INVESTIGATION OF THE INFLUENCE OF STABILIZERS ON THE VISCOSITY OF THE RECOVERED MIXTURE OF A HYPERTONIC DRINK FOR ATHLETES

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Abstract: When introducing plant and animal protein products, in addition to nutritional value, it is advisable to assess their physicochemical properties and technological indicators, in particular, homogeneity and consistency stability. The aim of research is to determine the effect of consistency stabilizers on the viscosity of a reconstituted hypertonic drink for athletes based on flaxseed cake, sesame seeds and whey protein concentrate.

The mass fraction of protein in the model dry mixture of a hypertonic drink, as well as in its individual components by the Kjeldahl method, the mass fraction of fiber – by the gravimetric method, the mass fraction of lipids – by the extraction-gravimetric method, the mass fraction of moisture – by the thermogravimetric method. The mass fraction of ash in the mixtures was carried out by the method of incineration followed by calcining the mineral residue at a temperature of 450 ... 600 °C. The effective viscosity in the reduced samples of mixtures without and with the addition of stabilizers was determined on a rotational viscometer "Rheotest 2". For the planning of the experiment and data processing, mathematical methods were applied using the Microsoft Office Excel 2003 software package.

The chemical composition of individual components and a model dry mixture of a hypertonic drink for the nutrition of athletes, including the content of compounds that have a stabilizing effect on the restored product, has been investigated. It has been proved that the effective viscosity of the reconstructed model mixture in comparison with the effective viscosity of the individual components of the mixture nonadditively increases. The mutual influence of the consistency stabilizers (gum arabic (E 414) and carboxymethylcellulose (E 466)) on the value of the effective viscosity of the reconstituted hypertonic drink was investigated. The developed model mixture of a hypertonic drink is recommended to be used for the development of competitive dry mixtures of hypertonic drinks of plant and animal origin for the nutrition of athletes.

Keywords: dry mixture, hypertonic drink, consistency stabilizers, flaxseed cake, sesame cake, whey protein, effective viscosity.

1. Introduction

The development and production of specialized drinks for athletes is due to a number of circumstances. In particular, common products, even if they have high nutritional and biological value, do not compensate for the significant energy consumption of athletes during physical exertion and the associated consumption of plastic compounds [1]. In addition, the absorption of macro- and micronutrients in the gastrointestinal tract is intensified if the bolus is sufficiently hydrated [2]. The above factors determine the use of specialized drinks by athletes. The body of athletes should receive the entire set of essential amino acids and polyunsaturated fatty acids in an increased amount [3, 4]. This need for sports nutrition can be fulfilled by the so-called hypertonic drinks, the osmolarity of which is more than 500 mOsm/l [5, 6].

In the works [7, 8], the composition of a protein-fat mixture for special purposes is proposed for the rational nutrition of athletes. The obtained research results found further development in the development of balanced amino acid composition of food systems based on oilseed meal and animal protein [9]. A model dry mixture of a hypertonic drink for athletes with a balanced amino acid composition has been developed on the basis of sesame seed cake, flax and whey protein concentrate in a ratio of 1: 4.4: 4.6, respectively. But it is worth noting that reconstituted hypertonic drinks of plant and animal origin, as a rule, are complex dispersed systems that contain an insoluble phase [10, 11]. Since the drink components insoluble in the dispersion medium tend to settle, there is a problem of consistency stability and, accordingly, the appearance and ease of consumption of such a drink.

The aim of this research is to determine the effect of consistency stabilizers on the viscosity of a reconstituted hypertonic drink based on flaxseed cake, sesame seeds and whey protein concentrate.

To achieve this aim, it is necessary to solve the following objectives:

1. Determine the content of substances with a potential stabilizing effect in the constituents and in the model basis of the hypertonic drink.

2. Investigate the value of the viscosity of the recovered components and the recovered model base of a hypertonic drink without adding stabilizers.

3. Investigate the mutual influence of the consistency stabilizers (gum arabic (E 414) and carboxymethyl cellulose (E 466)) on the viscosity of the reconstituted hypertonic drink.

