



Article

Study of Varietal Differences in the Composition of Heteropolysaccharides of Oil Flax and Fiber Flax

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Abstract: Flaxseed mucilage and its derivatives have been extensively investigated over the last decade, mainly due to their inherent techno-functional (thickening, gelling, interface-stabilizing, and film-forming) properties that are relevant in the food industry. Hydrocolloids are used to modify food properties, such as for stabilization and emulsion, and are also used to control the microstructure of the food. Increasing research attention has been paid to the application of hydrocolloid materials in gel particles for encapsulation or texture control in food, pharmaceutical, cosmetic, and probiotic products. Thus, it is important to investigate the properties of hydrocolloids manufactured from various sources and explore their possible applications in the food industry. The applied nature of the study of plant mucus substances is associated with the ever-increasing demand for their use in the food, cosmetic, and pharmacological industries, determining the related research priorities, including the development of the most effective methods for the extraction of glycans and the search for highly productive raw materials for the production of polysaccharides. The aim of this work was to study varietal differences in the compositions of heteropolysaccharides in the mucus samples of oilseed and fiber flax varieties using a modern methodological approach for obtaining glycans based on the ultrasonic extraction of polysaccharides. The seeds of 10 flax varieties were studied, differing in their morphotype, place, and time of creation. The obtained results indicated significant differences in the quantitative and qualitative compositions of the heteropolysaccharides of flax seeds of various varieties. The contents of reducing sugars in the studied varieties ranged from 5.61 ± 0.01 to 18.81 ± 0.01 mg/g, indicating significant differences in the structural organization of glycans in different flax varieties. Additionally, the results obtained here allowed us to conclude that the range of reducing sugars for flax heteropolysaccharides is significantly less than this range for oilseed flax varieties. The obtained results of the study of the composition of flax seed heteropolysaccharides allowed us to consider them as selection trait and genetic markers.

Keywords: polysaccharides; flax seeds; extraction; composition; monosaccharides; viscosity



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1. Introduction

Flax is one of the oldest economically important agricultural crops. Among other crops, flax seeds are distinguished by the composition and contents of functional ingredients and biologically active substances. In addition to valuable oils, they contain proteins characterized by a full set of essential amino acids, soluble dietary fibers in the form of non-starch mucus polysaccharides, as well as biologically active polypeptides and lignans [1]. The variety of biochemical compositions testifies to the expediency of the deep processing of flax seeds and obtaining from them an assortment of useful and demanded products. In the production of polysaccharide and protein substances, biologically active lignans will make it possible to obtain products with added value and increase the efficiency in industrial processing of this crop.

Flax seeds are characterized by the presence of a significant amount of soluble dietary fiber, the basis of which is heteropolysaccharides. Flax seeds are also characterized by a high content of polyunsaturated fatty acids and protein. [2]. The structural elucidation of crude (non-fractionated) flaxseed mucilage demonstrated the co-existence of major polysaccharide fractions: an acidic arabinan-rich rhamnogalacturonan-I (RG-I) fraction and an arabinoxylan with a β -D-(1 \rightarrow 4)-xylan backbone neutral fraction [3,4]. During the past few decades, numerous polysaccharides have been explored from natural resources and have proven their biological activities or bioactivities, such as their antioxidant, antimicrobial, antidiabetic, anticancer, immunomodulatory, and nutraceutical actions [2].

Polysaccharides of flax seed mucus are food technology ingredients similar to hydrocolloids [5,6], which are necessary for the structural formation and stabilization of food masses. In addition, flaxseed mucus has attracted attention as a source of biologically active oligosaccharides [7]. An analysis of data from studies of flax seed polysaccharides [6,8] showed that based on their functional and technological properties, they can be used in food technologies as thickeners, stabilizers, moisture-retaining agents, and are also physiologically necessary components of food, allowing them to be considered not only as a technological additive, but also a biologically valuable ingredient.

The nutritional, technological, and functional properties of the polysaccharide complex from flax seeds include the following aspects [1,3,5,8]:

- It is a natural soluble fiber;

- It is a prebiotic;

- It is non-toxic;

- It has a low calorie content;

- It has fairly high resistance to heat treatment, acidic environments, and yeast fermentation, showing stability during the entire technological process;

- It can improve the texture and organoleptic characteristics of bakery products;

- It has no smell, taste, or color; therefore, it is convenient for introduction into recipes.

