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Contents

Technological and chemical aspects of storage and complex processing of industrial hemp seeds

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Abstract

Introduction. The work's aim is theoretical and experimental studies of the aspects of industrial hemp seeds' storage technology, as well as the composition and quality of their processed products.

Materials and methods. Research materials are the seeds of industrial hemp of the Hliana variety, press oil, and hemp kernel. To study industrial hemp seeds' composition and quality during long-term storage (12 months), we prepared 12 polypropylene containers filled with the original hemp seeds after their initial processing.

Results and discussion. It was found that the moisture content in the seeds was 8.2–10.0%; seed purity was 97.5–99.8%; oil content was 31.9–34.3%; the weight of 1000 seeds was 17.7–19.2 g; bulk density of sources was 503,8–530 g/l. The reduction of the seeds' oil content in the second half of the shelf life was found. The yield of pressurized filtered oil increased at the end of the shelf life. The increase of the oil acid value during the seeds' entire shelf life (0.91–1.46 mg KOH/g) was detected. The peroxide value in the first half of the shelf life of hemp seeds did not exceed 5 ½ O mmol/kg, and in the second half, it increased to 10 ½ O mmol/kg. The primary unsaturated fatty acids in the studied hemp oil are oleic (14.9–19.4%), linoleic (53.4–56.6%), α-linolenic (11.3–16.2%). The ratio of essential acids ω-6 and ω-3 in the studied oil samples is close to ideal – 3.4:1–5.0:1. The yield of press cake was 67.1–70.0% at the humidity of 6.6–9.0% and at the oil content of 9.5–12.3%. The filter sludge result was 4.6–8.6% at 4.4–16.8% moisture and 49.2–64.4% oil content. The hemp kernel yield was 33.2–41.4%; content in hemp kernel: moisture – 6.9–7.8%, impurities – 0.01–0.04%. It was established that the oil content in the hemp kernel obtained from the seeds of the Ukrainian selection of the Hliana variety increased by 5.9–8.5% in comparison with the control.

Conclusions. The expediency of using the industrial hemp seeds of the Hliana variety for analytical processing at standardization of storage conditions within a year is proved.

Introduction

In current conditions, the industrial interest in hemp seeds is increasing, thanks to the knowledge of their high nutritional value and potential functionality. However, there is still a lack of awareness and a great deal of confusion between industrial and medical cannabis. There is insufficient research in the scientific literature on nutritious and healthy hemp-based foods [1].

The main parameters that affect hemp seeds' shelf life and quality are humidity, temperature, and shelf life.

There is enough information in scientific sources concerning the research of hemp seeds' storage conditions as seed material [2–5]. According to Canadian researchers, the rational conditions for long-term storage of hemp seeds (66 months) to preserve seeds' viability are a temperature of 5 °C and moisture content in the sources – 6%. The authors found no benefit from oxygen-free seed storage [2]. It should be noted that the data of work [3] on long-term storage (36 months at a humidity of 5–7%) of hemp seeds varieties cultivated in India are consistent with the data of the work [2].

According to [4], the influence of storage conditions of hemp seeds grown in Thailand on the change of their quality indicators was revealed. For long-term storage (12 months), the seeds were packed in aluminum foil and polypropylene bags. Germination and strength of seeds packaged in both types of materials at room temperature did not change for six months, and during 8–12 months of storage, germination energy decreased by 30%. The authors suggested temperature of 15 °C as the best condition for the hemp seeds' storage.

In studies [2–5], insufficient attention is paid to changes in hemp seeds' composition and quality during its long-term storage. Also, no scientific information has been found on hemp seeds' storage as raw materials for complex industrial processing.

One of the standard methods of hemp oil production is the pressing method [6]. To increase the oil yield when using the pressing technique, it is proposed to use pre-microwave treatment of hemp seeds [7], ultrasound treatment [8], and enzyme treatment [9]. In our opinion, microwave processing of oilseeds in industrial conditions is problematic in technical, energy, environmental, and social terms for humans. The use of enzyme preparations for hemp seeds' pre-treatment requires testing in an industrial setting for cost, ecology, and feasibility.

To ensure almost complete extraction of oil from hemp seeds, the method of cold pressing in conjunction with the extraction of supercritical CO_2 is used [8, 10, 11].

Studies [12] and [13] compare the yield and composition of hemp oil extracted by supercritical CO_2 extraction, n-hexane extraction using the Soxhlet method, and the press method utilizing an expeller. Extracritical CO_2 extraction revealed the highest content of tocopherols; the content of γ-tocopherol increased 2–3 times. The content of pigments (chlorophyll and carotene) in the oil also increased. The maximum oil yield (37.3%) was obtained by the Soxhlet method from hemp seeds treated with ultrasound. In [14], when liquefied dimethyl ether was used as an extractant, hemp kernel oil's yield and quality were better than when using traditional organic solvents. In our opinion, the authors' claims regarding the process' setup simplicity, economic efficiency, and the possibility of dimethyl ether recovery without traces of solvent remaining in the raw material are yet to be checked in production conditions.

