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Utilization of seed from *Cucurbita maxima*, a pumpkin variety of Bangladesh, converting into refined oil and oilcake

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Abstract
Pumpkin seed oil, also called as pepita oil can be a substitute of conventional edible oil now a days. A method has been developed to use this under-utilized pumpkin seed which is a common vegetable in Bangladesh. This study suggests finding a new alternate of edible oil as well as proper utilization of nutritionally rich pumpkin seed rather than wasting into the environment. Pumpkin seed oil was extracted from dried pumpkin seed by expeller and it was purified by the refining steps-degumming, neutralization, deodorization and bleaching. The crude and refined oil were characterized. Acid value was decreased from 2.36 to 0.34 mg/ g as KOH (Potassium Hydroxide); color was lightened from Yellowness (Y) = 20, Redness (R) = 20 to Yellowness (Y) = 6, Redness (R) = 3; moisture was decreased from 0.26 to 0.05%; insoluble impurities was changed from 0.32 to 0.05% and unsaponifiable matters has been lowered from 2.17% to 0.92%by refining where no fundamental changes occurred in iodine value, saponification value, peroxide value, refractive index and specific gravity after refining. The characteristic parameters were within the limits mentioned for edible oil in codex. Fatty acid composition remained same, although total tocopherol decreased from 361.9 mg/kg to 300.69 mg/kg. The observed pumpkin seed oil was rich in linoleic and oleic acid- 36.43 and 36.89%. The nutritional benefits of oilcake found after oil extraction were determined also. Protein and fat was 54.78% and 4.16% respectively as well, iron, calcium, magnesium and manganese was found 30.29, 21.45, 2.27 and 0.30 mg/ 100 g respectively in oilcake.

Keywords Pumpkin seed · Refining · Acid value · Fatty acid composition · Tocopherol · Oilcake

1 Introduction

Pumpkin (*Cucurbita maxima*), a member of *Cucurbitaceae* family is one of the most common and popular vegetables in Bangladesh. It is a good source of carbohydrate, Vitamin A, C and minerals. It is grown in Bangladesh in an area of about 140,000 hactares and the average yield is 20–25 metric tonnes/ hactare [1]. Pumpkin fruits are popular in making curry and different sweet dishes as well as its leaves, vines and flower are used as vegetables. In addition, pumpkin seeds (also known as pepita) are worldwide very popular snack food in roasted and salted form for its rich content of oil and protein [2]. A numerous seed can be found in a mature form of pumpkin fruit. Pumpkin seeds are affluent source of unsaturated fatty acids as they contain 38 to 60% oil that mostly have oleic and linoleic fatty acids [2]. On the basis of the information that consumption of 70–80 g pumpkin seed per day is useful for human health, it is suggested to include in diet and medicine [3].

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As global demand of vegetable oil is increasing day by day, searching of alternating sources of edible oil is a fundamental issue at present. Considering the high oil content, pumpkin seed can be utilized into edible oil. Although pumpkin seed oil is not produced commercially in a large extent, it is consumed as salad oil, soup ingredient and minced meat seasoning or frying oil in some countries like Austria, Slovenia and Hungary [3]. It is not only highly unsaturated oil having predominantly oleic and linoleic acid, but also a significant source of vitamin E (tocopherol) [4]. Several health benefits can be encountered by pumpkin seed oil like reducing prostate size, improving bladder compliance promoting hypoglycemic activity, prevention of lower level of gastric, breast, lung, colorectal and prostate cancer [4].

Besides the application of pumpkin seed in the production of edible oils, it can be furthermore utilized as oilcakes remained after the oil extraction. Its cake can be used as poultry or fish feed for being nutritionally rich since it contains considerable amount of protein and low cellulose [5]. Oilseed cakes are valuable by-products of oil extraction process that contain high concentration of fiber and non-starch polysaccharides [6]. Therefore, they can be consumed as high fiber diets in treatment of constipation, diverticular disease, colonic cancer, coronary heart disease and diabetes [6].