In addition, the biomedical role of flax seed polysaccharides is known; they contribute to decreases in the glycemic index and cholesterol content in the blood, with positive effects in the prevention of diabetes and reductions in the risk of coronary insufficiency having been shown [5,9–11]. It is believed that flax seed polysaccharides exhibit moderate immunoprotective properties, and are used as enveloping and laxative agents [6,7].

Linum seed polysaccharides aid in epidermal regeneration, the improvement of wound contraction, and the restitution of skin wounds, whereby the healing of laser burns in mice began to accelerate within 3 days, but did not exhibit any hemolytic activity in human erythrocytes [9].

The possibility of developing edible protective films both based on flax heteropolysaccharides and in combination with chitosan and alginates is being investigated [11].

The qualitative and quantitative compositions of polysaccharides from flax seed mucus depend on the varietal characteristics and regional and annual climatic conditions [12]. The chemical composition and structure-conformational properties of flaxseed gum can vary depending on its genotypic and phenotypic characteristics, and the extraction, isolation, and purification conditions are also well known for impacting its proximate and osidic compositions and consequently its technofunctional profile [3].

Extraction is the first and foremost stage in the isolation of bioactive polysaccharide compounds. The existence of a broad range of extraction methods can be classified into conventional and non-conventional methods, where the appropriate extraction method is selected based on the physiochemical nature of the bioactive molecule. The conventional methods include maceration, hot water extraction, alkaline and acidic extraction, heat reflux extraction, and Soxhlet extraction, while the non-conventional methods involve microwave-assisted extraction, ultrasound-assisted extraction, enzyme-assisted extraction, subcritical water extraction, supercritical fluid extraction, accelerated solvent extraction, hydrodynamic cavitation extraction, and negative pressure cavitation extraction [13].

A promising method of intensifying the extraction of plant polysaccharides from natural raw materials is the use of ultrasonic exposure. Ultrasound-assisted extraction studies under the principle of acoustic cavitation, in which bubbles are created under pressure followed by collision. This enhances the mass transfer and diffusion with the solid matrix, thereby disrupting the cell wall and leading to the release of the intracellular contents into the solvent. This technique follows a two-step process: the diffusion and disruption of the cell wall and rinsing of the cell content after cell disruption. This method exploits lesser amounts of energy and solvents to reduce the particle sizes of the compounds [14].

The purpose of this work was to study the varietal features of the differences in composition of mucus samples obtained from seeds of various varieties of flax and flax by weight. The applied nature of the work was associated with a steady increase in demand for natural hydrocolloids for their use in the food and pharmaceutical industries.

2. Materials and Methods

As a research material, the seeds of 10 flax varieties were studied, differing in their morphotype, place, and time of creation, including varieties of oilseed flax (Voronezhskij, Norlin, Flanders, Zheltyj (yellow), Korichnevyj (brown)) and long-living flax (Alpha, Lenok, Rosinka, Regina, Novotorzhsky). The seeds were obtained under the same growing conditions in experimental fields in the same season. The main characteristics of the flax seeds used in this work are given in Table 1.

Table 1. Characteristics of flax seeds of the studied varieties.

Variety Name	Humidity, %	Weight of 1000 Seeds, g	Seed Color
Regina	5.06	7.23	brown
Lenok	5.07	4.77	brown
Novotorzhsky	5.42	7.35	brown
Alpha	4.98	6.77	brown
Rosinka	5.12	4.36	brown
Zheltyj (Yellow)	5.54	4.56	yellow
Norlin	5.23	7.09	brown
Voronezhskij	4.97	7.41	brown
Korichnevyj	5.07	7.42	brown
Flanders	5.11	6.90	brown

To determine the method of extraction of mucus substances from the shell of flax seeds, numerous experimental studies in this direction were analyzed. In various studies, the duration of extraction, ratio of raw materials to water, and temperature of the hydromodule vary greatly, and the time to extract the target components can range from tens of minutes to days [15–22].

Under the influence of ultrasonic vibrations, faster and more active destruction of plant tissues occurs, which leads to intensification of the extraction process and makes it possible to increase the contents of biologically active compounds in the solution [14]. The use of ultrasonic exposure accelerates the extraction of polysaccharides and at the same time preserves their structural properties.

