Research Article

The Technology and Composition of Functional Food Ingredients Obtained by Sorption of the Polyphenolic Compounds From Cranberry on Coagulated Egg Albumen

Isabella Lvovna Stefanova[1], Elena Vladimirovna Kropacheva[1], Anastasia Yurievna Klimenkova[1], Irina Borisovna Perova[2] and Vladimir Kimovich Mazo[1*]

[1]All-Russian Research Institute of Poultry Processing Industry - branch of the Federal Scientific Center, "All-Russian Research and Technological Institute of Poultry" of Russian Academy of Sciences, Rzhavki, Moscow Province, Russia
[2]Federal Research Center of Nutrition, Biotechnology, and Food Safety, Moscow, Russia
ORCID
Vladimir Kimovich Mazo; 0000-0002-3237-7967

Corresponding Author: Vladimir Kimovich Mazo; email: dp.vniipp@mail.ru

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Abstract. The technologies for developing food products for people with type 2 diabetes involve enrichment with polyphenolic compounds that have hypoglycemic and/or hypolipidemic properties. The production of ingredients for introduction into such food products should involve the techniques of concentration of natural polyphenols on certain food-grade protein matrices. In this study, a technology was developed for the production of a functional food ingredient, which was a complex of polyphenols (mostly anthocyans) from cranberries with coagulated egg albumen. The optimal parameters of sorption of anthocyans from cranberry juice on the albumen during the coagulation of the latter were determined. The contents and profile of anthocyans within the resulting food ingredient were assessed. The concentration of total anthocyans (recalculated to equivalents of cyanidin-3-glucoside) was determined by pH-differential spectrophotometry; the profile of individual anthocyans was determined by high-performance liquid chromatography. Sensory evaluation of the resulting ingredient (through a taste panel test) evidenced the possibility of including the product in the functional foodstuffs. The technology developed can be used in the design of functional food ingredients for subsequent introduction into anti-diabetic food products.

Keywords: coagulated egg albumen, cranberry juice, anthocyans, functional food ingredients

1. Introduction

New biotechnological approaches to the enhancement of bioavailability of vegetable polyphenolic compounds with proved hypolipidemic and cardioprotective properties and positive influence on the carbohydrate metabolism [1, 2, 3, 4] can be used for the expansion of the range of functional food ingredients (FFIs) and specialized foodstuffs (SFs) aimed at the prophylaxis of metabolic disorders. One of these approaches (quite simple technologically) is the sorption of polyphenols on food-grade protein matrices during the coagulation of the latter [5]. The resulting colloid particles can be used as a FFI with improved palatability (due to lower astringency of the polyphelos) to be included into the SFs.

The aim of the study presented was to develop a technological approach to the production of FFI where polyphenols from cranberry are sorbed on the coagulated egg albumen.

2. Materials and Methods

The objects of the study were as follows: native egg albumen (EA) containing 14-16% of protein; cranberry juice (CJ) produced from cranberries (*Oxycoccus palustris* Pers.) via blending in a cutter with subsequent centrifugation and decantation.

The complexes of polyphenols (including anthocyans) from CJ with coagulated EA were produced via the thermal heating (by vapor) of EA with CJ at constant stirring to the temperature 82±1^{0}C on lab model of the coagulator including blender-mixer IS-5 (Russia) with subsequent separation of the clot of the coagulated product from the liquid whey.

To optimize the sorption the values of pH in the EA-CJ mixtures at different EA:CJ ratios and heating temperatures were determined. The first stage of the study was to determine pH values in the EA-CJ mixtures at different EA:CJ ratios at 20±2^{0}C. The final coagulation temperature of EA-CJ mixture for the targeted sorption of the CJ polyphenols during the thermal coagulation of the EA was determined by the heating of 80:20 EA-CJ mixture to 80, 82, 84, and 86^{0}C.

Concentration of total protein in the resulting products (FFIs) was determined by Kjeldahl's method according to GOST 31469-2012 protocol. Concentration of total anthocyans (in equivalents of cyanidin-3-glucoside, C3G) was determined by pH-differential spectrophotometry on Shimadzu UV-1800 spectrophotometer (Shimadzu Corp., Japan) in the wavelength range 190-1100 nm [6].

The profiles of individual anthocyans were determined by high-performance liquid chromatography (HPLC) [7] on chromatograph Agilent 1100 (Agilent Technologies, USA) with degasator, binary pump, column oven, autosampler, and diode-matrix spectrophotometric detector. The data were processed on the ChemStation for LC 3D Systems (ver. B.04.03.16) software.

The sensory characteristics (color, taste, aroma, texture) of the samples of FFI were determined by taste panel tests (5-score system) according to GOST 31720 protocol.

Table 1: The profiles of anthocyans in the FFIs obtained at 82±1^{0}C and different EA:CJ ratios

	Initial CJ concentration				
	100%			50%	
	EA:CJ ratio				
	90:10	85:15	80:20	80:20	60:40
	Individual anthocyans, % of total anthocyans				
Cyanidin-3-galactoside	22.3	22.3	22.9	18.7	22.3
Cyanidin-3-glucoside	2.5	2.0	2.1	2.2	1.9
Cyanidin-3-arabinoside	21.1	19.2	19.6	16.8	19.7
Peonidin-3-galactoside	32.3	34.5	34.0	37.1	33.8
Peonidin-3-glucoside	5.6	6.5	6.2	7.2	6.4
Peonidin-3-arabinoside	16.2	15.4	15.2	18.1	15.8
Malvidin-3-arabinoside	traces	traces	traces	traces	traces

Table 2: Concentration of total anthocyans in the FFIs depending on final coagulation temperature

Coagulation temperature, ^{0}C	100% native CJ	**80**	**82**	**84**	**86**
Total anthocyans, mg/100 g of DM	17.56	3.14	3.79	2.97	1.96

3. Results and Discussion

The mixtures of 100% (non-diluted) CJ with the EA at EA:CJ ratios 90:10; 85:15 and 80:20 had pH values 5.84±0.10; 5.40±0.10; 5.47±0.25, respectively, meaning that these doses of the CJ resulted in pH values sufficient for the coagulation of the EA during the thermal heating.

