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# RESEARCH OF DISPERSION PROPERTIES OF OILCAKES

***Annotation:*** *This article presents the results of research on the dispersion properties of oilseed cakes after oil extraction for further use in the bakery, confectionery, and pasta industries. Soybean, pumpkin, sunflower, peanut, and flax seed cakes were used in the work. Oilseed cakes are a high-protein product and can serve as an alternative gluten-free raw material for the production of flour products. The microstructural characteristics of the oilcake's surface were determined using an electron microscope-micro analyzer JXA-8230 from JEOL at the Scientific Center for Composite Materials LLP, Almaty. Sample images were obtained at an accelerating voltage of 20 kV, an electron beam current of much less than 1 nA, and aperture diaphragms No. 3 and 4. Laser analysis of particles of the applied materials up to nanoparticles was also performed. The smallest particle distribution is in sunflower cake (D10=3.177 um, D50=6.403 um, D90=10.007 um, Dav=6.529 um), the largest is in flax cake (D10=34.127 um, D50=61.243 um, D90=89.052 um, Dav=61.519 um). The research aimed to establish the microstructure and analysis of the particles of oilseed cakes and further influence the phase transformations and technological properties of bakery, confectionery, and pasta products.*

***Key words****: oilseed cakes, analysis, electron microscopy, laser analysis, nanoparticles.*

## Introduction

According to United Nations forecasts, by 2050 the world's population will grow to about 9.7 billion people [1]. This growth creates an acute demand for the production of protein-rich foods for human consumption that are affordable, plentiful, nutritious, and sustainable. The major source of high-quality proteins is animal husbandry. It is necessary to look for sources of sustainable plant-based alternatives to replace animal food sources in the human diet [2].

The purpose of this article is to discuss the possibilities and problems associated with the use of oilseed cake proteins, such as sunflower, pumpkin, soybean meal, peanut, and flax cake in the food industry, which is a by-product of processing oilseeds and contains up to 50% protein. The global production of secondary products of the fat and oil industry is estimated at 636 million metric tons in 2022/2023 [3]. The proteins of some oilseed cakes can be turned into food ingredients that can be used for their nutritional value or functional properties in human food products [4].

Earlier, studies were conducted on the physicochemical, fatty acid, amino acid composition, and food safety of the cakes of the above-mentioned crops [5]. In this article, we provide an overview of the dispersion properties and their potential application in the production of bakery, confectionery, and pasta products.

This highlights the potential contribution of the use of secondary products of the fat and oil industry to the achievement of some of the United Nations Sustainable Development Goals: «Zero hunger»; «Good health and well-being» and «Sustainable food production and consumption» [6]. As a result, converting an abundant by-product into a valuable food ingredient can lead to healthier and more sustainable global food supplies.

## Research methods

Researching a scanning electron microscope with an energy-dispersive microanalysis system (without sample preparation). A snapshot of the surface of the finished sample at high magnifications (>x3000).

Samples in the form of powders or crushed pieces were delivered in labeled plastic bags. The samples were mounted in brass holders on the slide table of the JEOL scanning electron microscope-microanalyzer JXA-8230 flush with the sample holder section. Thus, the same experimental conditions for observation and measurement of all samples were created. The installation corresponded to the positions of the samples with respect to the electron beam as close as possible to the perpendicular.

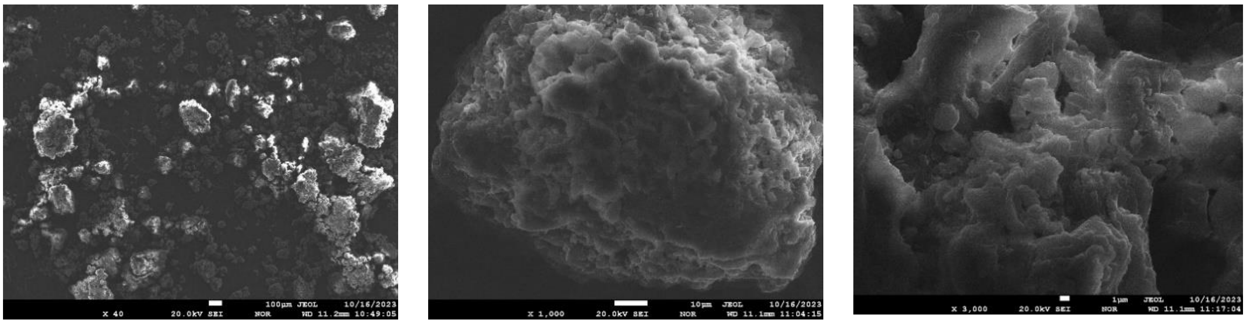
Sample images were obtained at an accelerating voltage of 20 kV, an electron beam current much less than 1 nA, and aperture diaphragms No. 3 and 4. Such shooting conditions at low magnifications ensure confident observation and registration of particles from a micron to hundreds of microns, and at high magnifications – submicron particles.