Any crude oil extracted from plant or fish sources contain impurities such as free fatty acids (FFA), phospholipids and volatile compounds and mono-, di-, triglycerols [7]. Although pepita oil, like other vegetable oils is rich in different essential components, it contains such kind of impurities in its crude stage as well. Hence, refining of the extracted crude oil is very important to remove the contaminants that adversely affect the quality of oil, thus to make it edible, increase the shelf life and for consumer acceptance. To remove the detrimental and flavor producing components, while retaining some of the most desirable components is now becoming a challenge to the oil refining industries [7].

The main purpose of the study was to characterize and evaluate the potentiality of refined pumpkin seed oil and oilcakes and thus utilize the pumpkin seed into edible purpose. The crude oil extracted from seeds of *Cucurbita maxima*, most available variety of Bangladeshi pumpkins was investigated and a four stage refining process was designed to make it edible. The refining process included degumming, neutralization, deodorization and decolorization stages. The physico-chemical properties of the refined oil and nutritional composition of the oilcake was also analyzed in this study.

2 Materials and methods

2.1 Oil extraction

Ripe fruits of *Cucurbita maxima* were collected from local market of Dhaka, Bangladesh. 2.5 kg seed was separated and dried at 65 °C for 24 h. The dried seed was pressed in expeller (Oil Press, IBG Monforts Oekotec, Germany) for oil extraction. In previous studies, the oil was extracted by solvent extraction from pumpkin seed [2–4]. The crude oil was collected in glass bottle and stored for further processing and analysis of physico chemical properties (Moisture content, Acid value, Peroxide value, Iodine value, Saponification value, Unsaponifiable matter, Refractive Index, Relative Density and Color), fatty acid composition and tocopherol content. Extracted crude oil (688 g) was left for decantation and then the oil was separated from sediment. The oil cake found from the expeller were also collected and stored for nutritional analysis. All reagents used were from Merck, Germany and standards (metal standard used for AAS) were from Sigma Aldrich, USA. All the analyses were done in triplicate.

The undesirable compounds present in crude pumpkin seed oil was removed by four refining stages- degumming, neutralization, deodorization and decolorization.

2.2 Degumming

470 g separated crude pumpkin seed oil (Moisture 0.26% and Acid Value 4.34), was prewarmed at 65 °C on water bath. For degumming, 0.9% (w/w) of 5% phosphoric acid (H_3PO_4) aqueous solution was added slowly and dropwise to the oil with continuous stirring. The mixture was then heated for 30 min at 65 °C on water bath and allowed to settle for 8 h. The gummy material was removed from the oil by filtration. Tsaknis et al. used 0.3% phosphoric acid (H_3PO_4) solution and heated the solution at 80 °C for 10 min [2]. The concentration of phosphoric acid (H_3PO_4) solution depends on the amount of gummy materials of crude oil. Temperature is a factor of oil deterioration, so in this study the processing temperature has been kept as lower as 65 °C.

2.3 Neutralization

The filtered pumpkin seed oil was neutralized with 10 ml 0.29% NaOH aqueous solution under heating on water bath at 65 °C for 35 min with occasional stirring. It was then left to settle soapstocks for 12 h and the soapstocks was separated by filtration. The neutralized oil was washed four times with 1:1 (v/v) warm (75 °C) water. Previously, 4.125 M NaOH solution was added at 80 °C [2]. The strength of NaOH also depends on the acid value of the degummed solution.

2.4 Deodorization

The neutralized oil with water was dehydrated at 65 °C on water bath under vacuum for 45 min. Finally the moisture content of the oil was reached to 0.05%. In the study of Tsaknis et al. moisture has been removed by heating at 105 °C [2], but in the present study vacuum technology has been used for not producing unwanted hazards at high temperature.

2.5 Decolorization/ Bleaching

Tsaknis et al. used 3% Tonsil Optimum earth technical powder with 2% activated carbon for bleaching stage [2]. In the present study, dehydrated oil was bleached with 1% preheated Fuller's Earth under vacuum for 20 min and was allowed to settle for 18 h. This bleached pumpkin seed oil with Fuller's Earth was filtered by "Vacuum Filtration Unit" (Rocker 300) using nylon membrane filter. 330 g Refined pumpkin seed oil (Moisture 0.05% and Acid Value 0.34) was obtained as final product.

The Refined pumpkin seed oil was packed and sealed in glass bottle for preservation and further analysis.

