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RESOURCE-SAVING TECHNOLOGY FOR GERMINATING SOY BEANS

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Abstract. The article describes the relevance of using soybean sprouts in the nutrition of the population, and, consequently, the feasibility of developing resource-saving technologies for sprouting soybeans. The influence of various technological parameters (temperature, humidity, convection) on the rate of germination of soybeans in a steam convection apparatus has been determined; the organoleptic indicators of the quality of sprouts were evaluated for various parameters of germination. An rational technology has been developed for germinating dry soybeans to sprouts 5 cm long. The possibility of extending the shelf life of the obtained soybeans by means of intensive cooling and vacuum packaging has been studied; the storage period is set. The nutritional value of the resulting product was assessed.

Keywords: soybeans, seedlings, vegetable protein, germination technology, increased nutritional value.

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РЕСУРСОСБЕРЕГАЮЩАЯ ТЕХНОЛОГИЯ ПРОРАЩИВАНИЯ СОЕВЫХ БОБОВ

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Аннотация. В статье описана актуальность использования проростков сои в питании населения, а следовательно, и целесообразность разработки ресурсосберегающих технологий проращивания соевых бобов. Определено влияние различных технологических параметров (температуры, влажности, конвекции) на скорость прорастания сои в пароконвекционном аппарате; оценены органолептические показатели качества ростков при различных параметрах проращивания. Разработана рациональная технология проращивания сухих соевых бобов до ростков длиной 5 см. Изучена возможность продления сроков хранения полученных проростков сои с помощью интенсивного охлаждения и вакуумной упаковки; установлен срок хранения. Проведена оценка пищевой ценности полученного продукта.

Ключевые слова: соя, проростки, растительный белок, технология проращивания, повышенная пищевая ценность.

Introduction. Adequate nutrition is one of the most important conditions for maintaining human health and performance. The imbalance of various components of food, a decrease in physical activity, as well as a widespread deterioration of the ecological situation

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have led to an increase in the number of diseases associated with malnutrition, including cardiovascular diseases and diseases of the gastrointestinal tract.

The question of the insufficient amount of complete and easily digestible proteins in the diet of the Russian population is quite acute. There are only a few sources of high biological value protein: milk, meat, eggs, and isolated soy proteins. Currently, the increase in the volume of produced animal protein lags behind the growing needs of the population; the use of various sources of soy proteins in food production will make up for this deficit.

Proteins of animal origin are complete, they are assimilated by the human body by 93-98% and contain a full set of essential amino acids in optimal proportion. Almost all plant proteins are not complete, as they have a deficiency of essential amino acids and are absorbed only by 62-80%. The exception is soy proteins, which contain essential amino acids in proportions close to animal proteins; after heat treatment destroying protease inhibitors, they are absorbed by 86-95% [13].

The development and organization of industrial production of new healthy food products with high nutritional and biological value, balanced in accordance with the physiological needs of various age and social groups of the population, is the leading direction of food biotechnology in the Russian Federation.

In connection with the above, the development of a technology for germinating soybeans, which differs from traditional methods in simplicity, shortening the germination time, and reducing material costs, is relevant.

Materials and methods. The objects of the study were dry soybeans for germination, developed according to STO 21318887-009-2013 LLC Sampo and corresponding to the sanitary quality standards of food raw materials and food products in accordance with TR CU 021/2011, as well as sprouted soybean sprouts 5,00±0,05 cm long.

In the course of the study, the organoleptic indicators of the quality of germinated sprouts (appearance, color, smell, taste) were analyzed using standard methods. To determine the nutritional value, measuring and calculation methods were used (according to tables of chemical composition). Evaluation of the nutritional value of soybean seedlings was carried out for men and women of the III group of physical activity and the age group of 30-39 years in accordance with MR 2.3.1.2432-08 "Norms of physiological needs for energy and nutrients for various groups of the population of the Russian Federation" [12].

Determination of shelf life and storage of soybean sprouts and packaged sprouts was carried out in accordance with MUK 4.2.1847-04 “Methods of control. Biological and microbiological factors. Sanitary and epidemiological assessment of the justification of the shelf life and storage conditions of food products” [2].

For statistical processing of the results, we used the Statistica 6.0 software package. When comparing the mean values for two samples and multiple comparison of the means, the difference is considered significant at the 95% significance level ($p < 0,05$).

