Вивчено залежність деформації зсуву емульсії на основі ядра соняшникового насіння від її фізико-хімічних показників. Розраховані структурно-механічні показники емульсії

Ключові слова: структурно-механічні властивості, емульсія, фізико-хімічні показники

Изучена зависимость деформации сдвига эмульсии на основе ядра подсолнечникового семени от ее физико-химических показателей. Рассчитаны структурно-механические показатели эмульсии

Ключевые слова: структурно-механические свойства, эмульсия, физико-химические показатели

The dependence of emulsion on the basis of sunflower seed kernel shear strain on its physical and chemical indices was studied. The structural and mechanical indices of the protein and fat emulsion were calculated

Key words: structural and mechanical indices, emulsion, physical and chemical indices

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THE RESEARCH OF STRUCTURAL AND MECHANICAL PROPERTIES OF EMULSION ON THE BASIS OF SUNFLOWER SEED KERNEL

P.V. Gurskiy
Ph.D., Associate Professor
Department equipment and engineering and food processing industries*

D.O. Biduk
Assistant
Department of technology of processing and food industry
*Kharkiv Petro Vasylenko National Technical University of Agriculture
44, Artem Street, 44, Kharkov, 61002
Contact tel.: +38 093-481-80-16

F.V. Pertsevoy
Doctor of Technical Sciences, Professor
Department of Food Technology*

A.A. Kolesnyk
Ph.D., Associate Professor
Department of foreign languages
*Kharkiv State University of Food Technology and Trade
333, Klochkovskaya Street, Kharkov, 61051

Formulation of the problem and its relationship with important scientific and practical items

The experience of valuable and accessible diet creation problem solving testifies to the possible ways of the use of sunflower and protein products of its processing in composition of the new food products. In the vegetable world this agricultural culture is characterized by the high contain of protein (16...19%), which is balanced on amino acid composition, fat (64...66%), which contains polyunsaturated fatty acids, and also wide spectrum of vitamins and minerals [1–4].

The creation of technologies of the combined products with vegetable origin protein production corresponds to the domestic conception of healthy diet, allows solving the problems of the animal origin raw material rational processing and effective use of high biological and nutritional value and functional and technological properties of sunflower proteins [1–4].

Analysis of the research and publications

Use of oil raw material protein products, primarily the sunflower, in food technologies is well known. Both domestic (V. G. Sherbakov, V. N. Krasilnikov, T. T. Shakirov) and foreign (F. Sosulski, K. Leelavathi, L. Talley, G. Sodini) scientists were engaged in the problems of their use [3; 9; 10].

As literature analysis shows, the involving of whole sunflower seed kernels in food production is less studied, but no less perspective. Traditionally sunflower seeds of oil-bearing sorts are used for sunflower-seed oil producing; the pastry type of sunflower is used for halva, nuts-and-honey bar nuts substitute production. The modern technologies of use of sunflower seed kernels for short pastry, ice-cream, lean mayonnaise production are known [4–6].

The technology of emulsion on the basis of sunflower seed kernel for its use in composition of the new food products as vegetable filler was elaborated by us. Possibility of the emulsion use depends on its properties, foremost, on structural and mechanical properties; it causes the necessity of structural and mechanical properties studding.

Structural and mechanical properties of emulsion systems are closely linked to molecular co-operations in them, to the features of structure and heat motion of their structural elements, to co-operation of these elements one with other and to the molecules of dispersion environment.

The purpose of the experiment was:

- study the structural and mechanical properties of the emulsion sunflower seed kernels that containing different amounts of crushed kernels and vegetable oil, to determine the rational range of concentrations of the major components in the prescription;
- identification quasi-instantaneous of the elastic modulus and rise to the emulsion's elastic modulus with over a range of concentrations of vegetable oil;
- establishing the kinetics of elasticity, plasticity and elasticity of the emulsion in the range of concentrations of the major components in the prescription;

The presentation of the basic research of the material

The emulsion samples with different physical and chemical indices are subjects of research. Emulsion was prepared by grinding the sunflower seed kernel with mass fraction of solids 40, 50 and 60%, addition of sunflower refined deodorized oil in amount 0, 50 and 100% and pH values 3,9...4,1. The influence of protein and fat mass fraction (table 1) on structural and mechanical properties of emulsion was determined in the samples (table 2).