2.6 Method of analysis

2.6.1 Analysis of oil

Acid value (AV), Peroxide value (PV), Iodine value (IV), Saponification value (SV), Unsaponifiable matter (Nonsap) were measured following the standard IUPAC method [8]. Refractive Index (RI) was measured by the ABBE 60 series Refractometer (BELLINGHAM + STANLEY LIMITED, UK). Density meter DMA35N, manufactured by Anton Paar, Austria was used to measure the relative density. Color of the studied samples was measured by Lovibond tintometer, (Model F; Salisbury, Wilts, England) using 1 inch (2.54 cm) cell.

2.7 Analysis of fatty acid composition

2.7.1 Preparation of fatty acid methyl ester (FAME)

Relative concentration of fatty acid (FA) from oil samples were measured as their corresponding methyl esters according to the method described in IUPAC (1979) with a minor modification [8]. 5–7 drops of oil was taken in 15 ml test tube and 3 ml of 0.5 M sodium methoxide (prepared by mixing metallic sodium in methanol) was added and digested by stirring in a boiling water bath for about 15 min. It was allowed to cool to room temperature and 1 ml of petroleum ether (b.p 40–60 °C) was added followed by 10 ml deionized water, mixed gently and allowed to settle for 5–6 min. The distinct upper layer of methyl ester in petroleum ether was separated carefully in a capped vial and used for analysis. 200 mg of different fatty acid standard in their respective methyl ester form were dissolved separately in 10 ml petroleum ether (b.p 40–60 °C) in a series of screw-capped test tubes. Aliquots of 1 µl fatty acid methyl ester (FAME) were injected and the peaks of fatty acids were recorded for their respective retention time and areas by the data processor unit of GC.

2.8 Gas chromatograph

Fatty acid composition was analyzed using gas chromatograph (Shimadzu GC-14B, Japan) equipped with flame ionization detector and fused silica capillary column (FAMEWAX, Crossbond® polyethylene glycol, 15 m × 0.25 mm × 0.25 µm film thickness, Restek; Pennsylvania, USA). Splitless injection technique with nitrogen as carrier gas at a constant flow rate of 20 ml/min was used. Injector temperature was 250° C, initial oven temperature was 150 °C and held for 5 min. Temperature was increased at a rate of 8 °C/min to 190 °C and then increased to 200 °C at a rate of 2 °C/min and held for

10 min. The fatty acids were identified by using respective fatty acid methyl ester standards (FAME mix) and presented as relative percentage done by the automated GC software (Class GC-10,version-2.00). Figure 1 shows the chromatogram of fatty acid composition of refined pumpkin seed oil.

2.9 Tocopherol estimation

Tocopherol content of extracted oils was measured using a method developed by Majid et. al., 2019 with slight modification [9]. The tocopherol contents (α, γ and δ) were determined by a High Performance Liquid Chromatograph (Shimadzu Corporation, Japan) equipped with a main controlling unit (SCL-10AVP), two high pressure pumps (LC-10ATVP), a degasser (DGU-14A), a column oven (CTO-10ASVP) with 20 µL injector loop and a UV detector (SPD-10AVP) controlled by a single Class VP software along with a Luna C18 column (250 mm X 4.6 mm I.D., 5 µm particle size).

2.9.1 Extraction of tocopherol

Samples were prepared by dissolving 10 g of oil in 50 ml amber color volumetric flask with dichloromethane and methanol. The standard stock solution of α, γ and δ tocopherol were prepared by dissolving 0.005 g of each tocopherol in 50 ml dichloromethane and methanol to get a final concentration of 100 µg/ml. Both sample and standard were sonicated in ultrasonic bath for 5 min and then filtered with 0.45 µm syringe filter in a 1.5 ml glass vial and an aliquot of the overlay was injected into the HPLC column. All of the standards and samples were run in triplicate.

2.9.2 HPLC condition

Detection was performed at 295 nm using UV–VIS Detector for all tocopherols (α, γ and δ). Solely methanol was used as the elution solvent. The analytical column was kept at 25 °C. The separation was done at isocratic mode. Flow rate was 1 ml/min and run time for each standard and sample was 20 min. The sample injection volume was 20 µL. Concentration of α, γ and δ tocopherols were determined with external standards. Data was collected and processed by Class-VP Chromatograph Laboratory Automated Software (Shimadzu Corporation). Figure 2 shows the chromatogram of tocopherol content of refined pumpkin seed oil.

