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RESEARCH OF TECHNOLOGY FOR EXTRACTION OF COLORING SUBSTANCES FROM AMARANTH FLOWERS

Saidkhodzhaeva Dildora Olimjon's daughter [1],
Choriev Abusattar Jo'rayevich [1], ***Usmonzhonova Khulkar Umarqulovna*** [1],
Akramova Rano Ramzitdinovna [1], ***Baltabaev Ulugbek Narbaevich*** [1]

[1] Tashkent State Technical University named after I. Karimov

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Abstract

The article is devoted to the study of the technology for extracting dyes from amaranth flowers of the Amaranthus tricolor variety. The chemical composition of 2 varieties of amaranth was analyzed. The physicochemical parameters of the coloring matter were studied.

Keywords: *amaranth flowers, chemical composition, coloring matter, extraction, concentration, toxicological properties, organoleptic and physico-chemical indicators*

Introduction

The search for alternative ways to increase nutritional status, health levels, life expectancy, reduce morbidity among the population and mobilize the protective forces of the human body in a comprehensive solution to the problem of preserving the gene pool is relevant.

Due to the downward trend in the standard of living of the population in a number of countries, as well as a significant shortage of protein foods, there has been a need to develop and create, based on modern technologies, qualitatively new plant-based food products. Which would differ not only in their nutritional properties and storage stability, but also in their accessibility to all segments of the population.

A priority direction of science is also the improvement of technology for enriching food products with macro and micro nutrients obtained through complex processing and production of products from non-traditional sources of raw materials.

Literature Review

Finding new plant sources of food protein, biologically active additives, as well as developing technology for their processing to obtain products of increased biological and nutritional value with a functional focus is one of the urgent tasks of the baking industry.

Many experts consider amaranth to be one of the most promising plants for universal purposes. This plant is native to South America. Its unique properties have been confirmed by modern researchers. Amaranth is intensively cultivated in the mountainous regions of Nepal, India, Mexico and Peru.

Recently, amaranth plantations have increased in China, Africa, the USA, and Canada. In these countries, both amaranth grain and its leaf mass are used.

Amaranth is superior to traditional crops in terms of nutrient content, especially protein and fat (Zelenkov, V.N., 2000). In Russia, over 150,000 people are employed under amaranth, but they use it mainly for feed needs. For a comprehensive study of amaranth, research centers have been organized in the USA, Mexico and a number of other Latin American countries, where attention is paid to selection and genetic work and the collection of hormone plasma from local species and species introduced from other regions. More than 1,000 forks have been collected at the Rodhals Research Center (USA) alone. Using modern selection methods, new varieties of amaranth have been created in the USA, Ecuador, Argentina, and Mexico. Five species of amaranth are believed to be of American origin. Another type of amaranth of Asian origin is cultivated in America (Kononkov, P.F., 1997).

In our country, the need to use amaranth in agriculture as a new food and silage crop in the program for the use of world plant resources was pointed out by Academician N.I. Vavilov back in 1932. However, research work with amaranth and other new crops, begun on his initiative, was stopped after his death. And only in recent years have amaranth been intensively introduced into agriculture in neighboring countries.

The chemical composition of useful substances in amaranth is given in Table 1. (Saidhodzhaeva, D.O., CHoriev, A.ZH. 2023; Saidkhodzhaeva, D., Choriyev, A., Akramova, R., Yulchiev, A., Tukhtaev, Sh. 2023; Saidkhodzhaeva, D., Choriyev, A. 2022).

Table 1. *Chemical composition of useful substances in amaranth, g/100g*

Name	Proteins, g	Carbohydrates, g	Fats, g	Cellulose, g	Calorie content, kkal
Amaranth	14	70	7	7	370

From this table 1, we can say that the amount of carbohydrates is the most, which is 79 g/100g.

Methods

The assessment of the chemical composition of dyes was carried out using physical and chemical methods.

Results And Discussion

Natural dyes (NDCs) are complex organic compounds produced by living organisms and color various cells and tissues of animals and plants. Most PVCs have significant physiological and antibiotic activity. They are often used as medicinal products. The increase in allergic and cancer diseases caused by environmental pollution has led to the need to expand the production of harmless natural food dyes.

The production of natural dyes currently does not meet the needs of the market, either in quantity or range. This problem is solved partly through synthetic dyes. Therefore, improving the existing technology of natural dyes is an important task of our time.

Food dyes are subject to strict requirements in terms of their harmlessness, lack of interaction with components of food formulations, color strength, high degree of coloring at low concentrations of dye, ability to dissolve in water or fat, as well as uniform distribution in the mass of food products, absence of foreign tastes and smells.

Over 2000 different plants containing dyes are known, but only a few of them have found practical use, mostly belonging to the legume, asteraceae, mulberry, and madder families.

