JUSTIFICATIVA EXPERIMENTAL DO RENDIMENTO DE PROTEÍNA DE SOJA NO EXTRATANTE DURANTE O ESMAGAMENTO DO GRÃO DE SOJA NA FORMA ENCHARCADA**EXPERIMENTAL STUDY OF THE YIELD OF SOY PROTEIN IN THE EXTRACTANT WHILE THE ABRASION-RESISTANT SOYBEANS IN SOAKED FORM****ЭКСПЕРИМЕНТАЛЬНОЕ ОБОСНОВАНИЕ ВЫХОДА СОЕВОГО БЕЛКА В ЭКСТРАГЕНТ ПРИ ИСТИРАНИИ ЗЕРНА СОИ В ЗАМОЧЕННОМ ВИДЕ**KLASNER, Georgy Georgievich^{1*}; SPIRIDONOV, Alexandr Maximovich²

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RESUMO

Atualmete cada agricultor se depara com a tarefa de fornecer ao seu gado alimentos de alta qualidade que contribuam para asua saúde e crescimento rápido. Também é do conhecimento geral que as grandes propriedades têm mais oportunidades de implementar seus projetos e colocar em operação novas tecnologias e dispositivos. O dispositivo apresentado possibilita a obtenção de um produto de transformação de grãos de soja em leite de soja, queijo de soja "tofu", ou em uma base protéica de soja para preparação de rações para animais de fazenda e aves em pequenas propriedades. Este artigo explica o método experimental para encontrar os valores ótimos da velocidade de rotação do disco móvel, a temperatura do extrator, a lacuna entre os discos móvel e estacionário do triturador e a proporção do hidromódulo. Os valores ideais são aqueles que contribuem para o máximo rendimento de extração de proteína. Fatores experimentais: temperatura ambiente de 17 °C a 22 °C, pressão barométrica de 93325 PA a 96658 PA, umidade relativa de 65% a 85%. A extração de proteínas em uma emulsão é baseada nas propriedades físicas e químicas da difusão de compostos orgânicos dissolvidos, tendo a água como extratante. Como resultado, foram encontrados métodos para a produção eficaz de proteína de grãos de soja, o que pode aumentar o rendimento da suspensão para 24-28 Gr. Esta é a maneira mais eficiente de produzir proteína para modificação da alimentação usando este dispositivo.

Palavras-chave: *soja embebida em grão, abrasão de grão, curva de run-out, característica mecânica.*

ABSTRACT

Nowadays, every farmer is faced with the task of providing their livestock with high-quality food that will contribute to their rapid growth and health. It is also common knowledge that large farms have more opportunities to implement their projects and put new technologies and gadgets into operation. The presented device makes it possible to obtain a product of processing soy grain into soy milk, soy cheese "tofu", soy protein base for preparing feed for farm animals and poultry in small farms. This article explains the experimental method for finding the optimal values of the speed of rotation of the movable disk, the temperature of the extractant, the gap between the movable and stationary disks of the shredder, and the ratio of the hydromodule. Optimal values are those that contribute to the maximum protein yield. Experimental factors: ambient temperature from 17°C to 22 °C, barometric pressure from 93325 PA to 96658 PA, relative humidity from 65% to 85%. Protein extraction in an emulsion is based on the physical and chemical properties of the diffusion of dissolved organic compounds, with water as the extractant. As a result, methods have been found for the effective production of protein from soy grains, which can increase the yield of the suspension to 24-28 Gr. This is the most productive way to produce protein for feed modification using this device.

Keywords: *soybean soaked in the grain form, grain abrasion, run-out curve, mechanical characteristic.*

АННОТАЦИЯ

В наше время перед каждым фермером стоит задача давать своему поголовью качественное питание, которое будет способствовать их скорому росту и здоровью. Также, общеизвестно, что большие хозяйства имеют больше возможностей для реализации своих проектов и введения в эксплуатацию новых технологий и гаджетов. Представленное устройство позволяет получать продукт переработки зерна сои в соевое молоко, соевый сыр "тофу", соевую белковую основу для приготовления кормов для сельскохозяйственных животных и птицы в условиях небольших ферм и хозяйств. В данной статье разъяснён экспериментальный метод нахождения оптимальных значений скорости вращения подвижного диска, температуры экстрагента, зазора между подвижным и неподвижным дисками измельчителя, соотношения гидромодуля. Оптимальными значениями считаются те, что способствуют максимальному выходу белка. Факторы проведения экспериментов: температура окружающей среды от 17°C до 22 °C, барометрическое давление от 93325 Па до 96658 па, относительная влажность воздуха от 65% до 85%. Экстракция белка в эмульсии основана на физико-химических свойствах диффузии растворенных органических соединений, в качестве экстрагента выступает вода. В результате найдены методы эффективного получения белка из соевого зерна, с помощью которых можно повысить выход суспензии до 24-28 гр. Это наиболее продуктивный способ выработки белка для модификации кормов с помощью данного доступного устройства.

