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PREPARATION AND PROPERTIES OF FINELY DISPERSED FOODSTUFFS FROM RAW VEGETABLE MATERIALS

A low-waste technique for preparing liquid and paste-like finely dispersed emulsion and suspension systems of whole leguminous and cereal seeds (soya, lupine, amaranth, oats, wheat, and buckwheat) has been developed. These systems have almost complete set of nutrients, biologically active substances, and minerals of the original plants. They have an aggregative stability of 5–15 days or more without the use of stabilizers and emulsifiers.

Keywords: emulsion and suspension systems resistant to stratification, holistic raw plant material, and dispersing homogenizer.

Since the mid-twentieth century, in the world leading countries, there is a tendency towards expanding the range of plant-based protein foodstuffs and using the vegetable proteins (soya, lentil, lupine, pea, amaranth, and oats) as substitute for the animal ones [1–3]. Soybeans are notable for the best content of nutrients and are the most widely cultivated source of dietary protein. Western countries use primarily the protein concentrates, solvent cake and flour. Their manufacture (mainly in United States, unlike in the Eastern countries) is based on differentiation into components through moisture and heat treatment, treatment with organic solvents, treatment of shredded fat-free seeds with peroxide, alkali, and salt solutions, ultrafiltration, and sedimentation of proteins. This implies the use of multi-stage and energy consuming processes, as well as the removal of major part of biologically active substances contained in soybeans. The adverse effects are compensated by adding vitamins, fats, emulsifiers, flavorings, protein isolates or concentrates [2, 4].

Previously, in the USSR and Ukraine, soybeans were processed with full oil content [1, 5]. However, the technology was energy-consuming, high-waste (20%), and water-contaminating. In the 1980–1990s, the technologies of soybean processing for the manufacture of food and feed products improved, although some shortcomings left (long duration of some stages, large amount of solid sludge, high temperature of treatment, etc.) [6, 7]. Therefore, new technological solutions are still relevant.

In all cases, the initial stage of processing is to reduce the size of processed material by rolling and grinding. Processes and tools for polymorphic transformation of solid (including herbal) matter into a powder or a homogeneous suspension are an important object of research in physical chemistry of solids. Depending on the purpose and type of plant material, there are two grinding methods: the "*dry*" grinding for processing the cereal seeds into solvent cakes and the "*wet*" grinding for processing the seeds with contain of fats exceeding 5%. Because of the loss of original value of the plant components the crops are as vulnerable to the processing as high-protein plants. Powdering (flouring) of cereal seeds involves the removal of membranes, aleurone layer, and seed bud and graded milling of the residue to obtain dispersions of particles having various sizes (of different varieties) by multiple stepwise grinding/shaking process. Fine grinding (particle size ranges 400–600 microns) applies almost exclusively to endosperm [8]. The same concerns the powdering of skimmed soybean, lupine, and amaranth [2, 4]. *BUHLER* (Switzerland) technology is the most successful (but expensive) low-waste (2.5–3.5%) and fine-dispersion (particle size 75 ÷ 105 mm) way of manufacturing fine powders [2] of: 1) full-fat soybeans peeled at a temperature of 120–135 °C and dehydrated to a moisture content of 3–5% and grinded by 6-roller mill; 2) cereal seeds without shells grinded by 8-roller mill.

For the "wet" grinding, another important factors (in addition to dispersing) are the intensity of blending of two-phase system (*solid grinded particles* and *liquid dispersion*) and the ratio of phases. In principle, the methods for obtaining suspensions do not differ from those for obtaining emulsions (except for condensation). The only differences are the object of dispersing and the energy costs. It is believed that in the case of combined continuous shear and vibration, the factor that destroys the disperse structures (which the biological objects are referred to) is forced oscillation. The fractured fragments of matter are transferred due to continuous shear and new, more homogenous system forms. So far, these conditions for the formation of highly concentrated suspensions have been the implemented only for the systems containing finely dispersed particles of SiO_2 (aerosil-300-*Degussa AG*). Among the existing machines, those in which shear-turbulent processes are realized when grinding occurs in the annular gap between the stator and the rotor under the action of forces generated on the surface of the blade can be suitable.

