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**Viktor Sheichenko,
Dmytro Petrachenko,
Nataliia Sova,
Vitaliy Shevchuk,
Ihor Marynchenko,
Oleh Prymakov,
Denys Sheichenko**

DETERMINATION OF THE INFLUENCE OF MOISTURE OF DEHULLED HEMP SEED KERNELS ON STORAGE QUALITY INDICATORS

The object of research is the regularities of the process of storing dehulled seeds of industrial hemp, seed moisture, storage packaging, structure of dehulled hemp kernels. The effect of the moisture content of the kernels of industrial hemp seeds of the "Glesia" variety on their storage period was studied. It was noted that hemp seeds are a source of easily digestible vegetable protein and contain a wide range of phytonutrients important for the health of cells, blood vessels and internal organs of a person. The kernels of industrial hemp seeds are a ready-to-use product.

The shelling of seeds (separation of the shell from the kernel) was carried out mechanically by a centrifugal sheller of our own design. The diameter of the sheller impeller was 162 mm, the gap between the impeller and the reflecting deck was 80 mm, the impeller rotation speed was 2000 min^{-1}.

The influence of humidity (21.6%, 16.3%, 12.0% and 8.8%) of hemp seeds on the storage period and quality indicators of kernels obtained from it was studied. Whole and crushed kernels without husks were stored in polyethylene bags without access of air from May to August under normal room conditions. It was found that kernels with a humidity of 21.6% became unusable after 15 days of storage due to the appearance of visible traces of mold. On the 30th day of storage, the mass in the bag turned into a white homogeneous mixture. It was noted that a whole kernel with increased humidity deteriorates faster compared to crushed ones. It was found that kernels with a seed humidity of 16.3% did not have visible signs of mold growth on the 15th day. However, mold was found in the bags on the 30th day of storage. In packages with whole kernels, it is more actively developed, and in packages with crushed kernels – insignificant traces. At seed moisture content of 12.0% and 8.8% after three months of storage, the packages with kernels remained unchanged. Visually, no visible signs of the appearance and reproduction of mold were found in these packages.

Logistic dependencies of the probability of kernel suitability for consumption have been established depending on seed moisture, storage duration, and kernel structure. The importance of controlling the initial seed moisture content to ensure the proper quality of the final product was noted.

Keywords: *industrial hemp, seeds, dehulling, kernels, storage, processing, humidity, mold, packaging, nutritional value.*

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1. Introduction

Industrial hemp (*Cannabis sativa L.*) is valued for the strength and durability of the fibers obtained from its stems, as well as for seeds with a high content of beneficial elements and vegetable oil [1]. The main difference between *Cannabis sativa L.* and *Cannabis indica* is the low content of the psychoactive component tetrahydrocannabinol (THC). In Ukraine, industrial hemp is considered to be hemp with a THC content of no more than 0.08%, in the EU countries – 0.2%, in the USA, Canada, China – 0.3% [2]. The use of industrial hemp products does not cause drug intoxication.

The relevance of conducting research on the storage of dehulled kernels of industrial hemp seeds is due to the need to find complex technical and technological solutions, the implementation of which will ensure long-term preservation of products with high nutritional and biological indicators. The established rational storage parameters minimize the risks of product spoilage due to the development of pathogenic microflora, which will make it possible to reduce losses and increase production efficiency.

Industrial hemp seeds, due to their high nutritional value, have significant economic potential [3]. On average, industrial hemp seeds contain from 25 to 35% fat, 20–28% protein, 25–37% carbohydrates (including fiber), 5–6% minerals and 4–8% moisture [3, 4]. Studies [5] have noted the antioxidant activity of hemp seeds. Various bioactive compounds have been found in hemp seeds: flavonoids, tannins, sugars, acids, proanthocyanidins, carotenoids and citric acid metabolites. The seeds are characterized by the highest protein content of 33 g per 100 g of sample.

The bulk of hemp seeds was used until recently to obtain oil by cold pressing. The oil was characterized by a high content of polyunsaturated fatty acids. Thus, according to the results of [6–8], the content of these acids in hemp oil was over 70%. The main share of essential omega-6 linoleic acid was about 55%, omega-3 alpha-linolenic acid (12–18%), and omega-6 gamma-linolenic (1–3%) and omega-3 stearidonic acids (< 1%). According to studies [9], polyunsaturated fatty acids prevailed in the lipid fraction of hemp seed oil bodies, and linoleic acid accounted for approximately 61% of the total amount of fatty acids. In addition, the seeds contain easily digestible protein with an optimal composition of amino acids, where arginine plays a key role. Compared to soybean proteins, hemp seed proteins contain fewer protease inhibitors and are considered less allergenic than other plant seed proteins [10].

