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Investigation of Morphological and Physical-Chemical Parameters of Melon Seeds from the Chillaki Variety

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Abstract The purpose of the research was to study the possibility of complex processing of melon seeds to obtain melon oil and high-protein cake based on local raw materials. Morphological and physico-chemical characteristics of melon seeds of the widely grown Chillaki variety have been determined. Melon seeds have a high content of crude protein and oil. The fatty acid composition and the amount of fatty acids of the oil obtained by pressing were studied. Chromatographic and spectrometric studies have shown that the oil contains 13 fatty acids, mainly linoleic (42.10%) and oleic (27.98%). The content of palmitin (9.76%), stearin (4.21%) and decanoic acid below 10% was determined, which means the functionality of the resulting product. The rich micro and macronutrient composition of cake determines its use as a vitamin and protein component of food products.

Keywords Melon seeds, Oil, Proteins, Fatty acids, Mineral components

1. Introduction

As experts know, the fat-and-oil industry of the Republic of Uzbekistan was focused on the processing of cotton seeds obtained from 6 million tons of raw cotton and the production capacity was 3,600 thousand tons per year in terms of raw materials. This led to the construction of several gigantic factories, the production capacity of which reached 1200 tons per day. This led to an increase in the 2000s in the processing capacity of oilseeds up to 4,000 thousand tons per year. Despite the conservation of some capacities, in 2022 production capacities amounted to 3,300 thousand tons for cotton seeds and more than 1.1 million tons for processing non-traditional oilseeds. It should be noted that soybean and sunflower processing capacities did not exist in the 2000s. Today, the sources of oilseeds are approximately 1,300 thousand tons per year.

Despite the large production capacity and all efforts to increase oilseeds, the country remains highly dependent on imports for certain types of oil and fat products. In 2022, more than 52% of vegetable oil resources were formed in the country's food market due to imports.

It should be noted that 300 of the existing 500 enterprises are small and cannot conclude import contracts for a large batch of raw materials on their own, because working capital of these enterprises does not allow this. When it comes to raw materials, we mainly mean sunflower seeds. But the seeds of soybean, flax, rapeseed, sesame, safflower are also in demand on the Uzbek market. Feed additives cover part of the costs due to demand.

Meanwhile, there is a large stock of waste from the canning and wine industry, such as seeds of grapes, pomegranate, melon, watermelon, tomato, stone fruits, which are currently used irrationally. Also, it is possible to produce functional pharmaceutical oils.

In the Republic of Uzbekistan, the annual cultivation of various varieties of melon is 1056 thousand tons and is growing rapidly throughout the country. Considering that melon seeds make up more than 3% of the total mass, more than 32 thousand tons of seeds are lost annually, from which 14 thousand tons of functional edible oil could be obtained.

Also, other sources of oil are practically lost due to the lack of organization of collection and the lack of regulated technologies for processing these seeds. If we organize the collection and processing of at least half of the existing sources of raw materials, then the annual income in the republic will be more than 250 million US dollars, which means covering the entire amount of imports of sunflower oil.

The composition of melon oil is dominated by unsaturated fatty acids and natural melon oils are represented by linolenic, linoleic and oleic, while saturated ones include palmitic and stearic. Thanks to this composition, the beneficial properties of melon oil are obvious, which determine the use of this plant product in the fields of

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medicine and food production.

Based on the foregoing, we have studied the physicochemical and quality indicators of dried seeds of the Chillaki melon variety in order to determine the possibility of complex processing and wide use of the products obtained from it, including cake in the food direction.