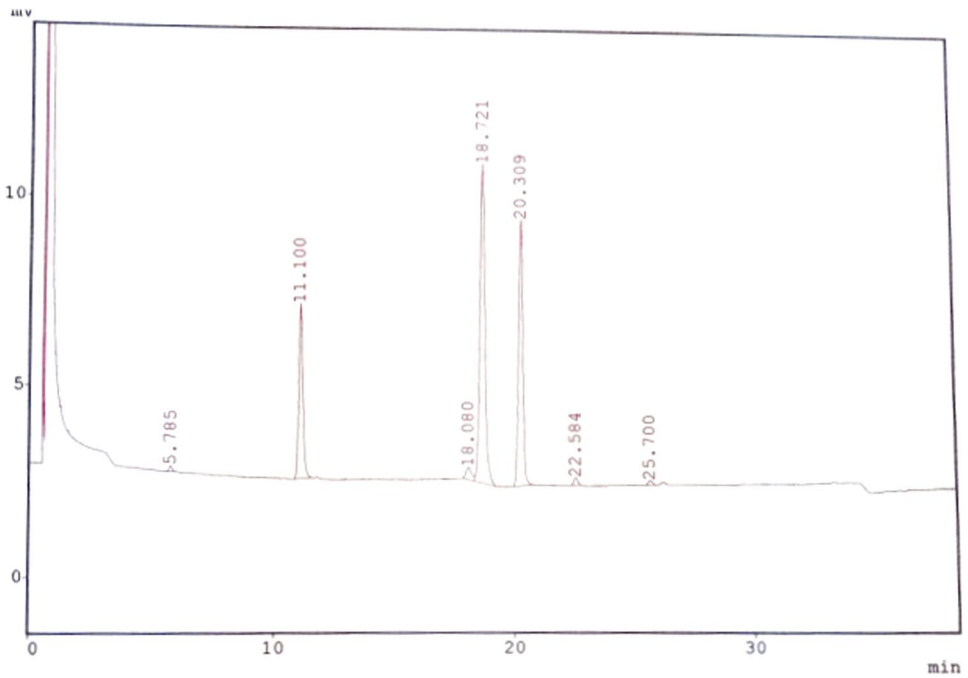
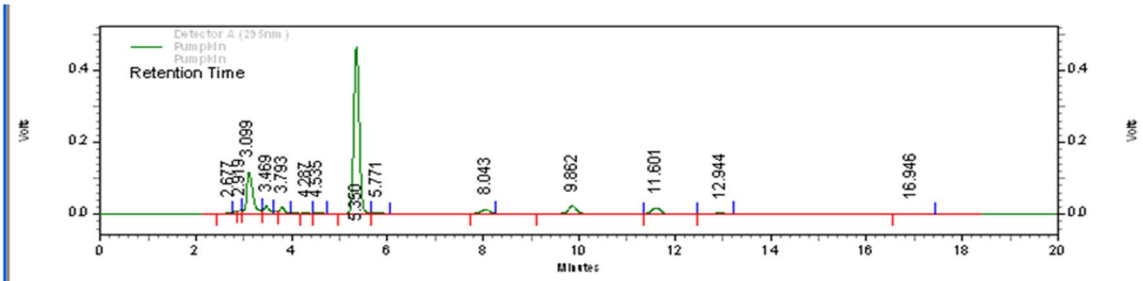


Fig. 1 The chromatogram of fatty acid composition of refined pumpkin seed oil



Detector A (295nm)

Pk#	Name	Retention Time	Area	ESTD concentration	Integration Codes
11	Delta Tocopherol 4.0 mg	9.862	390782	15.762	VB
12	Gamma Tocopherol 4.6 mg	11.601	264226	15.720	VB
13	Alpha Tocopherol 7.7mg	12.944	75650	5.203	VV
Totals			730657	36.686	

