, 1-12 (2017)
[12] AOAC, Official Methods of Analysis of AOAC International (17th ed.). Association of Analytical Communities, Gaithersburg, MD, USA (2002)
[13] AOCS, Official Methods and Recommended Practice of the American Oil Chemist's Society (4th ed.). American Oil Chemist's Society, Champaign, IL, USA (1989)
[14] AOCS, Official Methods and Recommended Practice of the American Oil Chemist's Society (5th ed.). American Oil Chemist's Society, Champaign, IL, USA (1998)
[15] AOCS, Official Methods and Recommended Practice of the American Oil Chemist's Society (3th ed.). American Oil Chemist's Society, Champaign, IL, USA (1984)
[16] AOCS, Official Methods and Recommended Practice of the American Oil Chemist's Society (7th ed.). American Oil Chemist's Society, Champaign, IL, USA (2017)
[17] TSE 894, Yemeklik Bitkisel Yağlar-Muayene Metodları. Resmi Gazete, Ankara, Turkey (1970)
[18] L.S.K. Dassanayake, D.R. Kodali, S. Ueno, K. Sato, Physical properties of rice bran wax in bulk and organogels. Journal of the American Oil Chemists' Society, 86, 1163–1173 (2009)
[19] C.P. Tan, Y.B. Che Man, J. Selamat, M.S.A. Yusoff, Comparative studies of oxidative stability of edible oils by differential scanning calorimetry and oxidative stability index methods. Food Chemistry, 76, 385-389 (2002)
[20] F. David, P. Sandra, A.K. Vickers, Column Selection for the Analysis of Fatty Acid Methyl Esters Application (2005). Retrieved from https://www.agilent.com/cs/library/applications/5989-3760EN.pdf
[21] TSE EN ISO International Standards Official Methods 12228:1999, Animal and Vegetable Fats and Oils-Determination of Individual and Total Sterols Contents-Gas Chromatographic Method. International Organization for Standardization, Geneve, Switzerland (1999)
[22] E. Grilo Camara, P.N. Costa, C.S.S. Gurgel, A.F.M. Beserra, F.N.S. Almeida, R. Dimenstein, Alpha-tocopherol and gamma-tocopherol concentration in vegetable oils. Food Science and Technology (Campinas), 34, 379-385 (2014)
[23] A. Vallverdú-Queralt, J. Regueiro, J.F.R. Alvarenga, X. Torrado, R.M. Lamuela-Raventos, Home cooking and phenolics: effect of thermal treatment and addition of extra virgin olive oil on the phenolic profile of tomato sauces. Journal of Agricultural and Food Chemistry, 62, 3314–3320 (2014)
[24] I. Moulehi, S. Bourgou, I Ourghemmi, M.S. Tounsi, Variety and ripening impact on phenolic composition and antioxidant activity of mandarin (citrus reticulate blanco) and bitter orange (citrus aurantium l.) seeds extracts. Industrial Crops and Products, 39, 74-80 (2012)
[25] S. Krist, G. Stuebiger, S. Bail, H. Unterweger, Detection of adulteration of poppy seed oil with sunflower oil based on volatiles and triacylglycerol composition. Journal of Agricultural and Food Chemistry, 54, 6385-6389 (2006)
[26] F.W. McLafferty, Wiley Registry of Mass Spectral Data (7th ed.). John Wiley & Sons Ltd., New York (2005). ISBN: 978-0471473251, CD-ROM.