For all sample sites selected for scanning electron microscopic (SEM) examination, the mode of observation and shooting in secondary electrons (SEI) was used. The name of the microphotograph files in JPEG format indicates the observation mode (shooting) and magnification.

Laser particle analysis of applied materials up to nanoparticles. Information about the tests of the laser particle detector: Sample Info. Sample Name: 1 [Average]: Sample Refractive Index: 1.57 – i * 0.100. Delivery Date: 2023-9-25. Testing Info. Measuring Time: 9/25/2023 4:02:04 PM: UltraSonic Time: 0s. Disperse Medium: 1. Dispersant: 1. Sample Concentration: 9.382497. Analysis mode R-R distribution

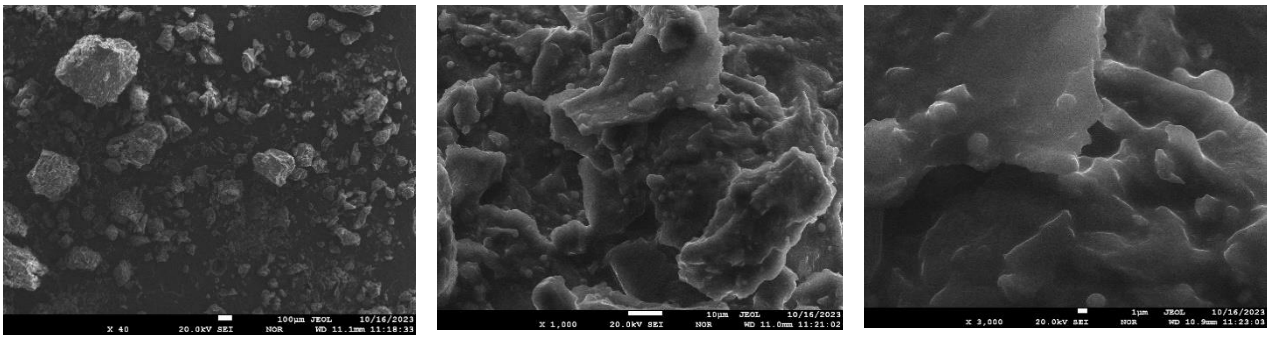
**Research results**

For comparability of images and characterization of the microstructure during electron microscopy of the submicrometer range, 3 micrographs were obtained for each sample with magnification X 40 (over the plan), X 1000 and X 3000.



