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THE IMPORTANCE OF THE CHEMICAL COMPOSITION OF STEAM JUICE OF SUGAR SORGHUM IN THE PREPARATION OF FEED FOR BEES

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Annotation: The article provides information about the high need of bees for natural, vitamin-and-mineral-rich local foods, the results of a chemical analysis of sweet sorghum stem juice processed to create food for bees, as well as the beneficial properties of the results obtained, intended for creating food for bee colonies. The information about the ability of the sweet sorghum plant to produce the expected harvest even in an arid, salty climate, the stem juice is rich in carbohydrates, vitamins, macro- and microelements is also given.

Key words: sweet sorghum, stem juice, chemical composition, result, carbohydrates, vitamins, mineral’s, protein, amino acids, arid.

Introduction. The growth of the world's population presents a number of global challenges; along with resources necessary for human needs such as drinking water, electricity, natural resources, etc. causes food shortages and lack of naturalness. Therefore, the duty and task of the intelligentsia is to contribute to the solution of these problems. It is especially important to expand the range of natural food products and preserve the naturalness of their composition. As a result of the growth of consumer culture in countries around the world, the demand for honey and honey products is increasing. This, in turn, requires solving problems associated with feeding bee colonies.

The unique natural and climatic conditions of our republic are very favorable for the cultivation and development of a bee colony based on new technologies. That is why beekeeping is one of the leading branches of agriculture. However, due to the reduction in the size of natural green spaces, parks and green areas in our country, even during the season, there is a lack of nutrition for bee colonies. For the development of the beekeeping industry, for the life and reproduction of bees, it is necessary to create natural and environmentally friendly feeds containing proteins, fats, carbohydrates, minerals and vitamins. All this means that providing the beekeeping industry with additional food products is one of the important and urgent tasks[1].

Therefore, in recent years, due to the chronic feeding of sugar to the bee colony in the republic and the lack of vitamins, fats, carbohydrates, amino acids, micro- and macroelements in such feeds, bees after winter become weak, susceptible to diseases and have a weak ability to reproduce. This requires feeding bees natural, vitamin- and mineral-rich food sources [2].

Today, about 50-55% of the arable lands of our republic are subject to varying degrees of salinization. The sweet sorghum plant chosen as the object of study can be grown in any climatic conditions of our republic, including in arid and saline lands. Sweet sorghum is not only a high-yielding plant, but also removes 31 to 75 t/ha of salts from the soil, as well as toxic substances such as chlorides and sulfites. The sweet sorghum plant is so resistant to salt that when irrigated with salt water from the Caspian Sea, the yield of green mass was 52.7 t/ha [3;4].

High-sugar varieties of this plant are considered domesticated, and some varieties can be harvested up to twice a year.

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The amount of dry matter in the varieties of sweet sorghum selected for the study with a high level of sugar content “Karabosh”, “Orange-160”, “Uzbekistan 18” averages 18-23%, which is significant when extracting juice up to 70-80% from the stem [5;6].

The stem juice of sweet sorghum is rich in carbohydrates, amino acids, minerals and vitamins, and serves to ensure the normal functioning of bees and the production of high-quality honey, which helps strengthen the food supply of beekeeping farms.

Purpose of the study. The purpose of the ongoing scientific research is to conduct a chemical analysis of the processed juice of the sweet sorghum varieties “Karabosh”, “Orange-160”, “Uzbekistan 18”.

Research methods and materials. One of the objectives of the study is to prepare environmentally friendly natural food with high nutritional value to replace traditional food with sugar in the off-season for bees. While sugarcane juice contains only sucrose (crystallizing sugar), sweet sorghum juice contains glucose and soluble starch in addition to sucrose, which inhibit crystallization. This, in turn, reduces the crystallization of honey. In terms of content, sugar obtained from sweet sorghum is superior to sugar from beets and sugar cane, since in addition to sucrose it contains fructose and glucose. Sweet sorghum stalk syrup contains the following minerals: Ca, P, Mg, K, Na, Cu, Zn, Co, Mn, Fe, S, up to 3% protein, all essential amino acids, vitamins B1, B2, PP, E and C. This condensed juice can be used not only for feed, but also in the food industry, and this is currently very relevant. The amount of sugar in the juice obtained from selected varieties is 18-25%, that is, 18-20% of the total mass is sugary substances [6;18].

