STUDYING OF INFLUENCE OF WAYS OF PROCESSING ON EFFICIENCY OF EXTRACTION OF PAINTING PIGMENTS FROM AN AMARANTH

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Abstract

In this article the study of methods of treatment is shown on efficiency of extraction of dyeings pigments from a plant amaranth. As a result of the got results the ground of receipt of dye is given from an amaranth by water solution and extracting by an ethyl spirit, study of functionally-technological properties of dye in different environments, that safe-health people, and also safely to use in the production of food products,answering the necessary requirements of Law on safety of food products. An analysis is Given, that dye from an amaranth possesses high stability to the change of pH environment and stability to influence of temperatures and that color forms addition Amaranth can be used for preparation of products, the technological process of production of that envisages heat treatment not exceeding 70°C.

Keywords: Amaranth, extracting, extraction of pigments, technology, extraction of dye-stuff, stability of the red colouring of dye

Introduction

Based on analysis of published data regarding the use of coloring agents in food production, it is apparent that the majority of dyes currently offered on the market are of chemical origin. However, with the development of researches in the field of toxicology, their use in food in almost all countries of the world has the restricting tendency.

In this regard, it is important to explore the possibility of using some of them in food production; and search for new natural dyes in animal, vegetable and microbial environment, meeting the necessary technological requirements is as well actual.

Crops can be used for production of the dye that allows using raw materials more efficiently. Local plant material (amaranth) having the most digestible nutrients and strengthening nonspecific immunity and antioxidant protection of human body[1] serves as the source of the coloring agents.

Objective on the basis of comprehensive researches is to develop the technology of amaranth food dye production, development of physical and chemical principles of the process of extraction from raw materials, methods of study of the effect of its processing on the efficiency of extraction of pigments.

Problems

Formation of a conventional food coloring is carried out by adding salts of nitrous acid. From the hygienic point of view synthetic dyes have a negative impact on the living organism, as a danger of accumulation of elevated concentrations of carcinogenic compounds in the biochemical transformation of residual sodium nitrite occurs. Therefore, the search of natural food dyes is one of the important tasks of the food industry.

Theoretical background: the concept of social services assessment

Appearance and composition of amaranth leaves: Amaranth - is an annual purple-red or yellow-green herb, reaching 2.5-4 m in height. Amaranth leaves accumulate up to 29% high-quality protein in proportion to dry weight. Their content of ascorbic acid and carotene (68 and 5.7 mg per 100g of green weight, respectively) substantially exceeds many vegetable and melon crops. More vitamin C (per 100 g of green weight) Amaranth (food additive E123) – is a chemical substance of synthetic origin – azo dye, bluish-red, red-brown, or red-purple color, derived from coal-tar pitch. E123 colorant is a water-soluble powder, which decomposes at 120°C, without melting. Chemical formula of the food additive E123: $C_{20}H_{11}N_2O_3Na_{10}S_3$ [2].

In nature, there is a plant with the same name, unrelated to food additive E123, and in contrast to the useful and beautiful annual plant, sometimes causing great harm to the body, by eating [2].

However, still no accurate scientific data exists, proving that E123 dye is a carcinogen for human body. Earlier, E123 dye was used in the food industry as an additive in dry mixes for cakes, mixes for jelly and breakfast cereals. Besides, the additive E123 is used for preparation of semi-finished biscuit and beverages [3].

Other uses of amaranth. [2]:

• in cosmetics industry, in manufacture of lipstick, rouge, etc.;

as a dye for dyeing of paper, synthetic and natural fabrics, leather and phenol formaldehyde resins.

On the basis of theoretical studies production of a safe amaranth food dye, development of technology, physical and chemical principles of the extraction process from raw materials, study of effects of methods of processing on the efficiency of extraction of pigments were embedded in the foundation of our research.

Research methodology

Characteristics of research subjects and the the test pattern

The the present studies was selected Amaranth A.Cruentus L. (group 1), which is characterized by low content of green and yellow pigments, but plenty of Amaranthine.

In this research, during study of the selected color-forming additives were determined their solubility, resistance to temperature and pH change, preservation of color dye solutions during storage, as well as their impact on the main components of the dyed product.

Technology of producing anthocyanic dye comprises two main processes: extraction of colorant by extraction and preparation of a concentrated, storage-stable dye-product suitable for direct use.

Experiments were carried out with different lots of dyes produced in laboratory, and in production environment of LLP "Alibi".

The dye prepared in the laboratory has bright-pink color with a slightly noticeable purple tint.

By means of recording of displayed activity the following methods can be distinguished Volumetric, Tsiganova (2002), Photometric, Belenky (1984), Borodkin (1981), chemiluminescent, Kharlamov (1989), fluorescent Bolotov and others (2008), electrochemical Arkhipova (2000) and a number of more specific Ryzhov and others (2006) , including method of tissue markers.