The dehulling process involves removing the inedible, indigestible outer shell of the hemp seed, which contains mostly insoluble and indigestible fiber [10]. Dehulled hemp seeds are used both as a food product in their natural form and for the preparation of various dishes and beverages.

According to research [10], dehulled seeds are characterized by an increased content of vegetable protein (35%) and fat (49%) compared to whole, untreated seeds. In [11], it was noted that hulled hemp seeds contained a greater amount of fat and protein compared to unhulled seeds. The authors also note that extracts of dehulled seeds showed a better antibacterial effect.

Dehulled hemp seeds have excellent nutritional value, a composition of mineral elements in a bioavailable form. Research [12] has established that hulled seeds, compared to unhulled ones, have a higher content of phosphorus, potassium, magnesium and zinc. At the same time, whole seeds contained a greater amount of calcium, manganese and copper.

In [13], it was noted that the dehulling process improves the quality of seeds. Thus, compared to the incoming untreated seeds, the protein content and the content of macro and microelements (phosphorus by 1.5 times, zinc and cobalt by 2 times) increased 1.5 times in the dehulled seeds. The dehulled seeds were characterized by a high content of essential amino acids and lysine.

The stability of raw material indicators is of crucial importance in the development of appropriate storage technologies. Proper storage of dehulled industrial hemp seeds is a key factor in preserving their nutritional and biological value. Improper storage conditions can lead to oxidation of fatty acids, a decrease in protein quality, and the development of pathogenic microflora. Since dehulled seeds are a food product, it is important not only to preserve the nutritional value of the seeds, but also to ensure their long-term safety for consumption.

According to the results of the analysis of literary sources on the processes of storing dehulled hemp seeds, a number of factors were noted that determine their safety. Among them: the initial quality and humidity of the raw material, the temperature in the storage room, the storage period and conditions, contamination with impurities and fungal infection of the seeds, the packaging material in which the material is stored [14]. A significant effect of temperature and humidity on the quality of seeds during storage has been noted. With low initial seed quality, room temperature is considered the most favorable conditions for preserving the quality indicators of the raw material. The use of low temperatures and humidity stops the processes of seed spoilage and allows to extend the storage period.

The preservation of the quality of corn seeds is achieved due to the low humidity of the input raw material [15]. For long-term storage of seeds, the authors suggest its initial humidity at 11%, and the temperature in the room at 50% humidity not higher than 20°C. A mandatory requirement for storage is the tightness of the packaging.

The influence of various factors (temperature, packaging material, storage period) on the process of preserving *Schefflera abyssinica* seeds was studied in [16]. It was noted that the storage period had the greatest impact on the quality of the material, with an increase in which the quality decreased. The highest percentage of germination was observed for seeds stored at sub-zero temperatures (– 10°C). The packaging material (polyethylene or aluminium bag) had no effect on seed preservation.

In [17], the negative effect of low temperature on the preservation of seed material was noted. At the storage temperature (4°C at a humidity of 40–50%), the shortest storage period of seeds, in particular their germination, was established. To preserve the quality of seeds during storage, the authors recommend a temperature of 25°C and an air humidity of 2–5%.

In [18], the process of storing pearl millet seeds was investigated. The qualitative characteristics of seeds were established depending on the storage period and type of packaging. It was noted that the qualitative indicators of seeds (viability and germination) deteriorated with an increase (0–16 months) in the storage period, regardless of the packaging material (wooden, plastic, cement container). An increase in the storage period led to a corresponding decrease in the amount of starch and sucrose in the seeds. Seeds were best preserved in plastic containers.

In [19], the effect of packaging material (PICS, SGP, polypropylene, metal, jute fabric) on mold growth, germination, and mycotoxin levels in chickpea seeds was investigated. It was noted that during storage in PICS bags, SGP bags, and metal bins, the temperature and humidity of chickpea seeds remained stable, while jute and polypropylene bags increased these values. Storage in jute and polypropylene bags resulted in the spread of mold infection and reduced seed germination. The research results show that PICS and SGP bags prevent mold growth, stop the accumulation of mycotoxins, and maintain chickpea germination for six months of storage [19].