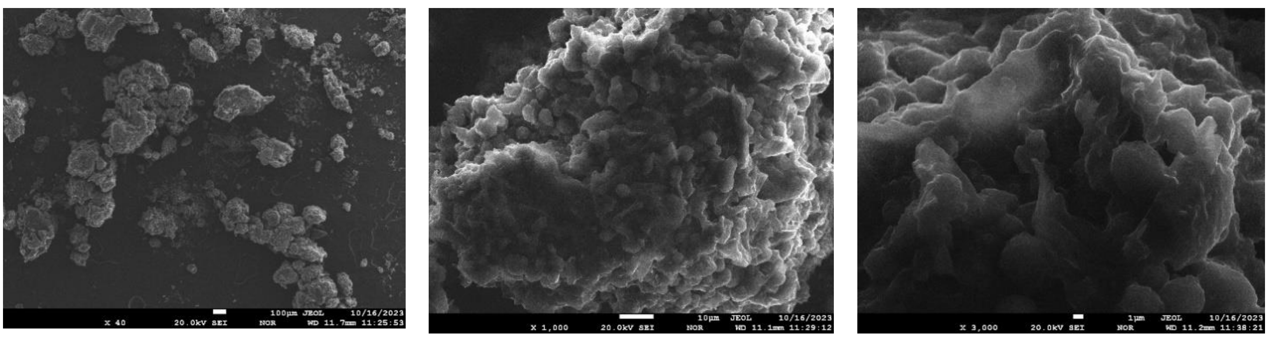
X 40 X 1000 X 3000

Figure 1 – Micrographs of soybean meal



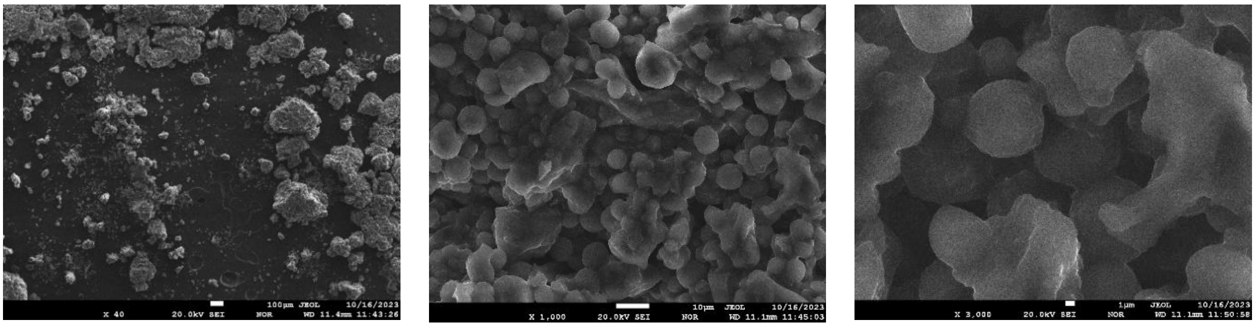
X 40 X 1000 X 3000

Figure 2 – Micrographs of pumpkin meal



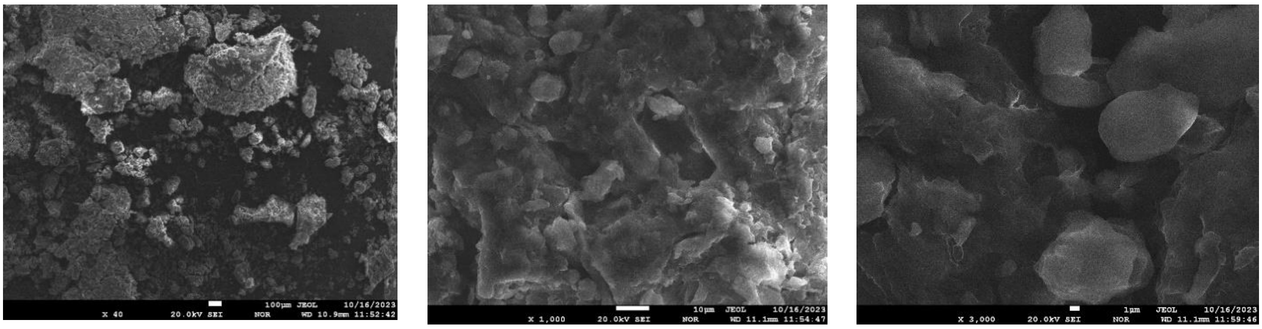
X 40 X 1000 X 3000

Figure 3 – Micrographs of sunflower meal



X 40 X 1000 X 3000

Figure 4 – Micrographs of peanut meal



X 40 X 1000 X 3000

Figure 5 – Micrographs of flax meal

Particle size is a crucial parameter of the quality of food suspensions, affecting their rheological behavior, overall stability, as well as sensory perception. Table 1 shows the results of laser particle analysis of the applied materials to nanoparticles. Measurements of particle size distribution in powders and suspensions. The samples are inert about water and completely dissolve in it.

The term «Dev» means the average particle diameter (Dav).

In the table, the term «D10» means the particle diameter (D10 value) of the particles at the 10% position when counting from the smallest particle diameter size of 0% (minimum) to 100% (maximum) in the particle diameter distribution.