Results and findings

The dye used for food production is not a chemical amaranth dye but a natural pigment Amaranthine.

Technology 2. In ATU were conducted extensive studies of amaranth food dye obtained by extracting with acidulous aqueous solution.

Leaves, stem of a plant during flowering and after flowering, during seed maturation are used for obtaining of the dye.

Flowsheet of amaranth dye extraction
Raw materials: leaves and stems
↓
Preparation of raw materials
↓
Grinding
↓
Extraction
↓
Pressed mass ← pressing → filtration → stabilization → vacuum evaporator → concentrate.

Technology for producing dye is comprised of two main processes: obtaining of substances by extraction with distilled water and preparation of a concentrated, storage-stable dye-product suitable for direct use.

A method for extraction of a sustainable natural dye from amaranth includes the following processes: grinding of raw material, water extraction followed by concentration of the final product at room temperature + 20°C. The used raw material is picked in a period of three weeks before flowering to one week after flowering.

The plant is used dried, which does not reduce the yield of the end product. Extraction is carried out by water at a ratio of 1: (1-2) days for fresh (green) plants and 1: (7-10) for dried plants.

All test samples of dyes had organoleptic characteristics relevant to stated in Table 1 and the norms set in the technical documentation (TU 18-4-2-75).

Table 1. Physical and chemical characteristics of dyes samples from amaranth

Density at 20 ° C, kg / m	Mass fraction of dry substances,%	Content of coloring agents, g/kg	Acidity at 1 cm3 of I M solution NaOH per 100 g of dye	pH
1162	39 6	49,5	115,0	3,2
1110	32,0	46,8	115,0	3,0
1175	39,8	49,8	116,0	3,1
1132	31,3	49,5	114,0	3,2

Technology for production of a dye in the laboratory To obtain the colorant from raw part of amaranth the raw material is grinded in the grinder, obtained mass is poured with solvent (water-alcohol mixture) in a ratio of 1:10, and is kept for 24 hours, stirring occasionally. The resulting mixture is passed through a press and separate a liquid portion which is filtered, and the resulting extract is stabilized with citric acid in 1 ml per 1000 g of colorant proportion. Then in vacuum extractor or drying oven at a predetermined temperature 75 % of the original solvent volume is removed.

The resulting thick colorant - clear, cherry-red color, stable during storage. Yield of the liquid dye – approximately 1.2 % of green weight.

For dye production from dry plant material it is grinded to 3-5 mm in size, poured with solvent in a ratio 1:10, and left for 24 hours. Then obtained material is pressed and the liquid portion is separated, filtered and the resulting extract is stabilized with citric acid in proportion 1 per 1000 ml of extract. Further in a vacuum extractor or a drying oven the solvent is removed to constant weight.

The resulting dry mass has brown-red color. Output of the dye from its dry weight is about 1.27%.

Natural dye contains foliaceous part of plants in native or dry condition of the following chemical composition, %:

Water - 0.5-90;
Carbohydrates (sugar) - 0.5-5;
Protein - 1,2-28;
Fats - 0.2-2.2;
Dietary fiber (cellulose) - 0,3-38;
Pectin - 0.2-10;
Ash - 0,2-30.

Technology 2. Production of dye from amaranth by extraction with ethyl alcohol.

According to this method production of anthocyanins dye is carried out as follows: pressed skins of amaranth leaves care grinded and extracted with ethyl alcohol (96 % vol.), water duty 1:5. Raw treated then is sequentially processed with ethyl alcohol 2-3 times at a temperature of 55-60°C for 1.5 hours.

A single extraction does not allow to extract the pigments completely, while the degree of extraction is approximately 60 - 70%. Two- or three-fold repeated process allows extracting almost all (95%) of the dye from the raw material. Using a process temperature less than 50°C considerably increases the extraction time and decreases the yield; temperature of over 60°C is undesirable due to possible oxidation and polycondensation reactions, which impair the quality of the product. Concentration of anthocyanins in the extract reaches a maximum during the extraction in this temperature modes for 1-1.5 hours; further increase in extraction time therefore is impractical.

The obtained extracts are then separated from the feedstock, combined, and settled at 10-20°C for 6-10 hours (sufficient time for settling of insoluble compounds at a temperature of 10-20°C, lower temperatures are not economically feasible to use due to increase in energy consumption) with followed filtration and concentration by distillation of ethyl alcohol under vacuum. Concentration is carried out until the residual solids content is at least 55 %.

Use of the less polar and more low-boiling ethyl alcohol instead of water allows reducing concentration temperature, and the additional use of vacuum can significantly accelerate this process, thereby increasing the safety of natural polyphenolic compounds.

Ready dye concentrate is poured into containers and sent for storage in the warehouse.