Table 1

Physical and chemical indices of emulsion

№ of the sample	Vegetable oil mass fraction, % to the mass of grinding kernel	Solids mass fraction of grinding kernel, %	Substances mass fraction in emulsion, %			Correlation protein : fat
			Solids	Protein	Fat	
1	0	40,0 ± 0,8	40,0 ± 0,8	7,81 ± 0,16	29,51 ± 0,59	0,264
2	0	50,0 ± 1,0	50,0 ± 1,0	9,79 ± 0,20	36,88 ± 0,74	0,265
3	0	60,0 ± 1,2	60,0 ± 1,2	11,81 ± 0,24	44,32 ± 0,89	0,266
4	50	40,0 ± 0,8	60,0 ± 1,2	5,19 ± 0,10	53,01 ± 1,06	0,098
5	50	50,0 ± 1,0	66,7 ± 1,3	6,49 ± 0,13	57,89 ± 1,16	0,112
6	50	60,0 ± 1,2	73,3 ± 1,5	7,91 ± 0,16	62,92 ± 1,26	0,126
7	100	40,0 ± 0,8	70,0 ± 1,4	3,89 ± 0,08	64,62 ± 1,29	0,060
8	100	50,0 ± 1,0	75,0 ± 1,5	4,88 ± 0,10	68,48 ± 1,37	0,072
9	100	60,0 ± 1,2	80,0 ± 1,6	5,92 ± 0,12	72,21 ± 1,44	0,082

The analysis of physical and chemical indices of the systems showed that the addition of refined deodorized vegetable oil in amount of 100% to the grinding kernel with initial solids content 40,0 ± 0,8, 50,0 ± 1,0 and 60,0 ± 1,2% causes the increase of fat mass fraction to 1,6...2,2 times - within the limits of 29,51...64,62%, 36,88...68,48%, 44,32...72,21% and reduce protein content in 2 times within the limits of 7,81...3,89%, 9,79...4,88% and 11,81...5,92% accordingly. The solids content increases and it is in the interval 40,0...80,0%.

The analysis of table data shows that at addition of vegetable oil 100% the correlation of protein : fat changes from 0,264...0,266 for samples without vegetable oil to 0,060...0,082 at addition of oil 100% to mass of the grinding kernel. Thus this correlation increases toward the solids mass fractions increase in terms of addition of the fixed amount of vegetable oil. In other words, the emulsion becomes more concentrated on fat as the dispersible phase and less concentrated on protein as its stabilizer.

Structural and mechanical properties were determined by plane-parallel elastoplastometer of D.M Tolstoy. Shear deformation of emulsion which was placed between plates, one of which is immobile metallic, other is mobile from organic glass, was studied. The measuring method is based on shear deformation determination, attributed to the thickness of sample at permanent tension. As a rule, not deformation, but pliability, is the measure of process that is the deformation attributed to constantly operating tension. The pliability in terms of the linear character is constant and does not depend on tension. Experimental data were expressed as the creep curves and the correlation of relative deformation from tension action time $\gamma = f(\tau)$ was graphed (fig. 1-3) [7; 8].

The kinetics of creep curves of emulsion standards with solids content 40,0...80,0% without vegetable oil (curves 1–3) and with its in amount 100% from the mass of the grinding kernel (curves 4–9) with solids content 40,0...60,0% is presented on the fig. 1–3.

The most fluid samples are 1, 4 and 7 with general deformation (213,2...256,4) × 10^{-3} at solids content 40, 60 and 70% accordingly as we can see from the data of fig. 1–3 and table 2. In spite of solids content increase in the examined row as compared to 1 sample in 1,50...1,75 times the growth of general deformation of the samples takes place only in 1,08...1,20 times. In other words, the addition to emulsion of vegetable oil in amount 100% from mass of the grinding kernel increases solids content in the system that is insignificantly reflected on its fluidity.

The analogous dependence is observed for curves 2–5–8 and 3–6–9, general deformation of which is (21,6...23,8) × 10^{-3} and (13,0...13,9) × 10^{-3} accordingly. The analysis of the functions shows that mass fraction of grinding kernel solids has an influence on the fluidity of the emulsion samples. So, the decrease of this index for samples with vegetable oil and without it in an interval 60,0...50,0% causes the insignificant increase of general deformation – from (13,0...13,9) × 10^{-3} to (21,6...23,8) × 10^{-3}, while the reduce of solids contain to 40,0% causes the spasmodic increase of samples fluidity, it is evident from the fig. 1–3 at comparison of curves 1–3, 4–6 and 7–9.