In this work, the ultrasonic extraction of polysaccharides from flax seeds was achieved. Aqueous extracts of polysaccharides were obtained at room temperature using an ultrasonic dispersant IKSONIC U 50 (IKA®-Werke GmbH & Co. KG, Staufen, Germany). The following process parameters were applied: the ratio of raw materials to the extractant was 1:10 (weight), the intensity of the ultrasonic treatment was 276 W/cm², and the duration was 16 min [23].

The concentration of glycans in the extract solutions was determined using the anthron method [24]. A 0.1% solution of anthron was prepared in concentrated sulfuric acid. Then, 2 mL of anthronic reagent was added to 1 mL of drug solution (100 µg/mL—the

concentration was determined by the dry sample). The tubes were incubated at 90 °C for 20 min in a water bath, and then cooled to room temperature.

The protein concentration in the extracts was determined by the bicynchonate method [25].

The content of reducing sugars in the preparations was determined with 3,5-dinitrosalicylic acid [26]. The method is based on the oxidation of 3,5-dinitrosalicylic acid of the carbonyl group of mono- and polysaccharides to the carboxyl group, which leads to the transition of the color of solutions from yellow to red-brown.

Chromatographic studies of glycan extracts were carried out by HPLC. The chromatographic system Spectra-Physics (SpectraLab, Markham, ON, Canada) was used, equipped with a comparison refractometer, which allows measurements to be carried out in the entire region of refractive coefficients. An analytical column made of stainless steel 500 × 10 was used. The polymer carrier Reprogel-H, which is a weak cation exchanger, was used as a stationary phase. The column was characterized by the presence of 160,000 theoretical plates, and the peak asymmetry coefficients did not exceed 1.005. A solution of sulfuric acid (9 mmol/L) was used as the mobile phase. The feed rate of the eluent was 0.5 mL/min.

The viscosity of linseed mucus extracts was determined using a Ubbelode viscometer (capillary diameter—1.18 mm; constant—0.12 mm²/s²) at a constant temperature of 20 °C.

The mathematical data processing was carried out using the traditional statistical analysis packages MS Exel © and Stadia ©.

All experiments were performed in triplicate.

3. Results

3.1. Results of Determining the Total Amounts of Mucus and Protein Contents for the Studied Flax Varieties

The data obtained in the study of fiber flax seeds in the analysis of the total amounts of mucus released and the contents of reducing sugars and proteins in it are shown in Table 2. The compositions of the oil flax seeds are presented in Table 3.

Table 2. Results obtained from the study of fiber flax seeds.

Variety Name	Mucus, mg/mL	Reducing Sugars, mg/g	Proteins, %
Regina	18.73 ± 0.01	9.54 ± 0.01	6.45 ± 0.02
Lenok	15.32 ± 0.01	9.12 ± 0.01	4.02 ± 0.02
Novotorzhsky	23.52 ± 0.01	6.42 ± 0.01	6.44 ± 0.02
Alpha	16.34 ± 0.01	7.91 ± 0.01	4.12 ± 0.02
Rosinka	19.61 ± 0.01	8.51 ± 0.01	4.07 ± 0.02

Table 3. Results obtained from the study of oil flax seeds.

Variety Name	Mucus, mg/mL	Reducing Sugars, mg/g	Proteins, %
Zheltyj	18.31 ± 0.01	18.81 ± 0.01	7.12 ± 0.02
Norlin	19.21 ± 0.01	9.42 ± 0.01	7.15 ± 0.02
Voronezhskij	19.32 ± 0.01	5.61 ± 0.01	3.06 ± 0.02
Korichnevyj	20.91 ± 0.01	13.03 ± 0.01	4.12 ± 0.02
Flanders	19.91 ± 0.01	9.93 ± 0.01	3.03 ± 0.02

3.2. The Results from Determining the Monosaccharide Composition of Heteropolysaccharides of the Studied Flax Varieties

The data obtained in the study of the monosaccharide compositions of the seeds of fiber flax are shown in Table 4. The compositions of the oil flax seeds are presented in Table 5.

Table 4. Monosaccharide compositions of fiber flax seed mucus samples.

