

*The need to intensify the process of extracting sugar substances from sweet sorghum stalks in order to improve the quality and yield of the target product has been substantiated. Existing techniques of sugar substance extraction used in sweet sorghum processing technologies have been analyzed. The application of a combined technique for extracting sugary substances has been proposed implying the production of pressed and diffusion juice.*

*The results of optimizing the press technique of juice extraction from sorghum stalks are given. The equations of material balance of products and sugars have been built, depending on such factors as the degree of pressing, the initial content of solids and sugars in the stalks. A procedure for calculating the yield of pressed juice, cake, and the content of total sugars has been devised, according to which the preliminary pressing of the stalks ensures the extraction of juice in the range of 25–35 %, the yield of the pressed cake is 75–65 % on average, with a sugar content exceeding 60 %.*

*It has been experimentally established that the use of the anti-current process of extraction of sugar substances from the pressed cake ensures their complete extraction from raw materials.*

*The rational parameters for this process have been defined. At a temperature of 66–70 °C and a duration of 20 minutes, it is possible to obtain an extract whose content of solids is 13.0 %, total sugars – 11.10 %, and whose purity is 85.38 %.*

*The research was carried out in order to intensify the extraction of sugar substances from sweet sorghum plant raw materials, to improve the technical level of the extraction process, and implement the devised method under industrial conditions. Further implementation of these results in the food industry could make it possible to establish the production of a wide range of sugar-containing products, both organically and as a natural substitute for sugar in food products*

*Keywords: sweet sorghum, sugary substance extraction, pressed, diffusion juice, food syrup*

# STUDYING THE PROCESS OF EXTRACTING SUGARY SUBSTANCES FROM THE STALKS OF SWEET SORGHUM IN THE TECHNOLOGY OF MAKING FOOD SYRUPS

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## 1. Introduction

The modern development of food technologies is aimed at expanding the range of high-quality and safe products, in particular, sugar-containing syrups from those raw materials whose cultivation would involve the use of organic methods. Accordingly, such products must meet the requirements for the application of such manufacturing techniques and processes that exclude the chemical treatment of raw materials

and semi-finished products. In addition, it is important to preserve the natural components of plant raw materials in the composition of finished products, which ensures their nutritional value and usefulness for human consumption. Current trends in the expansion of the range of food products lead to a scientific and practical interest in the industrial production of sugar syrups from sweet sorghum. This highly productive crop accumulates in the juice of stalks during the ripening period from 10 to 20 % of sugary sub-

stances, which differ slightly in sugar content from sugarcane and beet [1, 2].

The composition of sugary substances of sorghum juice includes, in different ratios, disaccharides (sucrose, maltose) and monosaccharides (glucose, fructose), depending on varietal characteristics and agroclimatic conditions of its cultivation [3, 4]. This feature of the composition of sugary substances in sorghum predetermines the production of sweet foods in the form of food syrup. It should be noted that syrups derived from sorghum stalks contain a large list of minerals, in particular: Ca, P, Mg, K, Na, Cu, Zn, Co, Mn, Fe, S, essential amino acids, vitamins B1, B2, PP, E, C [5]. The presence of these necessary natural substances makes sorghum syrup a unique product that resembles biologically active substances or honey [6, 7] in its effect on the human body.

Thus, it is a relevant task, when choosing the technology of obtaining syrup from sweet sorghum, to preserve all nutrients in it. That could ensure the production of a healthy food product that might be quite widely used as a natural substitute for sugar, as well as be useful as a source of mineral and biologically active substances.