Keywords: соевые бобы в замоченной форме, измельченное зерно, кривая биения, механические характеристики.

1. INTRODUCTION

That soya is a significant supplier of vegetable protein, while the soy is rich in essential composition and content of amino acids, and feed value reaches of 1.45 units (Bortnikov, S. 2005. efficiency of using full-fat extruded soy / S. Bortnikov // Mixed fodder.- - No. 1.- Pp. 51-52.). Soy is a typical crop and is used both in pure form after treatment and in animal feed for feeding almost all farm animals. The main value of soybean in comparison with other forage crops is the lowest cost protein, which composition is an analog to expensive animal protein (Dotsenko S.M., Tilba V.A., Skripko O.V. 2012. Problems of the Soya Processing for Food. Food Manufacturing Industry. No. 7, Pages 18-21.).

Scientists come to a consensus that the most promising direction for the preparation of soybeans for feeding to agricultural animals is a liquid preparation of the protein suspensions, which is soy milk, which by its biological value, is not inferior to the whole, cow milk (Baturin, A. K. 2006 Chemical composition and energy value of food products: Handbook of Mccans and Widdowson. under the General editorship of A. K. Baturin. Saint Petersburg: Profession, - 416). However, the use of soybeans in the diet of farm animals in the conduct of personal subsidiary farm or small farm animals is not large, in the absence of a universal small-sized and low

power consuming equipment for processing grain for animal feed.

Thus, there is a need to develop a universal technology of preparation of a protein emulsion applicable in the conditions of private farming.

In this regard, the purpose of this research is the justification of constructive-regime parameters of the chopper soaked soybeans to improve the efficiency of the cooking process of protein-rich feed.

2. MATERIALS AND METHODS

The analysis of methods of processing soybeans to prepare soybean fundamentals has shown that using crushed dry grain more finely ground (0,35 to 0,5 mm) is the most significant yield of protein extraction because processing technology "dry method" (energy-intensive, their use for small volumes of production in the livestock enterprises of small farms are not economically profitable. The energy consumption of the grinding process can be reduced if its strength is reduced by pre-soaking "wet method" (Frolov V.Ju., Sysoev D.P., Klasner G.G. 2015. Optimization of Parameters of the Chopper of the Soaked Soya Grain No.3. P 24-25. Farm Machinery Operator; M. SH. Begeulov, 2006 sh. Fundamentals of soy processing. M.: Delhi print). To implement the processes of the preparation of food products based on soybeans (substitute for

whole milk, curd and whey, and add insoluble soy residue in concentrated feed, with the aim increase their nutritional value) the technological scheme (Figure 1) waste-free production.

Was made a prototype (Figure 2), which conducted a series of multi-factorial experiments with the aim of experimental substantiation of constructive-regime parameters of the chipper.

A priori ranking of the factors concerning previously conducted research allowed to identify the most relevant factors (Table 1).

The study was divided into two phases and was carried out on the experimental setup chopper soaked soybeans in laboratory and production conditions:

- the first stage was conducted to study the physicomachanical properties of the swollen soybeans after soaking in water. It is necessary to establish the dependency of the density (ρ), the strength of the swollen grain of the material (J) to change the moisture content (W) and the mass (m) of the degree of swelling, as well as the completeness and quality output of the soy protein in extent (G) from the hydraulic module (h) (the number of water servings supplied when the grain was abrasive) and the water supply temperature (t).

- the second stage was devoted to studying the process of soy milk production and optimization of the main factors that influence the PA process. So the second stage of the research task was to determine the optimal constructive-regime parameters of the chopper, soybean grain, determination of the main characteristics of the developed device.

In experimental studies, the following tasks were solved:

- determined the physical and mechanical properties of soaked soybeans which is a raw material;

- studied the quality indicators of the process, namely extraction of the protein in the emulsion.

The experimental setup adequately allows the required limits to vary the values of selected factors influencing the process of grinding soaked soybeans, followed by separation of the soy protein.

The frequency of rotation of the lower disk coated with an abrasive coating changed the switching speed of the installation. The switch operates in three modes as it was made

replaceable abrasive discs with curved grooves. Curved grooves has different angles of intersection (α -60°, α -90°, α -120°). The clearance between the abrasive discs was exhibited by putting washers between the top of the abrasive cone and the housing cover of the chipper (therefore, in the course of the experiment asked the clearance between the abrasive discs 3, 4, and 5 mm). The roughness of the abrasive surface of the disk is achieved by applying adhesive to the abrasive stone, corundum, the value of roughness was selected $R_a = 50$, $R_a = 250$, $R_a = 450 \mu m$ (Frolov V.Ju., Sysoev D.P., Klasner G.G. 2015. Optimization of Parameters of the Chopper of the Soaked Soya Grain No.3. P 24-25. Farm Machinery Operator).