2. Materials and Methods

The object of the study was the melon seeds of the Chillaki variety. Melon is an annual plant of the gourd family with a well-developed root system. Its main tap root penetrates to a depth of 4 m. Lateral roots are located mainly in the near-surface soil layer. Above-ground shoots reach a length of 3 m, strongly branched, stiff-haired, with antennae, hollow inside. Unlike watermelon, melon leaves are not separate, but whole or five-lobed, round or kidney-shaped, up to 14 cm long, up to 20 cm wide [1, p.16]. The flowers are large, orange-yellow, with a deeply five-parted corolla. Male flowers are collected 5-15 in because. to obtain. The female flowers are solitary, larger than the male ones. Along with dioecious flowers, bisexual flowers sometimes occur, and underdeveloped stamens are found in female flowers. Fruits of different varieties differ in shape and size, weight, taste, color of the pulp and peel. The length of the fruit ranges from 4 cm to 2 m, and the weight - from several tens of grams to 20 kg. Seeds are white or cream, 0.5 to 1.5 cm long [2].

Seeds from mature and fresh samples were used in the studies. Analyzes were carried out in three parallel samples in accordance with the methodology. At the first stage of the research, the morphological composition of the seeds was determined, i.e. the content of pulp, protein and other substances in it, husks, moisture, oil and other indicators. At the second stage of the research, melon oil was obtained from the seeds of the Chillaki melon variety by pressing.

We have chosen a Chinese-made ZX-130 press for processing samples. The press is designed in such a way that it can work in 2 modes, i.e. and in the "prepress" and "expeller" modes.

The analysis of the obtained pressing oil was carried out according to the following methods:

- color of oils on the Lovibond color meter;
- the acid number of oils was determined and a 1% alcohol solution of phenolphthalein was used as an indicator [4, 10 p.]. The method is based on the titration of an oil sample with an alkali solution in the presence of the phenolphthalein indicator. A neutralized mixture of alcohol and diethyl ether was used as a solvent for the oil. K.ch. (in mg KOH/g) was calculated according to the formula C.h. \u003d 5.611 a k / m, where: 5.611 - titer to 0.1 n potassium hydroxide solution, ml; a - the amount of 0.1 n caustic alkali solution used for titration, ml; k - titer correction; m is the mass of the analyzed oil, g;
- the mass fraction of moisture and volatile substances was determined;
- the degree of oxidation of oils was assessed by the peroxide value determined by the iodometric method;
- the oil content in the processed materials was determined by the exhaustive extraction method in the Naaba apparatus [8, 661 s];
- humidity of oil-containing materials and miscella concentration were analyzed by the gravimetric method [9, 18 p.];
- the content of crude protein and its soluble fractions in cakes was determined by the Kjeldahl macromethod [10, 302 p.].
- to study the physico-chemical composition of the obtained oils, a Clarus 600 Perkin-Elmer gas chromatograph (USA) was used in the laboratory of applied technologies of the Institute of Bioorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan. Quantitative analysis of fatty acids was carried out under the following conditions: column - Restek, Stabillwax, column length - 60 m, column diameter - 0.32 mm, detector - FID, conveyor gas - nitrogen, thermostat temperature of the temperature gradient - 1-8 min, 80℃; 8-18 min, 130℃; 18-22 min, 180℃; split - 1/10; injection amount - 1 µl. Fatty acids were methylated based on derivatization.

3. Literature Review

In industry, vegetable oils are extracted from oilseeds by pressing (cold or hot) or organic solvents. Also, a combined method is used, including pressing, followed by extraction of oil from the cake with a liquid solvent. When it comes to functional raw materials, it is worth noting that for stone fruit and fruit and vegetable seeds, the development of a press method for extracting oil is promising, because. Pressed oil is considered more valuable, especially cold-pressed [11].

Cold pressing is one of the pressing methods without heat or at low temperature. After cold pressing, the temperature of the oil and the acidity coefficient are low. Cold-pressed oil (except cottonseed oil) usually does not require refining, and after precipitation and filtration, the finished oil is obtained [12, p.88-96; 13, p.40-51].

Melon seed oil, rich in linoleic acid, is used for frying and cooking in parts of Africa and the Middle East due to its unique flavor. Many studies have been published on the oxidative stability of vegetable or fruit oils, but little has been reported on the stability of melon seed oil. Modification of the fatty acid composition of melon seed oil by the inclusion of oleic acid (18:1) was investigated. Modified melon seed oil was obtained with a better balance of monounsaturated (18:1) and essential fatty acids (18:2), and improved the seed oil's oxidative stability and nutritional value [14].

