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INFLUENCE OF CLIMATIC FACTORS AND SEED STORAGE PERIODS ON THE QUALITY OF LINSEED OIL

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Introduction. For a number of reasons, almost no fibrous flax is grown in Ukraine, however, the sown areas of oil flax, suitable for making oil, have increased significantly, and the spectrum of its economic use includes the food industry [1]. However, according to the data of the State Statistics Service, the area of linseed cultivation in Ukraine is growing. So, if in 2000 the area sown under this culture was only 2.2 thousand hectares, then in 2020 it will be – 13.7 thousand hectares. An increase in the area of flax cultivation is an additional source of quality raw materials for the processing industry [2].

Storage before processing and rational use of linseed oil remains the most difficult task. It can be solved only with a deep study of the biochemical processes occurring in the seeds, the use of their physiological properties during processing, storage and processing of oil raw materials. Varietal characteristics and abiotic factors of the growing season have a significant influence on the quality of linseed oil. Therefore, research in this area is of scientific interest.

Analysis of recent research and publications. The oil content in flax seeds depends on a number of factors, primarily on varietal characteristics and growing conditions [3]. Climatic factors, namely light, heat and moisture, have a significant impact on the process of oil formation in flax seeds. Depending on the geographical latitude, the value of the iodine number of linseed oil varies as follows: Arkhangelsk – 195, Moscow – 180, Tashkent – 154 gJ2/100g oil [1].

I. F. Drozd determines the varieties of oil flax that have optimal quality indicators for the soil and climatic conditions of Precarpathia for the period 2009–2018 and establishes the most favorable year for the impact on quality formation. The author comes to the conclusion that the weather conditions of the years of cultivation affect the oil content in the seeds, determines the most stable variety in terms of oil content and establishes the relative fluctuation of this indicator depending on the weather conditions of the year of cultivation [4].

Loss of quantity and quality of oil in seeds during storage is important for the processing industry. L. Ovsyannikova, L. Valevska, Yu. Hryschuk, G. Evdokymova determined the effect of seed storage regimes and terms on the quality of linseed oil. t was determined that the mode of storing seeds in a dry state is optimal, and lowering the storage temperature from 15 to 5 °C significantly slows down the growth of the acid value of the oil and significantly reduces the loss of oil content in the seeds, especially during long-term storage. So, if for the Liryna variety, when seeds were stored for 12 months at a temperature of 5C, the loss of oil content was 4.7%, then at a temperature of 28 °C the loss increased to 12.2% [5].

Oil flax is more demanding on heat during maturation and requires more than fibrous flax. This culture is drought-resistant, and its need for water is less than that of fiber flax [6, 7].

The currently known climatic changes contribute to the growth of the area of oilseed linseed in the conditions of the Polissia of Ukraine.

Many publications draw attention to the relevance of the problem of adaptation of agricultural production to climate change. Thus, the question of the impact of changes in the amount of precipitation on the development of some agricultural crops is considered in the article by N. Vozniuk, V. Skyba, O. Likho, Z. Sobko, T. Klymenko. The authors determined that the annual amount of precipitation for the period from 2011 to 2021 in the regions of Polissia varied between 326–627 mm/year, which creates a moisture deficit for this zone within the range of 100–150 mm/year [8].

The researches of V. Balabukh, O. Tarariko, T. Ilienko, V. Velychko found that climate change actively affects the formation of productivity of agroecosystems, and this effect must be taken into account to obtain high-quality crops of both traditional and heat-loving crops [9].

An additional factor contributing to the cultivation of linseed in the conditions of Polissia is the low coefficient of accumulation of radiocesium by plants, which is important in the conditions of the zone of radiation pollution [10].

The goal of the research. The purpose of the work is to identify the features of the formation of the quality of linseed oil, depending on the variety, the shelf life of seeds and abiotic factors of the growing season.

Methodology of the research. The object of research: the processes of forming the quality of oil of domestic and foreign breeding varieties depending on the abiotic conditions of the growing season and changes in the terms of storage of raw materials.