Experiments conducted in Russia have shown that in the conditions of the North Caucasus (September-March) some varieties of sweet sorghum can be stored in bunches for 170 days. This makes it possible to provide manufacturing enterprises with raw materials for a long time. Currently, in many foreign countries, sweet sorghum is used in the food industry for the production of juices, syrups, streams and in various other areas.

From an economic point of view, 1 ton of sweet sorghum sugar is 20% cheaper than 1 ton of beet sugar. If beet sugar is replaced with sweet sorghum syrup, the cost of confectionery products and soft drinks will decrease [19].

In order to fully analyze the chemical composition of the stem juice of sweet sorghum, chosen as the object of study, experiments were carried out together with leading specialists in the laboratory of the Institute of Bioorganic Chemistry named after Academician A.S. Sadykov of the Academy of Sciences of the Republic of Uzbekistan.

Several methods were used in the experiment. To determine the amount of water-soluble vitamins, GOST 32903-2014 was used. The analysis was carried out by HPLC (high performance liquid chromatography) using a diode array detector (DAD).

Method for determining the amount of water-soluble vitamins.

5-10 g of sample was weighed on an analytical balance and placed in a flat flask with a capacity of 300 ml. 50 ml of 40% ethanol solution was added to it. The mixture was boiled with vigorous stirring for 1 hour, equipped with a magnetic stirrer and reflux cooler, and then stirred at room temperature for 2 hours. The mixture was cooled and filtered. 25 ml of 40% ethanol was added to the remainder and re-extracted 2 times. The filtrates were combined and filled to the mark with 40% ethanol (5÷10%) into a 100 ml volumetric flask. The resulting solution is centrifuged at a speed of 7000 min^{-1} for 10 minutes. The upper part of the resulting solution was taken for analysis. Working solutions of water-soluble vitamins with a concentration of 1 mg/ml were prepared. To do this, 50 mg of each vitamin standard was weighed on an analytical balance and dissolved in 40% ethanol in a 50 ml volumetric flask.

Phosphorus, acetate buffer systems and acetonitrile were used as eluents in the determination of water-soluble vitamins by HPLC (high-performance liquid chromatography). Initially, working standard solutions were introduced into the chromatograph, and then prepared working solutions [24; 25].

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Determination of carbohydrates in concentrated sweet sorghum juice. Determination of the amount of carbohydrates, that is, monosaccharides, in the stem juice of sweet sorghum was carried out using high-performance liquid chromatography. To do this, the contents of the sample being determined are degreased and a certain amount of the defatted substance is taken. The resulting sample is extracted with water and kept for a certain time in an ultrasonic water bath to speed up the extraction process. After completion of the extraction process, it is filtered or centrifuged, the supernatant (liquid part) is collected and quantitative analysis is carried out using high-performance liquid chromatography (HPLC) [25].

The determination of the amount of free amino acids was carried out according to the method presented in GOST 34230-2017.

The composition and quantity of amino acids in the sample were determined by the Cohen-Daviel method in the form of FTC derivatives of amino acids.

Precipitation of proteins and peptides from the aqueous extract of the sample was carried out in centrifuge dishes. To do this, 1 ml (exact volume) of 20% TSA was added to 1 ml of the test sample. After 15 minutes of centrifugation at 8000 min^{-1} for 10 minutes, a precipitate formed. 0.1 ml of supertant was separated and lyophilized (freeze dried). The hydrolyzate was evaporated, the dry residue was dissolved in a mixture of triethylamine-acetonitrile-water and dried. This process was repeated 2 times to neutralize the acid

Phenylthiocarbamyl derivatives (PTC) of amino acids were prepared by reaction with phenylthioisocyanate according to the method of Stephen A., Cohen Daviel. Amino acid derivatives were determined by HPLC.

Determination of the amount of heavy metals, macro- and microelements in juice by mass spectrometry with inductively coupled plasma ICP-MS.