Fig. 2 The chromatogram of tocopherol content of refined pumpkin seed oil

2.10 Analysis of oilcake

Protein and fat content of the oilcake was found using Kjeldahl apparatus and Soxhlet extractor respectively. The mineral content (Calcium, Magnesium, Manganese and Iron) was analyzed by Flame Atomic Absorption Spectrophotometer (FAAS), Model AA-6800 SHIMADZU, Japan after digesting the samples in fume chamber with Nitric acid (HNO_3) and Perchloric acid ($HClO_4$) (Assay ≥ 99.7%, Merck, Germany) following AOAC official method 985.35 [10]. The FAAS was equipped with hollow cathode lamp of the respective element and a deuterium lamp for background correction was used. For Calcium (Ca) estimation the spectrometer's monochromator was adjusted to 422.7 nm (wavelength), slit width was 0.5 nm and lamp current flow was 10 mA. The spectrometer's monochromator was adjusted to 285.2 nm (wavelength), slit width was 0.5 nm and lamp current flow was 8 mA for Magnesium (Mg) estimation. For Manganese (Mn) estimation wavelength, slit width and lamp current flow were 279.5 nm, 0.2 nm and 10 mA respectively. For Iron (Fe) estimation the spectrometer's monochromator was adjusted to 248.3 nm (wavelength), slit width was 0.2 nm and lamp current flow was 12 mA.

3 Results and discussion

The yield of oil extracted from the collected pumpkin seed was found 30.03% where previously it was found 48.6% [2], 31.6–38.6% and 10.9–30.9% [4]. The oil content depends on the seed variety, maturity, seed weight, length etc. [3]. The studied oil content exceeds that of some conventional oil seeds like cotton seed (15–24%), soybean (17–21%) and olive (20–25%) [11].

The extracted crude oil was dark brown which had also greenish color in thin layer. This considerable difference in color from other oil is for its higher content of chlorophyll and carotenoids [5]. Also, it had a mild nutty odor due to the consequence of its composition and production method, usually by-products from lipid, protein and amino acid degradation [5], which was removed by the deodorization step of the refining process. This is the final stage of refining to extend the shelf life by removing odor creating components and trace elements [5]. The color of refined oil was measured in 1 inch cell of Lovibond Tintometer and found Yellowness (Y) = 6, Redness (R) = 3 where in crude oil it was Y = 20, R = 20. Previously, in the study of Tsaknis et al. Yellowness (Y) has been decreased from 15.0 to 3.2 and Redness (R) from 10.9 to 5.0 to make the crude oil in to refined [2].

The physicochemical characteristics of crude and refined pumpkin seed oil have been shown in Table 1. From the table it can be clearly seen that there are no fundamental changes in the basic characteristic parameters like Specific gravity, Refractive Index, Iodine Value and Saponification Value. Specific gravity, Refractive Index, Iodine Value and Saponification Value of the crude pumpkin seed oil was found 0.9156 at 20 °C, 1.4624 at 40 °C, 98 and 178 respectively.

Table 1 The characteristic parameter of crude and refined pumpkin seed oil

Characteristics	Crude	Refined
Color (visual)	Dark brown	Redish brown
Color in Lovibond Tintometer (1 inch cell)	Y = 20, R = 20	Y = 6, R = 3
Odor	Nutty flavor	No flavour
Moisture (%)	0.26	0.05
Insoluble impurities (%)	0.32	0.05
Refractive Index at 40^0C	1.4624	1.4621
Specific gravity at 20^0C	0.9156	0.9122
Acid Value, as KOH (mg/g)	2.36	0.34
Peroxide Value (meq O_2/kg)	4.82	5.28
Saponification Value as KOH (mg/g)	178	176
Unsaponifiable Matter (%)	2.17	0.92
Iodine Value	105	103

