Shaped jelly marmalade with cranberry concentrate

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Abstract. The use of fruit raw material and its processing products in production technologies of marmalade products is a promising direction in the correction of nutritional value and consumer properties. Hence, cranberries, which are a recognized source of healthy, biologically active and minor food components, as well as natural colors, preservatives and antioxidants, present a particular interest. The paper presents the results of the study on the use of cranberry ingredient in the form of juice concentrate in the preparation of pectin-based jelly marmalade. Cranberry juice concentrate was added in the amount of 6-15% to the weight of white sugar in the marmalade jelly. Marmalade was prepared under laboratory conditions according to a traditional scheme, which includes the preparation of sugar-dextrose syrup with a jellying agent, boiling of marmalade mass, its molding and gelation, extraction of marmalade from molds and white sugar coating. The gelation was carried out at a room temperature of 23°C for 2 hours. It is shown that the use of cranberry juice concentrate in the formulations of marmalade products allows making a product with high organoleptic indicators (appearance, shape, consistency, taste, color, smell). Positive influence of cranberry juice concentrate on structural and mechanical properties of pectin-based marmalade products is revealed, which is demonstrated by the increase of marmalade jelly strength. Taking into account the results of organoleptic analysis and studies of structural and mechanical properties, a formulation of shaped jelly marmalade was developed with addition of cranberry juice concentrate in an amount of 13% to the weight of white sugar in the jelly mass. It was found that shaped jelly marmalade meets the regulatory requirements prescribing its quality and contains biologically active substances and minor components of cranberries.

1. Introduction
The use of fruit raw material and its processing products in production technologies of marmalade products is a promising direction in the correction of nutritional value and consumer properties [1, 2, 3, 4]. This approach ensures market saturation with natural, high-quality products with recognized attributes of ripe berries and fruits, such as natural color, natural taste and aroma, containing a complex of natural components useful for human health, which have a beneficial effect on the functioning of human organs and systems. The introduction of a wide range of fruit and berry ingredients allows significantly expanding the assortment of marmalade products, differentiating consumer preferences and creating progressive technologies for the new generation products.

A promising raw material is cranberries, the nutritional and therapeutic properties of which have been known for a long time. Cranberries contain a diverse complex of nutritional, biologically active and minor components, as well as natural colors, preservatives, antioxidants, which triggers the interest in this berry among nutrition experts and food producers [5, 6]. The implementation of a natural potential of cranberries in marmalade technologies will allow improving the nutritional profile of finished products, making them attractive with unique taste, reducing the risk of microbial infection.

The introduction of cranberry ingredient into the formulation of marmalade products requires a reasoned approach to develop technological recommendations for its application from the point of...
view of increasing the nutritional value and ensuring structure, quality and consumer properties of finished products guaranteed by the manufacturer, which makes the present studies relevant.

2. The purpose of the study is to analyze the effect of cranberry ingredient in the form of juice concentrate on organoleptic, physical-chemical, structural-mechanical properties and nutritional value of pectin-based jelly marmalade.

3. Materials and methods

3.1. Materials

The study used the following:
- cranberry juice concentrate obtained on the basis of directly squeezed juice, separated from the skin and seeds of berries, pre-treated with the composition of enzyme preparations Laminex BG 2 (manufactured by Genencor International BVBA, Danisco Company, Belgium) and Fructocim P-6L (manufactured by Erbsloeh Geisenheim AG, Germany) using vacuum evaporation method [7]. The concentrate represented a thick, viscous liquid (dry matter content 53%), having marron color with flavorful taste and smell typical for cranberries; it was characterized by high concentration of essential and minor components, natural colors, organic acids, preservatives and high antioxidant activity [7].
- apple pectin WEJ-2 (E440; manufacturer – ZPOW PEKTOWN S.A., Poland).