It is known that the degree of extraction of coloring matter from plant raw materials depends on many factors: its biochemical composition, degree of grinding, nature of the extractant and extraction conditions. There are various known methods for obtaining anthocyanin dyes from plant raw materials, which consists in processing plant raw materials, which are used as chokeberry pomace (RF patent No. 2008314), beets (RF patent No. 2081136), grape waste (US patent No. 3963700), carrots (patent US No. 4939086) blueberries, black currants and other berries (Czech Patent No. 292834), red potato juice (US Patent No. 6180154), rose petals or crushed red cabbage, aqueous solutions of acid and/or alcohol, extract separation, concentration and receiving the finished product. From sunflower, by processing with solutions of organic acids, extract separation and concentration, a red natural anthocyanin dye, resistant to light and temperatures, is obtained, which is successfully used in the food, cosmetic and pharmaceutical industries (US patent No. 6132791).

There is also a known method for producing anthocyanin dye from waste food raw materials, for example cherries, plums, grapes, in which from the primary hydrochloric acid extract, after neutralization, the coloring substances are precipitated with slaked lime, after which the precipitate is pressed off and dissolved with concentrated hydrochloric acid (USSR author's certificate No. 218358).

There is a known method for producing anthocyanin food coloring from dried chokeberry pomace by crushing the raw material, treating it with acetaldehyde containing 0.5–10 parts by weight. concentrated orthophosphoric acid from the reaction medium, filtration, drying and extraction of dyes with heated ethyl alcohol acidified with butyric acid, and separation of the organic layer from the raw material (RF patent No. 2099371).

Anthocyanin dye from plant raw materials is known, containing cyanidin glycosides, pionidin glycosides, pelargonidin glycosides, organic substances and mineral salts at a certain ratio of components (RF patent No. 2177015). This food coloring retains its natural red color when exposed to a pH environment from 2.0 to 7.0, with all treatments: freezing, boiling, irradiation with direct sunlight.

There is a known method for producing a pigment additive from plant raw materials (parsley). Dried parsley is crushed, then extracted under countercurrent conditions with 96% alcohol at a raw material to extractant ratio of 1:2–1:4 for no more than 40 minutes in the presence of MgCO3 or MgO, or their mix-

ture 0.1–1.0% on the amount of raw materials at 10–22 °C. The extract is filtered, collected in a common container, the solvent is distilled off and concentrated at a temperature not exceeding 40 °C and a residual pressure of not more than 1333 Pa for 1 hour. Dry until the dry matter content is 78–80% (RF patent No. 2154075).

There is a known method for producing green food dye from carrot tops by extracting the raw material with an organic solvent, saponification with alkali, acidification, stabilizing the dye, converting it into a water-soluble form and subsequent drying (author St. 266117, C09 V 61/00, USSR No. 1307201/28–13).

However, the disadvantages of the known methods are the use of non-food chemicals in the technological chain, which makes the further use of the dye not harmless, as well as the unreasonable labor intensity of the technological process.

Dying substances are usually isolated from various parts of plants, the color of which is due to the presence of anthocyanins, carotenoids, flavonoids, chlorophylls, etc.

The quality of natural dyes largely depends on the conditions in which the plants developed (climate, soil, etc.). It is also influenced by the technology of extracting dye from raw materials. Currently, technological methods for isolating natural food dyes are increasingly being improved. The raw materials are pre-frozen, dried, and treated with steam. The latest technologies, in particular membranes, are used to extract dyes. An increase in the yield of dyes can also be achieved by treating plant tissues with hydrolytic enzyme preparations.

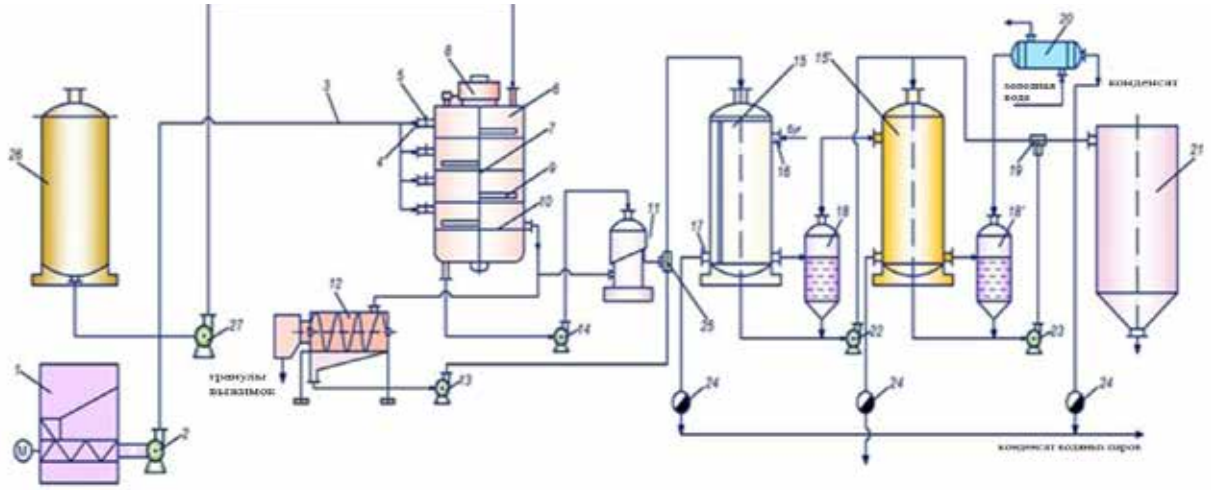
There is also a known method for producing a paste-like food coloring from beet pomace: after separating the juice, the pomace is extracted with water at a temperature of 70–80 °C, then the resulting extract and beet juice are mixed and the resulting mixture is filtered, a stabilizer is introduced into the resulting mixture, followed by instant heating to 80 °C and cooling to 30 °C, yeast is introduced into the cooled juice in an amount of 0.1% and fermented, after which condensation is carried out at a temperature not exceeding 60 °C (RF patent No. 2031100). There is also a known method for producing powdered food coloring from beets by grinding, pressing, stabilizing the juice with ascorbic acid, pasteurization, cooling to a temperature of 20–22 °C, adding baker's yeast Saccharomyces cerevisiae in an amount of 0.03–0.07% by weight of the juice, fermentation, filtration and drying on inert media (RF patent No. 2102418).