Table 2. Comparative quality characteristics of powdered food colorant.

Indicator	Value index
Technology 1. Extraction with acidulous aqueous solution	
Organoleptic characteristics: A) Appearance B) Taste B) Color	 Dry, free-flowing powder without lumps Sour, without foreign flavor red
Technology 2. Extraction with ethyl alcohol,	
Organoleptic characteristics: A) Appearance B) Taste B) Color	 Dry, free-flowing powder without lumps Sweet, faint smell without taste Intense red

Physical and chemical composition of the amaranth dye is the basis for creation of theoretical assumptions and theoretical and practical aspects of use in food products.

Table 3. Physical and chemical characteristics of the amaranth dye

Dye sample number	Content			pH 3 %-solution of the dye	Titratable acidity	
	Solids, %	Colorants, г/кг	Ash total %		Degr.	ml 1N / 100 g
Technology 1	94,3	40%	9,8	5,8	0,7	1,0
Technology 2	95%	90%	7,9	6,6	0,6	1,0

Based on the results of studies on basic properties and physical and chemical characteristics the organoleptic characteristics are as follows: extract of deep-red color, taste and smell - typical to the feedstock, mild, without foreign flavor and smell. Sweetish taste of the dye.

Amaranth dye is a hygroscopic product. Therefore, the density of the dye was determined by two methods:

Areometer, pyknometer at a temperature of 20^0C. For comparison the relative density of the dye determined by aerometer and pyknometer were implemented appropriate tests.

The data obtained are shown in (Table 4).

Table 4. Results of the determination of the relative density

Dye	Relative density, determined by	
	Areometer	Pyknometer
Aqueous dye extract	1,019 1,009	1,019 1,008
Concentrated dye	1,156 1,156 1,154 1,154	1,158 1,157 1,155 1,166

The solids content of the dye is determined by drying the sample with sand in a drying oven at 130^0C for 50 min (Table 5) and by refractometric method.

Table 5. Content of dry substances

Dye sample number	Solids (in%), determinedby		
	Drying the sample at 105^0C to constant weight	Drying the sample at 130^0C for 50 min	Refractometric method
1	25,7	25,8	32,3
2	27,5	27,5	37,0
3	26,6	26,8	34,7
4	28,8	29,1	38,0
Average	27,15	27,3	35,5

This dye based on experimental data is recommended for use. Acceptable daily intake - is the amount of food additive per 1 kg of body weight.

Analysis of the data proves that the use of food colorant in the required dosage is absolutely safe. Also, synthetic dyes may cause allergic reactions to some people especially susceptible.

Furthermore, the use of the dye can improve the nutritional value of the product, enrich it with vitamins and micronutrients.

Enrichment with vitamins is also possible by using certain dyes - carotenoids (β - carotene E 160a and β-apo-8'-carotenal E 160e, ethyl ester of beta-apo-8 carotenal E 160f and violanxanthin E 161e), having the activity of vitamin A, as well a colorant riboflavin E 101 which is vitamin B2.

However, these food colorants are prepared mainly by chemical synthesis.

The dye obtained from amaranth, enriches food products by micronutrients (iodine, iron, calcium).

Table 6.Effect of the proposed process for preparation of the amaranth dye on safety of its red color

Type of dye	Interval of the red color stability of the dye, pH	Degree of change of red color of the dye after two hours of heating at t = 800C,%
Technology 1	1-6,6	10
Technology 2	1-5,8	16

Table 7.Chemical composition of the amaranth dye

Components	Content, % per solids (fluctuations from-to)
Water	86,5
Fats	
Proteins	
Carbohydrates	19,8
Cellulose	
Minerals	
in mg per 100 g	
Na	86
K	288
Co	37
Mg	43
P	43
Fe	1,4
Vitamins β - carotene	0,01
B1	0,02
B2	0,04
PP	0,2
C	10

Amaranth dye is a hygroscopic product. The experiments for storage of dye samples under different relative humidity are carried out in exsiccators, the relative humidity in which is adjusted with sulfuric acid solutions of the respective concentrations. Dyes in an amount of 5g in boxes are placed in exsiccators over sulfuric acid solutions at a relative humidity of 90, 80, 70, 60, 50, 40, 30 and 20%. After a certain period of time, the moisture gaining and losses in the dyes are evaluated.

Conclusion

Amaranth dye is highly resistant to pH change and resistant to temperature effects. It should be noted that the color-forming additive amaranth can be used in the preparation of foods, which manufacturing process involves heat treatment under 70°C.

Suggestion

Within these results we received a justification for obtaining amaranth dye by water solution and extraction with ethyl alcohol, the study of functional and technological properties of the dye in different environments that safe for human health, as well as safe to use in food

production meeting the essential requirements of technology, as well as processing methods for efficiency of pigments extraction were given.

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