3.2. Preparation of experimental samples of shaped jelly marmalade

A typical formulation of pectin-based jelly marmalade, Apricot, was used as a basic formula [8]. Taking into account the chemical composition of the cranberry concentrate, apricot solder and citric acid were excluded from the formulation. Cranberry juice concentrate was added in the amount of 6-15% to the weight of white sugar. Marmalade was prepared under laboratory conditions according to a traditional scheme, which includes the preparation of sugar-dextrose syrup with a jelling agent, boiling of marmalade mass, its molding and gelation, extraction of marmalade from molds and white sugar coating. The gelation was carried out at a room temperature of 23°C for 2 hours.

3.3. Assessment of organoleptic and physicochemical indicators

Organoleptic and physicochemical indicators of shaped jelly marmalade were assessed in accordance with GOST 6442-2014. Marmalade. General specifications.

3.4. Methods of structural and mechanical analysis

The jelly strength was determined using a Strucutrometer ST-2 texture analyzer equipped with Valenta and Bloom indenters. The Bloom indenter was introduced into the prepared sample was to a depth of 4 mm at a speed of 1.0 mm/s after a touching force of 7 g. The maximum loading force in g is interpreted as the Bloom strength of the jelly [9].

The limit load required to destroy the surface of the jelly was determined by the Valenta indenter with the following parameters: loading rate – 12 g/s; motion speed up to the contact with product sample – 0.5 mm/s; force at the point of contact of the indenter with the sample – 100 g; depth of penetration – 15 mm.

3.5. Study of chemical composition

The total sugar content (total sucrose and reducing sugars) was determined by the photocolorimetric method based on oxidation of the total sugar with potassium dichromate in a strongly acid medium. The measurement was carried out on a photoelectric colorimeter KFK-3 at a wavelength of \( \lambda = 670 \text{ nm} \) and a cuvette thickness of 5 cm [10].

The weight fraction of titratable acids was determined by titration of the 0.1n alkali solution of the extract obtained from the known weight of the studied product over phenolphthalein [10].

The total content of polyphenol compounds was determined by a modified Folin-Ciocalteau technique using a pre-constructed calibration curve of the gallic acid [11].

The total content of flavones and flavonols (on a rutin basis) was determined by spectrophotometric analysis [11]. The optical density was measured at a wavelength of 415 nm. A calibration curve of standard routine solution (rutin trihydrate, 95%, (Sigma), CAS: 207671-50-9) was used for quantitative calculations.
The anthocyanin content was determined via differential spectrophotometry [11].
The tannin content was determined by permanganatometric titration over indigosulfonic acid [11].
The vitamin C content was determined by iodometric backward titration [10].

4. Results and discussion

The organoleptic indicators of experimental marmalade samples were assessed in comparison with shaped jelly marmalade with cranberry juice purchased in a chain store (control) according to such criteria as color, taste, smell, consistency, shape.

The results of the analysis showed that the marmalade samples had a dense consistency, a uniform structure, a smooth edge on a fracture and a glossy surface covered with white sugar.

In terms of taste, color and smell, the best were found to be marmalade samples with addition of cranberry juice concentrate in the amount of 10-13% to the sugar weight in jelly: the product acquires a saturated red color, taste and light aroma typical for cranberries. The increase of the dose of concentrate to 15% intensifies the taste of cranberry and gives the product a pronounced sour taste and astringency.

The study of structural and mechanical properties of marmalade samples showed that with the increase of concentrate dosage the strength of the jelly increases, which is expressed in the increase of indenter loading force (Figure 1). With the increase of the concentrate dosage from 6% to 15% the maximum local deformation of marmalade jelly makes 4 mm due to triple increase of the loading force.

![Figure 1](image-url)  
**Figure 1.** Relationship between loading force (g) and degree of local deformation (mm) according to Bloom for marmalade samples with different doses of cranberry concentrate

The obtained results are consistent with the results of the study of structural and mechanical properties of marmalade samples carried out using Valenta indenter. The main idea of the study is to determine the loading force that causes the jelly failure (Figure 2).
Figure 2. Relationship between loading force (g) and penetration depth (mm) of Valenta indenter in marmalade jelly samples with different doses of cranberry concentrate.

The study of the strength of the marmalade samples with different doses of cranberry concentrate makes it possible to assess the studied indicator by the inclination angle of curves characterizing the value of local stresses depending on the depth of indenter penetration: the inclination angle of curves successively increases with the increase of the concentrate dosage in the marmalade mass (Figure 3).