The aim of research is to determine the moisture content of dehulled industrial hemp seed kernels that will ensure their long-term storage without loss of quality (stability of appearance, no mold development).

2. Materials and Methods

2.1. Object, subject and conditions of research

The object of research is the regularities of the process of storing dehulled industrial hemp seeds, seed moisture, storage packaging, structure of dehulled hemp kernels.

The subject of research is the relationship of seed moisture with storage quality indicators of dehulled kernels, their storage period and conditions for minimizing negative changes during storage.

The scientific hypothesis is that there are such rational parameters of the humidity of dehulled kernels of industrial hemp seeds, thanks to which the risks of product spoilage are minimized and its high-quality long-term storage is ensured.

To achieve the aim, the following objectives were set:

– to establish the stability of visual indicators of storage quality (appearance of kernels, presence or absence of mold) of dehulled hemp seed kernels depending on the packaging material (polyethylene bags);
– to establish the effect of industrial hemp seed moisture on the storage period of dehulled kernels obtained from it;
– to investigate the influence of the structure of dehulled hemp kernels (whole and crushed) on their storage period.

In the studies, the stability of the appearance, the presence or absence of mold were taken as visually established indicators of the storage quality of dehulled hemp seed kernels. This approach made it possible to carry out the initial practical assessment of the condition of the product without the involvement of complex laboratory methods, to avoid additional risks of economic and image losses. The proposed criteria correspond to production conditions, where the initial visual assessment is considered to be the main one when making important technological decisions.

Assumptions made in the research process:

– all seed samples were stored in the same conditions before the experiment, which excluded the influence of external factors on the results obtained;
– storage was carried out in sealed polyethylene bags without air access, which allowed to assess only the influence of the initial moisture content of the seeds;
– control checks of the condition of the seeds were carried out at the same time intervals (15 days), which made it possible to correctly compare the storage period of the samples.

Simplifications used for conducting the research:

– the experiment used seeds without calibration in size, which corresponded to real production conditions;

– the possible influence of external factors, such as microbiological contamination, which could affect the research results, was not taken into account;

– morphological changes in seed kernels during storage were not analyzed, the main attention was paid to visual characteristics (presence of mold, color change, etc.);

– the determination of storage quality was based on the preservation of the appearance of the kernels and the absence of signs of spoilage without analyzing the chemical composition of the product after storage.

Visual assessment was carried out according to a standardized procedure: fixed observation intervals (every 15 days), identical packaging, storage and control conditions. This approach ensured the repetition and comparison of results, which made it possible to attribute it to acceptable methods of primary control in production conditions.

The above assumptions and simplifications were made to ensure the reproduction of experimental data and the formation of reliable conclusions regarding the influence of seed moisture on the storage quality of dehulled kernels.

To formalize the obtained data and identify quantitative relationships between the studied variables, mathematical models were built in the form of logistic regression equations. This made it possible to determine the influence of each factor (seed moisture, storage period and kernel structure) on the probability of kernels being suitable for use.

2.2. Experimental research methodology and kernel suitability assessment

The research used industrial hemp seeds of Ukrainian selection of the "Glesia" variety. The research used seeds that were stored in polypropylene bags under general conditions in a warehouse.

Microbiological safety of food products is considered to be one of the determining factors in the prevention of food poisoning and human intoxication. One of the mandatory criteria for assessing the safety of food products is its compliance with current microbiological standards, in particular regarding the presence of pathogenic microorganisms, such as bacteria of the Escherichia coli group (*Escherichia coli*), *Salmonella spp.*, as well as mold fungi and yeast in the finished product [20].

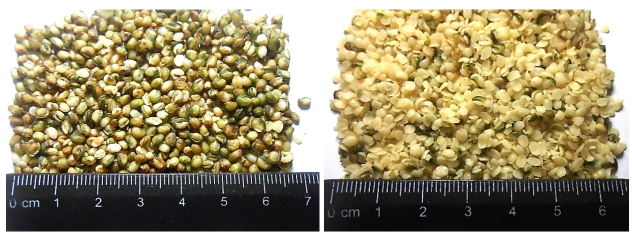
The technological process of producing dehulled hemp seeds did not involve heat treatment of raw materials. Therefore, ensuring the proper level of microbiological safety at all stages of the production cycle has become particularly relevant. Minimization of the risks of microbial contamination was achieved through a set of preventive measures that met the provisions of hygienic requirements [21] for the production and service of food products.