The studies [15–20] research the fatty acid composition of various hemp oil samples and the ratio of essential polyunsaturated fatty acids ω-6 to ω-3. The generalized fatty acid composition depends on hemp's growing conditions [15] and the extraction of oil from seeds and its refining [16].

Seed samples used in work [17] contained 81% of polyunsaturated fatty acids: linoleic – 59.6%, γ-linolenic – 3.4%, α-linolenic – 18%. It is also noted that the oil's highest resistance to oxidation was obtained by extracting the raw material at 300 bar and 80 °C. In [15], it was found that the range of linoleic and α-linolenic acids in samples of hemp seed oil, zoned in Iran, was 57.55–63.98% and 7.57–22.91%, respectively.

In summarizing the above data, it was found that the primary unsaturated fatty acids in hemp oil samples are oleic, linoleic, α-linolenic. The ratio of essential polyunsaturated fatty acids in hemp oil is close to ideal: ω-6 and ω-3 as 2:1–3:1. From the studied sources of information, the effect of long-term storage of hemp seeds on the extracted oil's fatty acid composition was not revealed.

Work [21] presents the data on the content of micro and macroelement composition of Romanian hemp seeds in two fractions: kernels and seed coats. To improve the technology of obtaining hemp kernels and shells, the conditions and devices for implementing this process are considered. This requires further experimental production studies [31].

The aim of our work is theoretical and experimental research of industrial hemp seeds' storage technology aspects, as well as the composition and quality of the processed hemp seed products.

Materials and methods

The object of research is the technology of industrial hemp seeds' storage and processing.

Materials

Research materials are the industrial hemp seeds of Ukrainian selection of Hliana variety, press oil, and hemp seed kernel. A distinctive feature of this variety is the absence of the psychotropic substance tetrahydrocannabinol.

To ensure the biological value and competitiveness of hemp seeds and products of their processing, it is necessary to perform a systematic study of their composition and quality at different technological stages. These stages include harvesting and primary processing of hemp seeds [23], long-term storage, and complex processing. To study the composition and quality of industrial hemp seeds during long-term storage (12 months), we prepared 12 containers (polypropylene bags) filled with original hemp seeds after their initial treatment with the following indicators: mass fraction of moisture – 9.06%, seed purity – 99,75%, the mass fraction of oil, in terms of dry matter – 32.99%, acid value of fat – 0.65 mg KOH/g, peroxide value – 2.63 ½ O mmol/kg, the weight of 1000 seeds – 17.74 g [23]. The study began on October 10, 2018. The indexation of industrial hemp seeds' samples to study its composition and quality: 0 – the original model (October 2018), the following samples (1–12) were taken at intervals of one month (November 2018 – October 2019). 12 samples of oil and 12 samples of hemp kernel were obtained from each piece of stored industrial hemp seeds. The indexation of oil and hemp kernel samples corresponded to the original industrial hemp seed samples' indexation.

Samples of hemp oil were obtained using a PCI 250 screw press, and examples of hemp seed kernels were obtained using an experimental centrifugal device to isolate the kernel.

Obtaining prototypes of hemp oil by cold pressing

Preparation of samples. Hemp oil production differs from other oilseeds in that there is no "raw material preparation" stage before pressing. Before loading into the auger, hemp seeds are not subject to wet-heat treatment and don't require cleaning from the shells, but must comply with the current regulatory documentation requirements for humidity and degree of purity. Therefore, before extracting oil from industrial hemp seeds, each sample was controlled according to these parameters monthly for a year.

Description of methods and settings. A PSh-250 screw press, designed for continuous cold pressing of vegetable oils from oilseeds was used to obtain the oil. The design of the auger, the auger chamber, and the grain cylinder allow for optimal temperature and pressure conditions for pressing oilseeds and ensures the required degree of oil recovery. The productivity of the screw press PCI-250 is 150 kg/h, the yield of unfiltered oil is 22.8–24.2%, the output of cake is 50.1–66.7%, the oil temperature at the outlet of the press is up to 55 °C.

Order of research. The raw material was uniformly fed into the inlet of the screw press, and then it was fed into the grain chamber. In the working section of the press, a screw shaft acted on the raw material, due to which the squeezing and extraction of the liquid phase from the seeds — oil — took place. The grain compartment's bottom and walls have slots through which the oil flowed into the storage tank, which was located at the bottom, and the petals came out as press cake at the end of the horizontal working zone.

Oil purification was carried out by sedimentation filtration. Oil in the amount of 20 liters was loaded into bag filters with gabardine fabric, which had the following characteristics: height – 75 cm, filtration area – 0.94 m^2, filters were placed above the storage tanks. The duration of oil cleaning was 24 hours. The disadvantage of this filtration method is the direct contact of the oil with air, which increases the risk of oxidation of the finished product.

Production losses during pressing and filtration were the material's adhesion to the press's working organs, to the filter cloth, and to the inner surface of the containers into which the oil entered.

Processing of research results. The finished product yield was calculated as a percentage of the total weight of the raw material.

Obtaining prototypes of hemp kernel

Preparation of prototypes. Before isolating the kernel from industrial hemp seeds, each sample (monthly for a year) was controlled for moisture and purity.