The dependence of the oil yield, the mass fraction of crude protein and the residual oil content in the cake on the content of the fruit shell in the processed melon of the Amiri variety grown in Tajikistan was investigated. Melon seeds with an oil content of 35.3% were treated with IR irradiation with heating up to 90℃. Then they were brought down with a single blow in a modernized centrifugal roller. Samples of a model mixture of the core fraction of melon seeds with a fruit shell content of 8, 14, 20 and 25% were prepared from the resulting roll. Before oil extraction, each sample of the sound fraction was heated to a temperature of 68-70℃ in an installation with an IR power supply. The humidity of the samples was (6.0 ± 0.2)%. The extraction of oil from melon seeds was carried out in bench conditions on a DUO screw press (Farmet a.s). It was found that with a decrease in the content of the fruit shell in the core fraction up to 8%, the yield of melon oil increases to 37%, the content of crude protein in the cake on an absolutely dry substance increases to 56%, the oil content of the resulting cake decreases to 9%. At the same time, the quality indicators of melon oil are improved [15].

Research results show a high content of not only oil, but also protein in melon seeds. In our opinion, special attention should be paid to the protein content in this raw material, because the production of vegetable proteins in our Republic of Uzbekistan, despite the pissimistic results of the FAO and WHO analyzes, lags behind world producers. Observations show that there is a growing shortage of dietary protein in the world and its shortage is likely to continue in the coming decades. On average, the inhabitants of the Earth consume about 60 g of protein per day, at a rate of 70 g. The total protein deficiency is estimated at 20-25 million tons per year. Of the 7 billion people living on Earth, approximately half suffer from protein deficiency [16].

Climate change is exacerbating and already disrupting the production of staple crops such as wheat, rice, and maize in tropical and temperate zones, and without improved climate resilience, the situation is expected to worsen as average temperatures rise and extreme weather events become more frequent [12].

Today, 821 million people worldwide suffer from hunger or malnutrition, and 144 million young children are stunted, which also indicates the presence of hidden hunger [18]. The FAO claims that the pandemic has led to an increase in the number of people suffering from overweight and obesity worldwide. According to the release of the 2020 SOFI report, as a result of the COVID-19 pandemic, more than three billion people on the planet will not be able to afford healthy food [14].

A promising way to increase the resources of food protein is to increase the productivity of crop and livestock production based on the technologies for cultivating legumes, oilseeds, and cereals used both directly for food and for livestock feed [15].

In accordance with the recommendations of WHO and FAO, the value of the optimal protein requirement is 60-100 g per day, or 12-15% of the total caloric intake of food. In the total amount of energy, protein of animal and vegetable origin accounts for 6-8% each. In terms of 1 kg of body weight, the protein requirement per day in an adult is on average about 1 g, while for children, depending on age, it ranges from 1.05 to 4.00 g [19].

Increasing the amount of dietary protein through animal husbandry is less promising compared to crop production, because to obtain 1 kg of animal protein, 5-8 kg of feed protein is required. The coefficients of transformation of vegetable proteins into proteins of fed animals are very low (25–39%), and therefore 60–75% of the protein is lost in the food chain in undigested residues [16].

Analysis of sources of information, although the results of not so many studies are known, shows that melon seeds, like the pulp, are rich in valuable food ingredients. The melon variety called Chillaki is a widely cultivated variety throughout the republic, and therefore we decided to investigate the physico-chemical parameters of dried seeds of this particular variety.

4. Results

Mature melon seeds are a type of seed without endosperm. They consist of an embryo with large cotyledons and a seed coat. The seeds vary little in appearance and size. The morphological parameters of the studied seeds corresponded to the average statistical parameters, i.e. classified as medium size (length 1.14-1.18 cm, width 0.41-0.49 cm and thickness 0.21-0.36 cm).