Discussion. Soy is a natural biological nutritional corrector. It is a source of protein, a number of B vitamins, macro- and microelements, oligosaccharides, as well as biologically active substances (phospholipids, tocopherols, a complex of balanced polyunsaturated fatty acids, phytoextragens, etc.), this peculiarity of the chemical composition of soybean seeds allows you to obtain a large amount of biologically active additives and products of functional and medical nutrition. Soy is a multi-purpose crop. It is processed and used in many branches of economic activity; more than four hundred types are produced.

In addition to soy milk, tofu cheese, fermented foods, soy sprouts are popular and can be used to fortify protein and vitamins in a variety of foods and ready-to-eat meals.

Germination is the process by which the embryo dormant in the seed wakes up and begins to grow, turning into a seedling. After the seedlings are removed, the seeds are used to prepare a variety of soy products such as soy drinks, soy flour, bread, and soy milk [11].

Soybean sprouts have significant antidiabetic effects by regulating blood sugar levels and are more effective than oral antidiabetic drugs. Protein efficiency measurements showed that sprouting improved the nutritional quality of protein foods. During germination, the content of vitamin C increased from 0 to 25 mg / 100 g. The flour from germinated soybean seeds can be used to replace wheat flour in some mixtures to improve their nutritional properties. The selection of a soybean variety with the desired properties, combined with a suitable germination process, can provide a good source of bioactive compounds from soybean seeds for nutraceutical use. Germination induces hydrolysis of soy polypeptides and polysaccharides, limiting cross-linking of these macromolecules during and after heat treatment, thereby slowing down the coagulation of soy extract and facilitating food digestion. Soy milk produced from sprouted soy is better digestible and more nutritious than milk from non-sprouted soy [6, 8, 9, 22].

Soy sprouts that have reached 3,5-5 cm are considered optimal for consumption.

Results. The study of the technology of germination of soybeans to sprout was carried out using a steam convection apparatus "Rational" (SCC61WE-3NAC400V50/60). A sample of 100 grams of dry beans was sampled for germination, placed in a thin layer no more than 0,05±0,05 cm thick on a perforated gastronomic container and placed in a combi steamer under conditions of 100% humidity with a temperature change of (30 ± 1) °C, (32 ± 1) °C, (34 ± 1) °C, (36 ± 1) °C and convection with a power of 0,09 kW in the chamber of the apparatus (Fig. 1).

Figure 1. Germination of soybeans in the "Rational" steam convection apparatus

Technological requirements for soybean germination are characterized by the following indicators: temperature at which soybeans germinate at separate stages; moisture content in the chamber of the device; the ratio of oxygen and carbon dioxide in the soybean layer at separate stages of germination; duration of germination.

At the first stage, the optimum temperature for germination of soybeans was determined (the presence of sprouts at least 5,00±0,05 cm long in 90% of seeds) in a steam convection apparatus at various temperature conditions, 100% humidity, and no air conditioning. The results are shown in Fig. 2.

From the presented data it can be seen that the optimum temperature for germination of soybeans to sprouts 5,00±0,05 cm long is 30°C, at 100% humidity and in the absence of air conditioning; germination time – 76 hours. An increase in temperature showed a deterioration in the results, so at 34 °C the germination time was 95 hours. The germination mode under conditions of 100% humidity and a temperature of 36 °C is not effective, so there are signs of spoilage of raw materials.