Description of methods and settings. Separation of shells from industrial hemp seeds was performed on an advanced experimental centrifugal device (Figure 1, patents for utility model UA 122649 Device for crushing hemp seeds and UA 135810 Method collapsing industrial hemp seeds). The productivity of the device for isolating the hemp kernel is 80–100 kg/h. The working body's rotation speed is 1000–2500 min^{-1}, the drive power is 0.7 kW, and the dimensions of the device, m: body diameter – 0.38 and height – 0.34. The shape of the working body (wheel or disc) of the hemp kernel release mechanism affects the ability to break down the seed coat. The method of single-oriented impact [24], which is implemented in this device's design, is sufficient for the collapse of oilseeds. The impeller of a closed sectoral type has the prospect of further use, which requires additional production and experimental research [22].

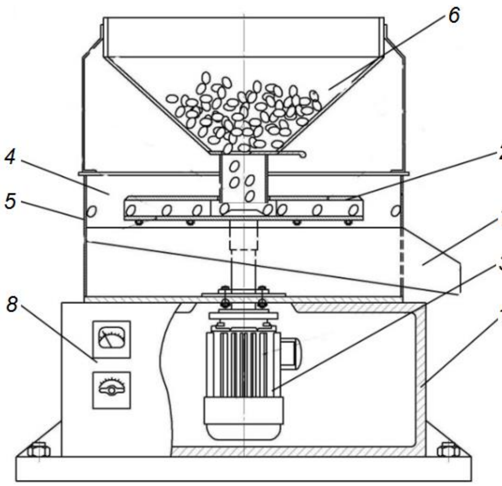

Figure 1. Device for collapsing hemp seeds:
1 – frame (frame, body, base); 2 – impeller; 3 – electric motor; 4 – working chamber; 5 – jack deck; 6 – bunker; 7 – unloading tray; 8 – control devices.

The impeller of the experimental device consists of two disks, the upper one of which has a loading opening, four sectors located between the disks and together form four radial profile channels with a hyperbolic shape of the lateral surfaces, a b

affle deck, made in the form of a cylinder with a smooth inner surface, an unloading chute has W-shaped in cross-section.

Research procedure. Industrial hemp seeds were loaded into hopper 6 of the device. Through the branch pipe and the loading hole in the upper disc, it fell on the lower disc 2. Under the action of centrifugal forces, the seeds began to move in the horizontal plane on the profile channels in the direction of the bumper deck 5. At the moment of the seed's contact with the deck, the fruit shell was destroyed, and the kernel was released. The resulting mixture fell onto the unloading chute seven and was removed from the device under the influence of vibration.

The resulting mixture was sieved successively on sieves with round and oblong holes. The separation by aerodynamic properties was carried out on a gravity air separator with an open vertical air cycle.

Processing of research results. The finished product yield was calculated as a percentage of the total weight of the raw material**.**

Determination of mass fraction of moisture

Preparation of prototypes. The initial weight of industrial hemp seeds and their processing products is 30 g. 5 g of seeds, kernels, cake, or sludge were weighed into two boxes [25, 26].

Description of methods and settings. The mass fraction of moisture in industrial hemp seeds and their processing products was measured via the thermogravimetric method in an oven with adjustable temperature [24].

Research procedure. Prepared weighing bottles with samples were placed in an oven and dried at 105 °C for 40 min (first weighing) and subsequent considering every 10 min until constant weight. After drying, the weighing bottles were removed from the cabinet with crucible tongs and placed in a desiccator for cooling for 15–20 minutes [26].

Processing of research results. Chilled weighing bottles were weighed closed on an analytical balance. Humidity was calculated to one decimal place according to the formula (1):

$$W = \frac{m_2 - m_3}{m_2 - m_1} \cdot 100\%, \quad (1)$$

where: m_1 – the weight of the empty box, g;

m_2 – importance of a box with a sample before drying, g;

m_3 – importance of a box with a model after drying, g.

Oil content measurement

The oil content in industrial hemp seeds and products of their processing was measured by the method of exhaustive extraction in a Soxhlet apparatus [27].

Measurement of acid and peroxide values. The acid and peroxide values of pressed hemp oil samples were measured by the titrimetric method according to [28].

Measurement of fatty acid composition

The fatty acid composition of pressed hemp oil samples was determined by gas-liquid chromatography according to the method described in [26, 29].

Results and discussion

Indicators of industrial hemp seeds' quality during long storage

Characteristics of the composition and quality of industrial hemp seeds of Hliana variety during the storage for 12 months are given in Table 1.