Structural and mechanical characteristics which are presented in table 2 were calculated by the results of emulsion deformation kinetics investigation.

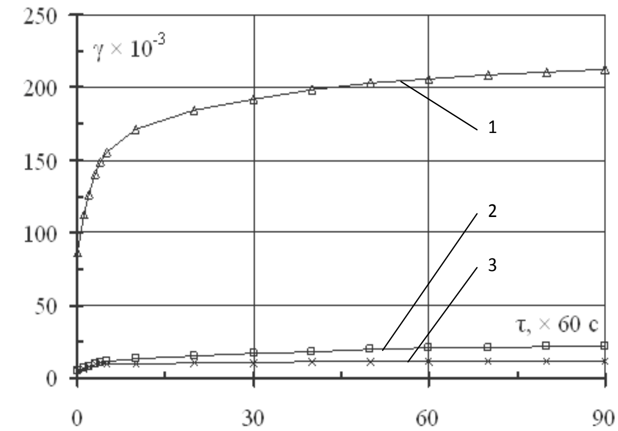

Fig.1. Kinetics of creep curves of emulsion samples with solids content: 1 – 40,0%, 2 – 50,0%, 3 – 60,0% without vegetable oil

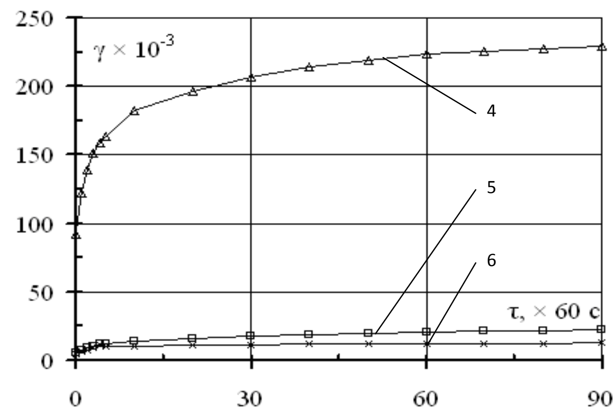

Fig. 2. Kinetics of creep curves of emulsion samples with solids content: 4 – 60,0%, 5 – 66,7%, 6 – 73,3% with 50% of vegetable oil

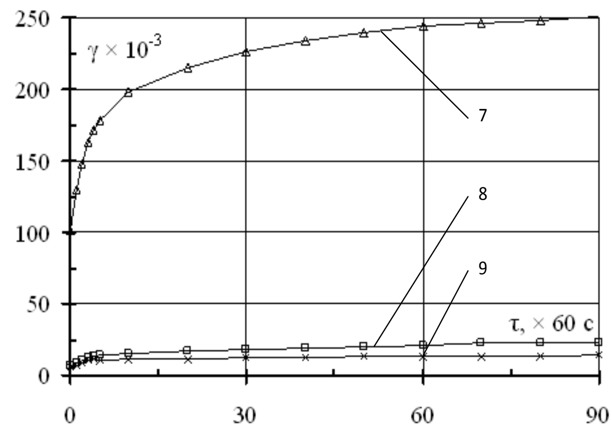

Fig. 3. Kinetics of creep curves of emulsion samples with solids contain: 7 – 70,0%, 8 - 75,0%, 9 – 80,0% with 100% of vegetable oil

The analysis of table 2 data shows that the conditionally instantaneous modulus of resiliency and high-elasticity modulus of samples reduces at the increase of vegetable oil mass fraction in the emulsion and at the decrease of the grinding kernel solids content.

The increase of grinding kernel solids content with vegetable oil and with it in an interval 50,0...60,0% causes the considerable compression of emulsion structure because of viscosity increase, that prevents to the process of its forming. The table 2 data show that samples with solids content 60% without vegetable oil and with its in amount 100% from the grinding kernel mass have maximal plastic viscosity. Extra adding of vegetable oil in amount 50 and 100% is causes viscosity reducing from 827,7 × 10^6 Pa × s to 588,6 × 10^6 and 545,1 × 10^6 Pa × s, i.e. on 28,9 and 34,1%.