To measure the energy characteristics of the used device To-505. For quantitative measurement of protein, the yield was used for laboratory flasks and scales VLTK-500. To change the speed of the motor was used in a dimmer built into the experimental setup. The temperature of fluid supplied to the chopper was measured using an electronic non-contact thermometer. Through the use of a measuring Cup was held the volume of the resulting liquid protein suspension.

The experiments were carried out in common in Krasnodar Krai grade soybeans "VILANA". Of grain, the material was taken 6 small servings, each of which consisted of 10 grains. The length of soybean grain was 6 mm. the mass of 10 grains of soybeans 1,767, and the amount of 10 grains was 1.4 ml (volume of grain was calculated at the displaced fluid from the measuring Cup after you're immersed in it). The pilot study took place at room temperature (20-22 °C), and the initial moisture content of the grains was 10 %. According to the experimental data (next Chapter) was built following dependencies: mass change (m), scope (v), and length (L) grain length of soaking (picture 3.5 – 3.6).

The essence of pressing from a physical point of view is the convergence and compaction of loose parts fodder. The increasing mechanical compression of the grain material eliminates air pores and voids. Further increase in pressure is not effective, because swollen grains mainly consist of compressible material is water.

Geometric size, particle shape, and internal structure of the grain material determine its physical and mechanical properties, to measure which is necessary to apply different methods and equipment. So to determine density, one of the main characteristics of the

grain material, knowing that the density is the ratio of the mass of substance (kg) contained in the volume of the substance (kg/m^3), can be applied micro metrically method.

3. RESULTS AND DISCUSSION

The experimental research was conducted on the Barra soya variety. 6 experimental samples with 10 grains in each sample were selected out of the whole batch of the soya grain. The grain's average length is made up of 6 mm. The mass of 10 grains was 1.767, the volume of 10 grains made up 1.4 ml when the grain's absolute humidity was 10%. The experiment was carried out with the room temperature (20-22 °C). According to the obtained values, the graph of dependence of increase in mass (m), volume (v), and length (L) of the grain on the soaking time was constructed (Picture 6).

Analysis of the graph (Figure 6) showed that the optimal time (T) of the soya grain soaking makes up 6-7 hours (the knock point in Figure 3). During the 6-hour soaking, the grain's length, mass, and volume make up $L = 13$ mm, $m = 0.36$ gr., $V = 0.34 \cdot 10^{-6} \text{ m}^3$. Further increase in time of soaking the soya grain is inefficient since when the grain is soaked for 24 hours, $m = 0.434$ gr., $V = 0.38 \cdot 10^{-6} \text{ m}^3$, and no change of the geometrical dimensions of soya is changed.

When knowing the change of the grain's mass and volume depending on the soaking time, we can calculate the change of the grain density (Figure 4). As the soaking time increases up to 7 hours, the grain density is lowered and makes up $\rho = 1.088$ g/ml. It is not reasonable to continue increasing the soaking time since later on, and the density reduction becomes somewhat stable.

While optimizing the operating process of the chopper of the soaked grain, the quality of the finished product, as well as the technical parameters of the process of obtaining the soya milk and curd, were studied.

While processing the results of the experiment, the dependencies of the suspense water duty with the extracting agent temperature of 55-70°C were constructed (Figure 7).

Dependence of the protein yield into the extract is based on the physical and chemical properties of solving the high-molecular organic compounds in the offered technology, and the extracting agent is potable water.

Analysis of the graph (Figure 8) makes it possible to conclude that the extracting agent is actively saturated to the water duty value of 1:10. When the water duty continuous to increase, the saturation becomes somewhat stable.

Grinding soaked soybeans were selected by these optimization criteria: output protein in the extractant – G (the response Y_3), the performance of the chopper – Q (the response Y_2), and power – kW N (the response Y_1). The results of the research were chosen as optimal values.