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## 2. Literature review and problem statement

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The primary stage and one of the main steps in the technology of obtaining a sugar-containing product is the process of extracting the target component, subject to its least losses, and obtaining a high purity product. Under industrial conditions, the most common methods of extraction of sugary substances from raw materials are diffusion and press techniques [8]. Sweet sorghum is similar to sugarcane in its ability to accumulate sugary substances in plant stalks, which implies similarity of the technology of their extraction, in particular by grinding the stalks on the roller press and obtaining pressed juice [9]. Thus, in works [10, 11], it is recommended that juice from sorghum stalks should be extracted on a two-roller roller press with a guaranteed extraction of 25–30 % of the juice to the mass of stalks. For more complete extraction of juice, it was proposed to involve a three-roller press for pressing the stalks, ensuring the extraction of juice in the range from 42 to 47 % by weight of the stalks [12]. The studies recommending the use of two- and three-roller presses do not solve the issue of the complete extraction of juice from raw materials.

The increase in juice yield can be achieved by involving multi-stage technologies for extraction of raw materials on roller presses, which are proposed in work [13]. However, significant amounts of electricity are consumed to achieve such extraction efficiency, which is not always economically justified.

One of the main factors influencing the process of juice extraction is the structure, condition, and, accordingly, the shape and size of raw materials, as well as the features of equipment for extraction. Thus, in work [14], it is proposed to carry out deeper grinding of stalks down to a size of 0.1 mm; a corresponding device was designed that ensures the destruction of the cell membranes and allows for a 23.6 % increase in the juice yield from the stalks. Deep grinding of stalks creates the basis for the transition to the juice of a significant amount of sugar, which can cause significant complications in the process of technological processing.

In work [15], the complex equipment of the Piedmont system for effective juice extraction is proposed. With this

method, the stalk is divided into a solid fraction and a core, which is passed through the auger press, which improves the pressing process and increases the productivity of the press. However, the use of appropriate equipment under industrial conditions, which would ensure the separation of stalk tissue into fractions, is associated with objective difficulties in its implementation, which makes such a study impractical.

An increase in the yield of pressed juice can be achieved by pre-thermal or chemical processing of plant raw material tissue, which serves to increase the permeability of the cell membranes for the extraction of sugary substances with pressed juice [16–18]. At the same time, these studies consider certain factors influencing the pressing process but are not completed from a technological point of view.

At the same time, it should be noted that the use of various modifications of the technique of mechanical pressing of stalks does not ensure the achievement of a high yield of juice, and, accordingly, sugar-containing syrup, per unit of raw materials. The issue of increasing the yield of the target product can be resolved by the combined use of press and diffusion methods of juice extraction.

Thus, in work [19], the author proposed, in order to achieve greater efficiency of the process of obtaining juice, the application of mechanical destruction of solid tissues in a sorghum stalk on roller crushers. That creates conditions for obtaining pressed juice of appropriate quality and ensures uniformity of the cake structure for further extraction process.

Over the past decade, scientists have been considering using a diffusion method to extract juice from sorghum stalks. Thus, the authors of [20] proposed obtaining juice from sorghum stalks by pressing on roller presses using several spins with the flow of juice to maximize the complete extraction of sugars from sorghum stalks. Under such conditions of the extraction process, about 87 % of sugars of their total content were obtained.

Paper [21] reports the results of a more in-depth extraction of juice from the stalks by pressing raw materials on the roller press and extracting additional crushed mass of stalks with distilled water at a temperature of 70 °C. The study has shown that if press and diffusion techniques of juice production are combined, more than 80 % of sugars of their total content can be extracted from the stalks of sorghum.

It should be noted that most scientific information on the technological aspects of the extraction of sugary substances addresses the processes of extraction and pressing in the production of sugar from beets. Thus, works [22, 23] analyzed the main directions of improvement of the technology of extraction of sucrose from beet chips, involving the use of chemical reagents for the preparation of nutrient water, optimization of the diffuse-press technique of sucrose extraction, control over microbiological processes, etc. In particular, the cited works investigated the use of the natural sorbent zeolite [24], coagulants – aluminum salts, flocculant of polyhexamethylene guanidine hydrochloride in the process of extraction for the treatment of nutrient water and beet chips [22]. Based on the mathematical treatment of experimental data, the rational parameters for the diffusion-press extraction of sucrose from beet chips [23] were established. At the same time, the issue of extraction of sugary substances from sorghum stalks is insufficiently studied, which requires further research and theoretical generalization.