The term «D50» means a particle diameter (value D50) in which the number of particle diameters on the larger side becomes equal to the number of particle diameters on the smaller side when the diameters of the powder particles are divided into two groups.

The term «D90» means the particle diameter (D90 value) of the particles at the 90% position when counting from the smallest particle diameter size of 0% (minimum) to 100% (maximum) in the particle diameter distribution.

Table 1 – Data on particle sizes of various types of oilcakes

| The name of the oilcake | Particle size | | | | S/V, m^2/cm^3 | D [3,2], um | D [4,3] um | Fitting Deviation |
|---|---|---|---|---|---|---|---|---|
| | D10, um | D50, um | D90, um | Dav, um | | | | |
| Soybean | 13.688 | 43.375 | 90.495 | 48.62 | 2520.587 | 23.80 | 48.620 | 0.337 |
| Pumpkin | 21.804 | 49.224 | 82.739 | 51.13 | 1632.598 | 36.75 | 51.13 | 0.149 |
| Sunflower | 3.177 | 6.403 | 10.007 | 6.529 | 11686.430 | 5.134 | 6.529 | 1.683 |
| Peanut | 9.841 | 41.655 | 104.516 | 50.93 | 3897.614 | 15.39 | 50.936 | 0.836 |
| Flaxseed | 34.127 | 61.243 | 89.052 | 61.519 | 1150.580 | 52.148 | 61.519 | 0.545 |

A graphic representation of the results of laser analysis of oil cake particles is shown in Figure 6 [7].

