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Innovative Technology of Making Candy (Paste Food) for Bees

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ABSTRACT: *Paste food is usually used in beekeeping in winter and has certain advantages over the liquid form: mixed nutrients and biologically active substances retain their beneficial properties (Gilliam a. Argauer, 1975) for a long time without disturbing the uniformity of the mixture. It is digested by hibernating bees satisfyingly. In addition, the traditional method of making candy by Scholtz (Root et al., 1964) is quite time-consuming and difficult, requires expensive and energy-intensive equipment, which makes the feed relatively expensive, and in case of weakness of the bee colony, its digestion is delayed and the feed dries up, accompanied by losses. Carbohydrates in such products mainly consist of sucrose, which does not indicate its physiological perfection.*

KEYWORDS: candy-paste food, invert sugar, β-fructofuranozidase, hydrolysis process, optical activity, crystallizing agent, protein additives, monosacharides.

INTRODUCTION

Research on improving the technological process

We have developed a different way of making candy that is less time consuming and physiologically improved. The main nutrient in it is completely hydrolyzed invert sugar (fructose + glucose), obtained through the enzyme β-fructofuranosidase (Madzgharashvili et al., patent of former USSR # 578 341 C 13 K 3/00, 1977). Initially, the aqueous solution of sucrose has a relatively low concentration (less than 60% by weight). This reduces the hydrolysis process to 24 hours. Then it is concentrated to 77-78% by weight using a method recently developed by us, which is based on the enhanced water evaporation from the solution by increasing its surface area at relatively low temperature (65-68^{0}C, Saqpatenti, Copyright # 5870, 2014). This method practically excluded the formation of 5-hydroxymethylfurfural in syrup (up to 6 mg / kg), and the evaporation rate (decrease in water content) was 15-17% per hour. This significantly reduced energy costs for food production, as a result of which the share of sugar in its cost was 78-80%.

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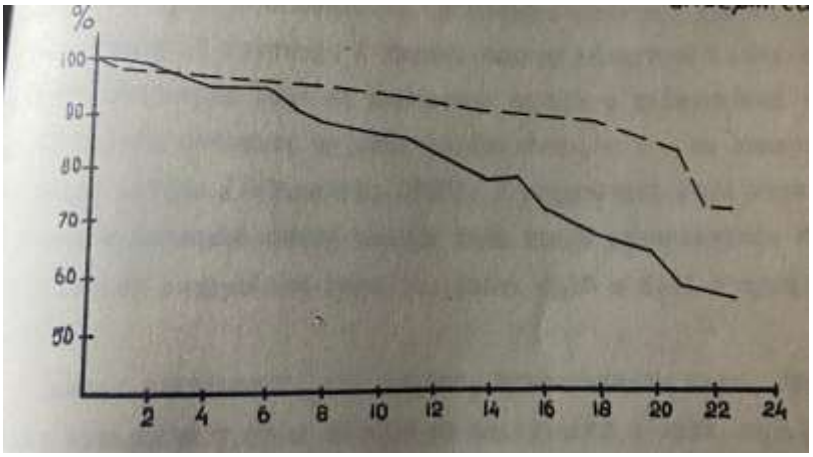
MATERIAL AND METHODS

The aim of the research was to create a cheap, doughy feed available for honeybees based on the presence of only monosaccharides (fructose + glucose) in the feed. Sugar was employed as a source material, which was hydrolyzed by the microbial β- fructofuranosidase with complete decomposition of sucrose within 24 hours.

The complete sucrose hydrolysis was checked by determining the optical activity of the solution using the polarimetric method (Bogdanov, 2002) according to harmonized honey research methods. To do this, the angle of rotation of the polarization plane was preliminarily determined in model solutions of various sugars (sucrose, glucose, fructose). It was found that when the content of simple sugars in the solution is at least 95% in terms of dry substance, its optical activity is close to -10^0 on the international sugar scale. At the end of the process, in order to thicken the low-concentration invert syrup relatively quickly, a new design of a two-body boiler has been developed, the essence of which is to radically increase the evaporation surface area with enhanced aeration of the solution. This significantly accelerated the concentration of the syrup heated to 68^0 C, the rate of moisture loss of which is 15-17% per hour, if the concentration of the solution at this time is in the range of 23-65%. At the end of the process, if it reaches 80% by weight, the evaporation rate decreases to 8-10%.

The physiological suitability of candy material for honeybees was determined by feeding young worker bees in entomological cages on relatively low-concentration feed (up to 65%): experimental group (60-75 in each cell) received invert syrup, the control group received honey of the same concentration. On the 22nd day of the experiment, the number of survivors in the experimental group was 72.5%, in the control group - 57%.