Before the start of experimental studies, thorough sanitary preparation of the production premises, technological equipment, work surfaces, auxiliary tools and containers for storing raw materials and finished products was carried out. To ensure the proper level of microbiological cleanliness, a set of disinfection measures was applied using recommended antimicrobial drugs in accordance with current regulatory documents [21]. Comprehensive sanitary treatment made it possible to minimize the likelihood of microbial contamination of raw materials during production, which ensured the reliability and scientific validity of the results obtained during the studies.

The presence of fungal infections, signs of self-heating or changes in chemical composition are consequences of product spoilage. Under such conditions, the method of visual operational assessment of the condition of kernels during storage should be attributed to effective methods of primary control.

Seeds were dehulled without calibration. Seeds were dehulled mechanically using a centrifugal sheller of our own design. The diameter of the dehuller impeller was 162 mm, the gap between the impeller and the reflecting deck was 80 mm, and the impeller rotation frequency was 2000 min^{-1} [22]. To separate the hempseed cake and separate the kernels, an air-sieve grain cleaning machine was used, which combined two separation methods: by geometric dimensions using sieves and by aerodynamic properties using air flow [23].

The initial moisture content of the seeds used for dehulling was 8.8%. Seed moisture content was determined by a generally accepted method using a laboratory drying oven [24]. The studies used seeds with a moisture content of 8.8%, 12.0%, 16.3%, 21.6%. The increase in humidity was carried out artificially, by spraying water on the seeds (for three days) followed by natural drying. The seeds were dried until they reached a dry state, no traces of water, and free flowability. Each batch of seeds with the appropriate moisture content was dehulled separately. Polyethylene bags are the most common packaging for storing and selling dehulled seeds. There are single- or double-layer bags. Sometimes, as the second (outer) layer, paper, polyethylene, or foil are used. The advantages of this packaging method include: a high level of tightness, resistance to long-term transportation, sufficient elasticity, insensitivity to moisture during storage. Therefore, the samples of whole (Fig. 1, *a*) and damaged (Fig. 1, *b*) kernels (without husks and impurities) isolated after the collapse were separately packed in single-layer polyethylene bags with a zipper (Fig. 2). The bags were closed hermetically, which prevented moisture and air from entering.



a *b*

Fig. 1. General view of industrial hemp seed kernels: *a* – whole; *b* – damaged

a *b*

Fig. 2. Example of packaging of samples of industrial hemp seed kernels: *a* – whole; *b* – damaged

The packaged samples were stored for 180 days with storage quality control every 15 days. Control was carried out visually. During the inspection, changes that occurred with the kernels, as well as the presence and intensity of mold development, were determined.

3. Results and Discussion

Botanically, the seed of industrial hemp is a nutlet 3–5 mm long, consisting of a hard shell and a soft embryo (Fig. 3). The hard shell serves as a protection for the embryo, from which the new plant develops. The embryo consists of two cotyledons, a germinal stem, and a germinal root [25].

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Fig. 3. Hemp seeds in section

Hemp seeds consist of a hard shell (husk) and a soft and plastic kernel (Fig. 3). The hard shell serves as protection for the embryo, from which a new plant develops. The embryo consists of two cotyledons, a germinal stem and a germinal root [25]. The kernel is white, covered on the outside with a soft, thin green seed film.

The effect of seed moisture on both the visual characteristics of the dehulled seed and the process of its storage has been established. Increased humidity makes it difficult to separate the seed film from the kernel. Dehulling seeds with increased humidity (16.3%) makes it possible to obtain a kernel covered with a film, which gives the total mass a green color (Fig. 4, *b*). When seeds with low humidity (8.8%) were crushed, a total mass of white kernels was obtained (Fig. 4, *a*).

a *b*

Fig. 4. General appearance of dehulled hemp seeds:
a – humidity 8.8%; *b* – humidity 16.3%

It was noted that an increase in seed humidity led to a corresponding increase in plasticity and bonding forces in the kernels. As a result, the kernels obtained after dehulling did not have free flowability, but were in lumps. The lumps were a mixture of whole kernels with particles of damaged kernels and film stuck to the outside.

