Influence of high-protein flour from sunflower shrot on the change in the properties of chocolate masses

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Abstract. The current trends forming a healthy diet dictate the need to create food products, including confectionery with high nutritional value. The use of nontraditional types of raw material in food production can contribute to their enrichment with proteins and micronutrients. The secondary resources of plant raw materials are currently actively used in solving food problems, being an additional source of naturally substances. A significant number of secondary resources is generated during the processing of sunflower seeds. High-protein flour «Bioproten» obtained from sunflower shrot with a protein content of 45-48% can serve as a perspective source of protein substances. The data on the amino acid composition of high-protein flour from sunflower shrot have been presented in the article. The influence of various dosages of high-protein flour from sunflower shrot on the change in consumer and technological properties of chocolate masses has been explored. The technological properties of the simulated chocolate masses promote the creation of a technology of the mass production as the preparation of liquid semi-finished products and in the process of forming finished products. The expediency of using this additive in the confectionery production, in particular chocolate, has been demonstrated. The composition of the chocolate mass that does not reduce the taste characteristics of the finished chocolate product is presented. A new technical result of the resistance of chocolate to fat bloom has been achieved.

1. Introduction

According to the concept of proper nutrition, a balanced human diet should include a well-known set of nutrients, where proteins are particularly important. Proteins determine the intellectual and physical development of a human ensuring balance and viability of the organism.

In today's world, there is a deficiency of comestible protein and lack of it is probably to persist in the coming decades. About 60 g of protein per day is accounted for every inhabitant of the Earth, while the standard is 70 g. Russia belongs to the group of countries where from 2.5 to 4.0% of the total population are in a state of chronic protein deficit according to FAO experts [1].

The most perspective way to solve the protein problem is to include additional types of protein-containing raw materials and additives with higher protein content and the most deficient essential amino acids in the food product formula.

Secondary resources of plant raw materials can be a source of natural protein. The oil and fat production processing sunflower seeds, mainly extracts only one component from them - oil of
vegetable origin, having a huge quantity of shrot which is used for agricultural purposes. Considering that the share of the final high-protein waste (sunflower shrot) accounts for more than 36% of the processed seed mass, its usage as a protein source is a perspective tendency that provides solution of the problem of scrap reclaiming of the oil and fat production and the problem of protein deficit and increasing biological values of food products [2].

Various types of protein products are used in the food industry which are based on the production of shrot and sunflower meal. For instance, a formula for prolong cookie enriched with a modified protein isolate from sunflower meal has been proposed [3]. The expediency of using sunflower flour produced from sunflower meal in the manufacture of butter cookie has been proved [4].

Part of the developments is aimed at improving the technology of baked goods enriched with protein isolate of sunflower shrot. As a result, new baked goods of high biological value from wheaten flour have been obtained [2].

Protein paste from sunflower shrot with high-protein is produced and recommended in the manufacture of various food products [5].

Sunflower processing products have been proposed as components of medical parenteral nutrition for patients with liver failure [6].

2. Research problem statement
Confectioneries make a significant contribution to the food diet of various age groups of the population, especially children and young people. These products are in regular fixed demand due to high flavor properties, affordability, ease of consumption. The nutritional value of confectioneries is marked by the significant content of carbohydrates and fats prevailing in comparison with proteins. In this regard, confectionery need a correction in chemical composition in the way of increasing biological value by enrichment with complete protein.

Based on a review of literature, it has been found that perspective sources of comestible protein that can be rationally used to increase the biological value of confectionery are nontraditional sources, including protein-containing ingredients of secondary plant resources.

High-protein flour «Bioproten» (fineness less than 160 microns) obtained from sunflower shrot with protein content of 45-48% is recommended for use in the meat, bakery, confectionery and formula feed industries as a perspective source of such protein substances [7].

The purpose of the study is to research the influence of high-protein flour from sunflower shrot on the consumer and technological properties of chocolate masses to identify its usage in the manufacture of confectioneries, in particular chocolate.