Thus, the search for an effective way to extract sugary substances from sweet sorghum stalks in the technology

of obtaining food syrup is relevant, which could ensure the improvement of the manufacturing quality of the target product and its yield.

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### 3. The aim and objectives of the study

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The aim of this research is to improve the process of extraction of sugary substances from sweet sorghum stalks under the conditions of press and diffusion techniques. This would make it possible to extract sugary substances from raw materials as fully as possible and ensure that the final product of high technological quality is obtained.

To achieve the set aim, the following tasks have been solved:

- to evaluate the effectiveness of the press technique of extraction of sugary substances from sorghum stalks;
- to build equations describing the material balance of products and sugary substances when the press technique of extracting juice from sorghum stalks is applied;
- to investigate the effectiveness of the anti-current process of extraction of sugary substances from sorghum stalk cake after pressing.

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### 4. The study materials and methods

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#### 4. 1. The materials used in the experiment

As plant raw materials, we used sweet sorghum stalks of the Mamont hybrid (Odesa selection, Breeding and Genetic Institute – National Center, NAAS of Ukraine). The samples of sweet sorghum were selected during the growing season of milk-wax ripeness of grain in the research areas of the field of the Institute for Bioenergy Crops and Sugar Beets, NAAS of Ukraine (Ksaverivka village 2, Vasylykiv region, Kyiv oblast).

#### 4. 2. The procedure of obtaining pressed juice

Sorghum stalks were pressed using a three-roller press with an 11-kW electric drive and a roll rotation speed of 7.7 m/min. After that, we weighed the resulting cake and determined the content of solids and sugars, namely sucrose and reducing substances. In addition, we determined the content of solids and sugars in the stalks before pressing.

#### 4. 3. The procedure of obtaining an extract

Sugars were extracted from pressed sorghum stalks in the following way. For our research, we used additionally crushed and pre-pressed sorghum stalks with a solid content of 31.4 % and, accordingly, the total sugar content of 8.74 %, including reducing substances – 3.7 %, sucrose 5.15 %. To simulate the stationary extraction mode, 450 g of crushed stalks were added to the capacity of 1,000 cm<sup>3</sup> and poured with prepared nutrient water in the amount of 600 cm<sup>3</sup>. To simulate the anti-current extraction process, alternately multistage extraction was used, directing the samples of extracts with a lower solids content, respectively, for extraction from stalks with higher sugar content. The duration of the extraction process was 20 minutes, the temperature range – 66–70 °C, and the ratio of phases of raw materials/extractant of 1:2. The obtained extract was used to determine the indicators of technological quality.

#### 4. 4. Methods for determining the main technological indicators of the quality of sweet sorghum juice, its extract, and cake

Both generally accepted and special methods of analysis and control were used, existing in the sugar industry, and adopted in international practice.

The content of total sugars, reducing substances, sucrose in the juice, extract, raw materials, and cake was determined by the iodine metric method [25]. Subject to determining these indicators in the raw materials and cake, we prepared samples in advance by conducting hot water digestion. The purity coefficient was calculated as the ratio of the total content of sugars in the product to the content of solids multiplied by 100 %. The starch content in the juice was determined by the Morell Doo Will method, which is based on the measurement of the optical density of the solution under investigation, acidified with vinegar acid and treated with potassium iodide, at the spectrophotometer SF-46, at a wavelength of 570 nm. The concentration of starch was determined according to the calibration chart [26].

The content of high-molecular compounds (HMC) and colloids was determined by the method of A. Dumansky and S. Harin in the modification of S. Korolkov and P. Silin. The method is based on the properties of hydrophilic colloids to coagulate in solution after the addition of ethanol, followed by their quantitative determination by the weight method.

The content of proteins was determined by the method of L. Reva, G. Simahina (with a biuret reagent) at the spectrophotometer SF-46, at a wavelength of 600 nm [27]. The dry solids content in the juice and extract (DS, % by product weight) was determined without preparation of the sample at a temperature of 20 °C by the refractometric method using the RPL-3 refractometer; in the stalks and cake – by weight. The activity of H<sup>+</sup> ions was determined by the potentiometric method using the universal ionomer EB-74 [27].

