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Justification Of The Technology And Parameters For Producing Modified Soy Flour.

Irina Vasilyevna Bibik*, Sergei Mikhailovich Dotsenko, and Igor Viktorovich Agafonov.

Far East State Agricultural University, Polytechnic str., 86, Blagoveshchensk 675005, Russia.

ABSTRACT

This article provides scientifically based data on feedstock and components, as well as a methodological approach necessary for designing the technology of producing flour for use as an additive in enriched food systems of the functional orientation of an expanded range.
Keywords: justification, technology, flour, process, suspension, coagulant, scheme, design, food system, functional orientation.

**Corresponding author*

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INTRODUCTION

Consideration of the range of functional foods in the Russian Federation is one of the strategic objectives set by the government of the country in the field of healthy eating [1]. At the same time, the basis of this strategy should be the rational use of raw materials in food technology [2].

The purpose of the research is the development of technology of modified soybean flour for use in food systems of a functional orientation.

Research tasks:

- justify the methodological approach to obtaining a given composition of the developed type of flour;
- to obtain mathematical models for the preparation of flour in the form of adequate regression equations, allowing to justify the parameters of innovative technology;
- develop a technological scheme for the production of modified soy flour with the required quality indicators.

MATERIALS AND METHODS

The studies were carried out on the basis of soybean ginger and soybean citrus suspensions obtained by grinding the presoaked soybean seeds and particles of fresh ginger or citrus peel in a ratio of 1: 1 in saline water. Under the same regimes and ratios, soya citrus suspension was prepared.

The biochemical composition and the energy value of the raw materials, ready-made suspensions are presented in table 1.

Table 1: Biochemical composition and energy value of raw materials, ready-made suspensions and coagulant

Product	Mass fraction of basic substances, %							Vitamins, mg / 100 g			Bio-flavonoids in terms of rutin	Energy value, kcal / 100 g
	water	proteins	lipids	carbohydrates	cellulose	minerals	organic acids	C	E	β-carotene		
Soybean seeds varieties "Lazurnaya"	12,3	39,0	17,5	20,0	5,0	6,1	-	-	8,3	1,2	450	414,4
Ginger*	78,9	8,9	0,7	10,8	2,0	0,7	0,5	5,0	0,26	-	25,0	80,0
Mandarin peel *	42,0	0,1	1,2	52,5	4,2	2,2	0,1	130	-	12,5	0,28	226,8
Orange peel *	43,0	0,1	2,4	49,9	4,4	2,0	0,2	170	-	0,3	0,2	217,2
Soybean ginger suspension *	85,2	5,5	1,5	6,7	1,1	2,5	-	65	1,6	-	25,0	66,7
Soya-citrus suspension *	85,1	5,4	1,4	7,2	1,9	2,6	-	80	1,7	-	25,0	70,6
Berry-acid complex on lingonberry pulp	86,9	-	0,8	9,0	3,3	2,2	1,5	150	-	-	27,0	56,4
Berry-acid complex on blueberry pulp	87,5	-	0,7	9,5	3,2	2,3	1,4	150	-	-	29,0	58,7

* data from the source [3].

In the process of research, the processes of soy protein isolation and its precipitation in suspensions - soybean ginger and soybean citrus protein-carbohydrate dispersed systems were studied. Analysis of numerous studies shows that the most preferable from the point of view of obtaining and isolating protein substances from soybean seeds, as well as other physiologically functional food ingredients (PFFI), is the process of their extraction from previously germinated soybean seeds to a certain seedling length [2, 4 - 6].

The use of a berry-acid complex as a coagulant allows one to exclude the loss of serum and obtain a colored protein-carbohydrate coagulum containing significant concentrations of PFFI in the form of vitamins and flavonoids.

RESULTS AND DISCUSSION

On the basis of the conducted exploratory experiments, it was established that the process of precipitation of soy proteins, by its thermo-acid coagulation, is characterized by the formation (agglomeration) of protein particles of a certain mass and size, which are subsequently precipitated by gravity. In this regard, when studying the process of protein coagulation, it was found that the mass of the formed protein particles of M_p depends on the active acidity of the liquid fraction - pH, the concentration of solids in the berry-acid complex solution, and the temperature of the dispersed medium - soy protein-vitamin suspension.