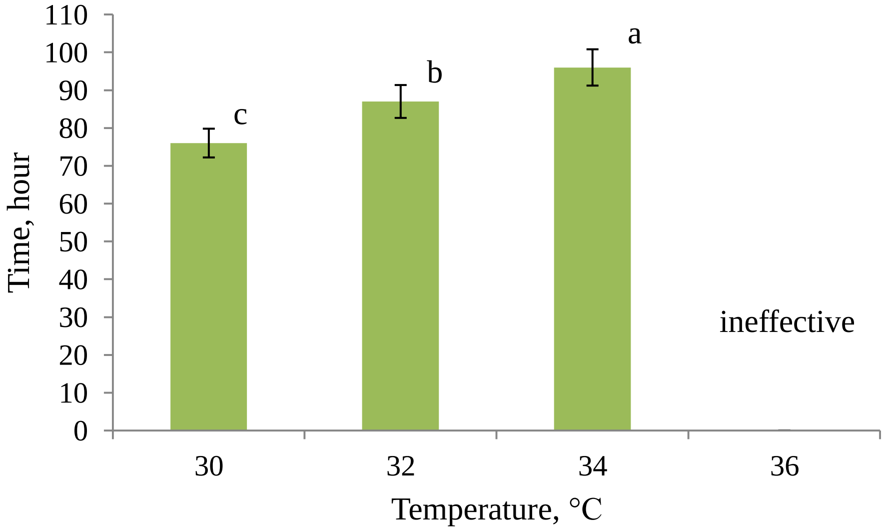

Figure 2. Influence of temperature on soybean germination time; (M±m) (n=6) (different letters denote intragroup differences, multiple comparison of means, LSD- test, $p<0,05$)

Organoleptic indicators of the quality of sprouted to sprouts 5,00±0,05 of soybeans are shown in table 1. According to the data in the table, the best organoleptic characteristics (appearance, color, smell, taste) are observed in sprouts germinated at a temperature of 30 °C; average score – 4,8.

In sprouts germinated under different modes, the dry matter content was determined, but no temperature dependence was observed, the dry matter content was 30,9±0,1%.

Next, the dependence of the germination time of soybeans on the air conditioning mode was determined (the power was changed from 0 to 0.36 kW) in a steam convection apparatus at 30 °C, 100% humidity. The experimental data are shown in Fig. 3.

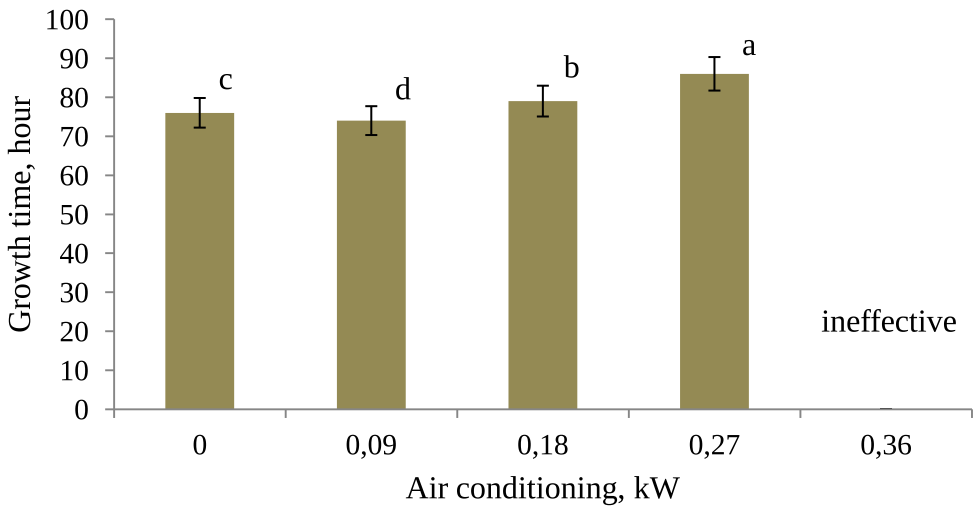

Figure 3. Influence of air conditioning on soybean germination time; (M±m) (n=6) (different letters denote intragroup differences are denoted by different letters, multiple comparison of means, LSD- test, $p<0,05$)

Table 1. Organoleptic characteristics of soybean sprouts; (M±m) (n=7)

Indicators	Sprouts sprouted at 100% humidity, temperature 30±1 °C		Sprouts sprouted at 100% humidity, temperature 3 ±1 ° C		Sprouts sprouted at 100% humidity, temperature 34±1 °C	
	Characteristic	Total score (according to a 5-point system)	Characteristic	Total score (according to a 5-point system)	Characteristic	Total score (according to a 5-point system)
Appearance	Soybean sprouts of uniform length 5,00±0,05 cm	4,80±0,02[a]	Soybean sprouts of uniform length 5,00±0,05 cm	4,70±0,02[b]	Soybean sprouts of uniform length 5,00±0,05 cm, presence of non-sprouted beans	4,70±0,01[b]
Color	Greenish-yellow	4,90±0,01[a]	Yellow	4,80±0,01[b]	White-yellow	4,60±0,01[c]
Odor	Soy, typical for healthy sprouts of this type	4,80±0,02[a]	Soy, typical for sprouts of this type	4,70±0,01[b]	Strong soy, typical for sprouts of this type	4,50±0,02[c]
Taste	Typical for healthy sprouts of this type	4,70±0,01[a]	Typical for sprouts of this type	4,60±0,02[b]	Typical for sprouts of this type	4,50±0,01[c]
Average score		4,80±0,02[a]		4,70±0,01[b]		4,60±0,01[c]