Table 1

Characteristics of physical and chemical quality indicators of industrial hemp seeds of Hliana variety

Samples	Moisture content,%	Seed purity,%	Oil content,%	Weight of 1000 grains, g	Bulk density, g/l
0	9,1±0,03	99,8±0,2	33,0±0,1	17,7±0,5	506,0±5
1	8,7±0,03	99,2±0,3	33,5±0,1	17,8±0,5	507,2±5
2	9,1±0,03	99,6±0,3	33,6±0,1	19,2±0,5	508,3±5
3	10,0±0,04	98,6±1,3	34,3±0,1	17,9±0,5	503,8±5
4	9,7±0,03	98,6±1,4	33,4±0,1	18,4±0,5	504,7±5
5	10,1±0,04	98,5±1,4	34,0±0,1	19,2±0,5	507,2±5
6	8,2±0,03	98,2±1,7	33,3±0,1	19,1±0,5	520,0±5
7	9,8±0,04	98,1±1,8	33,2±0,1	18,4±0,5	505,5±5
8	8,6±0,03	98,1±1,7	33,2±0,1	19,0±0,5	510,2±5
9	8,7±0,03	97,6±2,3	32,8±0,1	19,1±0,5	510,1±5
10	8,7±0,03	97,5±2,4	32,6±0,1	18,6±0,5	520,2±5
11	8,9±0,03	97,5±2,4	32,2±0,1	18,8±0,5	526,0±5
12	9,0±0,03	97,5±2,4	31,9±0,1	19,0±0,5	530,0±5
Control	≤11,0	≥90,0	≥30,0	-	-

Note: [a] 0 – the original sample (October 2018), the following examples (1–12) were taken at intervals of one month (November 2018 – October 2019);
[b] in terms of dry matter;
[c] the quality of the control sample was limited by the current technical requirements for industrial hemp seeds.

When analyzing the data in Table 1, it was found that during the long-term storage of industrial hemp seeds:

- The fluctuations in moisture content in seeds are explained by the influence of temperature and air humidity on its hygroscopicity;
- The purity of the seeds was within 97.5–99.8%, which exceeds the value of the control sample;
- The seeds' oil content was in the range of 31.9–34.3%, which is more than the control sample's respective value. The oil content in the seeds decreases from the second half to the end of the storage period (Figure 2), which is explained by the course of biochemical processes in it during long-term storage;
- The mass of 1000 seeds was in the range from 17.7 to 19.2 g, and the bulk weight of seeds was from 503.8 to 530 g/l. For the control sample, these technical indicators are not regulated.

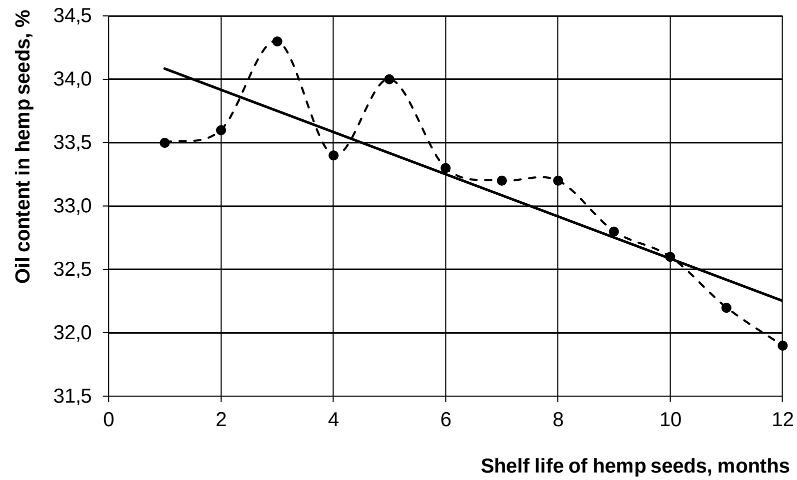

Figure 2. Dependence of oil content in industrial hemp seeds on their shelf life

The obtained data on the oil content in hemp seeds are correlated with the data of Morar M. V., Abdollahi M., Kriese U., and others [6, 15, 18]. The obtained data on the mass of 1000 seeds and a bulk pack of industrial hemp seeds of Hliana variety corresponds to the data of Klevtsov K. for sorts Zolotoniski and YUSO-31 [30].

Therefore, the above data show the possibility of using industrial hemp seeds of Hliana variety for rational processing to standardize storage conditions during the year.

Yield and quality indicators of hemp press oil

Hemp oil is a rare source of nutrition for the body due to a unique ratio of fatty acids ω-6 and ω-3 as 3:1. It is beneficial for the health of the cardiovascular system, skin, hormonal balance, diabetes prevention, and more. This feature of the oil helps to increase the industrial production of quality finished products [12].

Quality indicators of 13 samples of pressed, filtered oil obtained from industrial hemp seeds of the Ukrainian selection of Hliana variety are presented in Table 2.