Figures 1 and 2 show the dependence of the coagulation duration t_K on the mass fraction M_g% of dry substances in the berry-acid complex.

Analysis of the kinetics of structure formation in soybean ginger protein-carbohydrate dispersed system using an accepted coagulant shows that the process of thermo-acid coagulation of proteins in the soybean ginger protein-carbohydrate system lasts for 4.0 minutes.

Table 2 presents the composition of the products obtained.

Coefficients and graphs of equations.

Equation has the form: $$Y = (A - B \cdot \mathrm{e}^{-CX})$$

$$X = D - F \cdot \ln(A - Y)$$

Coefficient A before 4,013; Coefficient A final 4,002;
Coefficient B before 3,913; Coefficient B final 3,922;
Coefficient C before 0,224; Coefficient C final 0,184.

$$t_K = (4{,}02 - 3{,}92 \cdot \mathrm{e}^{-0{,}18Mg})$$

$$Mg = 32{,}5 - 5{,}4 \cdot \ln(4{,}02 - 100t_K)$$

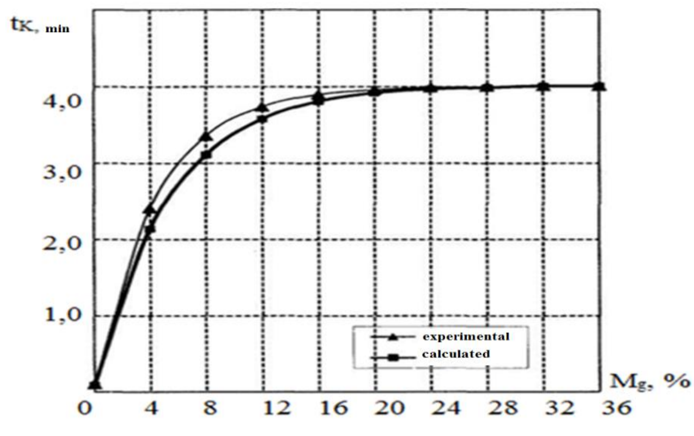

Figure 1: Dependence of the duration of coagulation of protein substances t_K on the mass fraction of the berry-acid complex M_g (lingonberry and cranberry) for soybean ginger suspension

Coefficients and graphs of equations.

Equation has the form: $$Y = (A - B \cdot e^{-CX})$$

$$X = D - F \cdot \ln(A - Y)$$

Coefficient A before 4,016; Coefficient A final 4,026;
Coefficient B before 3,916; Coefficient B final 3,926;
Coefficient C before 0,207; Coefficient C final 0,229;

$$t_K = (4{,}03 - 3{,}93 \cdot e^{-0{,}23Mg})$$

$$Mg = 26{,}1 - 4{,}4 \cdot \ln(4{,}03 - 100 t_K)$$

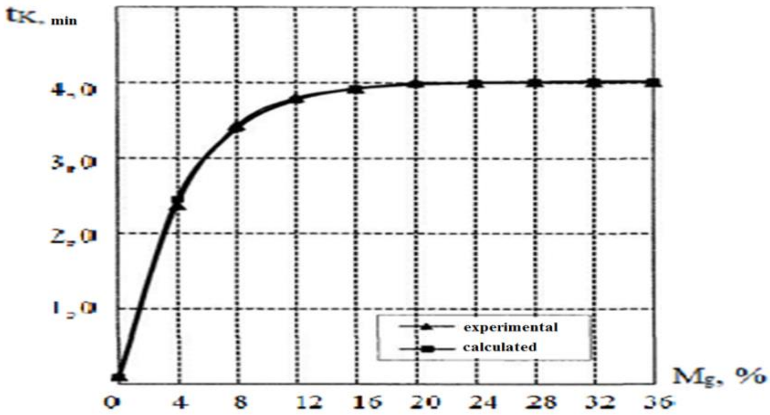

Figure 2: Dependence of the coagulation duration of tK protein substances on the mass fraction of the berry-acid complex Mg (blueberries and blackberry) for soybean citrus suspension