This principle is implemented in colloid mills with small conical gap. It requires a very precise adjustment for ensuring that the stator and rotor axes match each other and so do the stator cone-shaped outer surface and the rotor cone-shaped inner surface [9]. The degree of grinding is a few microns. For the devices where the seed is ground due to pressure pulsations, mechanical action of rotors, and hydrodynamic conditions in the gaps between the rotor and the stator, the essential factor for the destruction is hydrodynamic conditions, when the peripheral velocity of fluid in the gap can vary from zero to the speed of rotor. Solid particles are transported by fluid to the gap where they are destroyed. Such devices are called *rotary-pulsation* and *rotary-pulse* equipment. Among the machines of this type, there are the ones developed by the Institute of Engineering Thermophysics of the NAS of Ukraine. Some of them, such as fruit and vegetable dispersants and blenders, are designed for the food processing industry.

In industrialized countries, engineers and designers are developing devices for blending and dispersing liquid heterogeneous systems using the method of discrete pulse energy input (DPEI). *Obodovych* studied the dispersing of full-fat soybeans using a DPEI device after heat and moisture treatment of the seeds at a temperature of 95–98 °C for manufacturing a soybean paste in which particles having a size 30÷90 microns constitute the major part of treated seeds [10]. The experiments on grinding the plant material using a DPEI hydrodynamic cavitation disperser are also noteworthy. These experiments show that the textural size of crushed material essentially depends on the rotor diameter and rotation speed. The particles having a size of 5÷50 microns are obtained only for a rotor diameter of 80–120 mm and a rotation speed of 70 s^{-1} [11]. The review of published data on grinding of leguminous raw material presented below shows that it is nearly impossible to obtain fine emulsion and suspension systems of plant origin using the existing equipment.

This research is the result of R&D works on searching low-waste ways of processing full-fat raw plants (soybean, lupine, amaranth, oats, wheat, and buckwheat) for the manufacture of food or supplements thereto in the form of fine systems: flour, emulsion, suspension, stable liquid and paste-like systems without using high-temperature treatment, emulsifiers, stabilizers, odorants, and colorants.

This research deals with variations of physical-chemical parameters at all stages of processing, from the moisture and heat treatment of seeds to the inactivation of lipoxidase, trypsin inhibitors, and urease, the removal of excessive heavy metals, and the reduction of microbial contamination in the manufacture of food and health care products incorporating all useful components of raw materials, including proteins, vitamins, minerals, carbohydrates, fats, and fibers with associated proteins and fats. The type and chemical composition of the objects of study are presented in Table 1.

Since the research involves studying the conditions of grinding grain, leguminous and insulin-containing crops, it is necessary to determine a practical and sufficient set of known crushing and blending devices and to find new technical solutions capable of ensuring the desired dispersion characteristics. To evaluate the results of experiments, the conventional classification of disperse systems based on the size of particles (Table 2 [12]) and common methods of sieve analysis, microscopy (BIO-LAM-70), as well as nanomaterial analysis and characterization of disperse systems (*Zetasizer-R Nano S*, *Mauvern Ltd*., Mauvern, UK) have been used.