The content of seed pulp was 52.3-54.4% of the total mass. Accordingly, the husk content varied from 45.6 to 47.7%. Morphological and physicochemical parameters of the studied seeds are given in Table. 1.

Table 1. Morphological and physico-chemical parameters of seeds of melon variety "Chillaki"

Indicators	Content
The content of the gel part (pulp),%	52,3-54,4
Husk (shell) content, %	47,7-45,6
Weediness, %	3,9-4,1
Humidity, %	5,7-7,2
Absolute mass, g	3,9-7,8
Weight of 1 m3 of seeds, kg	590-630
Weight of 1000 seeds, g	42-44
Openness, %	27-35
Lipids	35,2-43,1
Squirrels	23,7-25,6
Cellulose	12,1-15,4
Ash	4,2-4,7

As can be seen from Table. 1, the contamination of seeds is 3.9-4.1%. It should be noted that before drying, melon seeds are rinsed with water or a slightly alkaline solution of caustic soda to remove mucous substances. Therefore, the weed infestation of the seeds is comparatively lower than that of other oilseeds. The moisture content of the seeds is in the range of 5.7-7.2%, which refers to low-moisture raw materials. The weight of 1000 seeds was 42-44 g, and the relative density was 590-630 kg/m3.

With regard to the chemical composition of the seeds, the lipid content of the seeds was determined by extraction with extraction gasoline. The lipid content was 35.2-43.1%. Proteins according to Kjeldal 23.7-25.6%, fiber in the range of 12.1-15.4% and ash content 4.2-4.7%.

From the seeds, the physico-chemical parameters of which are given above, oil was obtained by pressing in a ZX-130 press. Pressing was carried out with the use of hydrothermal treatment (HTT) before pressing and without treatment, i.e. cold pressing. The results of forpressing heat-treated and untreated oilseed pulp are shown in table. 2.

Table 2. The results of pre-pressing heat-treated and non-treated pulp

Indicators	Results	
	Cold pressed without pretreatment	Pressing with pretreatment at 80℃
Oil yield, %	24,3	26,2
Cake yield, %	74,8	69,3
Moisture loss, %	0,9	4,5
Balance:	100	100

As can be seen from the data given in table. 2, pressing mint without heat treatment yielded 24.3% crude oil. When the mint was moistened and processed at a temperature of 80℃ for 50 minutes. The increase in oil yield is significant, so 26.2% of oil was obtained from melon pulp. Hydrothermal treatment of the studied samples under gentle conditions (no more than 80℃) led to an increase in the yield of forpress oil.

Gentle hydrothermal treatment leads to some positive results. Along with an increase in oil removal, when heated to 80℃, starch transforms into dextrins, which are easily absorbed by the body, the main part of protein substances undergoes denaturation, which stiffens the material and retains drainage properties during prepressing. The fatty acid part and vitamins remain practically unchanged, and the absorption of nutrients improves by 20–25% [18,19].

We are conducting research to determine the optimal moisture content and temperature of pre-treatment before forpressing and the optimal parameters of expelling. However, in this message we will not dwell on the pressing indicators, because. The main purpose of the communication is to determine the morphological and physico-chemical parameters of the seeds and the fatty acid composition of the oil contained in the seeds.

Standard procedures for determining the physicochemical characteristics of seed oil samples were applied to determine the fatty acid composition of the seed oil. Common oil constants such as acid, iodine, peroxide, saponification, specific gravity and refractive index were evaluated according to the AOAC methods.

To determine the physicochemical composition of oils, a Clarus 600 Perkin-Elmer gas chromatograph (made in the USA) was used in the laboratory of applied technologies of the Institute of Bioorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan. To determine the content of fatty acids, the corresponding oil was hydrolyzed with a 10% alcoholic solution of KOH. The resulting soap was broken down to fatty acids with 50% sulfuric acid and extracted 3 times with diethyl ether. The diethyl extract was washed with water until neutral and dehydrated with anhydrous sodium sulfate, after which it was distilled off in a rotary evaporator. Fatty acids were methylated with freshly prepared diazomethane. The chloroform-containing part was distilled off, dissolved in hexane and analyzed by GC. The fatty acid composition of the oils obtained in the experiments are given in Table. 3 and in fig. 1.