Table 2: Biochemical composition and energy value of protein-vitamin-carbohydrate and protein-vitamin-mineral products

Product	Mass fraction of basic substances, %						Vitamins, mg / 100 g			Bio-flavonoids in terms of rutin	Energy value, kcal / 100 g
	water	proteins	lipids	carbohydrates	cellulose	minerals	C	E	β- carotene		
Soya-ginger-berry composition	53,0	14,3	5,2	20,0	4,3	3,2	150	2,4	-	24,3	202
Soya-ginger-berry serum	92,2	1,0	0,5	5,3	0,5	0,5	150	0,5	-	16,8	31,7
Soya-citrus-berry composition	54,0	14,0	5,7	19,0	3,7	3,6	145	2,8	-	21,8	198,1
Soya-citrus-berry serum	92,0	1,1	0,5	5,4	0,5	0,5	144	0,5	-	17,4	32,9

On the basis of the developed approaches, the most significant factors of the process affecting the organoleptic characteristics of soybean ginger and soybean and citrus flour are identified by prior ranking.

Three factors were identified as the main ones for obtaining flour: the mass fraction of the additive (ginger and citrus peel) - M_d,% (X_1); granule diameter - d_g, mm (X_2); drying temperature - t, °C (X_3) (Table 3).

The organoleptic assessment is accepted as the optimization criterion - N_{11-12}, points (Y_{11-12}).

As a result of exploratory experiments, the levels of variation by the indicated factors are determined. Table 3 presents the process factors and their variation levels.

Table 3: Factors and levels of variation for the flour production process

Levels	Factors		
	X_1 / M_d, %	X_2 / d_g, мм.	X_3 /t, ^{0}C
Top level (+)	75,0	3,0	100,0
Main level (o)	50,0	2,0	80,0
Lower level (-)	25,0	1,0	60,0
Variation Interval (E)	25,0	1,0	20,0

After the implementation of the experiment on the planning matrix and data acquisition, they were processed, Table 4-5.

Table 4: Regression dependence analysis Y_{11-12}=f(X_1,X_2,X_3)

Criterion	Standard deviation	R-correlations	Coefficient of determination R^2	F- criterion	Significance of F-criterion (p)
Y_{11}→ *max*	0,47	0,976	0,952	11,11	0,008
Y_{12} → *max*	0,54	0,974	0,950	10,58	0,009

Table 5: Regression analysis results

Criterion	a_0	a_1	a_2	a_3	a_{12}	a_{13}	a_{23}	a_{11}	a_{22}	a_{33}	Conclusion on adequacy	
											F_R	F_T
Y_{11}	22,32	-	0,57	0,38	0,37	0,62	0,37	-0,71	-1,05	-1,02	11,11	3,59
Y_{12}	22,84	-0,74	-	-	0,12	0,37	0,12	-0,84	-0,85	-1,79	10,58	3,59

On the basis of the mathematical processing of experimental data, obtained mathematical models that characterize the process of making flour, which, after sifting out insignificant coefficients, obtained the following form:

– in coded form:

$$Y_{11} = 22{,}32 + 0{,}57 \cdot X_2 + 0{,}38 \cdot X_3 + 0{,}37 \cdot X_1 \cdot X_2 + 0{,}62 \cdot X_1 \cdot X_3 + 0{,}37 \cdot X_2 \cdot X_3 -$$
$$- 0{,}71 \cdot X_1^2 - 1{,}05 \cdot X_2^2 - 1{,}02 \cdot X_3^2 \rightarrow \max$$
$$Y_{12} = 22{,}84 - 0{,}74 \cdot X_1 + 0{,}12 \cdot X_1 \cdot X_2 + 0{,}37 \cdot X_1 \cdot X_3 + 0{,}12 \cdot X_2 \cdot X_3 -$$
$$- 0{,}84 \cdot X_1^2 - 0{,}85 \cdot X_2^2 - 1{,}79 \cdot X_3^2 \rightarrow \max$$