Variety Name	Composition of Heteropolysaccharides, %						
	Xylose	Galactose	Arabinose	Fucose	Galacturonic Acid	Rhamnose	Glucose
Regina	53.41 ± 0.01	6.72 ± 0.01	12.02 ± 0.01	2.31 ± 0.01	23.91 ± 0.01	18.14 ± 0.01	2.02 ± 0.01
Lenok	54.41 ± 0.01	2.41 ± 0.01	8.75 ± 0.01	1.82 ± 0.01	24.91 ± 0.01	11.13 ± 0.01	1.76 ± 0.01
Novotorzhsky	51.82 ± 0.01	2.72 ± 0.01	7.43 ± 0.01	1.21 ± 0.01	28.70 ± 0.01	10.81 ± 0.01	1.34 ± 0.01
Alpha	57.71 ± 0.01	2.81 ± 0.01	6.38 ± 0.01	2.41 ± 0.01	25.91 ± 0.01	14.11 ± 0.01	1.56 ± 0.01
Rosinka	59.73 ± 0.01	2.72 ± 0.01	8.91 ± 0.01	3.43 ± 0.01	23.90 ± 0.01	19.75 ± 0.01	2.41 ± 0.01

Table 5. Monosaccharide compositions of oil flax mucus samples.

Variety Name	Composition of Heteropolysaccharides, %						
	Xylose	Galactose	Arabinose	Fucose	Galacturonic Acid	Rhamnose	Glucose
Zheltyj	27.32 ± 0.01	2.42 ± 0.01	16.21 ± 0.01	1.51 ± 0.01	29.42 ± 0.01	10.15 ± 0.01	1.32 ± 0.01
Norlin	22.31 ± 0.01	2.14 ± 0.01	26.13 ± 0.01	2.72 ± 0.01	24.02 ± 0.01	14.83 ± 0.01	3.11 ± 0.01
Voronezhskij	24.52 ± 0.01	1.73 ± 0.01	23.81 ± 0.01	2.13 ± 0.01	28.61 ± 0.01	10.92 ± 0.01	1.21 ± 0.01
Korichnevyj	28.32 ± 0.01	1.11 ± 0.01	24.14 ± 0.01	2.92 ± 0.01	28.73 ± 0.01	4.81 ± 0.01	1.73 ± 0.01
Flanders	56.31 ± 0.01	2.41 ± 0.01	7.62 ± 0.01	1.81 ± 0.01	24.71 ± 0.01	5.72 ± 0.01	2.31 ± 0.01

According to the chemical structure, linear and branched forms of polysaccharides were distinguished. In the case of non-starch polysaccharides, the degree of branching is evaluated based on the ratio of arabinose to xylose, galactose to rhamnose, or fucose to rhamnose. The ratios of these monoses are shown in Tables 6 and 7.

Table 6. The ratios of the contents of some monoses in mucus obtained from the seeds of fiber flax.

Variety Name	Ratio of Monosaccharides					
	Arabinose/ Xylose	Galactose/ Xylose	Glucose/ Xylose	Galactose/ Rhamnose	Fucose/ Rhamnose	Rhamnose/ Xylose
Regina	0.22	0.13	0.03	0.37	0.13	0.34
Lenok	0.16	0.04	0.03	0.22	0.16	0.20
Novotorzhsky	0.14	0.05	0.03	0.25	0.11	0.21
Alpha	0.11	0.05	0.03	0.19	0.17	0.24
Rosinka	0.14	0.04	0.04	0.14	0.17	0.33

Table 7. The ratios of the contents of some monoses in mucus obtained from oil flax seeds.

Variety Name	Ratio of Monosaccharides					
	Arabinose/ Xylose	Galactose/ Xylose	Glucose/ Xylose	Galactose/ Rhamnose	Fucose/ Rhamnose	Rhamnose/ Xylose
Zheltyj	0.59	0.08	0.04	0.24	0.15	0.37
Norlin	1.17	0.09	0.13	0.14	0.18	0.66
Voronezhskij	0.97	0.07	0.04	0.15	0.19	0.44
Korichnevyj	0.85	0.03	0.06	0.23	0.60	0.17
Flanders	0.14	0.04	0.04	0.42	0.32	0.10

The ratios of monoses suggest a polysaccharide chain with relatively small inclusions of side chains. Obviously, xylane chains with relatively small inclusions of arabinose side chains belong to this group of polysaccharide polymers.

3.3. Results of Determining the Viscosity of the Mucilage Samples of the Studied Flax Varieties

The rheological properties of flax mucilage depend on the composition and chemical structure of polysaccharides. The data obtained for the mucilage samples of flax seeds of the studied varieties are shown in Table 8.

Based on the experimental data, mucus from flax seeds of the studied varieties can be arranged in the following row according to their effect on the viscosity of aqueous dispersions: Zheltyj (yellow) > Norlin > Novotorzhsky > Regina > Voronezhskij > Korichnevyj (brown) > Rosinka > Lenok > Alpha > Flanders.