This method is used to determine the amount of macro- and microelements in food products. To do this, 0.0500 ÷ 0.500 g of the test substance is weighed on an analytical balance and placed in a Teflon container of an autoclave, then filled with the appropriate amount of purified concentrated mineral acids (nitric acid and hydrogen peroxide). The autoclave is closed and placed in a programmable Berghof microwave oven (MWS-3+). Depending on the type of substance being tested, the appropriate program is determined.

After decomposition of the substances placed in the autoclave, they are placed in volumetric flasks with a capacity of 50 or 100 ml and adjusted to the required level with 0.5% nitric acid. The amount of substances was determined by inductively coupled plasma mass spectrometry (ICP-MS).

Determination of protein content of condensed sugar corn stem juice

One of the methods for determining the amount of protein is the Kjeldahl method. This method involves calculating the amount of total protein by determining the amount of nitrogen. The essence of the method is the hydrolysis of organic substances in the sample using concentrated sulfuric acid (an amino group in the protein) with the formation of ammonium sulfate salts.

Азотсодержащие органические вещества $+H_2SO_4$ $(NH_4)_2SO_4+CO_2+H_2O$. (1)

After hydrolysis was completed, the resulting ammonium sulfate was treated with sodium hydroxide to convert it into ammonia:

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2NH_4OH \begin{cases} \nearrow 2H_2O \\ \searrow 2NH_3 \end{cases} \quad (2)$$

The ammonia or ammonium hydroxide formed as a result of neutralization is absorbed by a solution of sulfuric acid.

The remaining acid is titrated with an alkali solution and the amount of nitrogen is calculated from the calculated amount of ammonia. An accurate sample weighing 0.1 g was weighed from the test sample into a test tube for analysis, the error of which should not exceed

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0.1%. Quantitative analysis of the sample is carried out in a Kjeldahl flask. Next, the experiment was carried out according to the instructions.

Processing of the results obtained: the mass fraction of nitrogen (X) in the analyzed sample is calculated using the formula as a percentage of the sample mass by volume after titrating the amount of ammonia passed through dilute sulfuric acid.

$$X = \frac{(V_1 - V_0) * K * 0.0014}{m} * 100\,\%, \qquad (3)$$

where V_0 is the volume of 0.1 mol/l sodium hydroxide solution used for titration of 0.1 mol/l sulfuric acid solution, remaining from the trial experiment; V_1 is the amount of 0.1 mol/l NaOH (sodium hydroxide) solution used for titration of sulfuric acid; K – 0.1 mol/l sodium hydroxide solution used for titration; 0.0014—the amount of nitrogen equivalent to 1 ml of 0.05 mol/l sulfuric acid solution; m – mass of the final result obtained from five parallel indicators, g; X is the mass fraction of nitrogen in the sample.

When preparing additional food for bee colonies from the stem juice of sweet sorghum, the amount of carbohydrates in the bees' main source of nutrition is taken into account. For this reason, the amount of carbohydrates was regularly determined by the refractometric method according to ISO 2113-2013 at the growth stages of sweet sorghum varieties [20; 21].

At the same time, the pH of the juice produced in the stem when growing the varieties of sweet sorghum “Karabosh”, “Uzbekistan 18”, “Orange 160” was also monitored. The pH of sweet sorghum stem juice was studied by the potentiometric method on a Voltcraft PH-100 ATC pH meter (Germany) with an external electrode [22].

Research results and discussion. Based on research results, it has been established that the stem juice of sweet sorghum contains a sufficient amount of glucose, fructose, sucrose, maltose, all water-soluble vitamins C, B, mineral elements, amino acids and partial protein to create food for bees.

As can be seen from the results of Table 1, the amount of carbohydrates in the stem juice of the variety “Orange 160” is 46.48%, “Karabosh” 46.02%, “Uzbekistan 18” 47.43%. The amount of water-soluble vitamins in the variety “Orange 160” is 11.447 mg/g, in the variety “Karabosh” 10.405 mg/g, and in the variety “Uzbekistan 18” 13.405 mg/g. It has been established that the nutritional value of sweet sorghum juice, which is the object of the study, is quite high.