The proposed method of flouring of whole wheat and some other crops (rye, buckwheat, and soybeans) includes cleaning of seeds from husk, peeling, coarse and fine grinding of seeds and differs from the known methods by the fact that only the outer seed coat are peeled off and the whole grains with offals, aleurone layer, and seed bud are ground. In this case, the seed moisture is 5–12% [13]. Fine grinding is achieved by circulating a seed layer in closed hammer crusher with hinged plate hammers. This crusher has a regulated gap of 2÷5 mm between the fixed grooved part of the apparatus and the moving plates, and is equipped with a sieve having holes of 0.5÷1.0 mm. The gap is regulated by rotation speed 65÷80 m/s and width of the plate hammers 1÷5 mm depending on the particle size after coarse grinding. The device is designed for flouring the whole wheat seeds of any moisture content. When trying to flour full-fat soybeans or oats in the same manner, some problems were reported: an adhesion of crushed material (soybeans) and a large difference in size of particles of crushed seed (oats). Having studied the influence of seed preparation for crushing and powdering for the whole soybeans, the shelled soybeans, the micronized soybeans, the partly skimmed soybeans, and the full-fat seeds of lupine and amaranth the acceptable wetting parameters (2, 5, and 11%) and conditions of short-term IRR treatment at a temperature up to 120 °C were identified. The positive impact of selected conditions of preparation of seeds for crushing is illustrated in Table 3. The data relate to the fractional composition of crushed peeled and micronized soybeans and show a significant increase in the degree of powder dispersion.

Table 1

Chemical Composition of Plant Samples,% Dry Matter (DM)

Sample	Proteins, %	Fats, %	Carbohydrates, %	Ash, %
Soya native	42.2	20.9	16.3	6.1
Soya shelled	41.4	20.8	16.7	6.0
Micronized soya	43.5	21.3	16.4	6.6
Lupine native	38.3	6.8	25.7	4.4
Lentils native	24.9	1.5	46.4	2.9
Amaranth native	14.4	6.4	60.2	3.8
Jerusalem potato, tubers	2.2	0.2	16.6	1.0
Saccharine sorghum, stems	6.8	0.05	76.4	5.2

The same effect has been reported for grinding of amaranth and lupine seeds (crops having a lesser fat content and, consequently, less viscous seeds, as compared with the soybeans (Tables 4 and 5)).

Table 2

Conditional Classification of Grinding Degree by Size of Dispersed Particles

Degree of grinding	Particle size, μm
Coarse	10000÷1000
Medium	1000÷100
Small	100÷10
Fine	10÷0,1
Colloidal	0,1÷0,001

Thus, it has been showed that under certain conditions of pretreatment of seeds of crops with a higher fat content (as compared with the wheat seeds) the use of crusher designed by the author team enables manufacturing powders with a particle size matching the standard for second grade wheat flour. These powders have satisfactory organoleptic properties. Based on them a method for manufacturing milk substitutes [14] has been developed. These beverages are highly competitive with "soy milk" produced of powders patented by *BUHLER* [2].

However, even under the optimal conditions of seed preparation and crusher parameters, it is very problematically to make emulsions and suspensions of finely dispersed powders, which would be stable, at least, for 1–2 hours without

Table 3

Fractional Composition of Soya Seed Powder for Intersection of Mill's Concave Hole 0.75 mm

Raw material, type of processing	Share of powder on the sieve, weight %						
	1.02 mm	0.75 mm	0.5 mm	0.385 mm	0.25 mm	0.075 mm	Rem.
Whole unshelled soya	0.3	0.3	6.3	21.3	43.0	28.5	0.6
Soya shelled	2.7	1.6	11.1	23.7	23.0	37.5	0.4
Micronized shelled soya	0.1	1.2	10.5	13.2	34.7	40.1	0.2

Table 4

Fractional Composition of Amaranth Seed Powder Depending on Intersection of Mill's Concave Hole

Intersection of mill's concave holes, mm	Share of powder on the sieve, weight %					
	1.02 mm	0.75 mm	0.5 mm	0.25 mm	0.075 mm	Rem.
1.00	–	0.67	6.22	14.16	63.49	0.75
0.75	–	0.31	1.47	23.74	72.74	1.74
0.5	–	0.25	25.94	44.22	27.67	1.81

Table 5

Fractional Composition of Lupine Seed Powder Depending on Intersection of Mill's Concave Hole