Mathematical treatment of our study results employed the Math CAD Professional and Microsoft Excel application package.

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### 5. Results of studying the process of extraction of sugary substances from sweet sorghum stalks

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To extract sugary substances from sorghum stalks, it is advisable to use pressing and extraction methods in order to obtain a product of high technological quality. An important task in determining the rational process parameters is to derive mathematical equations describing the yield of products in accordance with the material balance of the specified processes.

#### 5. 1. The results of studying the press technique of extraction of sugary substances from sweet sorghum stalks

The process of juice extraction and, accordingly, sugary substances at the first stage was carried out by the press method. The results of our study are given in Table 1.

If the juice is extracted from sorghum stalks by pressing, it can be argued that together with the juice it is possible to extract an average of 35–40 % of sugary substances. This is reflected in the technological indicators of cake after pressing. A significant proportion of juice and, accordingly, sugars remains in it – 8.74 %. This is because the press technique provides only for partial destruction of stalk tissue cells; the juice is extracted from them. Note that a significant proportion of non-torn cells remains in the cake.

**Table 1**  
Technological indicators of sorghum stalks before and after pressing

Indicator	Fresh raw material	Cake after pressing
Mass, kg	8.3	6.4
Mass share, %:		
dry solids	26.0	31.4
total sugars	10.26	8.74
reducing substances	4.94	3.70
sucrose	5.32	5.15

**5. 2. The results of research into the substantiation of a mathematical model of products and sugary substances when the press technique of juice extraction is used**

Based on the theoretical substantiation of the material balance of raw materials and products during pressing, a procedure has been proposed for calculating the yield of pressed juice, cake, and the content of total sugars in it. As variable parameters, the content of solids and sugary substances in the sorghum stalks before pressing has been selected, as well as the content of dry substances in the cake after pressing, the amount of dry matter losses during pressing.

Calculations employed the Math CAD Professional software.

Based on the above, the yield of pressed cake from sorghum stalks is:

$$W(g, x) = \frac{100 \cdot x \cdot (1 - H)}{g}, \tag{1}$$

where  $W$  is the yield of the pressed cake, %;  
 $n$  is the number of sorghum stalks, % (100 %);  
 $x$  is the solids content in sorghum stalks.  
 $H$  is the normative value of dry matter losses during pressing; based on the experimental studies, it is 0.05–0.08;  
 $g$  is the solids content in the pressed cake from stalks.

The yield of pressed juice:

$$B(g, x) = 100 - \left[ \frac{100 \cdot x \cdot (1 - H)}{g} \right], \tag{2}$$

where  $B$  is the pressed juice yield, %.

The loss of sucrose with the pressed cake is calculated depending on the extent of its pressing, the content of total sugars and solids in the sorghum stalks. For the mathematical modeling of the residual content of sugary substances in pressed stalks, equation (3) was used as a function of the variable parameters of solids content in pressed cake and sugar content in sorghum stalks:

$$Gs(g, S) = \frac{S \cdot \left[ 100 - \frac{100 \cdot \left[ 100 - \frac{100 \cdot x \cdot (1 - H)}{g} \right]}{100 - x} \right]}{100}, \tag{3}$$

where  $Gs(g, S)$  is the loss of sugars in cake, %;  
 $S$  is the content of total sugars in stalks, %;  
 $x$  is the solids content in stalks.

The range of changes in the parameters was, respectively:  $g - 28...36\%$ ,  $x - 24...26.5\%$ ,  $S - 12...17\%$ , at the steady value of the normative value of dry matter losses during pressing  $H - 0.069$ .

Below are the estimation dependences of the yield of the pressed cake (Fig. 1), the amount of pressed juice (Fig. 2), and the sugar content in the pressed cake (Fig. 3), on the extent of pressing –  $g$  (solids content in pressed cake). When determining the dependences of the yield of the pressed cake (W01–06) and the amount of pressed juice (B01–06) on the extent of pressing, the initial values of the solids content in the stalks were equal to 24 %; 24.4 %; 25 %; 25.5 %; 26 %; 26.5 %, respectively.