Table 2

Yield characteristics and physical and chemical quality indicators of filtered pressed hemp oil

Samples	Air temperature during pressing, ℃	Oil temperature at the outlet of the press, ℃	The yield of filtered oil,%	Acid value, mg KOH/g	Peroxide value, ½ O mmol/kg
0	-	-	-	0,91±0,07	6,0±0,2
1	-	-	16,6	0,91±0,07	3,6±0,1
2	-	-	15,5	0,94±0,07	4,4±0,1
3	-1	77,4	14,6	0,95±0,07	3,5±0,1
4	0	81,4	16,8	1,01±0,07	1,1±0,08
5	4,2	79,4	16,2	1,04±0,07	2,5±0,1
6	8,3	83,5	16,6	1,09±0,07	3,6±0,1
7	16,0	86,2	17,1	1,12±0,07	8,4±0,3
8	22,1	83,0	16,8	1,25±0,07	9,9±0,3
9	19,9	88,7	19,2	1,34±0,07	9,3±0,3
10	22,0	84,2	18,4	1,39±0,07	7,9±0,3
11	20,7	85,3	19,3	1,42±0,07	5,8±0,2
12	11,5	74,5	19,1	1,46±0,07	6,0±0,1

Note: [a)] 0 – oil obtained from the original sample of industrial hemp seeds (October 2018), the following examples (1–12) – oil obtained from industrial hemp seeds with an interval of one month (November 2018 – October 2019).

From the analysis of the data, Table 2 found that:

- The air temperature during pressing was in the range from -1 to +22.1℃;
- The oil temperature at the outlet of the press ranged from 74.5 to 88.7℃. The increase in oil temperature can be explained by the influence of air temperature and the equipment's design features. The search for rational modes of pressing the material to reduce the oil temperature at the outlet from the press to reduce the degree of its oxidation seems obvious;
- When packing the hemp seeds samples for long-term storage, the oil yield after filtration ranged from 14.6 to 19.3%. An increased product of filtered oil was obtained by pressing samples 9–12 (Figure 3);
- The acid value in the obtained oil samples ranged from 0.91 to 1.46 mg KOH/g (Figure 4). The obtained data do not exceed the normative amount of 1.5 mg KOH/g;
- In the first half of the shelf life of hemp seeds (samples 1–6), the oil's peroxide value did not exceed 5 ½ O mmol/kg. In the second half of the shelf life (samples 7–12), the oil's peroxide value increased to 10 ½ O mmol/kg. This is due to the increased storage temperatures of hemp seeds from May to August. It should be noted that it is advisable to conduct a study on filtered hemp oil oxidation over time to determine the totox value [25, 29].

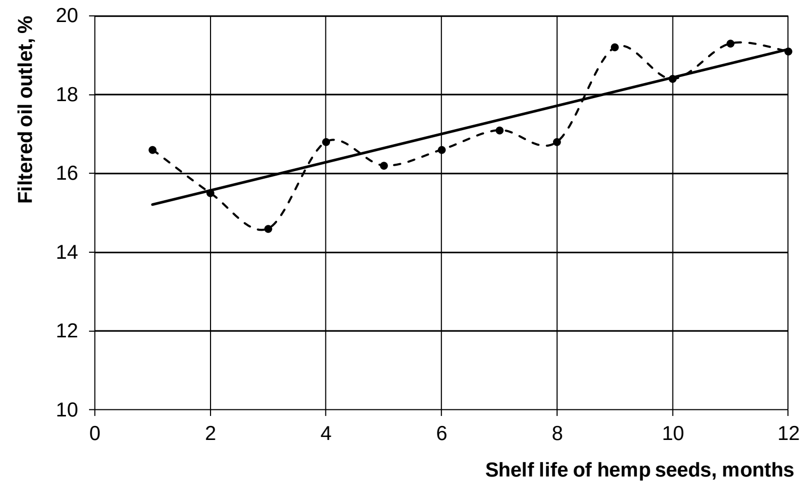

Figure 3. Dependence of the yield of filtered hemp oil on the shelf life of raw materials

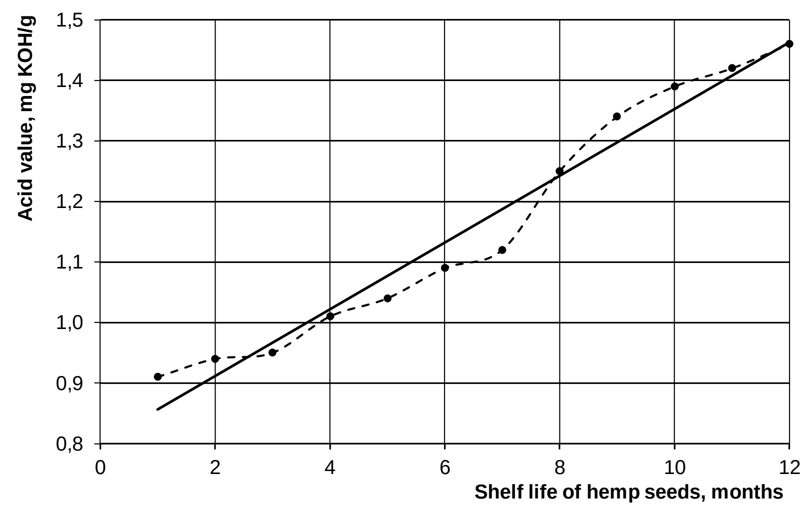

Figure 4. Dependence of the acid value of pressed hemp oil on the shelf life of raw materials

The yield of unfiltered pressed hemp oil in samples 1–12 (22.5–24.2%) is consistent with the yield of oil in the studies of C. Da Porto, K. Aladic, and others [8, 10, 17].

