ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

INDEX COPERNICUS INTERNATIONAL

Google Scholar Crossref doi SLIB.UZ Scientific library of Uzbekistan

Volume 10
Issue 4
2025

NamMTI ILMIY-TEXNIKA JURNALI TAHRIR HAY'ATI A'ZOLARI

EDITORIAL BOARD OF SCIENTIFIC AND TECHNICAL JOURNAL OF NAMANGAN INSTITUTE OF ENGINEERING AND TECHNOLOGY

DEVELOPMENT OF AN EFFECTIVE TECHNOLOGY FOR PRODUCING SOY MILK FROM LOCAL SOY RAW MATERIALS, STUDYING ITS COMPOSITION AND PHYSICAL AND CHEMICAL PROPERTIES

RAKHIMOVA GULMIRA

PhD Assistant, Namangan State Technical University, Namangan, Uzbekistan
Phone.: (0877) 211-6868, E-mail.: raximovag1983@gmail.com

Abstract: In this study, the issues related to the development of an efficient technology for producing soy milk from local soybean varieties were examined. The research investigated the effects of the soybean-to-water ratio (hydromodule) and soaking temperature on the quality of the obtained soy milk. It was established that at a hydromodule of 5:1, the chemical composition of soy milk is the most comparable to that of cow's milk, and the extraction of proteins from soybeans into the aqueous phase occurs most intensively. The optimal soaking temperature for soybeans was determined to be 50 °C, at which the highest yield and best quality of soy milk are achieved.

Keywords: soybeans, soy milk, water content, soaking temperature, protein extraction, physicochemical properties, technological process, local raw materials.

Introduction. Soybeans differ from other agricultural crops by their high protein content (36–50%), which makes them an extremely valuable plant. Their composition includes enzymes, organic acids, vitamins, pigments, and other substances [1, pp. 7–52; 2, pp. 121–126]. The amino acid composition of soybean proteins may vary slightly depending on growing conditions; however, no significant differences have been observed. In particular, the amounts of methionine and cystine are subject to some fluctuations. The lysine content in soybeans is ten times higher than that in wheat, corn, and rice, while the amount of tryptophan is nine times greater than in wheat. Soybeans contain enzymes such as urease, lipase, lipoxidase, peroxidase, catalase, glucosidase, and others, which belong to the group of water-soluble proteins and account for 80–90% of the total protein content [3, pp. 1–9; 4, pp. 214–228].

Materials and Methods of Research. There are numerous methods and technologies for producing soy milk; however, at present, intensive methods are predominantly used on an industrial scale. Each method has its own specific characteristics that influence the physicochemical composition and quality parameters of the resulting soy milk. All methods of soy milk production include the stages of grinding, filtration, boiling, and cooling. In addition, depending on the specific method, processes such as soaking, bleaching, and reagent treatment may also be applied. These processes are aimed at improving product quality and reducing the production time [5, pp. 280–284; 6, pp. 14–16]. Within the framework of our study, the protein content in soy milk was determined under laboratory conditions using the Kjeldahl method in accordance with GOST 23327–98, Methods for Determination of Total Protein [7, pp. 120–125]. The fat content was determined by the Gerber method in accordance with GOST 5867–90 [7, pp. 98–100], and the carbohydrate content was measured using high-performance liquid chromatography (HPLC) in accordance with GOST R 54760–2011 [7, pp. 116–119].

Results and Discussion. Based on data obtained from literature sources, the following procedures were carried out to produce soy milk using the traditional method from local soybean varieties. One hundred grams of the "Vilana" soybean variety were soaked for 5 hours in one liter of warm water. After soaking, the soybeans were ground using a kitchen blender with the addition of 0.5 liters of distilled water heated to 95 °C. As a result, a mass with a porridge-like consistency was obtained, during which the protein substances contained in the soybeans were transferred into the aqueous phase through extraction.