Intersection of mill's concave holes, mm	Share of powder on the sieve, weight %					
	1.02 mm	0.75 mm	0.5 mm	0.25 mm	0.075 mm	Rem.
1.00	2.9	0.97	8.22	15.15	72.14	0.62
0.75	2.0	0.52	2.47	20.53	73.25	1.27
0.5	1.6	0.30	23.94	34.25	38.23	1.68

Table 6

Change in Weight (%) of Whole Soya Seed When Contacting Distilled Water Depending on Duration and Temperature of Contact

Duration, years	Temperature, °C					
	16	26	35	55	75	90
0.5	123	123.2	125.3	138.9	147.0	161.6
1.0	140	137.7	149.2	161.2	167.7	203.4
1.5	149	150.2	162.4	182.8	194.1	214.9
2.0	160	163.3	175.2	196.4	217.9	218
3.0	168	189.9	196.5	221.0	228.5	219.8
22.0	225	231.3	233.0	233.3	220.8	230.1

Table 7

Increase in Weight of Soya Seed (%) in Aqueous Environments with Various pH Depending on Duration of Treatment

Duration, years	*pH*			
	2.5	8.0	11.4	12.5
0.25	26	16	37	23
0.5	40	32	52.3	42
1.0	53	50	69	61
2.0	72	72	96	90

adding emulsifiers or without subsequent grinding and homogenization in the presence of the dispersion medium.

It is assumed that to get finely-dispersion vegetable foodstuffs with heterogeneous phase and chemical composition it is necessary to meet the following conditions:

1) To use devices capable of grinding (dispersing) to certain specified parameters;

2) To use unaggressive physical, chemical, and mechanical factors of effecting raw materials, which can stimulate the formation of systems that are made of whole seeds, resistant to aggregation, and contain all major components of eatable part of plant.

Since the composition, seed structure and water absorption conditions can influence in different ways the resistance to mechanical stress and the dispersion of holistic plant material, the water absorption by the seeds of soya, lupine, and amaranth has been studied in aqueous media, at pH = 1.2÷12.5 and at a temperature of 15÷90 °C, in diluted solutions of acids, alkali, sodium chloride, mono- and disaccharides. Data in Table 6 and 7 illustrate how the chemical composition of the medium and the duration of swelling effect the growth of weight of soybeans. This information enables the optimization of swelling conditions.

Therefore, the maximum weight and volume growth for all objects of study has been determined, the qualitative and quantitative compositions of mass redistribution between liquid and solid phases during the swelling have been estimated. The mass transfer of proteins in the liquid phase has been established not to exceed 0.01%; that of saccharides accounts for 2%. The most significant changes are observed in the mineral composition of the seed as the content of inorganic component decreases by 10–50%, for the elements from light (S, P, K) to heavy (Cr, Mn, Co, Cu, Sr, Cd) ones. The possibility and conditions (acidified solution, microwave radiation) of irreversible inactivation of lipoxidase, urease, trypsin inhibitors, and polyphenol oxidase (applies to Jerusalem artichoke), which prevents deterioration of composition and organoleptic properties of legume-based suspensions and solutions of Jerusalem artichoke-based sweeteners have been identified.

The effect of pretreatment conditions (mechanical and heat treatment, watering, pH, and dura-

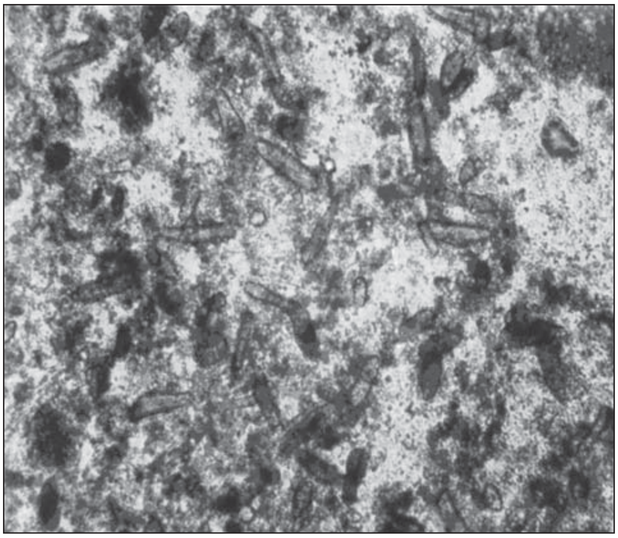

Fig. 1. Micro-picture of a sample taken from suspension obtained in RPM from whole soya seeds swollen in distilled water at a temperature of 50 °C