– in decoded form:

$$N_{11} = 5{,}93 + 2{,}54 \cdot d_g + 0{,}33 \cdot t + 0{,}01 \cdot M_d \cdot d_g + 0{,}07 M_d \cdot t + 0{,}02 \cdot d_g \cdot t - 0{,}001 \cdot M_d^2 -$$
$$-1{,}05 \cdot d_g^2 - 0{,}002 \cdot t^2 \rightarrow \max;$$

$$N_{12} = -7,01 + 0,03 \cdot M_d + 2,67 \cdot d_g + 0,67 \cdot t + 0,005 \cdot M_d \cdot d_g + 0,006 \cdot d_g \cdot t -$$
$$-0,001 \cdot M_d^2 - 0,84 \cdot d_g^2 - 0,004 \cdot t^2 \to \max;$$

The adequacy of the models obtained, according to the results of the regression analysis, with a probability of P = 0.95, with correlation coefficients R_{11} = 0.976 and R_{12} = 0.974 is confirmed by the inequality $F_R > F_T$ (table 5).

Table 6 shows the areas of extreme values of the factors X_1, X_2 and X_3, in which Y_{11} and Y_{12} tend to the maximum value.

Table 6: Extreme value areas

Criterion	X_1 / M_d	X_2 / d_g	X_3 /t	Y_{11-12} / N_{11-12}
$Y_{11} \to max$	0,23/6,50	0,37/1,86	0,31/20,34	22,5/23,0
$Y_{12} \to max$	0/1,91	0/1,89	0/68,81	22,8/23,0

Table 7 presents data on the chemical composition and energy value of modified soybean flour.

Table 7: Biochemical composition and energy value of the additive in the form of soybean-modified flour
$$(\bar{X} \pm m;\ p \leq 0,05)$$

Product	Mass fraction of basic substances, %						Vitamins, mg / 100 g			Energy value, kcal / 100 g
	water	proteins	lipids	carbohydrates	cellulose	minerals	C	E	Bio-flavonoids in terms of rutin	
Flour protein-vitamin-carbohydrate	8 - 10	19,4 - 20,5	8 - 9,2	40 - 42,2	8 - 10,5	7 - 8,7	100,0	5,8	24,3	371,2

By tasting it was established that the developed types of modified soy flour have an attractive appearance and color, fairly good taste and aromatic characteristics.

On the basis of the conducted research, a technological scheme (Figure 3) for the preparation of an additive in the form of soybean ginger and soybean citrus flour has been developed.

Thus, studies have established the optimal formulation, parameters and modes of the process of obtaining modified soybean ginger berry and soy citrus berry flour, as well as to develop the technology for their production.

Additive in the form of soy-protein-carbohydrate flour must comply with the requirements of the standard of the organization and be produced according to the technological instruction approved in the prescribed manner, in compliance with sanitary norms and rules for food industry enterprises.

In terms of physico-chemical parameters, the additive in the form of soy protein-carbohydrate flour should meet the requirements specified in Table 8.

Table 8: Physico-chemical indicators of protein-vitamin-carbohydrate supplements in the form of flour

Name of the indicator	Norm
Humidity,%, not more	10,0
Protein,%, not less	19,0
Fat,%, not more	5,0
Carbohydrates,%, not more	56,4
Mineral substances,%, not more than	4,2
Energy value, kcal / 100 g	368,1-393,66
Grind size: residue in%, no more than sieve number 35	2
Pass,%, at least on the screen number 43	70