The data analysis of correlation of viscosity values from solids content of samples without vegetable oil and with it shows that this index reduces in 3,5...4,4 times at the reducing of solids content to 50,0% and in 12,0...14,8 times at the reducing to 40,0%.

Table 2

Structural and mechanical characteristics of emulsion with different amount of vegetable oil and mass fraction of grinding sunflower seed kernel

Indices	Mass fraction of vegetable oil, % / Mass fraction of grinding kernel solids, %								
	0			50			100		
	60,0	50,0	40,0	60,0	50,0	40,0	60,0	50,0	40,0
Reversible deformation, × 10^{-3}	11,68	16,00	195,64	11,75	16,37	209,42	11,94	16,82	227,64
Irreversible deformation, × 10^{-3}	1,28	5,60	17,60	1,80	6,30	21,60	1,94	7,00	28,80
General deformation, × 10^{-3}	12,96	21,60	213,24	13,55	22,67	231,02	13,88	23,82	256,44
Shear stress, Pa	196,20	196,20	196,20	196,20	196,20	196,20	196,20	196,20	196,20
Pliability, Pa^{-1}, × 10^{-3}	6,61	11,01	108,69	6,90	11,55	117,75	7,08	12,14	130,71
Conditional instantaneous modulus of resiliency, Pa	45045,92	42042,86	2287,31	40717,44	33957,69	2092,18	36904,36	28480,65	1919,35
High-elasticity modulus, Pa	26787,01	17311,76	1785,80	28319,48	18528,86	1696,58	29631,30	19751,68	1564,32
Plastic viscosity, Pa × s, × 10^6	827,72	189,19	60,20	588,60	168,17	49,05	545,11	151,35	36,79
Ratio of reversible deformation to general deformation	0,90	0,74	0,92	0,87	0,72	0,91	0,86	0,71	0,89
Viscosity of elastic aftereffect, Pa × s, × 10^5	77,22	77,90	5,82	76,06	70,63	5,52	73,99	64,60	4,91

Continuation of Table 2

Relative resiliency, %	40,59	33,61	21,60	40,23	35,57	25,49	39,86	38,30	28,92
Relative plasticity, %	8,25	9,88	25,93	9,35	13,29	27,79	11,23	14,00	29,38
Relative elasticity, %	56,52	52,47	51,52	51,14	50,06	46,72	48,91	47,70	41,70
Relaxation period, s	49275,00	15428,57	60027,27	35240,00	14028,57	52355,56	33167,44	12977,14	42683,33

Results of calculations of relative plasticity, elasticity and resiliency confirm that the reducing of grinding kernel solids content of the emulsion without oil and with it in an interval 40,0...60,0% increases relative plasticity of emulsion on 17,7...18,4%, the indices of relative resiliency and elasticity reduce on 10,9...18,6% and 4,4...7,2% accordingly. The addition of vegetable oil in amount 100% for the samples of emulsion with solids content of the grinding kernel 40,0, 50,0 and 60,0% stipulates the increase of plastic properties within the limits of 3,0...3,5%, the reduce of resilient and elastic properties – 0,7...7,3% and 7,6...9,8% accordingly.

Conclusions

It is established that the use of sunflower seed kernel stipulates the possibility of PFE receipt on its basis with the wide spectrum of physical and chemical and structural and mechanical indices for its use as vegetable filler in technologies of the new food products. So, the samples of emulsion with protein contain about 3,89...11,81% are characterized by high fat contain – 29,51...72,21%, it allows to regulate its SMP in considerable limits.

The reduce solids contain in grinding sunflower seed kernel without vegetable oil and with it in amount of 60,0...40,0% stipulates spasmodic change of structural and mechanical indices. The adding of vegetable oil in amount of 100% to the samples of the emulsion with the fixed value of the grinding kernel S stipulates the less expressed change of structural and mechanical indices.

Reduction of particulate solids emulsion nuclei without oil and with it a range of 40,0...60,0% increase relative plasticity of the emulsion, the indicators of the relative elasticity decreases.

The increase of oil in the emulsion causes the increase of plastic properties, reducing the elastic and elastic properties.

In the production of emulsions efficient use of protein-based fat mass fraction of solids shredded core 50% with the addition of vegetable oil to 100% of its mass.

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