The amount of macro- and microelements and heavy metals in the juice was determined to the concentration of the juice, with a dry matter content in the juice of about 18÷23%. Macro- and microelements are found in almost the same quantities in all three varieties and provide the bees with the necessary minerals during the off-season.The results obtained are presented in Table 2.

Table 2

The amount of macro- and microelements in sweet sorghum stem juice

	Macro- and microelements 100 mg/g							
Sweet sorghum stem juice	Na^+	Mg^+	Al^+	Ca^+	K^+	Fe^+	Mn^+	P^+
	2.480	172.71	2.10	3.009.1	980.	109.2	2.909	77.43
	Macro- and microelements 100 mg/g							
	Mo^+	S^+	Cu^+	Se^+	Cr^+	Si^+	Sn^+	Co^+
	0.015	1.032	0.197	0.019	0.019	37.71	7.199	1.377

The table shows that the juice used as food for bee colonies contains macroelements such as Ca (3.0091 mg/g), K (9.806 mg/g), Fe (1.092 mg/g), Mg (1.7271 mg/g), P (7.743 mg/g) and

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provides the mineral content of the juice. The presence of such useful microelements as Al, Mn, Cu, Co, Si, Cr, Mo, S, Se, Zn was found in certain percentage amounts in the stem juice.

In the toxicology of food products there are elements belonging to the category of heavy metals, the limit of which is strictly defined in SanPiN. Exceeding the established limit can have a negative impact not only on the bees' body, but also on the quality and suitability of honey products for consumption.

Table 3.

Amount of heavy metals in sweet sorghum stem juice

Название продукта	Указанная норма не превышает мг/г					
"Оранжевое 160"	Zn	Cu	Pb	Cd	Hg	As
	1.377	0.19 7	0.029	0.002	0.005	0.00 5
"Корабош"	1.012	0.37	0.028	0.001	0.749	0.03 0
"Ўзбекистон 18 "	1.158	0.2	0.67	0.002	0.549	0.7
Согласно нормам СанПин	10.0	5.0	0.3	0.03	0.1	0.00 5

According to the results obtained, the amount of Zn in the stem juice of the Orange 160 variety is 1.377 mg/g, which is 7.7 times less than the permissible norm given in SanPiN 0366-19, the amount of copper (Cu) is 25 times less than the norm, the amount of lead (Pb) is 10.3 times less, the amount of cadmium (Cd) is 15 times less, the amount of mercury (Hg) is 20 times less, and the amount of arsenic (As) is within the acceptable range, and it has been proven that the stem juice of sweet sorghum , offered as food for bees, meets the requirements of SanPiN.

Particular attention should be paid to food raw materials grown in natural environments with an increased level of geochemical anomalies in the amount of heavy metals; in areas where enterprises of the metallurgical, mechanical engineering, mining, and chemical industries are located; near major highways and cities.

According to the table, the amount of dissolved substances in the stem juice of sweet sorghum at full ripening averages 19÷22 % for the early-ripening variety "Karabosh", up to 20.2÷22 % for the mid-ripening variety "Orange 160" and 22.4÷23 % in the late-ripening variety "Uzbekistan 18".

It has been established that the pH value in the juice of sweet sorghum of the three varieties does not differ sharply and is 5.15 for the early ripening variety "Karabosh", 5.20 for the variety "Orange 160" and 5.1 for the variety "Uzbekistan 18".

In conclusion, the results of our analyzes show that the juice obtained by processing sweet sorghum stalks is rich in beneficial properties. The amount of carbohydrates in the juice is 46.48% and the total amount of amino acids is 9.915 mg/g, which further improves the quality of the new food used for bee colonies kept on local feeds of various compositions, prepared with the addition of sugar syrup due to the lack of natural crops , plants and shrubs. Bees can get enough protein and amino acids only from plant pollen. The content of amino acids and partially protein in sweet sorghum juice ensures the achievement of this goal.

The presence in the juice of almost all water-soluble vitamins, essential macro- and microelements, and partly protein also increases the energy value of the studied feed. In addition, it has been established that the sweet sorghum plant produces the expected yield in all regions of our republic, even in arid, low-water areas, and there is also sufficient opportunity to obtain juice from the stem, which does not cause any particular difficulties in creating feed.

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