Given the likely synergism of non-starch polysaccharides with proteins associated with the formation of associates of varying degrees of strength, the behavior of flax polysaccharides in real food or pharmaceutical systems can be much more complex.

Table 8. Viscosity levels of the studied flax mucilage samples.

Variety Name	Viscosity, $\eta \times 10^{-3}$ MPa*s
Regina	65.23 \pm 1.24
Lenok	47.24 \pm 2.04
Novotorzhsky	76.12 \pm 1.14
Alpha	43.23 \pm 2.33
Rosinka	49.77 \pm 1.64
Zheltyj (Yellow)	97.96 \pm 1.71
Norlin	78.45 \pm 1.04
Voronezhskij	56.45 \pm 2.25
Korichnevyj	52.67 \pm 1.46
Flanders	42.33 \pm 1.14

4. Discussion

The aqueous extraction of flax seeds makes it possible to isolate native polysaccharides into the solution at the original molecular weight. Most often, the polysaccharides of flax mucus are isolated from whole flax seeds. Due to the fact that flax seeds contain a significant amount of water-soluble proteins that can be extracted from the kernels of crushed seeds along with polysaccharides, raw materials are not crushed before extraction. However, the process of the release of polysaccharides into the solution is accompanied by the parallel extraction of water-soluble fractions of proteins that are in the shell of flax seeds. Therefore, in the studied samples of polysaccharide products, we also determined the protein content.

The results obtained here indicate significant differences in the quantitative and qualitative compositions of heteropolysaccharides of flax seeds of various varieties. By analyzing the experimental data presented in the tables, it can be noted that the largest number of glycans is obtained from the seeds of the long-stemmed Rosinka and Flanders flax varieties. The smallest amount of polysaccharides among all analyzed varieties was noted in the yellow-seeded variety of oilseed flax. When considering the differences between the varieties of two morphotypes, oilseed and long-leaf, there was no clear separation of varieties according to the content of heteropolysaccharides. Consequently, this fact indicates the absence of a lecture focus on this trait, as well as the absence of a pronounced connection with traditionally valuable agronomic breeding traits (yields of fibrous and seed parts, etc.). Considering the composition of the obtained polysaccharides, it can be noted that the contents of reducing sugars for the studied varieties varied from 5.61 \pm 0.01 to 18.81 \pm 0.01 mg/g, indicating significant differences in the structural organization of glycans in various flax varieties. It can be noted that the xylose content in polysaccha-

rides isolated from fiber flax seeds was more than twice as high as the xylose content in polysaccharides isolated from oil flax seeds (with the exception of the Flanders variety). The content of arabinose in the polysaccharides isolated from oil flax seeds was more than twice as high as the content of arabinose in the polysaccharides isolated from fiber flax seeds. Obviously, the studied polysaccharides were xylan polymers with relatively small inclusions of arabinose side chains.

Additionally, the results obtained here allowed us to conclude that the range of content of reducing sugars for flax heteropolysaccharides is significantly less than this range for oilseed flax varieties. An increase in the content of reducing sugars corresponds to a decrease in the degree of polymerization of glycans. Based on the assumption that one reducing residue accounts for one polymer chain, the degrees of polymerization for the studied varieties range from 53 (yellow) to 178 (Voronezh), corresponding to the average values of the molecular weights of glycans at 10–32 kDa. If we consider polysaccharides as one of the biochemical components of the cell that increase the mechanisms of plant adaptability to adverse environmental factors [3], then further studies of this direction are necessary both from a theoretical point of view and for the purposes of breeding and seed practice.

Water-soluble protein fractions have been identified in the compositions of mucilage substances, which can probably be attributed to the components of complex glycan–proteionic complexes that make up part of the mucilage substances. The amounts of isolated protein were different in the studied varieties and the amplitudes of the differences in the varieties Flanders and Voronezh twice exceeded the minimum values, and in the varieties Norlin and Zheltyj twice exceeded the maximum value. The composition mainly contains albumins. When considering the role of the protein complex in mucus substances, it is necessary to study the features of the protein components of the cell wall of the flax seed shell. For applied use, when only a highly purified glycan component is required, it is necessary to purify the obtained mucilage substances.