For analytical studies, samples of flax seeds grown on sod-podzolic soils, poorly supplied with mineral nutrition elements, of Korosten district, Zhytomyr region, were selected.

In terms of quality and commercial purpose, the selected samples of linseed met the requirements of the state standardization system [11].

The cultivation technology was generally accepted. The oil content in seeds was determined by the defatted residue method using a Soxhlet apparatus [12].

The oil was produced on a laboratory screw press using the cold pressing method. The research was carried out at the department of technologies in crop production of the Polissia National University in accordance with the generally accepted methodology: acid number – by dissolving the oil with a mixture of ethyl alcohol and sulfuric ether; iodine number – according to the Hanus method.

Sampling and organization of experiments on storage of flax seeds were carried out according to appropriate methods. The raw materials for oil production were stored in a container in the refrigerator, the humidity of the seeds during storage was 2% lower than the critical one [13, 14].

Research results. The course of individual meteorological factors is presented in Table 1.

As can be seen from the data in Table 1, the average amount of precipitation over the years of research was significantly less than the long–term average. In this respect, the month of July stands out, during which, on average, for 2020–2022, the amount of precipitation was more than 3.5 times less in relation to the long-term average.

When characterizing precipitation for 2020–2022, one should note the significant diversity of their income, so if in May 2020 138.1 mm fell, then for the same period in 2022 – only 21.9 mm.

An analysis of the temperature regime for the years of research presented in Table 1 shows a clear trend of temperature excess in the period June-August over the long-term averages. In the period April-May, on average for three years, the sum of temperatures, on the contrary, was lower than the long-term average by 0.4–0.8 °C.

The considered weather conditions of the growing seasons of oilseed flax determined the following qualitative indicators of the seed yield, depending on the variety.

From the data in Table 2, it can be seen that the oil content in the seeds of the Liryna variety over the years of the experiment was higher compared to the Evryka variety. The maximum oil content in the seeds of both experimental varieties of flax was determined in the favorable year of 2021.

One of the main indicators of the quality of vegetable oils are iodine and acid numbers. A large iodine number (178.4–184.2) was characteristic of the variety of domestic selection, which makes the oil made from the seeds of this variety especially valuable when used for pharmaceutical, technical and food purposes. The acid number characterizes the quality of fats, mainly freshness, and indicates the relative content of free fatty acids. The presence of a significant amount of free fatty acids in raw materials for the production of edible oil is not allowed. According to current regulatory documents, the acid number in seeds for the production of edible linseed oil should be no more than 2.0 mg KOH/g.

The weight of 1000 seeds turned out to be a stable trait in terms of the genetic characteristics of the variety and somewhat changed depending on the conditions of the growing season.

The results of determining the quality of linseed oil depending on the shelf life of seeds are shown in table 3.

As can be seen from the data in Table 3, the storage period of oil flax seeds and its varietal composition had an impact on the collection and quality of linseed oil. The maximum oil content in seeds is set for the initial storage period – 38.8 and 44.5%, respectively, of the variety. At the end of the storage period, after 9 months, the oil content in the Evryka variety decreased by 4.1%, and in the Liryna variety by only 2.1%.

There is also a tendency to change the quality of processed products depending on the shelf life of raw materials. The iodine number allows you to evaluate the quality of the oil, its suitability for use. Since the addition of iodine occurs at the site of double bonds in the molecules of unsaturated fatty acids, the iodine number gives an idea

Table 1

The amount of precipitation and the average air temperature during the growing season of flax according to the data of the Korosten meteorological station

Month	Amount of precipitation, mm					Average air temperature, °C				
	2020 year	2021 year	2022 year	average for three years	medium perennial	2020 year	2021 year	2022 year	average for three years	perennial
April	32.2	34.2	53.6	40.0	44.2	9.4	8.2	7.9	8.5	8.9
May	138.1	101.1	21.9	87.0	58.3	11.6	14.8	13.7	13.4	14.2
June	67.1	83.5	60.3	70.3	76.3	20.2	20.9	20.7	20.6	18.5
July	31.1	35.5	15.3	27.3	96.5	20.4	24.1	21.4	22.0	19.2
August	28.2	53.2	27.1	36.2	75.2	20.6	21.0	23.8	21.8	18.9