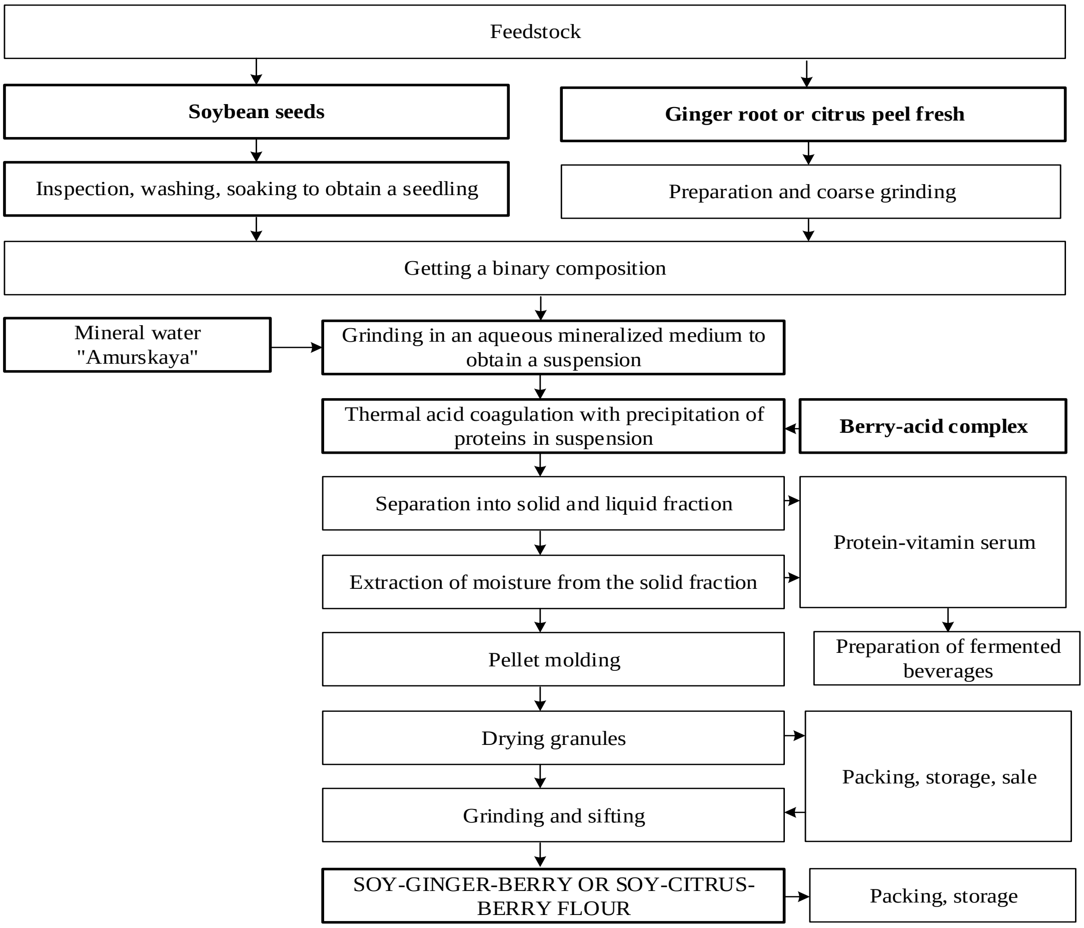

Figure 3: Technological scheme of the production of modified soybean ginger and soya citrus flour

Organoleptic protein-vitamin-carbohydrate flour should meet the requirements specified in table 9.

Table 9: Organoleptic indicators of protein-vitamin-carbohydrate flour

Name of the indicator	Characteristic
Appearance and color	Uniform powdery loose mass, without lumps, brown.
Taste and smell	A pleasant nutty taste and smell, without foreign tastes and odors.
Mineral impurities	When chewing flour moistened with water, should not be felt crunch.

CONCLUSION

Through a scientifically based approach, the necessary data were obtained, which allow, on the basis of protein-carbohydrate-mineral compositions and berry-acid complex, to obtain coagulates of a given composition and properties for the subsequent preparation of modified soybean flour.

On the basis of mathematical modeling, rational parameters of innovative technology for the production of flour are substantiated, which can be used as an additive in functional food systems.

The totality of the obtained data, as well as the developed production scheme can be used in the design of enriched food systems of a functional orientation.

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