Table 3. The results of determining the fatty acid composition of melon oil

Name of fatty acids	**Content, %**
C8:0	0,02
C10:0 decane (capric)	8,24
C14:0	2,32
C16:0	9,76
C18:0	4,21
C18:1 olein	27,98
C18:1 trans isomer	0,16
C18:1 cis isomer	0,21
C18:2 linol	42,1
C18:3 linolene	1,76
C18:3 gamma	0,87
C20:0	2,11
C20:2 cis 11.14	0,14
indefinite	0,12

A chromatographic study of the resulting melon oil showed that the composition contains 13 fatty acids (see Table 3). The composition of melon oil mainly contains linoleic (42.1%) and oleic (27.98%) acids. The content of palmitin (9.76%), stearin (4.21%) and decanoic acid (8.24%). Also, a small amount contains caprylic, arachidonic and myristic acids and trans and cis isomers in small quantities. Functional for melon oil was the content of myristic acid.

In the studies, IR spectroscopy was also carried out for all the studied oils. The spectra of the samples were recorded using an IRTracer-100 IR-Fourier spectrometer complete with a single ATR attachment with a diamond/ZnSe MIRacle 10 prism. It is designed for the analysis of solid, liquid, paste-like, gel-like and difficult-to-process substances in the scanning range: 4600 - 600 cm-1 . As is known, IR spectroscopy is mainly used to establish the structure and identify organic compounds, including chemicals. Detection and identification of substances by IR spectroscopy can be carried out as follows: detection of individual functional groups by characteristic absorption bands, comparison of the IR spectra of the test compound and a standard sample, identification of an unknown compound using an atlas or a computer library of IR spectra.