It was noted that an increase in humidity led to a significant reduction in the storage period of dehulled seeds (Table 1).

Table 1

Storage periods of dehulled hemp seeds depending on humidity

Storage period, days	Seed moisture							
	21.6%		16.3%		12.0%		8.8%	
	W	*D*	*W*	*D*	*W*	*D*	*W*	*D*
15	–	–	+	+	+	+	+	+
30	–	–	–	–	+	+	+	+
45	–	–	–	–	+	+	+	+
60	–	–	–	–	+	+	+	+
75	–	–	–	–	+	+	+	+
90	–	–	–	–	+	+	+	+

Note: *W* – whole kernels; *D* – damaged kernels; "+" – suitable; "–" – damaged

It was established (Table 1) that during the entire storage period, only the dehulled kernels from the seeds with a moisture content of 8.8% and 12.0% remained suitable for consumption. According to [26], the conditioned moisture content for hemp seeds is 13.0%. Thus, the recommendations on rational values of the moisture content of dehulled seeds for long-term storage were confirmed.

It is noted that the visual assessment was not accompanied by numerical measurements or statistical processing. That is why the conclusions were formed on the basis of clearly fixed time intervals, identical storage conditions and the gradation "suitable/damaged". This approach has practical value, because it made it possible to determine the boundary conditions under which the kernels retain their consumer properties.

It should be noted that the kernels (whole and damaged) with a moisture content of 21.6% on the 15th day of storage became unsuitable for consumption due to the appearance of visible traces of mold. After 30 days of storage, the mass in the bag turned into a white homogeneous mixture (Fig. 5), in which it is difficult to identify the hemp kernel.

a *b*

Fig. 5. Hemp seed kernel with a moisture content of 21.6% after 30 days of storage: *a* – whole; *b* – damaged

It was noted that at a moisture content of 21.6% of the dehulled seeds, it is not possible to ensure the safety of the main product – the seed kernel. An increase in humidity led to more intensive mold development. Before packaging, in order to reduce humidity, the seed kernels were dried. However, hemp seed kernels were characterized by a high content of polyunsaturated fatty acids. At elevated temperatures, these acids quickly oxidized, which led to product spoilage. Therefore, artificial drying of seed kernels not protected by a shell affected the nutritional and taste qualities of the product. The degree of influence requires further in-depth comprehensive research.

Samples of dehulled seeds (whole and damaged) with a moisture content of 16.3% on the 15th day did not have visible signs of mold reproduction. However, mold was detected in the bags after 30 days of storage. It was more actively developed in the bags with whole kernels (Fig. 6, *a*), and minor traces were detected in the bags with damaged kernels (Fig. 6, *b*). It was noted that whole kernels with high humidity deteriorated faster than damaged ones.

a *b*

Fig. 6. Hemp seed kernel with a moisture content of 16.3% after 30 days of storage: *a* – whole; *b* – damaged

It was noted that dehulling seeds with a moisture content of 16.3 did not ensure proper storage of the main product – the seed kernel, which was manifested in the appearance of mold.

It was established that samples of dehulled seeds with a moisture content of 12.0 and 8.8% did not change their properties during 90 days of storage. Visually, no visible signs of the appearance and reproduction of mold were found in these packages. The smell of the kernels (whole and damaged) in all samples (8.8% and 12.0%) was characteristic of dehulled seeds.

In order to analyze the influence of the studied factors on the suitability of industrial hemp seed kernels for consumption, experimental data were processed in the Statistica 10.0 software environment using the logistic regression method. The modeling results are given in Tables 2, 3.