* different letters denote intragroup differences, multiple comparison of mean, LSD- test, p<0,05

From the presented data it can be seen that the optimal power of air conditioning in the combi-steamer chamber for germinating soybeans to sprouts 5,00±0,05 cm long is 0,09 kW at 30 °C and 100% humidity; germination time – 74 hours. The least efficient air conditioning power was 0,27 kW (growth time was 86 hours).

In the process of germination, in order to improve the quality of the sprouts while reducing the time of their growth, convection with a power of 0,09 kW was switched on at various time stages: 12 h, 24 h, 36 h, 54 h after being placed in the chamber of the apparatus (Fig. 4). The data in the figure show that the growth time is noticeably reduced if the convection is switched on 12 hours after placing the soybeans in the combi steamer (73 hours).

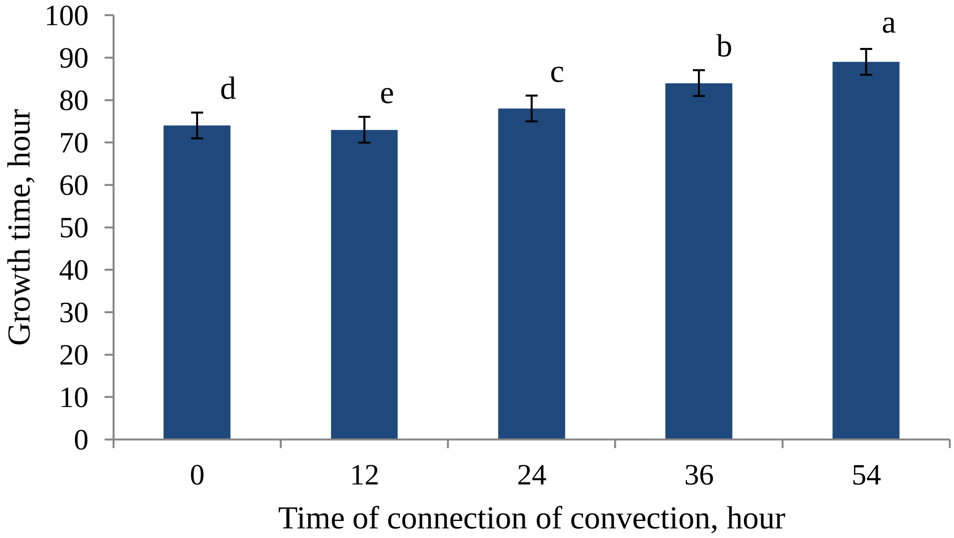

Figure 4. Duration of germination when convection is switched on with a power of 0,09 kW at various stages of growth; (M±m) (n=6)
(different letters denote intragroup differences are denoted by different letters, multiple comparison of means, LSD- test, p<0,05)

Thus, the optimal mode for germinating soybeans in a steam convection apparatus is determined: temperature 30± 1 °C, humidity 100%, air convection with a power of 0,09 kW 12 hours after placing in the chamber (beginning of germination).

The main indicators of the nutritional value of soybean sprouts obtained as a result of research are presented in table 2.

Table 2. The main indicators of the nutritional value of soybean sprouts [17, 21]

Indicator	Value
Protein, g	13,09±0,02
Fat, g	6,7 ±0,01
Moisture,%	69,0±0,5
Ash, g / 100 g	1,59±0,01
Vitamin C, mg	15,3±0,01
Vitamin B_1, mg	0,3
Vitamin B_2, mg	0,1
Calcium, mg	67
Iron, mg	2,1
Magnesium, mg	72
Potassium, mg	484
Sodium, mg	14

These tables demonstrate that the resulting product is rich in protein, vitamins and minerals. The resulting sprouts are recommended to be eaten, adding to salads, rice, hot dishes, as well as baked goods. It should be noted that they should not be eaten raw, you must first pour boiling water over them or blanch them for 30 seconds.