tion) on the fractional composition of particles in suspensions has been studied for the samples of soybean, lupine, amaranth, and buckwheat using Ukrainian-made blending devices (ultrasound disperser, three modifications of rotary-pulsation machines, including the rotary-pulse machine designed by the Institute of Food Chemistry and Technology of the NAS of Ukraine for medium-productive dispersing, homogenization, and obtaining of soya aqueous suspensions [14]).

The formation of systems resistant to aggregation for, at least, 20 minutes has been established to require five-six-time circulation of water-seed blend in such devices for grinding the swollen seeds under the optimal conditions (mash ratio 1/4÷1/10). Since the particle size in suspensions obtained in different devices differs by 5–10%, Table 8 shows the characteristics of seed suspensions for five cycles of treatment in RPM. One can see that the particles having a size of 150–500 microns dominate in the suspensions, with time before stratification ranging from 10–20 minutes (suspension of buckwheat seeds) to 1.5–2 hours (soybean and lupine suspensions).

A wide range of fractional composition and size of solid particles, as well as a heterogeneity of suspensions are illustrated by a micrograph of drops soybean suspension (Fig. 1). The samples were made by dropping a suspension on a slide and photographed every 5 minutes until the fluid dried out visually. The magnification of objects is 32–400 times.

For obtaining finely-dispersed compositions of plant material a dispersing homogenizer (DH)

Table 8

Distribution of Dry Matter (DM) in Liquid and Solid Phases and Fractional Composition by Solid Particles After Grinding of Swollen Seeds of Soya, Lupine, Amaranth, and Buckwheat in RPM (n =4)

Показник, од. виміру	Shelled soya	Shelled lupine	Amaranth	Buckwheat without glume
DM in suspension, %	10.58 ± 0.20	9.62 ± 0.32	18.33 ± 0.25	10.40 ± 0.18
DM in sediment, %	8.43 ± 0.34	7.49 ± 0.41	16.00 ± 0.31	9.19 ± 0.30
DM in liquid phase, %	2.15 ± 0.19	2.12 ± 0.23	2.28 ± 0.34	1.21 ± 0.21
Quantity of suspension, ml	880 ± 2	890 ± 2	878 ± 2	882 ± 2
Distribution of DM by fractional composition of solid phase, %				
2500–500 µm	15.03 ± 1.26	12.82 ± 1.09	14.64 ± 0.97	4.66 ± 0.41
500–250 µm	30.96 ± 2.60	21.95 ± 1.27	21.95 ± 3.16	17.43 ± 1.51
250–150 µm	26.43 ± 2.21	33.56 ± 2.74	32.78 ± 2.60	39.67 ± 3.83
150–50 µm	21.21 ± 1.79	24.78 ± 3.42	23.18 ± 2.41	27.09 ± 2.49
Less than 50 µm	5.93 ± 0,50	6.71 ± 0.79	6.16 ± 0.39	9.79 ± 0.54

has been designed and manufactured [15, 16]. By principle of its operation, the dispersing homogenizer is similar to the disk colloid mill for wet grinding (interaction of fixed and movable discs) and significantly differs from the already known devices by the following features:

- Formation of suspension layer handled;
- Movement of suspension layer in the chamber;
- regulation of gap between the moving and the fixed disks, which is done sequentially through a mechanism for rough and fine adjustment.