Based on the generalized logistic regression coefficients (Tables 2, 3), mathematical models were constructed that reflect the probability of kernel suitability for consumption depending on the relevant factors. The first model (1) describes the influence of seed moisture and kernel structure, the second (2) – storage period and structure. For clarity and ease of interpretation, the modeling results are presented in the form of graphical dependencies shown in Fig. 7.

$$\ln\left(\frac{p}{1-p}\right) = -8.646 - 0.656W + 0.224S, \quad (1)$$

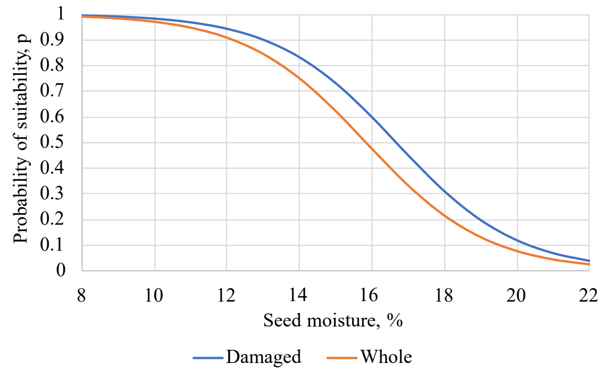
$$\ln\left(\frac{p}{1-p}\right) = -1.191 - 0.028T + 0.095S, \quad (2)$$

where $\ln\left(\frac{p}{1-p}\right)$ – logit function of the probability of kernel suitability for consumption; p – probability of suitability (1 – suitable, 0 – unsuitable); W – humidity, %; T – storage period, days; S – kernel structure (0 – whole, 1 – damaged).

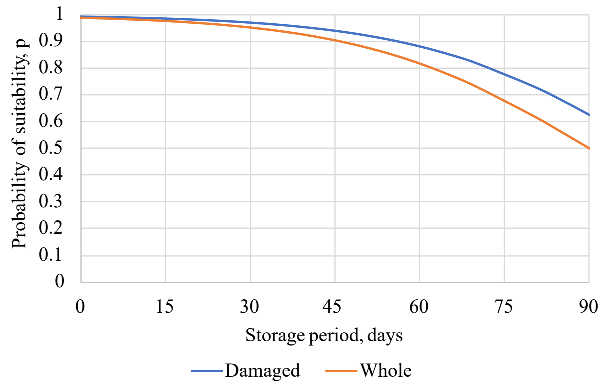
It was noted that seed moisture is the most influential factor that determines the probability of suitability of collapsed kernels for consumption. An increase in moisture leads to a sharp decrease in the probability of preservation. The effect of the storage period also turned out to be statistically significant, but less pronounced. Under conditions of increasing storage duration, the probability of suitability gradually decreased. As for the structure of the kernel, despite the fact that the dehulled kernels tended to be better stored, in both models this factor did not contain statistical significance.

The expediency of recommendations on compliance with the conditioned humidity in the processes of primary processing of hemp seeds before putting them into storage was noted. Under such conditions of implementation of seed dehulling, further technological processes of its processing and storage are significantly simplified. The operation related to the normalization of seed humidity is excluded from the technological chain of preparation of hemp for dehulling.

It was noted that storing dehulled seeds of high humidity in polyethylene bags leads to the development of pathogenic microflora during the first month of storage.



a



b

Fig. 7. Logistic dependences of the probability of kernel suitability: *a* – on seed moisture; *b* – on storage period

Using a polyethylene bag as a container for storing dehulled hemp seeds can provoke the development of mold and lead to spoilage of the product. Similar results [19] were obtained under the conditions of conducting studies on the chickpea seed storage process. It was noted that storage in polypropylene bags led to the spread of mold infection and reduced seed germination.

The use of polyethylene bags is permissible only if the humidity of the dehulled seeds is within the recommended values – 13.0%. The results of the conducted studies convincingly confirmed this conclusion.

For long-term storage, it is better to lay dehulled seeds, the humidity of which is within 8.0–12.0%. These conclusions coincide with the results of [15], in which it is recommended to achieve long-term storage of quality corn seeds due to the initial humidity of no more than 11.0%.

The range of humidity at which hemp seed kernels retained their consumer properties for a long time without visible changes and spoilage was noted. This will make it possible to avoid deterioration of product quality in practice and ensure the stability of nutritional properties of dehulled hemp seed kernels.

Table 2

Results of logistic regression of the probability of kernel viability depending on seed moisture and structure

Effect	Estimate	Standard Error	Wald Stat.	Lower CL 95%	Upper CL 95%	p-value
Moisture (%)	–0.656	0.182859	12.85508	–1.01402	–0.2972	0.000337
Structure (0 – whole; 1 – damaged)	+0.224	0.477201	0.22035	–0.71129	+1.1593	0.638773

Table 3

Results of logistic regression of the probability of kernel viability depending on storage period and structure

Effect	Estimate	Standard Error	Wald Stat.	Lower CL 95%	Upper CL 95%	p-value
Storage period (days)	–0.02809	0.012647	4.935112	–0.05287	–0.0033	0.026371
Structure (0 – whole; 1 – damaged)	+0.095	0.308954	0.095070	–0.51028	+0.7008	0.757828

The results obtained are consistent with studies related to the storage of corn and chickpea seeds [15, 19]. The aforementioned works confirmed the influence of the initial humidity of the product on its suitability for long-term storage.