Our analysis of dependences shown in Fig. 1 reveals that the yield of pressed cake from sorghum stalks averages 75–65 %.

The theoretical yield of pressed juice is on average 25–35 % by weight of sorghum stalks (Fig. 2).

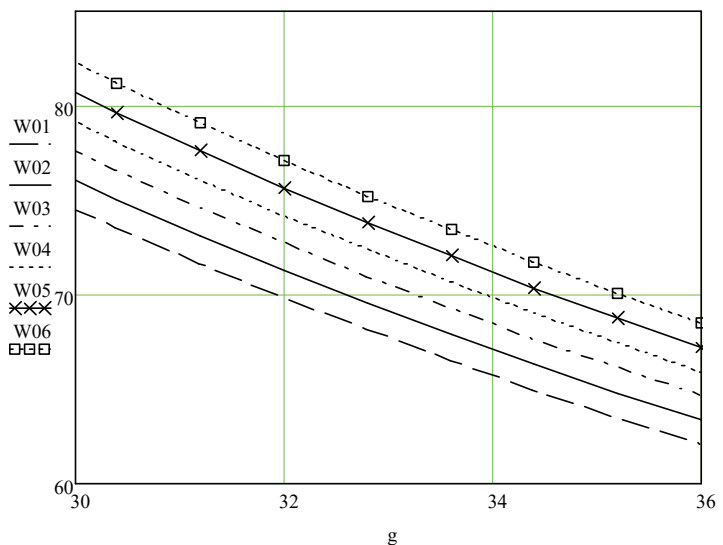


Fig. 1. Dependence of the yield of pressed cake ( $W$ ) on the solids content after pressing ( $g$ )

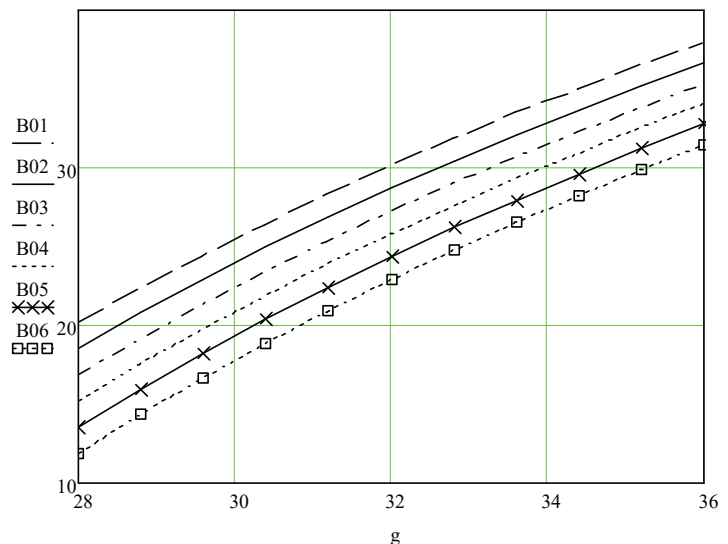


Fig. 2. Dependence of the yield of pressed juice ( $B$ ) on the solids content after pressing ( $g$ )

When determining the dependence of the total sugar content in the pressed cake (Gs01–06) on the solids content after pressing (Fig. 3), the initial content of total sugar in the stalks is, respectively: 12 %; 13 %; 14 %; 15 %; 16 %; 17 %.