The presented graphical dependencies allow determining the loading force corresponding to the failure of the marmalade jelly surface, since the dependencies lose their natural character.

The dynamics of deformation behavior of the marmalade jelly gives a clear idea of the jelly failure moment (Figure 3).

Figure 3. Dependence of the local deformation of marmalade jelly on exposure time (according to Valenta).

The analysis of the given graphical dependencies shows that the damage to the integrity of the marmalade jelly samples occurs within a period of 43–96 seconds, and with the increase in the dosage of cranberry juice concentrate, the duration of the deforming action resulting in the jelly failure also increases.

High strength of the jelly gives the marmalade excessive rigidity and brittleness, while low – leads to the deformation of finished products and negative consequences during storage. Therefore, when
selecting doses of cranberry juice concentrate for shaped jelly marmalade formulations, we focused on structural and mechanical characteristics of a standard sample of cranberry juice marmalade purchased in a chain store (Moscow).

The comparative analysis of the obtained results showed that the marmalade samples obtained with the addition of cranberry juice concentrate in the amount of 13-15% to the weight of white sugar are closest to the standard sample (Figure 4-6).

**Figure 4.** Change of loading force (g) on Bloom indenter depending on local deformation (mm) of marmalade control sample

**Figure 5.** Change of loading force (g) on Valenta indenter depending on the penetration depth (mm) into the marmalade control sample
Taking into account the results of organoleptic analysis and studies of structural and mechanical properties, a formulation of shaped jelly marmalade was developed with application of cranberry juice concentrate in the amount of 13\% of white sugar weight. Marmalade produced according to the developed formula met the requirements of GOST 6442-2014 Marmalade. General specifications. (Table 1).

Table 1. Physicochemical indicators of jelly marmalade with cranberry juice concentrate

| Indicators                                      | Value | Indicators according to GOST 6442-2014 |
|------------------------------------------------|-------|----------------------------------------|
| Moisture content, \(\%\)                       | 19    | 15-22                                  |
| Mass fraction of ash not soluble in hydrochloric acid with 10\% mass fraction, \(\%\), not more | 0.04  | 0.05                                  |
| Mass fraction of total sulfurous acid, \(\%\), not more | -     | 0.01                                  |
| Mass fraction of benzoic acid, \(\%\), not more | 0.01  | 0.07                                  |

The composition of shaped jelly marmalade was studied (Table 2).

Table 2. Composition of shaped jelly marmalade with cranberry juice concentrate

| Component                                        | Content in 100 g |
|--------------------------------------------------|------------------|
| Total sugar, g                                   | 81               |
| Organic acids (titratable) in equivalent of citric acid, g | 1.35             |
| Polyphenol compounds, mg                         | 80               |
| Flavones and flavonols (on a rutin basis), mg    | 55.56            |
| Tanning substance in equivalent of tanin, g      | 0.85             |
| Anthocyanins, mg                                 | 20.50            |
| Vitamin C, mg                                    | 7.0              |

The study revealed the presence of physiologically relevant components in the finished products, which contribute to the preservation and promotion of human health: polyphenol compounds with
antioxidant properties, including flavones, flavonols, natural pigments – anthocyanins, tannins, as well as organic acids and vitamin C.

5. Conclusion

The studies were carried out on the use of cranberry juice concentrate in the production of shaped pectin-based jelly marmalade.

It is shown that the use of cranberry juice concentrate in the formulations of marmalade products allows making products with high organoleptic indicators (appearance, shape, consistency, taste, color, smell).

Positive influence of cranberry juice concentrate on rheological properties of pectin-based marmalade products is revealed, which is demonstrated by the increase of marmalade jelly strength.

Taking into account the results of organoleptic analysis and studies of structural and mechanical properties, a formulation of shaped jelly marmalade was developed with addition of cranberry juice concentrate in the amount of 13% to the weight of white sugar in the jelly mass.

It was found that shaped jelly marmalade meets the regulatory requirements prescribing its quality and contains biologically active substances and minor components of cranberries.

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