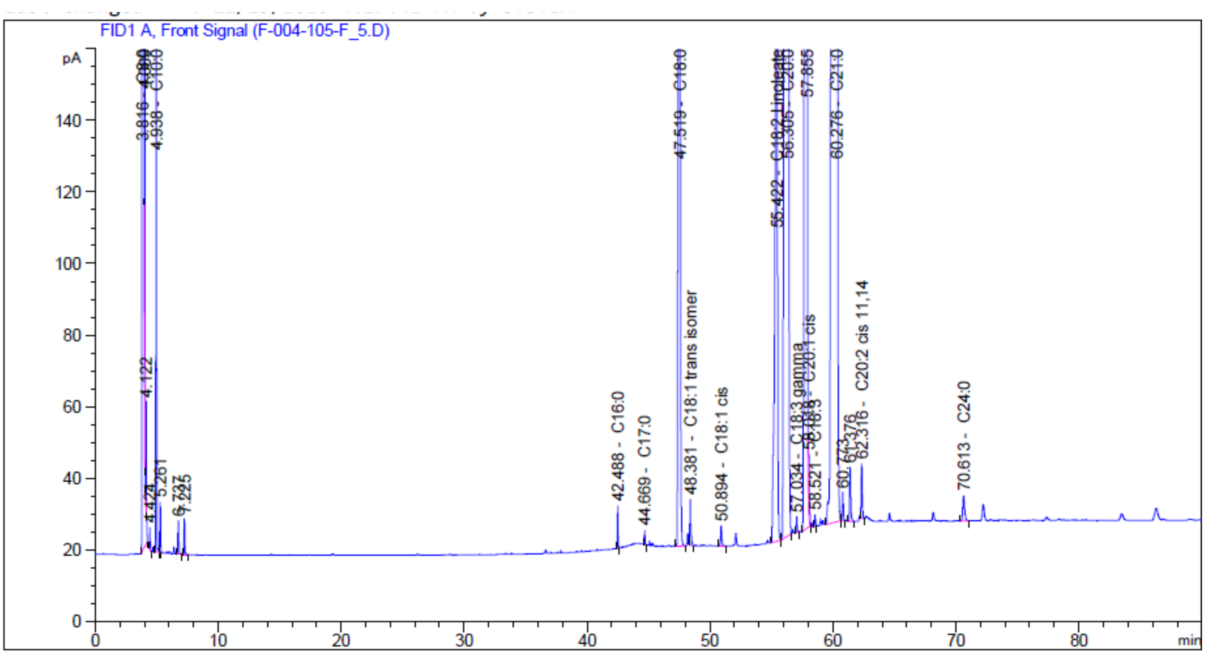

Figure 1. Chromatogram of pressed melon oil obtained by preliminary GTO

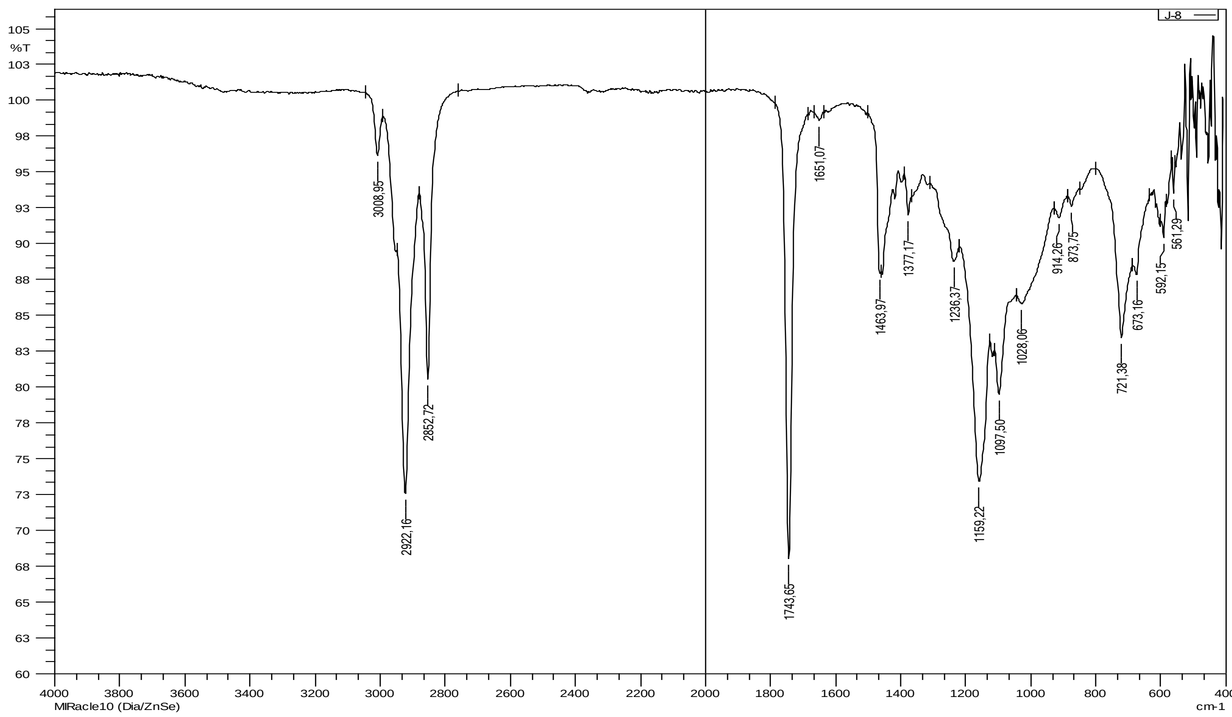

Figure 2. IR spectrum of expeller melon oil obtained by preliminary TRP

IR spectroscopy of the obtained compound (Fig. 2) shows free hydrogen bonds of carbon (=C-H) with an absorption band in the region of 3008 cm-1. Regions 2922-2852 cm-1 have a high absorption band of methylene (CH2) groups. The band of the carbonyl (C=O) group is visible in the very intense region of 1743 cm-1. There are 1463 cm-1 methyl (CH3) groups present in the field. 1377 cm-1 intense bonds of nitrate ions (NO3) are visible.