The oil content in our experimental samples of 1–12 seeds of industrial hemp was 31.9–34.3% and in the examples of work [6] – 30.89–33.25%. The obtained yield of pressing oil (samples 1–12) is 2% less than the product of oil in the study [6]. This is explained by the design features of the PSh-250 screw press, technological modes of pressing and indicates the need to improve the technology of pressing industrial hemp seeds.

The obtained data on the acid and peroxide values of experimental samples of press hemp oil is 1–12 less compared with the data of Morar M. V. and others [6] by 3 mg KOH/g and 17 ½ V mmol/kg. This can be explained by the difference in the technology of preparation and pressing of hemp seeds.

Analysis of the fatty acid composition of pressed hemp oil

To confirm the data on the biological value of hemp oil obtained from the seeds of the Ukrainian selection of the Hliana variety, its fatty acid composition was studied. The study results of the content of fatty acids in pressed hemp oil are given in Table 3.

When analyzing the data on the fatty acid composition of hemp seed oil in long-term storage (Table 3), it was determined that:

- the content of saturated fatty acids was: myristic – from 0.1 to 0.2%, palmitic – from 5.6 to 6.6%, stearic – from 3.3 to 3.5%, arachidonic – from 0.9 to 1.9%, behenic – from 0.2 to 0.9%, lignoceric – from 0.1 to 0.5%;
- the content of unsaturated fatty acids was: palmitoleic – 0.1%; oleic – from 14.9 to 19.4%, linoleic – from 53.4 to 56.6%, α-linolenic – from 11.3 to 16.2%, γ-linolenic – from 1.6 to 2.6%, gadoline – from 0.4 to 1.9%, gondoic – from 0.8 to 0.9%, dihomolinolenic – from 0.3 to 0.4%, erucic – from 0.1 to 0.4%, docosadienoic – from 0.5 to 0.7%, nervonic – 0.2%;
- the main unsaturated fatty acids in the studied hemp oil are oleic (14.9–19.4%), linoleic (53.4–56.6%), α-linolenic (11.3–16.2%);
- the ratio of essential polyunsaturated fatty acids in the studied samples of hemp oil is close to ideal (3:1÷5:1 [29]): ω-6 and ω-3 as 3,4:1÷5,0:1. Today, the exceptional importance of ω-3 polyunsaturated fatty acids for maintaining physical and mental health and preventing some diseases [25, 29].
- The obtained data on the fatty acid composition of experimental samples of hemp oil is correlated with the data [15–17].

Yield and quality indicators of by-products obtained in the production of filtered press hemp oil

Data on the yield and physicochemical parameters of by-products obtained in filtered pressed hemp oil production are presented in Table 4.

Table 3

Fatty acid composition of pressed hemp oil

N	Fatty acid	Fatty acid content of the sample,%												
		0	1	2	3	4	5	6	7	8	9	10	11	12
1	C 14:0 myristic	-	-	-	-	-	-	-	-	-	-	0,1	-	0,2
2	C 16:0 palmitic	5,8	5,9	5,8	5,6	5,8	5,8	5,7	5,8	5,9	6,1	6,2	6,1	6,6
3	C 16:1 palmitoleic	0,1	-	-	0,1	0,1	-	-	-	0,1	0,1	0,1	0,1	-
4	C 18:0 stearic	3,4	3,3	3,4	3,3	3,4	3,4	3,4	3,3	3,4	3,5	3,4	3,5	3,4
5	C 18:1 oleic	15,1	19,3	15,7	15,3	15,1	15,9	18,0	15,4	15,0	14,9	14,9	15,6	19,4
6	C 18:2 linoleic	54,6	55,8	54,1	54,9	54,9	54,9	53,4	55,3	54,2	54,0	54,6	54,4	56,6
7	C 18:3 α-linolenic	15,5	11,6	15,6	15,6	15,8	15,4	14,8	15,4	15,5	15,5	16,2	15,7	11,3
8	C 18:3 γ-linolenic	2,5	1,8	2,4	2,4	2,5	2,4	2,3	2,4	2,5	2,5	2,6	2,4	1,6
9	C 20:0 arachidic	1,8	-	-	-	0,9	1,5	1,6	-	1,8	1,9	-	-	-
10	C 20:1 gadoleic	0,4	0,8	1,0	0,9	0,8	0,4	0,4	0,7	0,4	0,4	1,9	1,5	0,5
11	C 20:2 gondoic	-	-	-	0,8	-	-	-	0,9	-	-	-	-	-
12	C 20:3 digomo linolenic	-	-	-	0,4	-	-	-	0,3	-	-	-	-	-
13	C 22:0 behenic	0,4	0,5	0,9	0,4	0,4	0,3	0,4	0,2	0,6	0,4	-	0,7	0,4
14	C 22:1 erucic	-	0,3	0,4	-	0,1	-	-	-	0,1	-	-	-	-
15	C 22:2 docosadienoic	-	0,5	0,7	-	-	-	-	-	-	-	-	-	-
16	C 24:0 lignoceric	0,2	0,2	-	0,1	0,2	-	-	0,1	0,3	0,5	-	-	-
17	C 24:1 nervonic	0,2	-	-	0,2	-	-	-	0,2	0,2	0,2	-	-	-