2. Methods

The mass fraction of protein in the model dry mixture of a hypertonic drink, as well as in its individual components is carried out by the Kjeldahl method. The mass fraction of fiber in the model dry mixture of a hypertonic drink, as well as in its individual components is carried out by the weight method. The mass fraction of lipids in the model dry mixture of a hypertonic drink, as well as in its individual components is carried out by the extraction-weight method. Determination of the mass fraction of moisture in a model dry mixture of a hypertonic drink, as well as in its individual components is carried out by thermogravimetric method. The mass fraction of ash in the model dry mixture of a hypertonic drink, as well as in its individual components, is carried out by the method of combustion, followed by calcination of the mineral residue at a temperature of 450 ... 600 °C.

The effective viscosity in the reconstituted samples of the individual components of the model dry mixture, in the reconstituted samples of the model dry mixture of the hypertonic drink without and with the addition of stabilizers is determined on a rotational viscometer "Rheotest 2" (Germany). This instrument is designed to measure the rheological properties of non-Newtonian fluids, such as thickener solutions, in a coaxial cylinder system. The restoration of the constituent and the actual model base is understood as the homogenization of their suspensions in purified water in a powder: water ratio of 1: 6, re-

spectively. Before determining the effective viscosity, the samples were kept for 2 hours at a temperature of 20 °C. All experiments were carried out in three parallels.

To determine the dependence of the value of the effective viscosity of model samples of a reconstituted hypertonic drink for athletes at a temperature of 20 °C on the content of gum arabic and carboxymethyl cellulose, a multifactorial regression method with the construction of response surfaces was chosen. To construct the model, the method of full factorial experiment was used. For the planning of the experiment and data processing, mathematical methods were applied using the Microsoft Office Excel 2003 (USA) software package.

3. Results

The results of studying the chemical composition of individual components, as well as a model dry mixture of a hypertonic drink are given in **Table 1**.

Table 1

The chemical composition of the model mixture of a hypertonic drink and its individual components

Name of substance	Protein, %	Cellulose, %	Lipids, %	Moisture, %	Ash, %
Flaxseed cake	37,4	35,6	12,5	6,2	5,4
Sesame cake	52,5	20,3	10,7	6,4	8,1
Whey protein concentrate	76,5	0	6,3	5,1	2,3
Model dry drink blend	56,9	22,2	9,5	5,7	4,2

The value of the viscosity of the recovered components and the recovered model base of a hypertonic drink without adding stabilizers at a temperature of 20 °C was investigated. The results of determining the effective body are given in **Table 2**.

Table 2

Effective viscosity of the reconstituted components and the reconstituted model base of a hypertonic drink without the addition of stabilizers at a temperature of 20 °C

Name of substance	Effective viscosity, mPa·s
Flaxseed cake	460
Sesame cake	410
Whey protein concentrate	220
Model dry drink blend	420

The mutual influence of the consistency stabilizers (gum arabic (E 414) and carboxymethyl cellulose (E 466)) on the viscosity of the reduced hypertonic drink was investigated. The mass fraction of gum arabic in the model samples of the dry mixture of the hypertonic drink varied in the range of 0 ... 8.0 % of the mass of the dry mixture with a step of 2.0 %. The mass fraction of carboxymethyl cellulose in the model samples of the dry mixture of the hypertonic drink varied in the range of 0 ... 4.0 % of the mass of the dry mixture with a step of 1.0 %. The obtained values of the effective viscosity of the model samples of the dry mixture of the hypertonic drink were in the range 420 ... 960 MPa·s. The surface of this dependence is shown in **Fig. 1**.

The equation of the model of two-factor polynomial regression of the second degree obtained by means of mathematical processing of experimental data, describing this dependence, has the form:

$$V(c_{ga}, c_{cmc})=385{,}83+44{,}37\cdot c_{ga}+203{,}75\cdot c_{cmc}-3{,}13\cdot c_{ga}^2-0{,}31\cdot c_{ga}\times \times c_{cmc}-25{,}00\cdot c_{cmc},$$

where $V(c_{ga}, c_{cmc})$ – effective viscosity of the model samples of the reconstituted hypertonic drink at 20 °C, mPa·s; c_{ga} – gum arabic content, % (in the range 0 ... 8.0 %); c_{cmc} – carboxymethyl cellulose content, % (in the range of 0 ... 4.0 %).