[27] NIST, NIST/EPA/NIH Mass Spectral Library. National Institute of Standards and Technology Standard Reference Data Program, MD 20899, Gaithersburg (2008)
[28] T. Altuğ, Y. Elmacı, Gıdalarda Duyusal Değerlendirme. Meta Basım Matbaacılık Hizmetleri, İzmir, Turkey (2005). ISBN: 975-97408-1-8
[29] M. Meilgaard, G.V. Civille, B.T. Carr, Sensory Evaluation Techniques. CRC Press, Boca Raton, ABD (1991)
[30] Minitab 16.1.1., Statistical Software 2010. Minitab Inc., State College, Pennsylvania, USA (2010)
[31] SPSS, SPSS Professional Statistics. SPSS Inc., Chicago, IL, USA (1994)
[32] A. Mansouri, A.H. Mirzabe, A. Raufi, Physical properties and mathematical modeling of melon (cucumis melo l.) seeds and kernels. Journal of the Saudi Society of Agricultural Sciences, 16, 218-226 (2017)
[33] R.D. O'Brien, W.E. Farr, P.J. Wan, Introduction to Fats and Oils Technology (Second Ed.). AOCS Press, Champaign, Illinois (2000)
[34] G.I.O. Badifu, Effect of processing on proximate composition, antinutritional and toxic contents of kernels from cucurbitaceae species grown in Nigeria. Journal of Food Composition and Analysis, 14, 153-161 (2001)
[35] A. Siddeeg, Y. Xu, Q. Jiang, W. Xia, Physicochemical and functional properties of flour and protein isolates extracted from seinat (cucumis melo var. tibish) seeds. Food Science and Biotechnology, 23, 345-353 (2014)
[36] S.S. Abiola, E.I. Kadiri, T.T. Kareem, Effect of melon seed meal addition on some quality characteristics of chicken sausages. Journal of the Science of Food and Agriculture, 84, 423-426 (2004)
[37] P.S. Bora, N. Narain, M.L.S. de Mello, Characterization of the seed oils of some commercial cultivars of melon. European Journal of Lipid Science and Technology, 102, 266-269 (2000)

[38] Codex, Türk Gıda Kodeksi Zeytinyağı ve Pirina Yağı Tebliği (Tebliğ No: 2017/26). Resmi Gazete, Ankara, Turkey (2017)
[39] Z. Petkova, G.A. Antova, K. Nikolova, T. Eftimov, Physicochemical characteristic of seed oils of bulgarian species pumpkin and melon. Bulgarian Chemical Communications, 46, 57-62 (2014)
[40] E. Yılmaz, Production and Utilization of the Value-Added Products from Citrus Seeds. Final Reports of the Project (TÜBİTAK COST 114O876) (2017)
[41] Codex, Türk Gıda Kodeksi-Bitki Adı ile Anılan Yağlar Tebliği (Tebliğ No: 2012/29). Resmi Gazete, Ankara, Turkey (2012)
[42] N. Jorge, A.C. da Silva, C.R. Malacrida, Physicochemical characterisation and radical scavenging activity of cucurbitaceae seed oils. Natural Product Research, 29, 2313-2317 (2015)
[43] A. Mariod, B. Matthaus, Fatty acids, tocopherols, sterols, phenolic profiles and oxidative stability of cucumis melo var. agrestis oil. Journal of Food Lipids, 15, 56-68 (2008)
[44] E.D. Co, A.G. Marangoni, Organogels: an alternative edible oil-structuring method. Journal of American Oil Chemists' Society, 89, 749-780 (2012)
[45] S. Mayfield, D. Van de Walle, C. Delbaere, S.E. Shinn, A. Proctor, K. Dewettinck, A. Patel, CLA-rich chocolate bar and chocolate paste production and characterization. Journal of the American Oil Chemists Society, 92, 1633-1642 (2015)
[46] A. Berger, P.J.H. Jones, S.S. Abumweis, Plant sterols: factors affecting their efficacy and safety as functional food ingredients. Lipids in Health and Disease, 3, 5-24 (2004)
[47] S. Mallek-Ayadi, N. Bahloul, N. Kechaou, Chemical composition and bioactive compounds of cucumis melo l. seeds: potential source for new trends of plant oils. Process Safety and Environmental Protection, 113, 68-77 (2018)
[48] A.C. da Silva, N. Jorge, Bioactive compounds of oils extracted from fruits seeds obtained from agroindustrial waste. European Journal of Lipid Science and Technology, 119, 1-5 (2017)
[49] A. Gioxari, D.A.A. Kogiannou, N. Kalogeropoulos, A.C. Kaliora, Phenolic compounds: bioavailability and health effects. In: B. Caballero, P. Finglas, F. Toldra (Eds.), Encyclopaedia of Food and Health (1st Edition). Academic Press, Oxford, 339-345 (2016)
[50] M. Murkovic, Phenolic compounds. In: B. Caballero, P. Finglas, F. Toldra (Eds.), Encyclopaedia of Food Science and Nutrition (2nd Edition). Academic Press, London, 4507-4514 (2003)
[51] D. Kourkoutas, J.S. Elmore, D.S. Mottram, Comparison of the volatile compositions and flavour properties of cantaloupe, galia and honeydew muskmelons. Food Chemistry, 97, 95-102 (2006)
[52] M. Öğütcü, E. Yılmaz, Comparison of the virgin olive oils produced in different regions of Turkey. Journal of Sensory Studies, 24, 332-353 (2009)