Innovative approaches to obtaining a green sweetener

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Abstract. On the backdrop of the general trend towards healthy diet, scientists have noted an increase in the incidence of diabetes in the most active part of the working population. An erroneous idea of a balanced diet formed by the mass media contributed to the consolidation of a sweet taste as the most desirable in diets. To reduce harmful effects of sugar while maintaining the familiar taste of food, one of the ways to "improve" nutrition is to use a natural sweetener which is called stevia. The article proposes the method of growing it in a controlled environment. The objectives of the study were to obtain raw materials with an optimal ratio of the amount of biomass and the content of sweet glycoside of stevioside in it, and approbation of the introduction of whole dried raw materials into the products. Growth environment was changed to create stress by varying the spectral composition of the light. Obtained results indicate differences in the accumulation of stevioside along the tiers of leaves, with a maximum at an average level, as well as in the different effects of red, white, and blue parts of the spectrum on plant development. It has been shown that the regime with transition from the white or red spectra giving an increase in green mass to blue, “switching” metabolic processes to the accumulation of secondary metabolites, which stevioside belongs to, should become optimal. Obtained raw materials showed compatibility in bakery product formulations and in soft drinks. The method is considered promising for use in the greenhouse complexes of the Arctic to provide the rations of the local population with a functional additive for preventive nutrition.

1. Introduction
The general tendency to consume a large amount of hydrocarbon on the background of a decrease in the optimum fat and protein components of nutrition in modern diets has entrenched in the last three decades, which contributed to the growth of diseases associated with metabolic disorders [1; 2]. According to the results of studies of eating behavior as one of the risk factors in the late 90s of the last century and in the early 21st century, scientists started talking about the “diabetes epidemic” [3; 4; 5], noting that a 70% increase occurred in the most active age group of thirty. Forecasts in these studies [5; 6] made before 2030, retain their tendency [7].

Sweet taste has firmly entered into life even in those products that are commonly referred to as “proper nutrition” products - cereal bars and muesli with a high fiber content; fermented milk drinks, which have always belonged to dietary drinks due to the positive effect on the digestive system and its microflora; protein mixed drink and bars, which are strongly associated in the minds of contemporaries with fitness style; freshly squeezed juices, the consumption of which often occurs in the morning reception instead of breakfast or in its composition. A negative attitude to fat and an erroneous desire to minimize it below physiologically justified norms requires energy compensation, which occurs, as a rule, due to hydrocarbon. The desire for a healthy lifestyle, actively created in the
minds of young people, is not free from the errors caused by mythologization in relation to some products, and “demonization” in relation to others, created by the media, far from a scientific understanding of the problems [8]. The total effect of a high level of consumption of sugary products is an increase in the incidence of diabetes and related disorders that pose a threat to life [9; 10].

Considering these facts, along with others, the state since the late 90s has been preoccupied with solving the problem of reducing the nation’s health problems related to the nutritional factor, following the example of Japan, which was the first to determine the formation of a new direction in nutrition for public health [11]. It is nutrition that is the least expensive resource for the state, due to which in the long term it is possible to create conditions for maintaining health. The main requirements are: a) the presence in food products of such ingredients that can support the physiological parameters of the body and adaptive mechanisms at an appropriate level; b) the usual organoleptic characteristics of such products, allowing introduced them into the consumer’s daily diet painlessly for ingrained consumer preferences; c) they should not be a medicine or have their forms, they should remain food in dosages and methods of use [11; 12; 13].

With regard to leveling the consumption of high doses of sugar due to functional products, one of the solutions is the use of substitutes, among which many researchers distinguish stevia, preferring it due to its inherent number of additional properties, besides high sweetness [14; fifteen]. One of these properties, in particular, is antibacterial and antifungal activity due to secondary metabolites. When using stevia as an alternative to sugar, anti-caries prophylaxis is also added to the main task of reducing hydrocarbon in the diet [15], the relevance of which has also become very high with the growth of sugar. It is worth noting that the anti-inflammatory and healing effects identified in stevia will also work [16].

Being a plant of a warm climate [11; 17], stevia requires appropriate growing conditions, so in the southern regions it began to be introduced into the culture. Today, the Siberian region, as well as the border or northern territories remote from the center, also strive to have their own independent raw materials base, in accordance with relevant strategic programs for the development of territories [18; 19; 20]. The main idea in this resource provision is to analyze the possibilities of reducing the cost of obtaining and introducing raw materials into traditional diets by organizing cultivation in places of consumption, which determined the purpose of our study. The presence of severe climatic conditions, the high total cost of energy spent on obtaining plant products, require modern technological solutions that optimize the parameters of the regulated conditions.

To date, the composition and influence of the plant has been studied in detail. The main substance (stevioside), responsible for the sweet taste, refers to diterpene glycosides. In this regard, in our research, one of the tasks was to solve the problem of exposure to plants using external stress factors to enhance the accumulation of plant biomass on the one hand and its sweet start, on the other hand. Thus, it becomes possible to relatively reduce the cost of obtaining a sweetener. As a detailed review of the chemical composition and functional properties of its individual components on the human body shows [16], a stevia leaf as a whole can be valuable for nutrition, without additional isolation of glycoside in its pure form. Thus, the second task is to test the use of the obtained raw materials in food production as one of the options considered its introduction into the recipe mixture in its pure form, which also has one of the results of cost reduction.