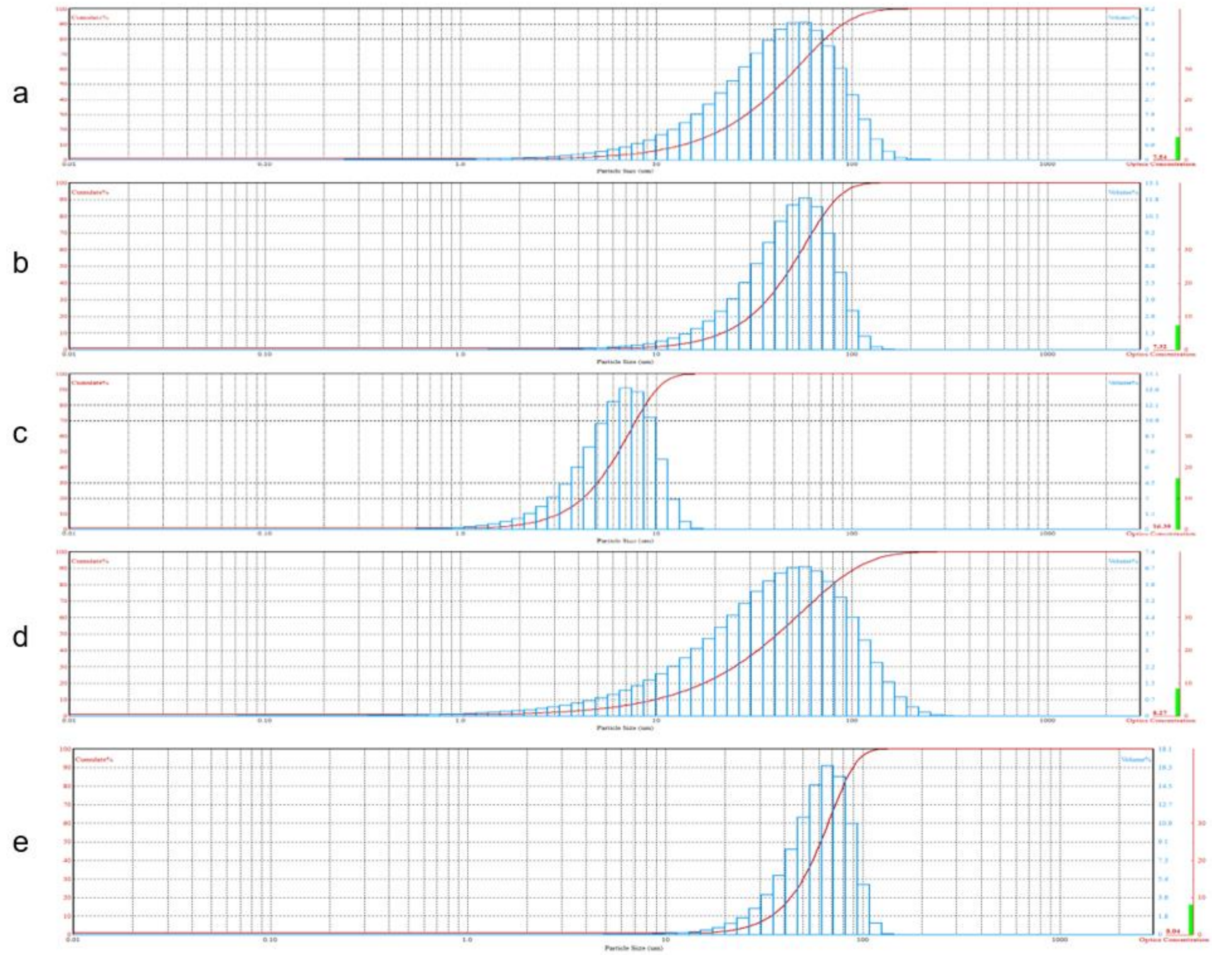



Figure 6 – Results of laser particle analysis:
a – soybean cake; b – pumpkin cake; c – sunflower cake; d – peanut cake; e – flaxseed cake

**Discussion of scientific results**

The soybean cake sample (Fig. 1) is a powder, which is an ensemble of agglomerated fine particles ranging in size from 4.5 to 16 microns. The particles do not have definite shapes. At high magnification, microcracks, microtubules (from 1 μm), and traces of plastic flow in the form of grooves and strands on the surface of particles are observed.

The sample of pumpkin cake (Fig. 2) is a powder, which is an ensemble of particles up to 0.6 mm in size. The particles do not have definite shapes, but there are partial signs of brittle fracture. The layered structure of the particles has been revealed, and traces of microparticles (up to 2 microns) are observed on the surface of the layers, which have not completely merged with their layers.

Malaysian scientists have studied pumpkin powder as a substitute for pumpkin pulp in various food products. Scanning electron micrographs showed that the particle sizes of the purified pumpkin powder were smaller particle size than the untreated samples amounting to 122.78 microns for untreated samples and 120.99 microns for processed samples. The image looks like a clot of scales [8].

The sample of sunflower cake (Fig. 3) is a powder, which is an ensemble of agglomerated fine particles with sizes from 1.5 microns. The particles do not have definite shapes, but there are partial signs of brittle fracture with traces of plastic flow in the form of grooves and strands on the surface of the particles. At high magnification, microcracks and microtubules (from 1 μm) are observed.

The peanut cake sample (Fig. 4) is a powder, which is an ensemble of agglomerated fine particles ranging in size from 2.5 to 22 microns. The particles have rounded shapes and smoothed surfaces with common cleavage areas, due to which a developed porous structure is observed in the material.

The sample of linseed cake (fig. 5) is a powder, which is an ensemble of agglomerated fine particles with sizes from 1.5 microns. The particles are partially rounded, and often do not have certain shapes, but have common cleavage areas, due to which a porous structure is observed in the material.

In studies of flax seed cake, SAM images showed the formation of relatively spherical particles that were folded or wrinkled. This can be explained by the interaction between the rapidly decreasing diffusion coefficient during moisture removal and an increase in surface tension, which leads to the formation of flattened particles with uneven/folded surface morphology. This research may open up a promising path for the production of natural and herbal spray-dried powders for food use as emulsion stabilizers [9].

The obtained results of scientists have shown that sourdough bread enriched with flaxseed cake can be a potential source of biologically active compounds with the possibility of obtaining high-quality products with improved nutritional profiles and desired health characteristics [10].

Laser analysis of particles of the materials used to nanoparticles showed the following results: the smallest particle distribution is in sunflower cake (D10=3.177 um, D50=6.403 um, D90=10.007 um, Dav=6.529 um), the largest is in flax cake (D10=34.127 um, D50=61.243 um, D90=89.052 um, Dav=61.519 um). In terms of size, all types of cakes comply with the standards.