Table 4

Characteristics of the yield and physicochemical indicators of the quality of related products obtained in the production of filtered press oil from hemp seeds for long-term storage

Samples	Press cake, %	Moisture content in the cake,%	Oil content in the cake^{s},%	Yield of filter sludge,%	Moisture content in the sludge,%	Oil content in the sludge,%
1	68,0	-	-	6,6	-	-
2	68,3	7,5±0,01	12,3±0,06	7,8	4,4±0,01	60,6±0,3
3	69,0	7,4±0,01	11,1±0,05	8,6	4,6±0,01	64,4±0,3
4	67,8	6,6±0,01	10,1±0,05	7,4	13,7±0,02	59,1±0,2
5	68,6	9,0±0,01	11,9±0,06	6,3	11,6±0,02	51,5±0,2
6	69,2	7,8±0,01	10,9±0,05	6,6	11,7±0,02	59,4±0,2
7	69,0	7,6±0,01	10,8±0,05	6,7	11,2±0,02	57,4±0,2
8	68,5	8,0±0,01	11,1±0,05	5,9	10,3±0,02	49,6±0,2
9	70,0	6,8±0,01	9,5±0,04	4,7	16,8±0,03	49,2±0,2
10	69,0	7,2±0,01	10,2±0,05	5,7	10,2±0,02	50,20±0,2
11	68,6	7,9±0,01	10,5±0,05	4,6	8,1±0,01	55,42±0,2
12	67,1	8,5±0,01	10,9±0,05	4,9	7,0±0,01	56,57±0,2

Note: a) samples (1–12) are by-products obtained from the production of industrial hemp seeds with an interval of one month (November 2018 – October 2019); b) in terms of dry matter.

From the analysis of data Table 4, it follows that:

- The yield of the cake was from 67.1 to 70.0% at a moisture content of 6.6 to 9.0% and an oil content of 9.5 to 12.3%;
- The yield of filter cake was from 4.6 to 8.6% at a humidity of 4.4 to 16.8% and an oil content of 49.2 to 64.4%. To reduce the oil and moisture content in the filter sludge, it is advisable to streamline the technological process of obtaining and filtering pressed hemp oil.

Yield and quality indicators of hemp kernel

Data on yield and physicochemical quality indicators of hemp kernel are presented in Table 5.

From the analysis of data Table 5, it follows that:

- the yield of hemp kernel ranged from 33.2 to 41.4%; cuttings were from 0.6 to 5.2%, substandard seeds were from 1.3 to 4.8%, intermediate products were from 53.3 to 61.2%;
- content in hemp kernel: moisture was in the range from 6.9 to 7.8%, oil was from 53.9 to 56.5% (Figure 5), impurities were from 0.01 to 0.04%. Fluctuations in the hemp kernel's moisture content are explained by the previous effect on the hygroscopicity of the stored seed temperature and humidity. It should be noted that the studied samples of hemp kernel obtained from the seeds of the Ukrainian selection of the Hliana variety contain 5.9–8.5% more oil compared to the control (48% [29]).

Table 5

Characteristics of the yield and physicochemical indicators of the quality of experimental samples of the kernel obtained from hemp seeds of long-term storage

Samples	Yield,%				Content,%		
	Hemp kernel	Chaff	Substandard seeds	Intermediate products[c]	Moisture	Oil[d]	Impurities
0	36,0	1,4	4,8	57,8	7,0±0,02	53,9±0,2	0,02±0,001
1	41,4	1,4	3,9	53,3	7,0±0,02	54,5±0,2	0,02±0,001
2	40,6	1,3	2,8	55,3	7,2±0,02	54,3±0,2	0,02±0,001
3	33,2	0,7	7,9	58,2	7,1±0,02	56,2±0,2	0,02±0,001
4	36,6	0,9	2,5	60,0	7,8±0,03	56,5±0,2	0,03±0,002
5[e]	-	-	-	-	-	-	-
6	35,3	5,2	1,3	58,2	6,9±0,02	55,0±0,2	0,02±0,001
7	39,1	0,6	2,0	58,3	7,7±0,03	55,5±0,2	0,03±0,002
8	34,8	1,4	3,2	60,6	6,9±0,02	55,1±0,2	0,04±0,002
9	34,9	1,6	3,8	59,7	6,9±0,02	55,1±0,2	0,02±0,001
10	35,2	2,7	2,6	59,5	7,0±0,02	54,5±0,2	0,02±0,001
11	36,2	1,9	3,1	58,8	7,1±0,02	54,3±0,2	0,01±0,001
12	34,4	1,5	2,9	61,2	7,3±0,03	54,1±0,2	0,03±0,002
Control[f]	-	-	-	-	≤7,0	≥48,0	-

Note: [a)] 0 – hemp kernel obtained from the original sample of industrial hemp seeds (October 2018), the following samples (1–12) – hemp kernel obtained from industrial hemp seeds with an interval of one month (November 2018 – October 2019);

[b)] sources with partially or entirely unseparated fruit skin;

[c)] a mixture of elements of industrial hemp seeds after separation of the kernel;

[d)] in terms of dry matter;

[e)] these studies are absent due to force majeure;

[f)] data of work are accepted for comparison [29].