The essence of the design is that the width and the state of flux are regulated not only by the distance between the movable and the fixed discs, but also by specially shaped surfaces of working bodies, which enable processing the emulsions or suspensions and obtaining the dispersions with a particle size of, at most, 0.5 μm. The solid particles suspended in water move between two surfaces with a small gap, with one of discs moving at a high speed relative to the other. It should be noted that in this small gap

Table 9

Particle Size Distribution of Dry Matter (DM) in Solid Phase in Soya Seed Suspensions (%) Depending on Conditions of Treatment and Grinding

Particle size, μm	Масова доля часточок відповідного розміру, %			
	Alkalization		Distilled water	
	Disperser	Primary suspension	Disperser	Primary suspension
Over 500	Сліди	1.3 ± 0.2	Trace	1.9 ± 0.2
500—250	9.45 ± 0.05	15.0 ± 1	11.65 ± 0.04	17.5 ± 1.4
250—150	14.71 ± 0.03	42.5 ± 1.6	17.03 ± 0.07	46.0 ± 2.1
150—50	17.50 ± 0.08	39.8 ± 2.6	23.10 ± 1.02	33.6 ± 2.4
Under 50	58.65 ± 1.07	2.4 ± 0.3	48.3 ± 0.08	1.6 ± 0.3

Table 10

DM Distribution between Liquid and Solid Phases and Fractional Composition by Solid Particle Size (%) in Finely Dispersed Suspensions of Amaranth Seeds Swollen in Environments with Various pH

Parameter, m.u.	*pH* of environment, *pH* units		
	7	7	10
	Capacity of disperser, l/hour		
	79.2	6.8	84.3
Temperature, °C	58	72	55
DM in solid phase, %	21.79 ± 0.16	11.34 ± 0.21	18.39 ± 0.37
DM in liquid phase, %	2.81 ± 0.22	7.29 ± 0.17	4.89 ± 0.28
Particles having a size ranging 500–250 μm, %	3.60 ± 0.28	2.56 ± 0.19	4.87 ± 0.34
Particles having a size ranging 250–150 μm, %	23.43 ± 0.32	14.23 ± 0.23	19.69 ± 0.47
Particles having a size ranging 150–50 μm, %	70.92 ± 0.93	81.33 ± 1.47	73.64 ± 2.23
Before fractionation	2 days	15 days	2 days
Odor	Weak, vegetable		
Color	Grayish		
Taste	Tasteless		

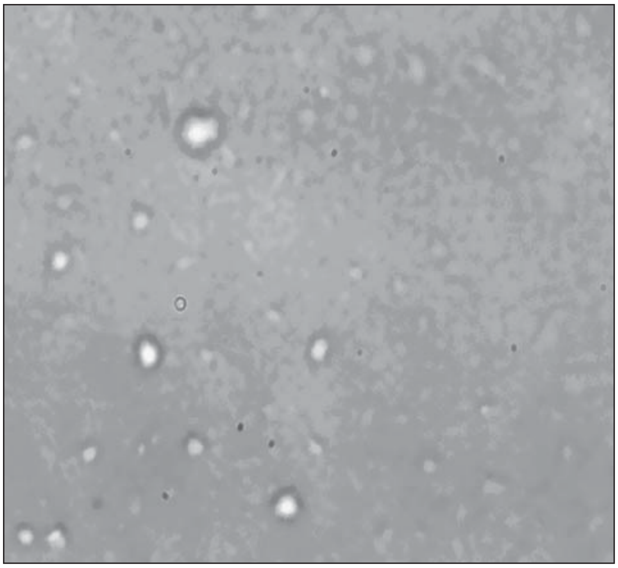

Fig. 2. Micro-picture of a sample taken from suspension obtained in DH from soya seeds swollen in distilled water

Таблиця 11

DM Distribution between Phases and by Particle Size in the Suspension Prepared of Soya and Buckwheat Seed Blend (1:1) Depending on Duration of Treatment in Dispersing Homogenizer (DH)