To extend the shelf life, soybean sprouts were packed in a plastic film using a vacuum sealer (Profi Cook PC-VK 1015). Then the packaged soybean sprouts were placed in an intensive cooling cabinet (PF 031AF CHILLY GN1) until the temperature of the packaged product reached +4 °C. It should be noted that when using an intensive cooling cabinet, the control temperature was reached in 12 minutes, in contrast to traditional cooling at a temperature of +4 °C, which takes 87 minutes. This fact is especially important to prevent the reproduction of microflora.

The finished packaged, chilled bags were stored at a temperature of (4±1) °C in within 12 days. To control the quality of soybean sprouts and establish the shelf life, three control points (4, 7 and 12 days) were determined, in which organoleptic and microbiological indicators, dry matter content were determined. The organoleptic characteristics of vacuum packed soybean sprouts cooled in an intensive cooling apparatus are presented in table. 3.

From the data in the table, it can be seen that the organoleptic indicators of soybean seedlings in vacuum packaging, cooled in an intensive cooling apparatus at a temperature of (4±1) °C and stored for 12 days are not worse than those obtained before cooling, and have high values.

The change in the mass fraction of moisture in soybean sprouts during storage in a vacuum package after cooling in an intensive cooling apparatus at a temperature of (4±1) °C is shown in Fig. 5.

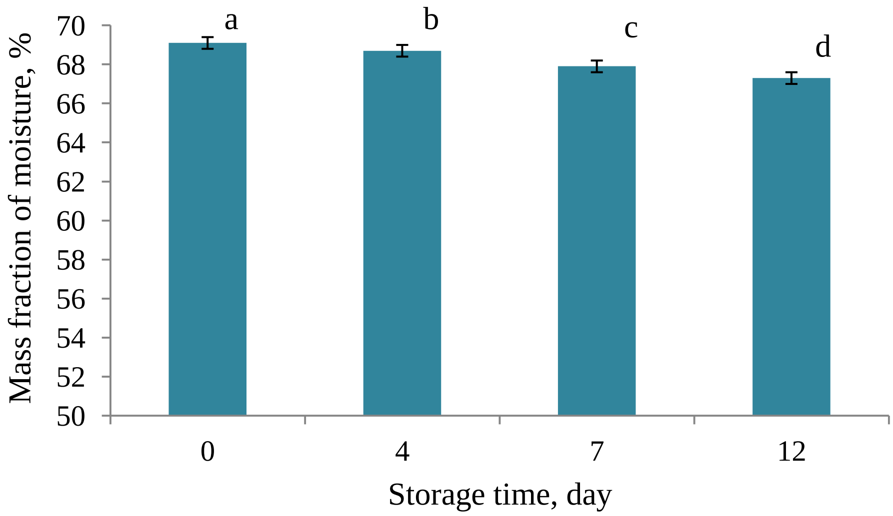

Figure 5. Moisture content in soybean sprouts when stored in a vacuum package at a temperature of (4±1) °C; (M±m) (n=6) (different letters denote intragroup differences, multiple comparison of means, LSD- test, p<0,05)

Thus, after 12 days of storage, the moisture content in chilled soybean sprouts in vacuum packaging decreases from 69,1% to 67,3%.

Microbiological indicators of soybean sprouts for different storage periods are presented in table 4.

Table 3. Organoleptic characteristics of vacuum packed soybean sprouts cooled in an intensive cooling apparatus when stored in the refrigerator; (M±m) (n=7)