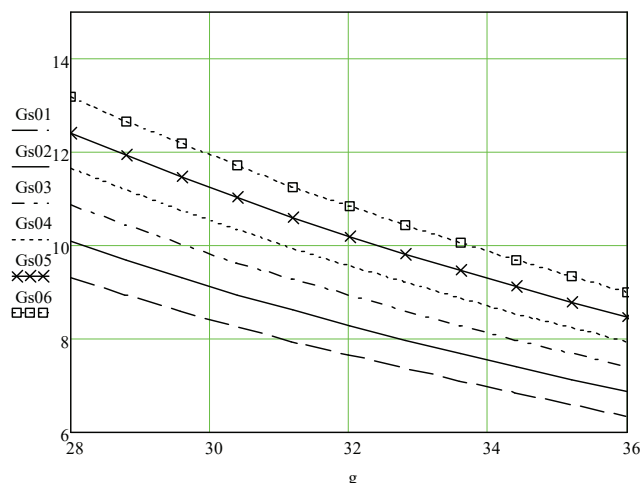


Fig. 3. Dependence of the total sugar content (Gs) in the pressed cake on the solids content after pressing (g)

Based on the experimental study and theoretical calculations, it has been shown that an average of 25–35 % of the juice is extracted by pressing sorghum stalks. At the same time, the yield of juice is influenced by the extent of stalk pressing and the content of cell juice in stalk tissue. The low yield of pressed juice can be due to both the varietal features of sweet sorghum and the late harvesting of the raw materials. In addition, it should be noted that the press technique does not provide for a sufficient mechanical opening of stalk tissue cells, which predetermines the presence of a significant juice content along with sugary substances (more than 60 %) in the pressed cake of stalks. Therefore, in the future, it is necessary to apply the process of extracting the cake of stalks for the additional extraction of sugars.

### 5.3. The results of studying the technique of extraction of sugary substances from a cake of sorghum stalks

To determine the rational parameters of extraction of sugars from the pressed cake of sorghum stalks, a series of studies were carried out to determine the dynamics of the transition of solids and the quality of the extract under different conditions of the process. The duration and temperature of the extraction process were selected as variable parameters.

An important indicator that determines the effectiveness of the extraction process is the dynamics of the transition of soluble substances into the extract. Fig. 4 shows the dependences of the dry solids content in the extract in the range of changes in the duration of the process up to 30 minutes. at a process temperature of 60 and 70 °C.

It should be noted that the accumulation of soluble substances in the extract occurs in accordance with known patterns of mass exchange processes, which are characterized by the transition of one or more components of the source substance from one phase to another.

Accordingly, the driving force of mass exchange processes is the difference in their concentrations [28]. In addition, the content of soluble substances in the extract is influenced by the ratio of extractant–raw materials, the surface area of their contact, and, accordingly, the extent of grinding of raw materials, the temperature, and duration of the process [29]. Extraction of soluble substances from the internal structures of the pressed cake to the extractant ends when equilibrium concentrations are reached between them [30].

It should be noted that under the appropriate conditions of the process of extraction of sugary substances from the pressed cake of sorghum stalks, the equilibrium state is achieved over a period of 25...30 minutes. However, over a period of 3...5 minutes, the extractant receives the order of 60–70 % of soluble dry solids to their total content in the extract, which is obtained within 30 minutes.

Based on our study, one can conclude that the effectiveness of extraction of sugars from pre-pressed sorghum stalks decreases after a process duration of 15–20 minutes, which indicates the achievement of equilibrium concentrations between the raw materials and extractant.

Table 2 gives the technological quality indicators of juice obtained by pressing and subsequent extraction of pressed cake from sorghum stalks. To this end, a study was carried out by modeling the counter-current extraction process using the above procedure.

Our analysis of the study results (Table 2) has revealed that the quality of the extract obtained from pressed cake and pressed juice is somewhat different in terms of technological indicators.

Thus, the pressed juice had higher values in terms of total sugar (13.06 %), reducing substances (4.32 %), sucrose (8.74 %), and, accordingly, the purity of juice (85.92 %). At the same time, the pressed juice had lower values in terms of starch (2.8 %), protein (0.87 %), and high-molecular compounds (10.92 %).