Parameter, m.u.	Duration of treatment in DH, 5 hours 20 minutes	
	5 min	20 min
Mash ratio (seed : water)	1 : 8	1 : 8
Temperature,°C input→output	15→35	22→65
DM, g/100 cm^3 in aqueous dispersion	10.58 ± 0.26	10.46 ± 0.20
DM in liquid phase, after treatment, %	36.8 ± 3.10	56.5 ± 2.18
DM in solid phase, after treatment, %	61.68 ± 2.64	42.47 ± 1.16
Particle Size Distribution, μm, (%)		
500—250	16.91 ± 1.13	3.16 ± 0.14
250—150	24.70 ± 1.65	6.04 ± 0.27
150—50	57.30 ± 3.90	89.73 ± 4.06

(0.05–0.1 mm), at a linear velocity of flux ranging within 30÷125 m/min, there is a considerable turbulence that stimulates the separation of parts by hydrophilic and hydrophobic properties. So, they act as dispersion stabilizers.

The characteristics of the dispersing homogenizer are as follows:

- The machine works without a pump, with the suspension moving by rotating the movable surface of the working chamber;
- The rotor is driven by an engine having a capacity of 0.7 kW and 3000 rpm;
- Gap between the rotor and the stator surfaces: 500÷3 microns;
- Capacity of DH (mash ratio ranges 1:6÷1:10) depending on the gap between the discs (within 15÷3 μm): 138.5÷3.5 l/h;
- Rotation speed of the moving surface of the working chamber: 50/s^{-1};
- Volume of the working chamber: 0.3 dm^3;
- Dimensions – 175×205×325 mm.

The dispersing homogenizer is designed for the fine grinding and homogenization of the plant material after the initial coarse grinding of swollen seeds (e.g., in RPM). Table 9 contains the characteristics of suspensions obtained using the dispersing homogenizer and in the rotary-pulsation machine.

The results clearly indicate the advantages in grinding capacity of the proposed device: the major part of sediment centrifuged from finely dispersed suspension is represented by particles having a size of 150÷50 microns or less. With the help an independent method using a module for the analysis of nanomaterials and characterization of disperse systems it is established that having been processed in the dispersing homogenizer, over 90% of solid plant material has a particle size of 1000–1500 nm or 3500–4500 nm depending on the swelling conditions (alkaline solution or distilled water, respectively) and the processing conditions (the gap between the working surfaces of homogenizer ranges within 3–15 microns). The improved degree of dispersion in terms of fractional composition of the solid phase in the superfine (processed by DH) and the primary (processed by RPM) suspensions is obvious. Its consequences are confirmed by data on homogeneity (Fig. 2) and high aggregative stability of finely-dispersed suspensions obtained using the dispersing homogenizer (Table 10).

A manifestation of mechanical stress in the chamber of dispersing homogenizer during the processing of roughly crushed seeds in the aquatic environment is an increase in temperature, from an initial suspension temperature of 16–23 °C to 50–80 °C at the outlet of the device. Tables 9 and 10 show that the treatment in DH leads to:

- Decrease in particle size of suspensions;
- Transition of more than 70% of dry matter into the liquid phase;
- Heating of fine dispersions up to 50–85 °C;
- Ensuring of aggregative stability of finely dispersed suspensions for 6–15 days at a temperature of 8–22 °C.

Research on obtaining stable emulsion and suspension compositions of plant material has enabled developing flow chart, hardware, and equipment for the main stages of the process. The process of obtaining stable emulsions and suspensions of plant material in modular design with full specification of basic equipment, as exemplified by soya "milk", consists of the following stages:

- Acceptance and preparation of raw material;
- Washing of soybean seeds;
- Peeling of soybeans;
- Moistening; hydrothermal treatment of soaked seeds;
- Coarse soybean suspension;
- Grinding, dispersing, and homogenization.

The parameters of chemical composition and aggregate stability of the semi-liquid sample obtained from whole soybeans and aquatic environment using the above process (mash ratio 1:8) are presented in Table 11.

Data in Table 11 testify to the reproducibility of laboratory experiments by the basic parameters of variances and show that the loss of dry matter when obtaining the finely dispersed suspensions does not exceed 0.5%.