Days of observation

Fig.1 Dynamics of worker honeybees in the cages on variety feed (% of daily conservation)

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RESULTS AND DISCUSSION

Result of biochemical studies of candy

The initial stage of the hydrolysis of sugar (sucrose) was to determine its optimal concentration in an aqueous solution in order to: a) completely dissolve it within one day; b) determine the required amount of the enzyme β- fructofuranosidase for this purpose; c) enable the formation of 5-hydroxymethylfurfural both during hydrolysis and concentration. We determined the optimal temperature of the enzyme activity in early trials, when we were preparing a regular invert sugar substitute for reserve honey (for winter). It was 65 ± 2^0C. At higher temperatures (>70^0 C), oxidation (browning) of sugars from the 3rd day and formation of 5-hydroxymethylfurfural observed.

As for the concentration of the aqueous sugar solution, based on the above goal, it had to be reduced to 50-55 wt.%. Its further growth slowed down the hydrolysis process and, accordingly, the crystallization rate of the finished product. For the same reason, it was necessary to double the dosage of the enzyme preparation, although due to the relatively low price of this catalyst, this did not lead to a significant increase in the cost of the candy mass (no more than 2.5%).

It was found that the optimal concentration of the finished candy mass (syrup) to accelerate its further crystallization is less than 80% by weight, however this does not cause the emergence of undesirable microflora, which can be explained by the ability of the syrup to be crystallized quickly (2.5-3 days). This fact did not create the same danger when non-traditional protein additives (peanuts, skimmed milk powder, inactive dry yeast, pollen) were included in the candy mass. It can be assumed that thanks to these additives, the total amount of water in the candy mass was reduced to 13-14%, thereby preventing the danger of souring.

One of the important issues at this stage of research was the creation of a crystal structure in candy for rapid implementation of the process, for which appropriate studies were carried out and a crystallization reagent with the required properties was selected. Well-expressed crystallization of the solution begins 8 hours after mixing the components and ends within 60-72 hours. When the syrup thickens, it is instantly cooled by injecting cold water into the machine jacket at 19-220°C. A crystallizing agent is added to it (crystallized invert, or technical glucose, or easily crystallizable honey) and the prepared homogenized mass is poured into plastic bags. The desired consistency (dense dough) is achieved after 72-75 hours, after which it is ready for sale.

Along with the crystallizing agent, high-protein additives recommended by Haydak (1966) and other researchers (peanut flour, dry inactivated yeast, dry skim milk, ground pollen) can be added to the candy mass (syrup). After applying the crystallizing agent and these additives, intensive crystallization of the mixture is observed, which is also facilitated by a decrease in the water content to 13-14% by weight (as

a result of the use of dry components), although it is still recommended to turn the packed product periodically (once every 12 hours) until complete crystallization is achieved in order to maintain the uniformity of the mixture.According to our research, neither dripping in the middle of honeycombs nor drying was observed during the digestion of candy test samples, so there is no need to limit the digestion time.

The main technological equipment required for the production of candy

The technical facilities necessary for making candy in this way include: a biological reactor with heating and mixing devices, a compressor, a refractometer, a polarimeter for determining the degree of sucrose decomposition by rotation of polarized ray in it (Bogdanov et al), measuring device for filling and packing the finished syrup. At the main stage of production, the device is serviced by one person, only at the final stage (filling -packaging) a support person is required, which minimizes the share of labor costs.

Fig.2. Samples of candy prepared by new technology:

Candy consists of only monosacharides

Candy with protein additions

Technical and economic evolution of candy production.

The main advantage of candy production using the new technology is that the main part of the production process (preparation of syrup with an enzyme preparation, hydrolysis, concentration of the solution, mixing with other additives, bottling and packaging in plastic bags) takes place in one machine, that is, the types and cost of production equipment are reduced as much as possible. We must not forget about the compressor for obtaining compressed air and the dosing and packaging machine, although this circumstance makes the presented technology still incomparable against the background of the traditional one.

CONCLUSION

Having created and applied a number of technological innovations, the authors have developed a technology for making candy (doughy feed for bees):

- The main nutrient in this food supplement is simple carbohydrates, similar to honey, which do not require processing by honeybees; It contains no substances harmful to honeybees, is suitable for use at any time of the year, the nutrients and medicinal substances included in its composition maintain stable biological activity;
- The main equipment of the candy factory is a bioreactor, in which the following occur: preparation of sugar syrup, enzymolysis, concentration, inclusion of additives in the candy mass, bottling and packaging of finished products. The rest are relatively inexpensive devices (compressor and doser-packer). The whole process is carried out by one person, an assistant is needed only for bottling and packaging, which makes the resulting product as cheap as possible. This is also the result of a radical reduction in electricity consumption and production area.
- In the technology of candy production, an innovative method of concentrating an aqueous food solution is used, which is much easier compared to other similar methods (vacuum, in conditions of high temperature - atmospheric pressure), a fast method of crystallization of simple sugars. This makes it possible to cook feed at any time of the year.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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