The disadvantages of the known methods are: low quality of products, low thermal stability, imperfection of the technological process.

Based on a patent search and a literature review, we proposed a technological scheme for the extraction of dyes from amaranth flowers (Fig. 1).

Taking into account the classification of natural dyes into flavonoids, betalains, quinones, chalcones and oxycetones, carotenoids, riboflavins, indigoids, porphyrins, taking into account their formation in the flower, fruit, leaf, body, bark, root, it is possible to form a single processing line with minor differences for one or another raw materials (Kacerikova, I.V., 1999).

Figure 1. *Technological line for extracting dyes from amaranth flowers*



1. Hopper for uniform supply of raw materials. 2. Pneumatic conveyor pump. 3. Pneumatic transport. 4. Entrance on the upper tier. 5. Gate 6. Extractor 7. Shaft. 8. Drive. 9. Mixer cam. 10. Dividing mesh. 11. Centrifuge. 12. Press granulator. 13, 14, 22, 23. Pumps. 15, 151. Evaporator housing. 16. Heating steam inlet fitting. 17. Condensate outlet fitting. 18, 181. Evaporator separator. 19. Refractometer. 20. Capacitor. 21. Tank for collecting condensate. 24. Condensate traps. 25.Tee. 26. Extractant storage tank

The extract is obtained directly from the raw material; it also contains solid particles. The components of the substrate consist of soluble and insoluble fractions; insoluble components are separated under the influence of gravity in settling tanks and filters, in the field of centrifugal forces. To do this, the extract in containers is subjected to sedimentation, centrifugation or separation using a separator. If necessary, the fabric is cleaned using a filter; a purer fraction is obtained using paper filters, and the purest fraction is obtained using ultrafilters.

According to the chemical composition, the extract is concentrated in a vacuum evaporator (VVE) after the degree of purity meets the parameters of the technological regulations. The technology has been improved through the use of vacuum evaporation of the extract in 2-hull complexes; the plant has its own extractant, so more than 2 tanks are used to store the extractant (Usmonzhonova, H.U. 2021).

Table 1. *Results of the analysis of the toxic properties of coloring substances extracted from the flowers of the amaranth variety Amaranthus tricolor*

№	Dose, *mg/kg*	Number of dead animals / total
1.	5000	0/6
2.	10000	0/6
3.	15000	0/6
	LD_{50}>15000 *mg/kg*	

In the Pharmacy-Innovation center located in the Yunusabad district of Tashkent, the toxicological properties of a concentrate of coloring substances extracted from the flowers of the amaranth plant were studied. *Amaranthus tricolor*.

The organoleptic characteristics of the dye concentrate obtained from the *Amaranthus tricolor* variety were studied. The color of the resulting dye turned out to be transparent red, without any foreign odors or tastes (Table 3).

Table 3. *Organoleptic characteristics of a concentrate of coloring substances obtained from amaranth plants*

Plant name	Color	Consistency	Smell	Taste

Amaranth plant *(Amaranthus tricolor)*	Transparent dark red	Fluid	No foreign odors	The unique taste of amaranth has been partially preserved

The physicochemical parameters of the concentrate of coloring substances obtained from amaranth plants were studied (Table 4.)

Table 4. *Physico-chemical indicators of a concentrate of coloring substances obtained from amaranth plants*

Plant name	**Relative density, g/l**	**Number of substances contained,%**	**Index, pH**	**The amount of coloring matter in the spectrum 540 *nm*, *g/l***
Amaranthus tricolor L.	1.000	9.4	4.4	4.3

Conclusion

A technology for extracting dyes from amaranth flowers has been proposed.

The toxicological properties of a concentrate of coloring substances extracted from the flowers of the amaranth plant Amaranthus tricolor were studied. The analysis results showed that it is suitable for use in the food industry.

The organoleptic characteristics of the dye concentrate obtained from the flowers of the amaranth variety Amaranthus tricolor, which complies with the standard, have been studied.

The physicochemical parameters of the dye concentrate were studied.

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Contact: corievabdusattor@gmail.com