Table 1. Composition of Soy Milk Obtained by the Traditional Method from Soybeans

Component Name, %	Quantity % Ratio of Water to Soybeans					
	9:1	7:1	5:1	4:1	2:1	1:1
Water	91,58	89,3	88,48	87,7	89,1	89,4
Protein	3,09	4,93	6,07	6,0	5,92	5,77
Carbohydrates	2,11	2,32	2,51	2,50	2,31	2,30
Fat	1,95	2,13	2,27	2,17	2,13	2,0
Ash	0,27	0,36	0,67	0,63	0,57	0,53

The resulting mass was filtered through sieves, which separated the soy milk. The obtained product, in terms of chemical composition and appearance, was similar to cow's milk. In the next stage of our study, experiments were conducted to determine the optimal ratio between soybeans and water. Soy milk was produced at various component ratios, and its chemical composition is presented in Table 1.

In this experiment, a total of 900 ml of water was added for soaking and grinding 100 grams of soybeans during soy milk production, resulting in a 9:1 ratio. Consequently, the concentration of dry matter in the obtained soy milk was quite low, and the mass fraction of water exceeded 91%. Using such soy milk as a substitute for natural cow's milk does not yield effective results. Moreover, this leads to a decrease in the productivity of the equipment used. Therefore, it is necessary to determine the optimal amount of water applied for soy milk extraction. Typically, the concept of a hydromodule is used in the extraction process. The hydromodule is the ratio between the solid material being extracted and the solvent (liquid). With an increase in the amount of solvent, the extraction process improves; however, the concentration of the resulting extract decreases. Thus, for each substance, there is an optimal hydromodule value at which the maximum yield and concentration of the extract are achieved. In order to determine the optimal hydromodule for the extraction of protein substances from soybeans using water, experiments were conducted under the aforementioned conditions: the soybeans were soaked, ground, and soy milk was obtained at various mass ratios of soybeans to water, ranging from 1:1 to 9:1. The obtained results are presented in Table 1 and Figure 1.

As can be seen from the chemical composition of the soy milk samples presented in Table 1, as the amount of water added to the soybeans for milk production decreases, the moisture content in the final product drops from 91.58% to 89.4%. When the hydromodule is reduced from a 9:1 to a 5:1 ratio, the moisture content decreases to 88.48%; however, with a further reduction of the hydromodule from 5:1 to 1:1, the moisture content increases again from 88.48% to 89.4%. The effect of the hydromodule value on protein content showed an inverse relationship. As the hydromodule decreased from 9:1 to 5:1, the protein content in the resulting soy milk increased from 3.09% to 6.07%, which can be explained by the reduced amount of added water. However, with a further decrease in the hydromodule from 5:1 to 1:1, the protein content declined from 6.07% to 5.77%. This is because, with insufficient water, the beans do not have enough time to swell adequately, and the protein extraction process is incomplete. As a result, the protein is not fully extracted from the beans, leading to a decrease in its concentration in the soy milk.

A similar pattern is observed in the changes of carbohydrate, fat, and ash content in the resulting soy milk.

As shown in the data presented in Figure 1, when the water-to-soybean ratio changes from 1:1 to 9:1, the degree of protein extraction gradually increases; that is, the amount of protein transferred from the beans into the solution rises, while its residual content in the okara decreases. At the same time, the mass fractions of moisture and volatile substances in the resulting soy milk change. With an increase in the amount of water added for soaking and extracting the soybeans to a 5:1 ratio, the mass fractions of moisture and volatile substances in the soy milk decrease from 89.4% to 88.48%. However, with a further increase in the hydromodule from 5:1 to 9:1, these values rise again—from 88.48% to 91.58%. Similar results are observed in the changes in the degree of protein extraction. As the amount of water increases to a 5:1 ratio, the degree of protein extraction rises from 74.2% to 93.5%. Further increases in the amount of water have virtually no significant effect on the degree of protein extraction.