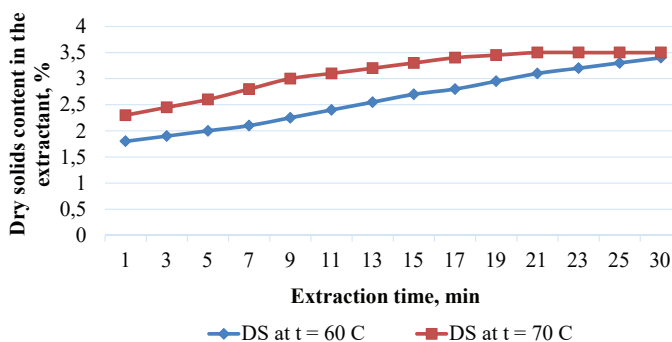


Fig. 4. The dynamics of accumulation of dry solids in the extract, subject to the stationary process of extracting them from the pressed cake of sorghum stalks at a ratio of cake/extractant 3:4

In the extract, the content of total sugars, reducing substances, sucrose, and purity were somewhat lower and amounted to (11.10 %, 4.20 %, 6.90 %, and 85.38 %), respectively. At the same time, an increase in the content of non-sugars was observed in the extract, namely protein substances (1.34 %) and high-molecular compounds (15.74 %). These discrepancies are primarily due to the lower content of sugary substances in the pressed cake after juice release.

**Table 2**  
Technological indicators of the pressed juice and extract from the pressed cake of sorghum stalks

Indicator name	Pressed juice	Extract
H <sup>+</sup> ion activity	4.9	4.7
Dry solids (DS) content, %	15.2	13.0
Starch content, %	2.8	3.1
Protein substances content, %	0.87	1.34
High-molecular compounds (HMC) content, % to DS mass	10.92	15.74
Total sugar content, %	13.06	11.10
Reducing substances content, %	4.32	4.20
Sucrose content, %	8.74	6.90
Purity, % of sugar to DS mass	85.92	85.38

In addition, under the conditions of additional grinding of the pressed cake and the anti-current extraction process at a temperature of 66–70 °C, more complete destruction of the cell membranes of raw materials occurs. This creates conditions for extracting, together with sugars, related substances (proteins, starch, and other high-molecular compounds).

The content of non-sugars in the extract is also determined by the extent of de-sugaring, or the residual content of sugary substances in the cake after extraction.

## 6. Discussion of results of studying the extraction of sugary substances from sweet sorghum stalks

The issue of extracting the juice and, accordingly, sugars from sweet sorghum stalks has not been sufficiently studied. In today's conditions, the most common way to extract them involves pressing but it does not ensure the proper yield of the target product. Our research is aimed at finding ways to intensify the process of extracting sugary substances from sorghum stalks. The use of the combined extraction of sugary substances by pressing and extracting can be considered a justified ultimate goal of this study, which makes it possible to increase the effectiveness of extraction of the target component, provided that pressed and diffusion juice of satisfactory quality is obtained. The proposed mathematical model – formulas (1) to (3) – makes it possible to conduct a theoretical analysis of the influence of the main parameters of the process on the yield of pressed juice (Fig. 2), as well as the yield of cake (Fig. 1), and the content of sugary substances in it (Fig. 3). It should be noted that with an increase in the dry solids content in the raw materials – the stalks of sorghum, the yield of the pressed juice decreases (Fig. 2), which leads to a decrease in the efficiency of the pressing process.

The derived estimation dependences of changes in the yield of pressed cake, the amount of pressed juice, and sugar content in the pressed cake relative to the initial dry solids content and the extent of pressing sweet sorghum raw materials are nonlinear. At the same time, our analysis of the established dependences has shown that the use of the press technique ensures the extraction of juice in the range of 25–35 %, the yield of the pressed cake is on average 75–65 %, with a sugar content exceeding 60 % of its initial content in the raw materials. The reported results of theoretical calculations are consistent with experimental studies by other authors [31, 32].