Indicators	Control		Shelf life					
			4 days		7 days		12 days	
	Characteristic	Total score (according to a 5-point system)	Characteristic	Total score (according to a 5-point system)	Characteristic	Total score (according to a 5-point system)	Characteristic	Total score (according to a 5-point system)
Appearance	Soybean sprouts of uniform length 5,00±0,05 cm	4,80±0,02[a]	Soybean sprouts of uniform length 5,00±0,05 cm	4,70±0,02[b]	Soybean sprouts of uniform length 5,00±0,05 cm	4,70±0,01[b]	Soybean sprouts of uniform length 5,00±0,05 cm	4,60±0,01[c]
Color	Greenish yellow	4,90±0,01[a]	Greenish yellow	4,90±0,01[a]	Greenish yellow	4,80±0,02[b]	Greenish yellow	4,80±0,02[b]
Odor	Soy, characteristic of healthy sprouts of this type	4,80±0,02[a]	Soy, characteristic of healthy sprouts of this type	4,80±0,02[a]	Soy, characteristic of healthy sprouts of this type	4,70±0,01[b]	Soy, characteristic of healthy sprouts of this type	4,60±0,02[c]
Taste	Typical for healthy shoots of this type	4,70±0,01[a]	Typical for healthy shoots of this type	4,70±0,01[a]	Typical for healthy shoots of this type	4,50±0,01[b]	Typical for healthy shoots of this type	4,50±0,01[b]
Average score		4,80±0,02[a]		4,80±0,02[a]		4,70±0,01[b]		4,60±0,02[c]

* different letters denote intragroup differences, multiple comparison of means, LSD- test, $p<0,05$

Table 4. Microbiological parameters of soybean sprouts during storage

Name of indicators	Test results after storage			Permissible levels
	4 days	7 days	12 days	
QMAFAnM, CFU/g	$<5 \cdot 10^4$	$<5 \cdot 10^4$	$<5 \cdot 10^4$	no more than $5 \cdot 10^4$
E. coli group bacteria (coliforms) in 0.1 g	not detected	not detected	not detected	not allowed
Pathogenic, including salmonella in 25 g	not detected	not detected	not detected	not allowed
Molds, CFU/g	< 50	< 50	< 50	no more than 50

From the data in the table, it can be concluded that during 12 days of storage of soybean sprouts in a vacuum package cooled in an intensive cooling apparatus, they comply with the requirements of TR CU 021/2011 [20]. Taking into account the safety factor of 1.3 (MUK 4.2.1847-04 [2]), we take the shelf life of soybean seedlings in a vacuum package – 9 days at a controlled temperature of 4±1 °C, air humidity 75%.

The technological scheme of germination of dry soybeans to sprouts 5,00±0,05 cm long using a steam convector, obtained during the experimental work, is shown in Fig. 6.