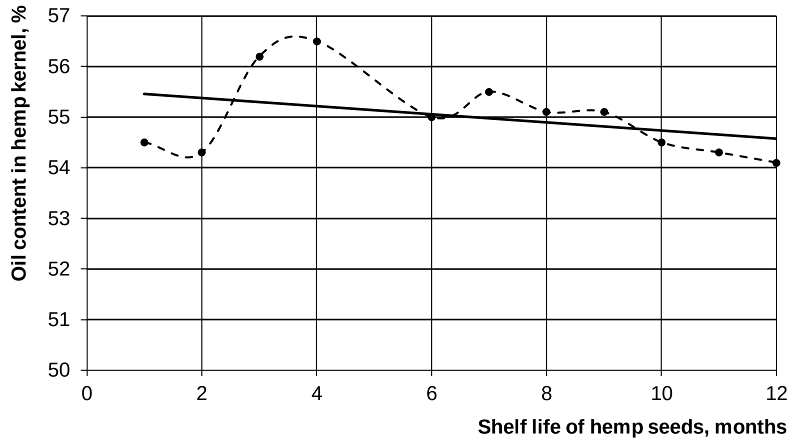

Figure 5. Change in the oil content of hemp kernels during the long-term storage of seeds

The decrease in the hemp kernel's oil content is due to the biochemical processes of life of the industrial hemp seeds and the conditions of their long-term storage.

Conclusions

1. The expediency of using the industrial hemp seeds of the Hliana variety for analytical processing at standardization of storage conditions within a year is proved.
2. To reduce the oxidation of pressurized oil, it is necessary to rationalize pressing hemp seeds. When pressing hemp seeds for long-term storage, filtered oil yield from 14.6 to 19.3% was obtained. The acid value in the obtained oil samples ranged from 0.91 to 1.46 mg KOH/g, which does not exceed the normative amount. In the first half of the shelf life of hemp seeds, the peroxide value of oil did not exceed 5 ½ O mmol/kg; in the second half, it increased to 10 ½ O mmol/kg.
3. The primary unsaturated fatty acids in the studied hemp oil are oleic (14.9–19.4%), linoleic (53.4–56.6%), α-linolenic (11.3–16.2%). The ratio of essential polyunsaturated fatty acids in the studied hemp oil is close to ideal: ω-6 and ω-3 as 3.4:1–5.0:1.
4. The yield of hemp kernel ranged from 33.2 to 41.4%. The oil content in the hemp kernel obtained from the seeds of the Ukrainian selection of the Hliana variety increased by 5.9–8.5% compared to the control (48%).

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Effect of natural sugar substitutes – mesquite (*Prosopis alba*) flour and coconut (*Cocos nucifera* L.) sugar on the quality properties of sponge cakes

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Abstract

Introduction. The aim of the research was to evaluate the physico-chemical and microbiological characteristics of sponge cakes with natural sugar substitutes – mesquite (*Prosopis alba*) flour and coconut (*Cocos nucifera* L.) sugar.

Materials and methods. The sponge cake was prepared from wheat flour, sugar, eggs with the addition of Coconut sugar and mesquite flour in ratio 3:1 as natural sugar substitutes. The sponge cakes with 100% sugar substitutes were processed at constant regime of baking concurrent with that of the control sample.

Results and discussion. Specific volume of cakes varied between 2.92±0.10 cm^3/g and 3.13±0.11 cm^3/g. In this studying the volume of the cake with sugar substitutes was smaller than this of cake control (219.00±2.07 cm^3). The greatest porosity was observed in the cake control (63.23±1.30%). The water-absorbing capacity of the cake with coconut sugar and mesquite flour (315.60±3.08%) is the lowest than that of the cakes cake control. Baking losses of all the samples were in the range of 15.27–17.55%. Sugar substituted cakes had less baking loss and was statistically different from control. Cake crust of control sample had the highest values of L* (58.46±2.25), a* (9.56±0.62) and b* (25.31±0.82). The crumb and crust color of cake with coconut sugar and mesquite flour mix was brownish and darker than cake control crumb and crust. The highest fat content was defined in the sample control (6.89%) and the lowest content was in the cake with coconut sugar and mesquite flour (5.66%). The highest percentage of carbohydrate was determined in the control (58.21%), as with the lowest content was the cake with coconut sugar and mesquite flour (23.50%). It is important to note that sponge cake with natural sugar substitutes could be tagged as foods and could support the claim "with high content of dietary fiber". The energy value of the cake with coconut sugar and mesquite flour being the lowest – 209.98 kcal/100g of product, with 37% lower than the control cake. From microbiologycal point of view results of to the first day of storage at room temperature, no evidence of pathogenic bacteria and mold was detected on the samples.

Conclusions. The sponge cake made with composite coconut sugar and mesquite flour exhibited fairly good technological characteristics. From a functional and nutritional point of view, these cakes contained significantly higher levels of dietary fiber than the traditional bakery products prepared with sugar.