Based on our results, it can be concluded that the increase in the efficiency of the process of extraction of pressed juice is achieved subject to optimal terms of harvesting raw materials in terms of achieving the dry solids content in the sorghum stalks of about 24–25 %. In the case of processing the raw materials of late harvesting, the stalk acquires a wooden structure with a dry solid content exceeding 28–30 %; the extraction of sugary substances by pressing becomes difficult. In addition, a decrease in the dry solids content (DS), and, accordingly, an increase in the content of cell juice in stalk tissue, can be achieved by pre-scalding the stalks.

The use of an extraction technique for extracting sugary substances from pre-pressed stalks (cake) makes it possible to obtain diffusion juice (extract) with a high dry solid content. Thus, in the case of the extraction process according to such technological parameters as the temperature  $t=66-70$  °C; duration, 20 min; hydro modulus, 1:2; we have established (Table 2) that the following indicators of the extract are achieved: dry solids content, 12.4...13.2 %; purity, 84...85 %.

Consequently, increasing the extent of pressing sorghum stalks and applying extraction could improve the effectiveness of the extraction of sugary substances. The results reported here could be used to improve the technological process of processing sweet sorghum with the production of food syrup. First, combining the press technique of extracting juice from sorghum stalks with an additional anti-current process of extraction of stalks (cake) makes it possible to ensure almost complete de-sugaring of the raw materials. Accordingly, with such technological processing of sorghum stalks, there will be no loss of sugars in waste, which would positively affect the economic indicators of production and the cost of the target product.

Second, as studies [4, 33] have shown, in the case of processing pressed juice, food syrup is enriched with amino acids, minerals, trace elements, and other biologically active compounds. These nutrients play an extremely important role in the vital activity of the human body.

At the same time, the technology of purification of pressed juice can ensure the production of an organic product without the use of chemical reagents [34]. As our study has demonstrated, the extract obtained from the pressed cake contains a greater number of non-sugars, in particular high-molecular compounds, which require the use of more advanced cleaning technology.

Our conclusions may be considered appropriate from a practical point of view since they make it possible to reasonably approach determining the technological parameters of the process of extraction of sugary substances from sweet sorghum stalks in order to increase the yield and quality of juice.

From the theoretical point of view, the material balance of products and sugary substances during the pressing of raw materials has been substantiated; the effectiveness of the process of extraction of sugary substances by extraction has been investigated; the quality analysis of juices has been carried out. Along with this, it should be noted that the quality of the extract depends on several factors that are not considered within the framework of the present study. That points to a potentially interesting scientific and practical area of further research. In particular, studies may be focused on defining the effect of temperature, pH of the extract on the quality of the extract and the characteristics of the effectiveness of the extraction process, in particular the diffusion coefficient, the degree of plasmolysis of stalk tissue cells. Such studies could make it possible to investigate microstructural

transformations in the system extractant–juice and determine the input variables of the process that significantly impact the effectiveness of the extraction of sugary substances, provided that there is the slightest transition of non-sugars.

Our results are part of research aimed at devising the technology of food syrups, including organic, from alternative sugar-containing raw materials – sweet sorghum.

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## 7. Conclusions

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1. It has been established that the use of a press technique for the extraction of sugary substances ensures the removal, together with juice, of an average of 35–40 % of sugary substances. At the same time, the technological indicators of the resulting cake indicate that more than 8–9 % of total sugars are guaranteed to be lost in it.

2. A mathematical model has been built for calculating the yield of pressed juice, cake, and the content of total sugars in it. The derived graphical dependences of changes in the yield of pressed cake, the amount of pressed juice, and the sugar content in the pressed cake relative to the initial dry solids content and the extent of pressing the raw materials are nonlinear. Our analysis of the established dependences has revealed that the use of the press technique ensures the extraction of juice in the range of 25–35 %, the yield of the pressed cake is on average 75–65 %.

3. The study results have allowed us to investigate the rational technological parameters of the anti-current process of extraction of sugary substances from sorghum stalk cake after pressing. These parameters are the temperature  $t=66–70$  °C; duration, 20–30 min; hydro modulus, 1:2, owing to which the following indicators of the extract are achieved: dry solids content, 12.4...13.2 %; purity, 84...85 %.

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