To substantiate its assessment of the influence of factors on the results of the experiment were calculated the regression equation of the second-order (program Statistica), which are in coded form (Equation 1):

$$Y_3 = -83,4565 + 0,0236 \omega + R 0,017367a - 8,61847 \alpha - 3,9973 h + 0,000006 \omega Ra - 0,000032 \omega \alpha + 0,001 \omega h + 0,0007 Ra \alpha - 0,016 Ra h - 0,0261 \alpha h - 0,00007 Ra^2 + 1,0806 \alpha^2 + 1,11143 h^2 \quad (\text{Eq. 1})$$

and the decoded form (Equation 2):

$$G = 21,35202 + 3,9244 \omega + R 5,452133a + 4,831567 \alpha - 5,29423 h + 0,0009 \omega Ra + 0,0005 \omega \alpha - 0,000086 \omega h + 0,0015 Ra \alpha - 0,0007 Ra h + 0,000089 \alpha h - \omega 0,0379^2 - 0,05217 Ra^2 - 0,04760 \alpha^2 + 0,0514 h^2 \quad (\text{Eq. 2})$$

After obtaining adequate mathematical models of the process, determined the coordinates of the optimum and studied by the response surface.

From the analysis of the dependence presented in figure 10, it can be concluded that the protein yield (G) in the extractant increased from 14 Gy to 24 Gy by increasing the speed of From the analysis of the dependence presented in figure 12, it can be concluded that for maximum protein yield (G) in the extractant, the angle of inclination of the abrasive groove should lie in the range $\alpha=80...105^\circ$.

Analyzing the graph of is shown in figure 13, we can conclude that the maximum protein yield (G) from 24 g to 28 g is observed with decreasing gap width (h) between the abrasive discs from 3.7 mm to 3 mm. The angle of inclination of the curved groove should lie in the range $\alpha=80...105^\circ$.

4. CONCLUSIONS:

The optimum soaking time interval was 6 to 7 hours. The force required to fracture the grain was 0.01 MPa, the density of the grain during the 7 hour soaking was $\rho = 1,088 \text{ g/ml}$; the moisture content was $W = 65\%$, and the average grain mass was $m = 0.37 \text{ g}$, and the volume $V = 0,34 \cdot 10^{-6} \text{ m}^3$.

To achieve the highest protein yield (G) in extent values of the rotation speed (ω) of the lower grinding wheel must be within $\omega = 157...172 \text{ rad/s}$. The clearance between the abrasive discs was $h = 3... 3.26 \text{ mm}$, the magnitude of the applied abrasive must be within $R_a = 260...450 \text{ }\mu\text{m}$, and the angle of curvature of the curved grooves was equal to $\alpha = 80^\circ...105^\circ$. The obtained experimental dependencies and the selected rational values of hydraulic module $\eta = 1:10$; the temperature of the extractant was $t = 55...60^\circ\text{C}$.

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Table 1. Factors and levels of their variation

Level	Factors			
	The angular velocity of rotation of the lower disc coated abrasive ω , rad/s	Grain size of abrasive R_a microns	The direction angle α of the grooves	The gap between the discs hmm
	X_1	X_2	X_3	X_4
The upper (+1)	172	50	$\alpha-120^\circ$	5
Main (0)	169	250	$\alpha-90^\circ$	4
Lower (-1)	141	450	$\alpha-60^\circ$	3

Table 2. Change of the grain density resulting from time of keeping it in water

Index	Time of the soya grain soaking in water Th								
	0	1	2	3	4	5	6	7	24
m, gr	0.18	0.28	0.317	0.32	0.34	0.34	0.36	0.37	0.43
V, ml	0.14	0.24	0.26	0.3	0.3	0.32	0.34	0.34	0.38
ρ . Gr/ml	1.26	1.14	1.22	1.07	1.12	1.08	1.06	1.08	1.14

Figure 1. Technology of making the soya milk and protein base for concentrated fodders

Figure 2. Scheme and general view of the experimental complex for the study of processes of production of feed products based on soy protein.

Figure 3. – The dependence of the mass change (m), scope (v) and length (L) grain length of soaking

Figure 4. Dependence of the change of the geometrical sizes of soybean from (time) degree of swelling

Figure 5. The relationship of the destruction of the swollen grains by means of pressure being applied

Figure 6. Dependence of increase in mass (m), volume (v) and length (L) of grain on soaking time

Figure 7. Graph of the dependence of density change on the soaking time

Figure 8. Dependence of protein yield G into the extracting agent on water duty η

Figure 9. Dependence of protein yield into the extracting agent G on temperature t

Figure 10. a cross-section of the surface of the protein yield in the extractant on a plane $X_1(\omega)$ from $X_4(h)$

Figure 11. a cross-section of the surface of the protein yield in the extractant on a plane $X_1(\omega)$ from $X_2(Ra)$

Figure 12. a cross-section of the surface of the protein yield in the extractant on a plane $X_1(\omega)$ from $X_3(\alpha)$

Figure 13. a cross-section of the surface of the protein yield in the extractant on a plane $X_4(h)$ from $X_3(\alpha)$