At the moment, chocolate remains one of the most popular food products not only for children, but also for adults. However, the spread of diabetes which is characterized by numerous adverse events and more increase in the world. Considering this, many nutritionists advise people with high sugar or to prevent diabetes excluding chocolate from their diet. Specialized food products with a modified carbohydrate profile are proposed as a source of carbohydrates in the diet. [8].

In the study the modification of the carbohydrate profile of chocolate provided the exclusion from its composition of sucrose, traditionally included in the formula for chocolate goods and the use of isomalt as a sugar substitute. Isomalt is a low-calories carbohydrate derived from sucrose. It has a low-glycemic, does not cause caries, protects the organism from surges in blood sugar levels [9].

3. Materials and methods

3.1 Materials
High-protein food flour from sunflower shrot («OZRKD Biotech-pro» LLC) is a functional product of deep biotechnological processing of sunflower shrot, has a delectable flavor and aroma, neutral colour, produced in accordance with TC 10.41.42-001-10152018-2019 «High-protein food flour from sunflower shrot «Bioproten». Technical conditions».
3.2 Determination of the amino acid composition of the high-protein flour from sunflower shrot
The amino acid composition of high-protein flour from sunflower shrot was determined by capillary electrophoresis on the «Kapel 103R» analyzer. The method of capillary electrophoresis is based on the separation of the charged components of a complex mixture in a quartz capillary under the action of an applied electric field.

3.3 Sensory analysis
The verbal scale was used to assess the intensity of the characteristic feature of flavor and aroma of the product using the profile method: 0 - no feature; 1 - only recognizable or felt; 2 - low intensity; 3 - middle intensity; 4 - strong; 5 - very strong intensity.

3.4 Determination of the mass fraction of moisture, fat, degree of grinding and plastic viscosity
The determination of the mass fraction of moisture in the chocolate masses was done by drying; mass fraction of fat - by the refractometric method with extraction of fat from the analyzed sample by monobromonaphthalene; degree of grinding by the method of Reutov; plastic viscosity by Casson.

3.5 Color determination
Chocolate color determination was done by an instrumental method based on the analysis of the optical characteristics of chocolate obtained using a Color i5 spectrocolorimeter (X-Rite Incorporated, USA). The reflectance spectra of the samples were measured in the wavelength region of 360-750 nm with an interval of 10 nm, with a measurement geometry of d/8 at a light source of D65 and a CIE colorimetric observer position of 10°. The coefficients of the reflectance spectra were converted into the color space coordinates CIEL*a*b* 1976: L* – lightness, a* – red (+a*)/green(-a*), b* – yellow (+b*)/blue(-b*).

4. Results and discussion
The underlying rationale of the components for the production of enriched products is information about the composition of the initial ingredients. Researches of establishing the nutritional and biological value of high-protein flour from sunflower shrot were conducted (table 1).

The results indicate that the amino acid composition of high-protein flour from sunflower shrot is characterized by the presence of all the essential amino acids, high content of glutamic and asparagine acids, arginine, glycine, alanine, proline, serine and tyrosine (table 2).

| Table 1. Qualitative composition of high-protein food flour according to samples average |
|---------------------------------|------|
| Indicators of product sample    | Content, % |
| Moisture, %                    | 9.90 |
| Dry matter, %                  | 90.10 |
| **Minerals**                   |      |
| Ash, including                 | 9.44 |
| Calcium                        | 0.49 |
| Phosphorus                     | 1.33 |
| Magnesium                      | 0.77 |
| Potassium                      | 1.93 |
| Sulfur                         | 0.62 |
| **Protein**                    | 40.55 |
| **Fats**                       | 1.31 |
| **Carbohydrates**              | 38.80 |
Table 2. Amino acid composition of high-protein flour from sunflower shrot, g/100g protein

| Essential amino acid | Indicator | Nonessential amino acid | Indicator |
|----------------------|-----------|-------------------------|-----------|
| Histidine            | 0.63      | Alanine                 | 1.93      |
| Isoleucine           | 1.78      | Arginine                | 3.66      |
| Leucine              | 2.97      | Asparagine acid         | 3.95      |
| Lysine               | 1.64      | Cysteine                | 0.63      |
| Methionine           | 0.95      | Glutamic acid           | 9.14      |
| Phenylalanine        | 2.08      | Glycine                 | 2.55      |
| Threonine            | 1.62      | Proline                 | 1.94      |
| Tryptophane          | 0.56      | Serine                  | 1.82      |
| Valine               | 2.38      | Tyrosine                | 1.28      |