It is known that for polymer solutions, the viscosity is a function of the molecular weight, size, and flexibility of the macromolecules. It is believed that flax seed polysaccharides are intermediates between flexible and semi-flexible polymers. It should be noted that the studied flax mucus is characterized by a fairly wide range of viscosities, with the greatest differences being noted between the varieties of oil flax. Flax seed hydrocolloids have good viscous, emulsifying, and stabilizing properties. Like gums, linseed mucus polysaccharides can be used as thickeners, stabilizers, and water-retaining agents. It is of interest to create flour confectionery products for specialized purposes, and the polysaccharides make it possible to endow rheological properties to such products, such as for biscuit dough.

In general, the conducted study on the compositions of the mucus substances of the flax seed shell allowed us to consider it as a potential source of glycans for production purposes, as well as to consider the further study of the composition of mucus and its formation during seed maturation, as well as its use as a breeding trait and genetic marker.

In addition, the actively expanding fields of application of hydrocolloids should be taken into account. They are successfully used in the production of confectionery and bakery products, various desserts, ice cream, and dairy products. The rapid growth in the production and consumption of hydrocolloids in food technologies is explained by their functional and technological properties, which ensure the quality of the products required by the modern market. Today, natural products and so-called “highly specialized” (e.g., vegetarian, gluten-free) energy products are becoming increasingly popular. Plant hydrocolloids largely ensure the given consistency or texture of a food product. They are characterized by high structure-forming, moisture-retaining, and stabilizing properties. Their versatility allows the rheological properties and structure of the finished product to be adjusted, from liquid to pasty to highly elastic. Comprehensive studies of the compositions and rheological and functional characteristics of the polysaccharide complexes from flax seeds of domestic varieties, as well as the determination of the relationship between

the rheological characteristics and functional properties, will make it possible to create competitive ingredients with high functional and technological performance.

5. Conclusions

Flax (*Linum usitatissimum* L.) is one of the most important industrial crops globally, being cultivated for its fibers (used extensively in the textile and bio-composite industry) and seeds. Flaxseed mucilage and its derivatives (deproteinized or fractionated) have been extensively investigated over the last decade, mainly due to their inherent techno-functional (thickening, gelling, interface-stabilizing, film-forming) properties that are relevant in the food industry. Flaxseed hull polysaccharides and their hydrolysates have antioxidant, immune-stimulatory, body fat mass, and weight controlling aspects, as well as other significant health benefits, including the suppression of acute postprandial glycemic response and glucose diffusion, and the regulation of the gut microbiota [3,4,9,27]

The yield, compositional characteristics, and rheological properties of the extracted mucilage are dependent upon the seed/water ratio, pH, and time–temperature extraction regime that are used [11,28]. The potential utilization of flaxseed gum as a commercially viable product requires the selection of cultivars that produce a consistent mucilage solution that can be freeze-dried, vacuum-dried, or spray-dried to generate a shelf-stable powder.

The minimum amount of polysaccharides among all the analyzed varieties was noted in the yellow-seeded variety of oilseed flax, which is consistent with the data presented in the literature [28].

In the present work, mucus samples of flax seeds of various morphotypes were studied. The monosaccharide compositions were determined for all the studied glycan samples. All polysaccharides studied contain arabinose, xylose, galactose, xylose, glucose, mannose, and fucose, but the contents of these monosaccharides differed in the different varieties. In addition, the studied flax varieties had different ratios of these monosaccharide units, indicating differences in the degree of polymerization of polysaccharide molecules. The established ratios of monoses in all studied glycans suggest a polysaccharide chain with relatively small inclusions of side chains. Xylan chains with relatively small inclusions of arabinose side chains belong to this group of polysaccharide polymers.

The study the quantitative and qualitative compositions of the glycans of the flax seed shell can be considered as one of the directions for creating a theoretical and methodological basis for culture selection in this crop.

In previous studies [28,29], the techno-functionality (thickening and swelling power, emulsifying and foaming capacity) of the gum extracts provided by the flaxseed cultivar and origin was clearly shown. Interestingly, the umami, bitter, and sweet sensory modalities, which are strongly driven by cultivar type, were identified as the primary determinants of flaxseed gum acceptability [29].

The study of the composition and properties of flax seed mucus will expand its use in the food and pharmaceutical industries. The analysis of the obtained results allowed us to conclude that all properties considered in this study depend on the variety. Therefore, it is justified to choose the most suitable variety, since this variety of properties of glycans opens up opportunities for the production of linseed mucilage for specific applications in the food and non-food industry.

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