Certain limitations of the conducted research were noted. These include hermetic packaging of products in polyethylene bags at room temperature.

Due to the practical focus of the study, the determination of the chemical composition of dehulled hemp seed kernels, as well as the analysis of their microbiological indicators, were not provided. The results were based solely on a visual assessment of changes in the appearance of the samples during storage. This approach, of course, reduced the reliability of a comprehensive assessment of all aspects of storage quality. However, the practical value of the results of visual assessment of the quality of dehulled hemp seed kernels under conditions of their long-term storage is an undeniable fact. In the future, research into the assessment of the chemical and microbiological composition of dehulled hemp seed kernels under conditions of long-term storage in various types of packaging materials is promising.

4. Conclusions

It was found that kernels with a moisture content of 21.6% on the 15th day of storage became unusable due to the appearance of visible traces of mold. On the 30th day of storage, the mass in the package turned into a white homogeneous mixture. It was noted that whole kernels with increased moisture deteriorate faster compared to crushed ones; at seed moisture of 12.0% and 8.8% after three months of storage, the packages with kernels remained unchanged. Visually, no visible signs of the appearance and reproduction of mold were found in these packages.

It was found that kernels with a moisture content of 16.3% on the 15th day did not have visible signs of mold reproduction. However, on the 30th day of storage, mold was found in the packages. In packages with a whole kernel, it is more actively developed, and in packages with crushed ones – insignificant traces.

According to the results of the conducted studies, logistic dependences of changes in the suitability of kernels for use on seed moisture, storage period, and kernel structure were determined. It was noted that the suitability of the dehulled kernels for consumption was most significantly influenced by the moisture content of the seeds.

The indicators of the quality of storage of dehulled hemp seed kernels established by the results of visual observation made it possible to determine the limits of change in the maximum permissible moisture values, at which their consumer properties are preserved.

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Conflict of interest

The authors declare that they have no conflict of interest regarding this research, including financial, personal, authorship or other, which could affect the research and its results presented in this article.

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Data availability

Data will be provided upon reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

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✉***Viktor Sheichenko,*** *Doctor of Technical Sciences, Professor, Department of Agricultural Engineering and Road Transport, Poltava State Agrarian University, Poltava, Ukraine, e-mail: vsheychenko@ukr.net, ORCID: https://orcid.org/0000-0003-2751-6181*

Dmytro Petrachenko, *PhD, Department of Agroengineering, Separate Structural Subdivision "Hlukhiv Agrotechnical Professional College of Sumy National Agrarian University", Hlukhiv, Ukraine, ORCID: https://orcid.org/0000-0002-1347-9562*

Nataliia Sova, *PhD, Department of Food Technology, Dnipro State Agrarian and Economic University, Dnipro, Ukraine, ORCID: https://orcid.org/0000-0003-4750-2473*

Vitaliy Shevchuk, *PhD, SeniorResearcher, Department of Agricultural Engineering, Uman National University of Horticulture, Uman, Ukraine, ORCID: https://orcid.org/0000-0001-8305-4714*

Ihor Marynchenko, *PhD, Department of Agroengineering, Separate Structural Subdivision "Hlukhiv Agrotechnical Professional College of Sumy National Agrarian University", Hlukhiv, Ukraine, ORCID: https://orcid.org/0000-0003-0082-1215*

Oleh Prymakov, *PhD, Senior Researcher, Head of Department of Scientific Research on Intellectual Property and Innovation Marketing, Institute of Bast Crops of National Academy of Agrarian Sciences of Ukraine, Glukhiv, Ukraine, ORCID: https://orcid.org/0000-0001-6274-9488*

Denys Sheichenko, *Department of Mechanical and Electrical Engineering, Poltava State Agrarian University, Poltava, Ukraine, ORCID: https://orcid.org/0009-0002-0427-479X*

✉*Corresponding author*