A research of the possibility of using high-protein flour from sunflower shrot as a source of increasing the nutritional value of chocolate was done. For this purpose, chocolate masses were prepared according to the formula of dark chocolate, in which part of the cocoa solids was replaced with high-protein flour from sunflower shrot in an amount of 5.0 wt.%, 10.0 wt.%, 15.0 wt.%, 20.0 wt.% and 25.0 wt.%.

Table 3. Composition of chocolate masses without and with high-protein flour from sunflower shrot

| Composition          | The sample number of chocolate masses / amount, wt. % |
|----------------------|------------------------------------------------------|
|                      | control 1 2 3 4 5                                   |
| Crude chocolate      | 10.00 10.00 10.00 10.00 10.00 10.00                 |
| Cocoa butter         | 30.00 30.00 30.00 30.00 30.00 30.00 30.00           |
| Cocoa solids         | 30.00 25.00 20.00 15.00 10.00 5.00                 |
| Sunflower flour      | 0.00 5.00 10.00 15.00 20.00 25.00                  |
| Isomalt              | 25.00 25.00 25.00 25.00 25.00 25.00                 |
| Stevia               | 0.01 0.01 0.01 0.01 0.01 0.01 0.01                 |
| Almond paste         | 0.45 0.45 0.45 0.45 0.45 0.45 0.45                 |
| Emulsifier           | 0.04 0.04 0.04 0.04 0.04 0.04 0.04                 |

Research of the quality of the resulting chocolate masses revealed mass fraction of moisture does not exceed 2% which corresponded to the standards of reference documentation (table 4).

The viscosity of the chocolate mass determines its technological properties, and it should have a constant optimal quantity (up to 20-25 Pa·s) (table 4). The molding process proceeds under the most favourable conditions with this viscosity.

The fineness degree defines the gustatory quality of the chocolate mass and the formed chocolate from it; therefore, good quality chocolate should have the fineness degree no less than 92% (table 4). A lower fineness degree makes the chocolate taste coarse and reduces its valuable organoleptic qualities.

Table 4 presented the data that fall in the plastic viscosity of the chocolate mass is observed with an increase in its composition in the proportion of high-protein flour from sunflower shrot with almost unchanged three other indicators that influence the viscosity of the chocolate mass. Subsequently, these research results can be applied in modeling chocolate masses taking into account its viscosity properties.

Influence of adding high-protein flour from sunflower shrot on changes in basic chemicals and energy density of chocolate is presented in table 5.
Table 4. Results of the research of the physical-chemical and technological properties of chocolate masses

| Amount of additive, wt. % | Plastic viscosity, Pa's | Mass fraction of moisture, % | Mass fraction of fat, % | Fineness degree by Reutov, % |
|--------------------------|------------------------|------------------------------|------------------------|-----------------------------|
| 0.0 (control)            | 6.3                    | 1.32                         | 38.7                   | 98.5                        |
| 5.0                      | 6.3                    | 1.63                         | 38.4                   | 98.2                        |
| 10.0                     | 4.5                    | 1.28                         | 38.2                   | 98.2                        |
| 15.0                     | 3.3                    | 1.18                         | 38.0                   | 98.7                        |
| 20.0                     | 3.0                    | 1.34                         | 38.7                   | 98.7                        |
| 25.0                     | 2.7                    | 1.54                         | 38.1                   | 98.1                        |