2. Research materials and methods
As a method for forming the optimal ratio of the productive biomass of the plant and the content of sweet glycoside in it, cultivation under the conditions of photoculture was chosen.

To provide the possibility of studying the photofactor, plants were rooted in clay pellets with a growing medium based on a modification of Knop’s solution. The main stress factor was the spectral composition of light, on the effect of which on certain types of plants, different researches have been conducted since the mid-twentieth century. As two options, in addition to the main "white" spectrum (400-700 nm) of radiation, "red" (600-700 nm) and "blue" (400-500 nm) are selected, which are two maxima of PAR (photosynthetically active radiation) with point of absorption by plant leaves. The
patterns of influence on the reaction of plants using this factor have been studied in detail in researches [21] and works [22; 23, etc.]. The red spectral region makes it possible to intensify the growth of biomass, while the blue one initiates the transition to the accumulation of secondary metabolites characteristic of the reproductive period. Since glycosides are classified as secondary metabolites, it was assumed that blue light should become the main stress factor for plants, displacing metabolic processes.

The experimental conditions and growing conditions are described in more detail in the works [11; 17]. Plants were irradiated with mercury lamps; the spectrum was affected by the use of color filters with specified characteristics [24].

3. Results and discussion

In the course of the study, the results showed that the effect on stevia cenoses under conditions of artificial cultivation allows rationing levels with a maximum of stevioside accumulation located in the midline with a minimum content of sweet glycoside in leaves located at the lowest level in the context of the vertical profile.

An analysis of the ratio of the photoperiod length and irradiation to biomass accumulation showed that the optimum irradiation is at least 60 W/m² PAR and the irradiation duration is 18 hours. Under these conditions, all tiers received enough light to provide photosynthetic reactions and prevented early leaf aging on the lower tier.

To ensure the same conditions, the planting density was also important, which, as determined in the experiment, was recognized as optimal with a density of 100 plants per m², allowing the maximum number of leaves to be accumulated.

An analysis of the spectral influence showed that the patterns of the effects of different spectral compositions on growth and metabolic processes were significantly different: the white and red spectra maximally contributed to the growth of the green mass of the plant with a low content of sweet glycoside in it; blue, on the contrary, gave a higher absolute output with lower volumes of biomass.

Thus, it can be assumed that in relation to stevia, the conclusion [11; 17] made regarding salidroside glycoside in Rhodiola rosea, on the feasibility of using spectrum changing modes at different stages of plant development: after accumulating sufficient biomass on white or red filters, transfer to grow the plants to the blue spectrum to initiate the accumulation of secondary metabolites, may be applicable.

For the introduction of stevioside after market analysis and generalization of consumer opinions [11; 17] we selected bakery products and soft drinks, the dosage of which was carried out taking into account the coefficient of sweetness. Stevia was introduced in a dry crushed form. In bakery products, natural sweetener showed good compatibility in terms of technological, tasting and quality parameters. In soft drinks, in addition, it did not affect the shelf life of the product, did not cause a violation of the structure of the drink during storage, and did not contribute to the precipitation.

4. Conclusion

Modern agricultural technologies and the development of more economical modern light sources as applied to greenhouses do not stand still. Thanks to the quite successful restoration and creation of new modern greenhouse farms, which were destroyed during the perestroika period and were hardly renewed in the following decades, at the present stage, it has ensured an increase in the production of greenhouse products.

To ensure the efficiency of greenhouse complexes, agricultural technologies take into account the influence of various stress factors, mainly related to food and water regimes, allowing increasing the yield of vegetable products. In relation to herbal raw materials, the value of which is primarily not biomass as a source of basic food substances, but its secondary metabolites, potential functional ingredients for nutrition that helps to maintain good health, changing the spectral composition is an important providing factor, the variation of which is most appropriate.
In this regard, the further development of research is aimed at studying the spectral features of the most economical modern light sources, providing not only the necessary levels of PAR, but also the ability to change the spectrum without the laborious manual replacement of filters with switching in automatic mode. This is important from the standpoint of reducing costs for the most expensive cost share in greenhouse growing of plant products. Now, when it comes to the active development of greenhouses beyond the Arctic Circle, experts have confidence in ensuring the profitability of local greenhouses; promising ways to reduce energy costs for heating and generating electricity, which are already used in practice in the Arctic and are developing enough [25], from the integration of greenhouses with livestock complexes, manure and waste from slaughtering livestock in which are used to produce methane gas for heating, to installations, using wind power. With regard to light energy consumption, optimization should go along the path of applying modern lamp variations that have advantages in a number of parameters (efficiency, service life, light output, etc.).

Further use of such raw materials should be focused on local manufacturers. Thus, the source of obtaining raw materials with a given composition and properties is technologically approaching not only to places of its industrial use as a valuable functional food raw material for preventive nutrition, but also to the consumer himself. From the point of view of using such unified technological cycles in the regions of the Arctic, this is justified both by preserving the freshness of raw materials, which is difficult to achieve in the conditions of early delivery of food, as well as its quality and useful properties.

From the point of view of the theory of functional nutrition, the most promising ways to enrich traditional diets is the introduction of functional ingredients into products in which the active principle undergoes the smallest changes. The feasibility of using the products developed in the course of research and testing in preventive nutrition, the functional properties of products and the possibility of using them in the food industry are confirmed by the conclusion of the Institute of Medical Problems of the North of SB RAMS.

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