There are 1236 cm-1 intense bonds of phosphorus and oxygen (P=O). Phosphorus-oxygen 1161 cm-1 and bonds (-P-O-) are visible. There are 1097 cm-1 perchloride (CLO4-) functional groups. There are 873 cm-1 of dioxide (-O-O-) groups. There are groups of carbon disulfide 603 cm-1 (-C-S-).

The fatty acid profile of the seed oil showed an unsaturated fatty acid content of 73.34% and a high polyunsaturated fatty acid (PUFA) content of 44.99%. The predominant fatty acid is linoleic acid (18:2), the content of which reached up to 42.1%. In the studied samples, monounsaturated oleic acid is contained in an amount of

27.98%. The presence of other fatty acids varied below 10%.

The fatty acid composition of edible oils plays an important role in their stability and nutritional value. Monounsaturated (18:1) and polyunsaturated (18:2) fatty acids have been found to be effective substitutes for saturated fat in cholesterol-lowering diets. However, it is also known that oils with a significant content of unsaturated fatty acids, especially diunsaturated (18:2), are susceptible to oxidation and can form products that promote atherosclerosis and carcinogenesis. Some studies involving experimental animals show that an excessive amount of linoleic acid promotes carcinogenesis [19, p. 20-21].

A Varian A 1475 atomic absorption spectrophotometer was used to measure the content of Mg, Fe, Zn, Cu, Ca, and K in the seeds. The seeds were dried at room temperature, hulled, and ground in an electric blender. Seed (100 g) and kernel (100 g) samples were extracted with petroleum ether using a Soxhlet apparatus for 6 hours. The extract was desolventized in a vacuum on a rotary evaporator at a temperature of 35℃, as a result of which oil samples were obtained as a residue [20].

Analysis of the mineral components of the ash showed a significant concentration of calcium, phosphorus, magnesium and potassium. The content of copper, zinc and iron varied from 17 to 42 ppm. The results obtained are presented in table. 4.

Table 4. Mineral components of melon seeds

Name of indicators				Content, mg/kg		
Iron	Calcium	Zinc	Copper	Phosphorus	Magnesium	Potassium
42	1035	39	17,8	5200	2100	7700

Chillaki melon seed oil had an amber color and a very characteristic nutty flavor. The oil was also stable at room temperature. Physico-chemical characteristics of seed oil are summarized in Table. 5.

Table 5. Physical and chemical characteristics of melon seed oil

The name of indicators	Content
Specific gravity at 20℃ (kg/dm3)	0,914
Refractive index, at 20℃	1,4733
Acid number, mg KOH/g	1,04
Saponification number, mg KOH/g	188
Iodine number, g/100 g	119
Peroxide value, mmol/kg	7,9
Unsaponifiable matter, %	1,02
Essential number	187

From Table. 5 shows that the iodine number is higher than that of cotton due to the increased content of unsaturated fatty acids in it. Peroxide and saponification number within standard indicators. The specific gravity and refractive index of the oil are also relatively high, which is also related to the content of unsaturated fatty acids. The physical properties of the oil showed that these properties of seed oil are similar to oils rich in linoleic acid.

5. Conclusions

The data presented suggest that melon seeds can be a useful product with good nutritional value. Melon seeds are high in crude protein and oil. A particularly high content was found in the kernel - up to 38% protein and 52% oil. The seed oil contains linoleic acid, which is a major fatty acid (42,15). Oil can be obtained from seeds, and cake, due to the high content of protein substances, can be used in the diet as a vitamin-protein component. We have begun research on the development of technology for protein flour and concentrate based on melon cake and meal.

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