Table 5. Influence of sunflower flour on the content of basic chemicals and energy density of chocolate

| Amount of additive, wt.% | Content in 100 g of chocolate, g | Energy density, kcal |
|--------------------------|----------------------------------|----------------------|
|                          | Protein                         | Fats                | Carbohydrates       |                               |
| 0.0 (control)            | 9.0                             | 40.1                | 30.2                | 518.0                         |
| 5.0                      | 9.8                             | 39.6                | 31.9                | 523.0                         |
| 10.0                     | 10.6                            | 39.1                | 33.5                | 529.0                         |
| 15.0                     | 11.4                            | 38.7                | 35.1                | 534.0                         |
| 20.0                     | 12.2                            | 38.2                | 36.7                | 540.0                         |
| 25.0                     | 13.0                            | 37.8                | 38.4                | 545.0                         |

As can be seen from the data presented, the use of high-protein flour from sunflower shrot in the production of chocolate led to an increase in the protein content in the product. Proteins contained 9.0 g in the control sample produced without adding high-protein flour from sunflower shrot. The replacement of 15.0 wt.% cocoa solids with high-protein flour from sunflower shrot contributed to an increase in the content of the component in chocolate by 26.6%. Undoubtedly, this is due to the fact that the additive used is a high-protein raw material that contributes to the enrichment of the product.

Based on the researches, it was found that to obtain chocolate with good organoleptic quality indicators, the recommended dosage of high-protein flour from sunflower shrot should be not more than 15.0 wt.% instead of part of cocoa solids. According with a such content, the additive gave the product an aroma and halva flavor, while the bright and flavorful taste of cocoa products characteristic of chocolate was clearly felt.

In previous researches [10], it was established that the additive of the isomalt-containing in the chocolate mass provides to increase the resistance of dark chocolate to sugar bloom and enhances the stability of this product containing milk fat to fat bloom.

In the patent [11], the authors considered that the additive of solid debris of plant origin into chocolate mass with a particle size of 0.06 to 1.0 mm increases the resistance of chocolate to bloom that occurs temperature variation during storage. In their opinion, this is due to the fact that in a homogeneous chocolate mass including particles of plant inclusions of a given size, the crystallization characteristics of the fat components that including in the chocolate composition change and the fusion process and recrystallization of cocoa butter during temperature variation occur less intensively inside-outside chocolate.

Therefore, it is expedient to research chocolate containing isomalt and high-protein flour from sunflower shrot for resistance to fat bloom.

The chocolate samples were exposed to temperature variation to form a bloom. The occurring of bloom was diagnosed by changing the lightness parameter L*(CIEL*a*b*), determined by instrumental measurement of the surface color of the chocolate. Lower data of the lightness L*(CIEL*a*b*) indicate darker chocolate color.
It was found that with the additive of high-protein flour from sunflower shrot in the formula composition of chocolate, its resistance to fat bloom increased in comparison with the control sample. Moreover, with an increase in the dosage of high-protein flour, resistance increases: an increase in the data of lightness L*(CIEL*a*b*) from the influence of temperature variation is insignificant, the surface color of these samples is darker (table 6).

### Table 6. Dependence of lightness L* on temperature variations during chocolate storage

| Heating/cooling cycle | Lightness L* |
|-----------------------|--------------|
|                       | Amount of additive, wt.% |
|                       | 0.0 (control) | 5.0 | 15.0 | 20.0 | 25.0 |
| 0                     | 23.39        | 24.00 | 24.38 | 24.41 | 25.97 |
| 1                     | 24.40        | 24.50 | 25.00 | 25.10 | 26.34 |
| 2                     | 24.51        | 24.70 | 25.27 | 25.20 | 26.50 |
| 3                     | 24.59        | 24.80 | 25.30 | 25.20 | 26.60 |
| 4                     | 25.45        | 25.30 | 25.50 | 25.50 | 26.80 |

#### 5. Conclusion

Thus, the proposed high-protein flour from sunflower shrot should be used to increase the biological value of confectionery, in particular chocolate.

The technological properties of the simulated chocolate masses promote to create a technology of the mass production, as the preparation of liquid semi-finished products and in the process of forming finished products.

The composition of the chocolate mass that does not reduce the taste characteristics of the finished chocolate product is presented. A new technical result of the resistance of chocolate to fat bloom has been achieved that increase its consumer property.

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