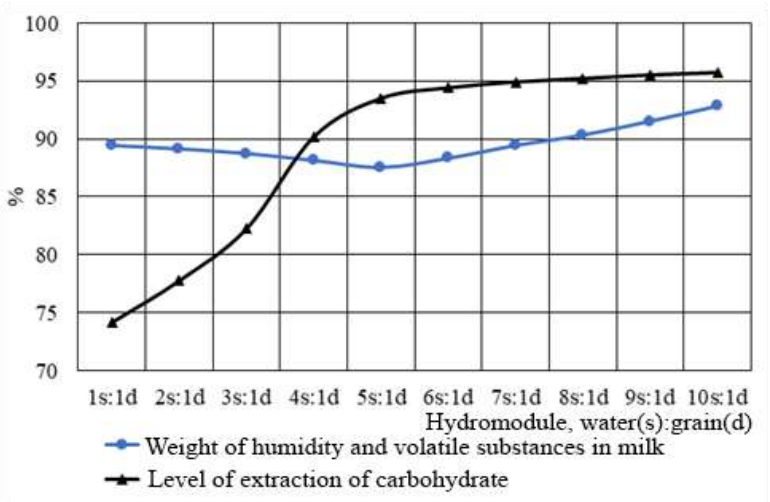

Figure 1. Effect of the Soybean-to-Water Ratio on the Concentration of the Resulting Soy Milk

From the obtained results, it can be concluded that at a water-to-soybean ratio, i.e., a hydromodule of 5:1, the concentration of soy milk is the highest, and the mass fraction of protein remaining in the okara reaches its lowest values.

It is known that the soaking of soybeans is an adsorption process, the course of which directly depends on temperature. An increase in temperature contributes to a reduction in viscosity, a weakening of intermolecular bonds, and an acceleration of diffusion processes, which, in turn, intensifies the sorption of water by the soybeans. However, considering that at temperatures above 60 °C proteins undergo intensive denaturation, it is advisable not to exceed this temperature limit during soaking.

Taking this into account, to determine the optimal soaking temperature, soybeans were treated using the traditional method in a water bath at temperatures ranging from 20 to 60 °C. The duration of the soaking process was determined until the soybeans reached maximum water absorption under normal conditions, i.e., until they absorbed water equal to 150% of their mass. In each experiment, the soaking process continued until this level of water absorption was achieved. The obtained results are presented in Figure 2.