These values are comparable to those of previously studied pumpkin seed oil [2, 5, 12]. As Specific gravity of practically all fats or oils lie between 0.900 and 0.950, it do not vary as a general rule to an extent [13]. Refractive Index of almost all vegetable fats and oils is also 1.458 to 1.477 at 40 °C according to CODEX alimentarius which supports the studied value [12]. As Iodine value of any oil expresses the content of unsaturated fatty acid contents [12], the studied crude oil has a considerable amount of unsaturation that matches with the value of Tsaknis et al. 1997 (107) and Alfawaz 2004 (105) [2, 12]. Accordingly, saponification value, another characteristic parameter of fats and oils, of the crude oil was found within the results of some conventional oils (168–265) mentioned in CODEX alimentarius [14]. However, these characteristic parameters did not change considerably after refining. Although Peroxide value, a measure of rancidity, has been slightly increased during refining in this study, 5.28 from 4.82, it was in the range adopted in CODEX alimentarius for edible oil (10 meq O_2/ kg) [14]. Even though in a previous study of Tsaknis et al., 1997 it was similar after purification, they mentioned that purified pumpkin seed oil should expected to show an overall stability compared to crude oil owing to reduction the α-tocopherol content [2].

Nevertheless, Moisture, Insoluble impurities, Acid value, Unsaponifiable matter and Color have been reduced after refining. Fats and oils should contain less than 0.3% moisture, preferably less than 0.05% to ensure stability, since its presence can lead to the development of rancidity, off-flavours, free fatty acids etc. [15]. In this study, moisture content has been reduced to 0.05% in deodorization step. According to the codex standard, insoluble impurities in edible oils should not exceed 0.05% [14]. However, insoluble impurities have been decreased to certain level by filtration. Acid value measures the free fatty acids present in the oils and fats, where a high content of free fatty acid indicates that the oil is inedible [13]. Acid value, being the most important factors that influences overall quality of oil and hence the price [7], should be up to 0.6 mg KOH/g oil according to codex [14]. Accordingly, it was possible to bring the Acid value of the refined pumpkin seed oil to 0.21 mg KOH/ g oil in neutralization step. Unsaponifiable matter has been reduced to 0.92% from 2.17% in refined oil, where previously, Tsaknis et al. 1997 reduced it from 1.22 to 0.79% [2]. The nonfatty components of oil contribute to the unsaponifiable matter that contains tocopherols, phytosterols, polyphenols and carotenoids [7]. However, the loss of these beneficial components should be minimal in refineries.

Fatty acid composition of crude and refined pumpkin seed oil is represented in Table 2. The table shows that oleic and linoleic acid have been found as the principal fatty acids, 37.38 and 36.15% in crude oil and 36.89 and 36.43% in refined oil respectively. Palmitic acid and stearic acid was found in a considerable amount whereas a small amount of myristic acid, behenic acid and lignoceric acid has been found. The above results were closely in agreement with those previously studied [2–5]. Nevertheless in the study of Afawaz, linoleic and oleic was found as 52.69 and 18.14% correspondingly [12]. Fatty acid composition of pepita oil can be effected by hybridization in open-pollinated as well as being of different genotypes [3]. However, pumpkin seed oil is rich in linoleic acid, an essential fatty acid; it can obviously include a new value to human nutrition. Moreover, it should be pointed that there is no significant changes in fatty acid composition after purification.

The tocopherol content detected in pepita oil has been shown in Table 3. No β-tocopherol was found, but α, γ and δ-tocopherol was found 47.2, 119.7 and 195.0 mg/kg respectively in crude pumpkin seed oil. The total tocopherol content observed in this study was lower that of studied pumpkin seed oils in Stevenson et al. 2007, but higher than the reported in Tsaknis et al. [2, 4]. In this study, δ- tocopherol was the foremost tocopherol found followed by γ- tocopherol which is

Table 2 Fatty acid composition of crude and refined pumpkin seed oil

Fatty Acids (%)	Crude	Refined
Myristic Acid (C14:0)	0.12	0.10
Palmitic Acid (C16:0)	19.23	19.17
Stearic Acid (C18:0)	6.39	6.68
Oleic Acid (C18:1)	37.38	36.89
Linoleic Acid (C18:2)	36.15	36.43
Linolenic Acid (C18:3)	ND	ND
Behenic Acid (C22:0)	0.31	0.26
Lignoceric Acid (C24:0)	0.42	0.47
Total Saturated Fatty Acids	26.47	26.68
Total Unsaturated Fatty Acids	73.53	73.32
Total Monounsaturated Fatty Acids	37.38	36.89
Total Polyunsaturated Fatty Acids	36.15	36.43