Table 2

The quality of flax seeds and oil depending on the variety and growing season

A variety of oil flax	Year	Weight of 1000 seeds, g	Oil content, %	Iodine number, gJ2/100g	Acid number, mg KOH/g
Evryka	2020	6.4	38.8±2.7	178.4	2.11
	2021	6.6	39.2±3.1	184.2	2.21
	2022	6.7	38.5±3.6	183.5	2.39
Liryna	2020	6.4	46.5±5.7	175.3	1.81
	2021	6.7	47.2±5.1	181.2	1.58
	2022	6.5	46.9±5.4	178.7	1.67

Table 3

Change in the quality of linseed oil depending on the varietal composition and shelf life of seeds, average for 2020–2021

A variety of oil flax	Seed storage period, months	Oil content, %	Iodine number, gJ2/100g	Acid number, mg KOH/g
Evryka	0	38.8±2.5	182.1	2.2
	3	37.1±2.1	181.7	2.7
	6	36.0±2.7	180.9	3.2
	9	34.7±2.5	179.6	3.7
Liryna	0	44.5±3.8	178.4	1.7
	3	43.8±3.2	172.5	2.3
	6	43.0±3.5	171.2	2.9
	9	42.4±3.9	169.5	3.4

of the content of these acids in the oil. The higher the iodine number, the easier the oil oxidizes, so it is more suitable for use as a medicine for the manufacture of varnishes, paints, drying oils and for eating without heating. In our studies, a decrease in the iodine number was also established, however, this process was extremely slow when stored in a refrigerator (Table 3). This indicator of oil quality, depending on the shelf life, decreased from 182.1 to 179.6 (by 1.4%) for the Evryka seeds decreases as a result of oxidation. Therefore, the value of the iodine number is also an indirect indicator of the freshness of the oil.

Acid number is one of the main indicators of the suitability of oil for food use. The indicator characterizes the content of free fatty acids, the number of which increases due to the breakdown of triglyceride molecules. The accumulation of free fatty acids indicates a decrease in its properties. State standards limit the content of free fatty acids in dietary fats. The value of the acid number characterizes the commercial grade and the good quality of edible fats. The acid number of linseed oil, on the contrary, increased with an increase in the duration of storage of flax seeds. So, at the end of the storage period, it increased to 3.7 for the Evryka variety and 3.4 for the Liryna variety, or 1.7 and 2.0 times. However, under optimal storage conditions, acid numbers were within the limits allowed by government regulations.

Conclusions. Under the recommended regimes and methods of storage of raw materials for the production of linseed oil, its quality indicators change slightly, and the processing products meet the requirements of current state standards.

The weather conditions of the growing season have a significant influence on the quality of linseed oil, namely on the oil content in the seeds and the degree of unsaturation of fatty acids.

Under the conditions of Polissia, linseed oil provides the iodine value of the oil – 178.1–182.1, which indicates a high content of polyunsaturated fatty acids in the oil and makes it possible to use it for medicinal, food and technical needs.

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Derebon I.Yu., Panchyshyn V.Z. Influence of climatic factors and seed storage periods on the quality of linseed oil

Purpose. The purpose of the research was to determine changes in the quality of oil flax seeds of different varieties on weather condition during cultivation and storage period. **Methods.** Laboratory and statical research methods used. The laboratory was used to determine the oil content of flax seeds and to establish the quality indicators of the oil obtained from flax seeds at different storage periods. Statistical for estimating the standard deviation in determining the oil content of seeds. **Results.** The article analyzes the weather conditions during the growing season of oilseed flax. It was determined that the amount of precipitation and air temperature during the research periods significantly deviated from the average long-term indicators, and the precipitation was characterized by unevenness of arrival. As a result of the conducted research, it was determined that the oil flax seeds grown in the agroclimatic conditions of Polissia of Ukraine have high quality and are suitable for use as food and technical raw materials. It was established that the Liryna variety had an oil content of 46.5–47.2 % on average over the years of experiments and was ahead of the Evryka variety by this indicator. Linseed oil had high quality indicators, its iodine value ranged from 178.4–184.2 gJ2/100g for the Eureka variety and 175.3–181.2 for the Liryna variety. A high iodine number determines a significant content of unsaturated

fatty acids, which determines the oil as valuable when using it for food, pharmaceutical and technical purposes.