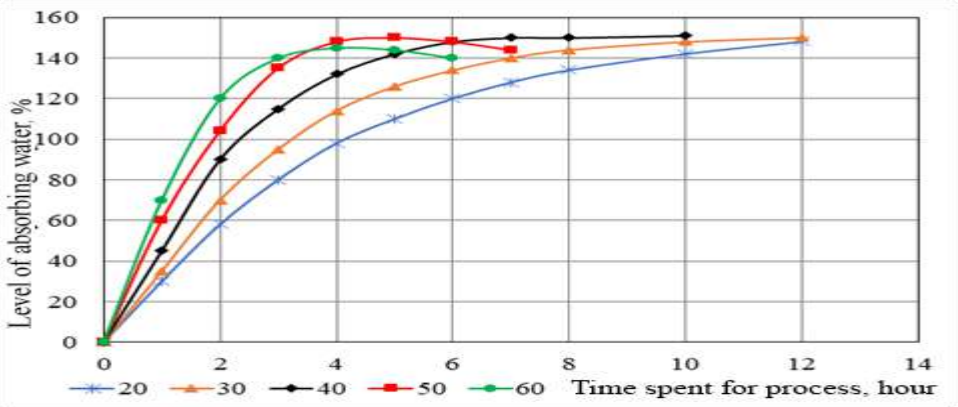

Figure 2. Effect of Process Temperature on the Duration of Soybean Soaking

From the data presented in Figure 2, it can be seen that at a temperature of 20 °C, the duration of soybean soaking was 12 hours. Increasing the temperature to 30 °C reduced the process duration to 10 hours, and at 40 °C—to 7 hours. A similar pattern was observed at 50 °C, when the soaking process decreased to 5 hours. However, at 60 °C, the degree of water absorption reached only 145%, failing to achieve the 150% level. At temperatures of 20, 30, and 40 °C, it was observed that the degree of water sorption by the soybeans increased with the duration of the process. However, this pattern was not observed at temperatures of 50 and 60 °C. At 50 °C, the mass of the soaked soybeans increased up to 5 hours of soaking, after which it began to decrease. This can be explained by the fact that at elevated temperatures, the dry substances contained in soy begin to extract into the water, and upon subsequent removal of the water, part of these substances remains in the liquid phase. The same tendency is observed at 60 °C and

above, which is why at 60 °C the mass of the soaked soybeans does not reach its maximum values.

Conclusion. Thus, based on the conducted studies, it can be concluded that at a soybean-to-water ratio of 5:1, the resulting soy milk is closest to cow's milk in terms of its chemical composition, and the extraction of proteins from soybeans into the aqueous phase occurs most efficiently. Furthermore, according to the experiments carried out to determine the optimal soaking temperature for soybeans, the best results for soy milk production are achieved at a temperature of 50 °C.

References:

1. Prisca Munene, Lydia M. Chabala, Alice M. Mweetwa. Land Suitability Assessment for Soybean (*Glycine max* (L.) Merr.) Production in Kabwe District, Central Zambia. / Journal of Agricultural Science; Vol. 9, No. 3; 2017, ISSN 1916-9752 E-ISSN 1916-9760 Published by Canadian Center of Science and Education. 1-16.

2. Yevloyeva, Kh.S. & Atabayeva, Saule & Rakhymgozhina, A.B. & Didorenko, S.V. & Kamshybayeva, G.K. (2022). The protein and amino acid content in seeds of kazakhstani soybean varieties. Bulletin of the Korkyt Ata Kyzylorda University. 62. 121-128. 10.52081/bkaku.2022.v62.i3.087.

3. Chotekajorn, Awatsaya & Hashiguchi, Takuyu & Hashiguchi, Masatsugu & Tanaka, Hidenori & Akashi, Ryo. (2021). Evaluation of seed amino acid content and its correlation network analysis in wild soybean (Glycine soja) germplasm in Japan. Plant Genetic Resources: Characterization and Utilization. 19. 1-9. 10.1017/S1479262121000071.

4. R.A. Badley, D. Atkinson, H. Hauser, D. Oldani, J.P. Green, J.M. Stubbs, The structure, physical and chemical properties of the soy bean protein glycinin, Biochimica et Biophysica Acta (BBA) - Protein Structure,Volume 412, Issue 2, 1975, Pages 214-228.

5. Ziegler, Valmor & Ferreira, Cristiano & Vanier, Nathan & Santos, Marco & Oliveira, Maurício & Elias, Moacir. (2016). Physicochemical and technological properties of soybean as a function of storage conditions. Brazilian Journal of Food Research. 7. 117. 10.3895/rebrapa.v7n3.3858.

6. Kuzniar, Piotr & Szpunar-Krok, Ewa & Findura, Pavol & Buczek, Jan & Bobrecka-Jamro, Dorota. (2016). Physical and chemical properties of soybean seeds determine their susceptibility to mechanical damage. Zemdirbyste-Agriculture. 103. 183-192. 10.13080/z-a.2016.103.024.

7. J.S. Fayziev, SH.N. Ataxanov, Yu.CH. Kenjaev,SH.D. Fayziev, X.M. Qanoatov, O.T. Mallabaev. Sut va sut mahsulotlarining texnik-kimyoviy nazorati. Toshkent, 2017. – 246 b.

CONTENTS

TECHNICAL SCIENCES: COTTON, TEXTILE AND LIGHT INDUSTRY

TECHNICAL SCIENCES: AGRICULTURE AND FOOD TECHNOLOGIES

CHEMICAL SCIENCES

TECHNICAL SCIENCES: MECHANICS AND MECHANICAL ENGINEERING