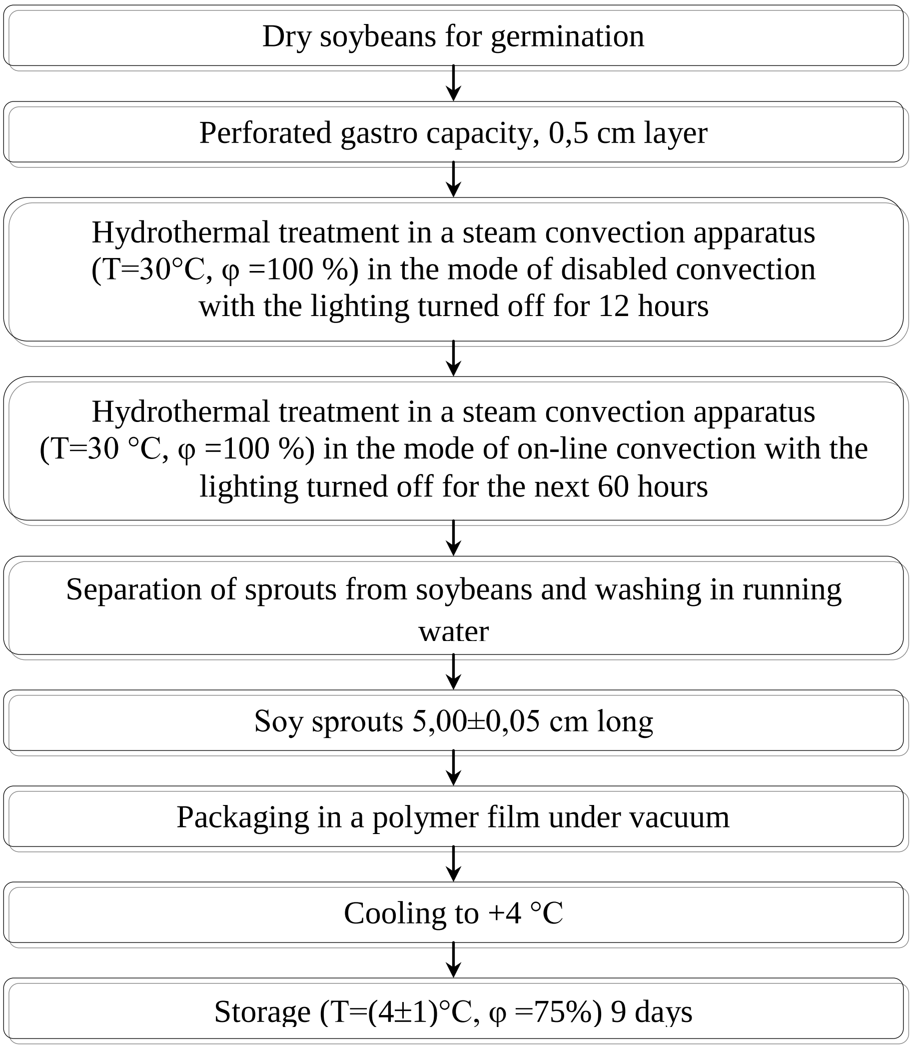

Figure 6. Technological scheme of germination of soybean sprouts using the "Rational" combi steamer (SCC61WE-3NAC400V50/60)

Evaluation of the nutritional value of soybean sprouts cooled in an intensive cooling apparatus was carried out according to indicators obtained as a result of our own research and reference data. Table 5 shows the level of satisfaction of the daily needs of the human body in basic nutrients at the expense of 100 g of soybean seedlings; the assessment was carried out for men and women of the III group of physical activity and the age group of 30-39 years (MP 2.3.1.2432-08) [12].

Table 5. Evaluation of the nutritional value of chilled soybean sprouts (100 g)

Indicator	Value	Daily requirement, mg, g/day [12]		Degree of satisfaction, %	
		men	women	men	women
Protein, g	12,8	89	74	14,4	17,3
Vitamin C, mg	8,3	90		9,2	
Vitamin B_1, mg	0,29	1,5		19,3	
Vitamin B_2, mg	0,05	1,8		2,8	
Calcium, mg	59	1000		5,9	
Iron, mg	1,3	10	18	13,0	7,2
Magnesium, mg	60	400		15,0	
Potassium, mg	355	2500		14,2	
Sodium, mg	10	1300		0,8	

From the results presented in the table, it can be seen that the satisfaction of the human body's daily need for physiologically functional food ingredients due to soybean sprouts is: in vitamin B_1 – by 19,3%, in protein – by 17,3% in women and by 14,4% in men, magnesium – by 15%, potassium – by 14,2%, iron – by 13,0% in men and 7,2% in women, vitamin C – by 9,2%. Thus, the studies carried out have shown that soybean sprouts, packed in vacuum bags and cooled in an intensive cooling apparatus, have a high nutritional value.

Conclusions. In the course of the study, the optimal mode of germination of soybeans was determined to obtain sprouts up to 5 cm long using a steam convection apparatus: temperature 30 °C at 100% humidity and air conditioning power in the combi oven chamber 0,09 kW; the duration of growth is noticeably reduced if the ventilation is switched on 12 hours after sowing soybeans (73 hours). With this mode, the best organoleptic characteristics of seedlings (appearance, color, smell, taste) are observed; the average organoleptic score was 4,8 points on a 5-point scale.

To extend the shelf life, soybean sprouts were packed in a polymer film using a vacuum packer, cooled in an intensive cooling cabinet until a temperature of +4 °C was reached, and stored for 12 days. It was determined that, under the given conditions, the organoleptic indicators of soybean seedlings are not worse than those obtained before cooling, and have high values. Evaluation of microbiological indicators showed that within 12 days of storage of soybean sprouts, it meets safety requirements. Taking into account a safety factor of 1.3 (MUK 4.2.1847-04), the shelf life of soybean seedlings in a vacuum package was set – 9 days at a controlled temperature of 4±1 °C and air humidity of 75%. The analysis showed that soybean sprouts, packed in vacuum bags and cooled in an intensive cooling apparatus, have a high nutritional value.

Thus, the developed technology for germination and storage of soybean sprouts allows you to save energy and time resources through the use of a combi steamer and an intensive cooling cabinet, as well as to obtain a product of high quality and increased nutritional value.

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