The maximum oil content in seeds is set for the initial storage period – 38.8 and 44.5%, respectively, of the variety. At the end of the storage period, after 9 months, the oil content in the Evryka variety decreased by 4.1%, and in the Liryna variety by only 2.1%. A decrease in the iodine value was established depending on the storage period. This indicator of oil quality, depending on the shelf life, decreased from 182.1 to 179.6 (by 1.4%) for the Evryka variety and from 178.4 to 169.5 (by 5.0%) for the Liryna variety. At the end of the storage period, the acid numbers of linseed oils increased. Thus, at the end of the storage period, the content of free fatty acids in the oil obtained from the seeds of the Eureka variety increased by 1.7 times, for the Liryna variety, this indicator doubled. Conclusions. The climatic condition of Polissia ensure the production of high-quality oil, and the considered terms of storage of raw materials for its production, subject to the use of optimal regimes, ensure the quality regulated by state standard.

Key words: iodine number, acid number, fatty acids, oil content, amount of precipitation.

Деребон І.Ю., Панчишин В. Вплив кліматичних факторів і строків зберігання насіння на якість олії лляної

Мета. Метою проведення досліджень було визначення зміни якості насіння льону олійного різних сортів залежно від погодних умов впродовж вирощування та строків зберігання. **Методи.** Використовували лабораторний та статистичний методи досліджень. Лабораторний використовували для визначення вмісту олії в насінні льону та для встановлення показників якості олії отриманої з насіння льону при різних строках зберігання. Статистичний для оцінки стандартного відхилення при визначенні вмісту олії в насінні. ***Результати.*** Встановлено, що кількість опадів і температура повітря за досліджувані періоди суттєво відхилялися від середніх багаторічних показників, а опади характеризувалися нерівномірністю надходження. У результаті проведення досліджень встановлено, що насіння льону олійного, вирощене в агрокліматичних умовах Полісся, має високу якість і придатне як харчова і технічна сировина. Визначено, що сорт Лірина в середньому за роки досліджень мав олійність 46,5–47,2% та випереджав за цим показником сорт Еврика. Лляна олія мала високі якісні показники, її йодне число коливалося у межах 178,4–184,2 гJ_2/100г для сорту Еврика та 175,3–181,2 гJ_2/100г для сорту Лірина. Високе йодне число зумовлює значний вміст ненасичених жирних кислот, що визначає цінність такої олії при використанні в харчових, фармацевтичних і технічних цілях.

Максимальний вміст олії в насінні встановлено на початковий термін зберігання – 38,8 та 44,5% відповідно сорту. Через 9 місяців після закладання на зберігання вміст олії в насінні сорту Еврика знизився на 4,1%, тоді як у сорту Лірина показник зниження вмісту олії в насінні становив лише 2,1%. Встановлено зниження йодного числа залежно від строків зберігання. Цей показник якості олії залежно від терміну зберігання зменшився від 182,1 до 179,6 (на 1,4%) у сорту Еврика та від 178,4 до 169,5 (на 5,0%) у сорту Лірина. Впродовж зберігання кислотні числа олії лляної навпаки підвищувалися. Так на кінець зберігання вміст вільних жирних кислот в олії отриманій з насіння льону сорту Еврика збільшився в 1,7 рази, а в олії з насіння сорту Лірина цей показник зріс у 3,4 рази. ***Висновки.*** Кліматичні умови Полісся забезпечують отримання високоякісної олії, а розглянуті строки зберігання сировини для її виробництва за умови використання оптимальних режимів забезпечують якість регламентовану державними стандартами.

Ключові слова: йодне число, кислотне число, жирні кислоти, олійність, кількість опадів.