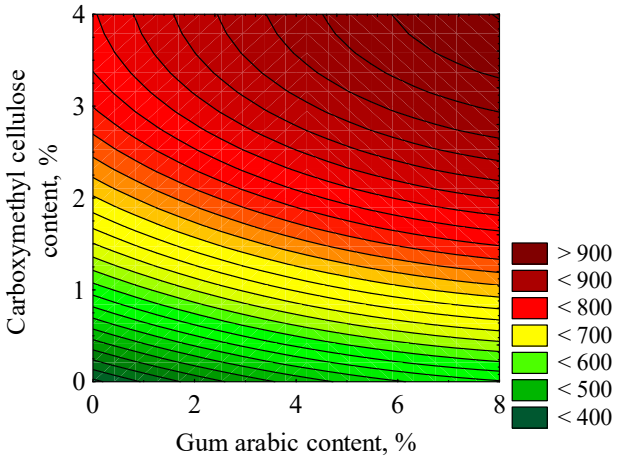

Fig. 1. Dependence of the value of the effective viscosity of model samples of a reconstituted hypertonic drink at a temperature of 20 °C on the content of gum arabic and carboxymethyl cellulose

As the results of the organoleptic evaluation of hypertonic drink samples have shown, the effective viscosity of the drink in the range of 680 ... 760 MPa·s is optimal from the point of view of the feeling of fullness in the mouth ("mouth-feeling").

4. Discussion

Table 1 shows the content of compounds having a potential stabilizing effect in individual components, as well as in the actual model dry mixture of a hypertonic drink. Such compounds are proteins (surface activity), fiber (thickening ability) and lipid complex, in particular phospholipids (emulsifying ability). The histogram in **Table 2** shows a non-additive increase in the effective viscosity of the reconstituted model mixture of a hypertonic drink in comparison with the effective viscosity of the individual components of the mixture. The obtained experimental results can be associated with the synergistic interaction of such consistency stabilizers as milk whey proteins, proteins, phospholipids and fiber of the oilseed meal mixture (**Table 1**).

From the experimental data (**Fig. 1**) it can be seen that under the influence of consistency stabilizers, the effective viscosity value increases from 420 to 960 mPa·s. Studies have shown that the addition of gum arabic separately in the indicated concentrations does not increase the effective viscosity of the reconstituted drink to more than 540 mPa·s. The addition of carboxymethyl cellulose separately to the dry mixture leads to an increase in viscosity from 420 to 830 mPa·s. The mutual non-additive effect of the selected thickeners on the value of the effective viscosity of the reconstituted model mixture has been proved. In particular, 2 % carboxymethyl cellulose and 4 % gum arabic (half of the maximum content of structure-formers in the mixture, which was studied) increased the viscosity of the model mixture to 860 mPa·s. This exceeds the viscosity of model mixtures containing individual thickeners at twice the concentration.

As a result of the research, rational concentrations of thickeners for a dry mixture of a hypertonic drink were selected, which were 0.7 ... 2 % for carboxymethyl cellulose with the simultaneous use of gum arabic 2 ... 5 %. The next stage of the study is to determine the sedimentation rate of the particles of the dispersed phase of the reconstituted beverage in the proposed range of thickener concentrations. The obtained research results are planned to be used to develop competitive dry mixtures of hypertonic drinks of plant and animal origin for the nutrition of athletes, which are balanced in amino acid composition and enriched with polyunsaturated fatty acids.

5. Conclusions

1. The content of substances with a potential stabilizing effect in the constituents and in the model basis of the hypertonic drink, in particular proteins, fiber and lipid complex, has been determined.

2. The value of the viscosity of the reduced components and the restored model base of a hypertonic drink without the addition of stabilizers has been investigated. The obtained data indicate the likelihood of a synergistic interaction of such consistency stabilizers in a model dry mixture such as milk whey proteins, proteins, phospholipids and fiber of oilseed meal.

3. The mutual influence of the consistency stabilizers (gum arabic (E 414) and carboxymethyl cellulose (E 466)) on the viscosity of the reconstituted hypertonic drink has been investigated. Rational concentrations of thickeners for a dry mixture of a hypertonic drink have been selected, which amounted to 0.7 ... 2 % for carboxymethyl cellulose with the simultaneous use of gum arabic 2 ... 5 %.

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