CONCLUSIONS

1. Available research and technical information on dispersing the plant material and obtaining from it the systems resistant to stratification and consisting of proteins, fats, carbohydrates, and water has been analyzed. The major disadvantages of existing dispersing techniques have been identified. A dispersing homogenizer has been designed on the basis of disk colloid mill. The pilot samples of DH have been produced. The device has enabled obtaining emulsions and suspensions with a particle size less than 0.5 microns from plant material. Technical solutions for dispersing the holistic plant material in an aqueous environment for the production of liquid and pasty foodstuffs based on soybeans, lupine, amaranth, oats, wheat, buckwheat, and roots of Jerusalem artichoke have been developed and implemented.

2. The effect of pretreatment conditions (mechanical and heat treatment, *pH*, temperature, duration) on the fractional composition of suspensions formed in aqueous environment (mash ratio 1:6÷1:9) using Ukrainian-made homogenizers (three modifications of rotary-pulsation machines) has been studied for soybeans, lupine, and amaranth seeds. It has been showed that to obtain in such devices the suspensions of solid particles having a size less than 20 microns is possible only after repeated treatment (5–6 cycles) of maximally swollen seeds of shelled soybeans at a mash ratio of 1:10.

3. The effect of dispersing conditions on the fractional composition of the solid phase and the temperature of suspensions, their organoleptic properties, and stability after the treatment using the existing devices and the proposed dispersing homogenizer. The finely dispersed suspensions of soybean, lupine, and amaranth have been established to show no signs of separation when stored refrigerated (at a temperature of (5÷8) °C) for six days. The suspension of lupine seeds have a strikingly high stability as they can be stored more than 2 months.

4. It has been showed that due to the breaking and shear forces acting on the suspension in the small gap between the working discs of dispersing homogenizer the crushing is accompanied

with an increase in temperature of suspension and removal of the substances that cause smell and taste typical for seeds of leguminous plants. The DH ensures an excellent homogenization that prevents stratification.

5. The process design for manufacturing finely dispersed foodstuffs from whole seeds has been proposed and elaborated. These food products have all useful compounds of the original material, are resistant to stratification for, at least, 5 days, and do not contain stabilizers, preservatives, odorants, colorants, and so on.

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ОТРИМАННЯ І ВЛАСТИВОСТІ ВИСОКОДИСПЕРГОВАНИХ ПРОДУКТІВ З РОСЛИННОЇ СИРОВИНИ

Створено умови маловідхідного перетворення цілісної зернобобової сировини (насіння сої, люпину, амаранту, вівса, пшениці, гречки) у високодисперсні емульсійно-суспензійні рідкі і пастоподібні системи, яким притаманна здатність до агрегативної сталості протягом 5–15 діб без використання стабілізаторів і емульгаторів. Системи мають практично повний набір їстивних, біологічно активних речовин і мінеральних компонентів вихідних рослин.

Ключові слова: агрегативно сталі емульсійно-суспензійні системи, цілісна рослинна сировина, диспергатор-гомогенізатор.

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ПОЛУЧЕНИЕ И СВОЙСТВА ВЫСОКОДИСПЕРГИРОВАННЫХ ПРОДУКТОВ ИЗ РАСТИТЕЛЬНОГО СЫРЬЯ

Созданы условия малоотходного превращения целостного сырья из семян бобовых и зерновых растений (сои, люпина, амаранта, овса, пшеницы, гречихи) в высокодисперсные эмульсионно-суспензионные жидкие и пастоподобные системы, обладающие способностью к агрегативной устойчивости в течение 5–15 и более суток без использования стабилизаторов и эмульгаторов. Системы обладают практически полным набором питательных, биологически активных веществ и минеральных компонентов исходных растений.

Ключевые слова: агрегативно устойчивые эмульсионно-суспензионные системы, целостное растительное сырье, диспергатор-гомогенизатор.

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