## Conclusion

Vegetable proteins are attracting increasing attention from scientists and manufacturers of the food industry. By-products of the fat and oil industry – oilcakes, which are formed after oil extraction and are a valuable feed ingredient for various types of livestock, are currently a potential source of protein and dietary fiber in human food.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## МАЙЛЫ ДАҚЫЛДАР КҮНЖАРАСЫНЫҢ ДИСПЕРСИЯЛЫҚ ҚАСИЕТТЕРІН ЗЕРТТЕУ

*Бұл мақалада нан-тоқаш, кондитерлік және макарон өнімдерін өндіру саласында одан әрі пайдалану мақсатында майлы дақылдардың майсыздандырылғаннан кейін алынған күнжаралардың дисперсиялық қасиеттерін зерттеу нәтижелері берілген. Зерттеу жұмыста соя, асқабақ, күнбағыс, жержаңғақ және зығыр тұқымдарының күнжаралары қолданылған. Майлы күнжаралар ақуызы жоғары өнім болып табылады және ұн өнімдерін өндіру үшін балама глютенсіз шикізат ретінде қызмет ете алады. Күнжаралардың бетінің микроқұрылымдық сипаттамалары Алматы қ. «Композиттік материалдар ғылыми орталығы» ЖШС JEOL фирмасының JXA-8230 электронды микроскоп-микроанализаторының көмегімен анықталды. Үлгілердің суреттерін алу 20 кВ үдеткіш кернеуде, электронды сәуленің тогы 1-ден аз және №3 және 4 апертуралық диафрагмаларда жүзеге асырылды. Сондай-ақ, нанобөлшектерге қолданылатын материалдардың бөлшектеріне лазерлік талдау жүргізілді. Бөлшектердің ең аз таралуы күнбағыс күнжарасында байқалады (D10 = 3,177 мкм, D50 = 6,403 мкм, D90=10,007 мкм, DAV=6,529 мкм), ең үлкені – зығыр күнжарасында (D10=34,127 мкм, D50=61,243 мкм, D90=89,052 МКМ, DAV=61,519 МКМ). Зерттеудің мақсаты майлы күнжараладың бөлшектерінің микроқұрылымын құру және талдау және нан-тоқаш, кондитерлік және макарон өнімдерінің фазалық өзгерістері мен технологиялық қасиеттеріне одан әрі әсер ету болды.*

***Түйін сөздер**: майлы дақылдар күнжарасы, талдау, электронды микроскопия, лазерлік талдау, нанобөлшектер.*

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## ИССЛЕДОВАНИЕ ДИСПЕРСИОННЫХ СВОЙСТВ МАСЛИЧНЫХ ЖМЫХОВ

*В статье приведены результаты исследований дисперсионных свойств масличных жмыхов после извлечения масла с целью дальнейшего использования в отрасли производства хлебобулочных, кондитерских и макаронных изделий. В работе использовались жмыхи семян сои, тыквы, подсолнечника, арахиса и льна. Масличные жмыхи являются высокобелковым продуктом и могут служить альтернативным безглютеновым сырьем для производства мучных изделий. Определение микроструктурных характеристик поверхности жмыхов производилось с помощью электронного микроскопа-микроанализатора JXA-8230 фирмы JEOL на базеТОО «Научный центр композитных материалов», г. Алматы. Получение изображений проб осуществлялось при ускоряющем напряжении 20 кВ, токе электронного пучка много меньше 1 нА и апертурных диафрагмах №3 и 4. Также проводили лазерный анализ частиц применяемых материалов до наночастиц. Самое мелкое распределение частиц у подсолнечного жмыха (D10=3.177 um, D50=6.403 um, D90=10.007 um, Dav=6.529 um), самое крупное – у льняного жмыха (D10=34,127 um, D50=61,243 um, D90=89.052 um, Dav=61,519 um). Целью исследований являлось установление микроструктуры и анализ частиц масличных жмыхов и дальнейшее влияние на фазовые превращения и технологические свойства хлебобулочных, кондитерских и макаронных изделий.*

***Ключевые слова**: масличные жмыхи, анализ, электронная микроскопия, лазерный анализ, наночастицы.*

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