Table 3 Tocopherol content of crude and refined pumpkin seed oil

Tocopherol content, mg/kg	Crude	Refined
Alpha Tocopherol	47.2	42.12
Gamma Tocopherol	119.7	101.21
Delta Tocopherol	195.0	157.36
Total Tocopherol	361.9	300.69

Table 4 Some nutritional facts of oilcake from pumpkin seed

Nutritional facts	Content
Protein (%)	54.78
Fat (%)	4.16
Iron (mg/100 g)	30.29
Calcium (mg/100 g)	21.45
Magnesium (mg/100 g)	2.27
Manganese (mg/100 g)	0.30

similar to most of the cultivars observed in previous study [4], nonetheless Tsaknis et al. 1997 found α- tocopherol only. The total tocopherol found in crude pumpkin seed oil was higher than that of some plant oils like grapeseed oil (121 mg/kg), Olive oil (177 mg/kg), peanut oil (226 mg/kg), although it is lower than some conventional edible oils like soybean oil (829 mg/kg), sunflower oil (609 mg/kg), rapeseed oil (468 mg/kg) [16]. The studied α, γ and δ- tocopherol as well as total tocopherol has been decreased after refining in accordance with the statement of Ergönüla and Köseoğlu, 2013 [17]. According to them, tocopherols are reduced during degumming and neutralizing step, since they are unstable in the presence of oxygen and in alkaline medium. Furthermore, tocopherols were adsorbed and oxidized by the bleaching earth in the bleaching step, which promotes also the loss of tocopherols, further affecting the oil stability [17]. The difference in the amount of tocopherols lost during refining process depends on the processing time and temperature as well as crude oil condition [2]. However, being affluent in γ- tocopherol that has greater antioxidant activities than α- tocopherol, pumpkin seed oil can be an attractive substitute from nutritional perspective.

3.1 Oilcake

The oilcake has been obtained from the pumpkin seed after expelling the oil and analyzed to know some of its nutritional value. In this study, protein, fat, iron, calcium, magnesium and manganese content of pumpkin oilseed cake has been observed and represented in Table 4. The protein content was 54.78% which was much more than that of palm kernel, sesame and copra cake (14–20%) and almost similar to that reported for groundnut cake (40–50%) [6]. The fat content was found as 4.16% that is lower than that of the mentioned oilcakes in Sunil et al., 2014 as fat content of oilcakes sometimes

depends on the oil extraction method [6]. Four minerals, iron (Fe), calcium (Ca), magnesium (Mg) and manganese (Mn) were investigated as literature says that high calcium intake can prevent fat accumulation, lower the risk of developing colon cancer; magnesium is good for hypertension, cardiovascular disease, osteoporosis; iron deficiency cause anemia and manganese is useful for blood clotting factor [18].

Iron content of pumpkin seed oilcake was 30.29 mg/100 g where iron content of rice bran oilcake, copra oilcake and sesame oilcake was found 7.3–18.9, 7.3–24.8 and 11.3–55.6 mg/ 100 g previously [6]. Accordingly, its calcium content was 21.45 mg/ 100 g where iron content of rice bran oilcake, copra oilcake and sesame oilcake was found 7.5–75.1, 58.9–72.8 and 144.4–560.9 mg/100 g [6]. No available data was found for magnesium and manganese of oilseed cakes. Since proteins from pumpkin have several medicinal activities like preventing blood coagulation, melanoma proliferation etc. [19], pumpkin seed oilcakes can be utilized by fortification in different food products due to its high protein value. It can be used in poultry or fish feed for its elevated protein and mineral content as well.

4 Conclusion

This study has demonstrated that pumpkin seed can be utilized fully by producing edible oil and value added products from its oilcake. Nonetheless, it should be reminded that pumpkin seed oil should be obviously refined to make it edible. The findings of the present study may help to proper utilization of pumpkin seed and thus help to find more alternative sources of edible oil and save foreign currency. However, based on the results of linoleic-oleic acid and tocopherol, it can be stated that properly refined pumpkin seed oil can be a good substitute of conventional plant oils like soybean, sunflower or rice bran oil.

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Data availability The partial datasets analysed during the study are available, but some datasets are not available at present as the study was performed four years before.

Declarations

Competing interests The authors declare that they have no competing interests.

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