Concentration of total anthocyans with 100% CJ, coagulation temperature 82±1^{0}C, and three aforementioned EA:CJ ratios was 0,75; 2,31 and 3,69 C3G mEq per 100 g of the product, respectively. With 50% CJ and EA:CJ ratios 80:20 and 60:40 concentration of total anthocyans was 0.58 and 4.07 C3G mEq/100 g.

The profiles of individual anthocyans in the FFIs obtained at coagulation temperature 82±1^{0}C and different EA:CJ ratios are presented in Table 1. The prevalent anthocyans in all cases were 3-galactosides and 3-arabinosides of cyanidin and peonidin. The effects of final coagulation temperature on total concentration and profile of anthocyans in the FFI are presented in Tables 2 and 3.

Table 3: The profiles of anthocyans in the FFIs obtained at different coagulation temperatures

	Coagulation temperature, ^{0}C			
	80	**82**	**84**	**86**
	Individual anthocyans, % of total anthocyans			
Cyanidin-3-galactoside	21.1	21.8	21.8	19.1
Cyanidin-3-glucoside	1.9	2.0	1.9	3.1
Cyanidin-3-arabinoside	18.7	19.6	19.1	17.1
Peonidin-3-galactoside	35.2	34.1	34.6	36.3
Peonidin-3-glucoside	6.8	6.5	6.7	7.4
Peonidin-3-arabinoside	16.3	16.0	15.9	17.0
Malvidin-3-arabinoside	traces	traces	traces	traces

The data presented above provided the basis for the optimization of the parameters of sorption: 100% CJ, EA:CJ ratio 80:20, temperature of thermal heating at coagulation 80-86^{0}C. The resulting concentration of total anthocyans in the FFI obtained at these conditions was 3.69 mg/100 g of DM, or 7.8% of the initial concentration of anthocyans in 100% CJ. The prevalent individual anthocyans were 3-galactosides of cyanidin and peonidin (Table 3).

The sensory evaluation of the FFIs obtained with 100% CJ revealed that if the percentage of CJ in EA-CJ mixtures was above 25% a bitterish off-flavor and violet color appeared while CJ percentage of 20% resulted in pink color, berrylike aroma, and pleasant taste of the product (Figure 1).

4. Conclusions

The new technological approach was developed involving targeted extraction and concentration of anthocyans from cranberries by sorption on the coagulated egg albumen. The optimal conditions for all stages of the production were determined. The scaling of this technology will result in the commercial production of functional food ingredient enriched with anthocyans and containing minimal amounts of easily digestible simple saccharides, for the subsequent inclusion into the egg-based foodstuffs aimed at the prophylaxis of metabolic disorders.

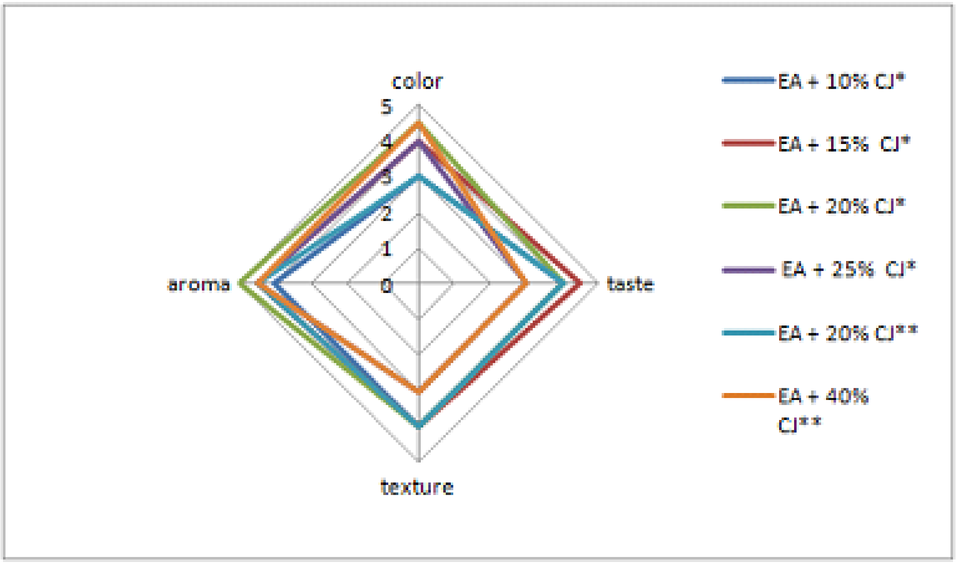

Figure 1: The profilogram of sensory evaluation of the FFIs. * - with 100% CJ; ** - with 50% CJ.

The results of the study presented are oriented to the specialists in the science and practice of nutrition interested in the new prospective technological approaches to the expansion of the range of functional food ingredients and foodstuffs.

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