AGRISCIENCE AND TECHNOLOGY
Armenian National Agrarian University
ԱԳՐՈԳԻՏՈՒԹՅՈՒՆ ԵՎ ՏԵԽՆՈԼՈԳԻԱ АГРОНАУКА И ТЕХНОЛОГИЯ
International Scientific Journal
ISSN 2579-2822

Journal homepage: anau.am/scientific-journal
doi: 10.52276/25792822-2023.4-383

UDC 664.858

Using Alternative Raw Materials in Sugar Confectionery Production

N.G. Hovhannisyan, H.V. Mkhitaryan, G.B. Aperyan, R.S. Hayrapetyan
Armenian National Agrarian University
narinehovhannisyan1984@mail.ru, hvmkhitaryan@gmail.com, aperyangayane79@gmail.com, ruzanna_hayrapetyan@mail.ru

ARTICLE INFO

Keywords:
marmalade,
pumpkin,
sea buckthorn,
puree,
secondary raw materials

ABSTRACT

A novel recipe and production technology for sugar confectionery, specifically marmalade, has been developed through scientific and experimental research. The findings affirm that pumpkin and sea buckthorn purees can effectively substitute traditional plum and apple purees, eliminating the need for various coloring agents. The suggested product represents a domestically-produced marmalade, particularly in the food market, and this endeavor will play a crucial role in advancing both marmalade production and the development of the raw material base.

Introduction

The global trends in food processing emphasize the utilization of alternative raw materials and the advancement of innovative technological processes in the food industry (Kalidas, 2020). Among health-friendly vegetable-based products rich in biologically active substances, marmalade stands out prominently (Emelike, 2019).

Within the European Union member states, marmalade composition adheres to specific European standards. The production process involves mixing ingredients and steaming at 10 ^{0}C until achieving the designated "exact content of dry matter" (Council directive 2001/113/EC of 20 December 2001, Official Journal of the European Communities).

The global confectionery market, valued at 199.8 billion USD in 2020, displayed positive dynamics with an average annual growth rate of 3.2 %. The sugar confectionery market achieved a value of 53.5 billion US dollars in 2020. Projections suggest a substantial growth of 22.6 % in the global sugar confectionery market by 2025, with an anticipated market size of US$ 65.6 billion. Marmalade products rank third in this segment, emerging as the most popular confectionery items (Skobelskaya, 2021).

In recent years, the market has seen a scarcity of fruit marmalade containing natural dietary fibers with physiological value (Chhikara, et al., 2022). Jelly-type marmalade lacks fibers due to the use of dyes, flavorings, and acidifiers (Zubchenko, 1999; Tefikova, 2018).

While jelly marmalades incorporate dyes, flavorings, and acidifiers, fruit marmalades employ fruit purees with gelling agents, enhancing their nutritional value (Emelike, 2019).

Key components in fruit marmalade production include fruit purees, sugar, molasses, citric acid, various pigments, and gelatinizers like agar-agar, agaroid, pectin, and occasionally gelatin or xanthan gum, the latter gaining popularity in recent years (https://yandex.ruu/patents/).

Pumpkin fruits are deemed essential in dietary and therapeutic regimens for conditions such as atherosclerosis, heart, intestines, kidneys, liver, and gall bladder diseases (https://calorizator.ru). Sea buckthorn fruits are rich in vital microelements, including iron, manganese, and magnesium, along with an array of vitamins and organic acids crucial for bodily functions. Fruits are rich in a variety of essential vitamins, including A, C, E, P, K, B1, B2, B3, and B6. They also contain significant amounts of ascorbic acid (ranging from 50 to 450 mg) and folic acid (0.79 mg per 100 g of fruit). Additionally, fruits contain various organic acids and sugars, constituting about 9 % of the fruit's composition (http://agroecoarm.com).

Recent years have witnessed several attempts to incorporate sea buckthorn fruit juice in marmalade production (Magomedov, et al., 2017). Marmalades are traditionally crafted from fruits and vegetables harvested at the technical ripening stage, ensuring that pectin substances are in the optimal state for effective jelly formation.

Materials and methods

The research concentrated on examining marmalade samples prepared from commercially available pumpkin and sea buckthorn puree. These samples were treated with sodium lactate and further enriched with ascorbic acid. Sodium lactate is selected because it is derived from the processing of vegetable raw materials that naturally contain sugars. Additionally, sodium lactate of natural origin is found in the human body and is produced in the intestines during the processing of lactic acid (https://pcgroup.ru).

Experimental samples were prepared using local Berkanush, Big-Max, and Saporik pumpkin varieties, with sea buckthorn puree serving as an additional source of ascorbic acid.

The objectives of the study were as follows:

Develop a novel recipe, technology, and thermal parameters for marmalade using local pumpkin and sea buckthorn purees.

Eliminate the use of potassium sorbate (E202), replacing it with a vegetable additive, sodium lactate, which functions as a moisturizing agent, a natural preservative, and, to a lesser extent, a gelling agent.

Exclude the use of various coloring agents.

To accomplish the final research goals, the following tasks were outlined:

1. Investigate the chemical composition of local pumpkin varieties, including the comparative analysis of pectin substances present in them.
2. Substitute synthetic ascorbic acid with a natural food product, specifically sea buckthorn puree.
3. Evaluate the qualitative characteristics of the final samples, considering sensory and physicochemical indicators.
4. Determine optimal raw material quantities, create a new recipe, and develop the sequence of technological processes for marmalade production.

Qualitative characteristics of the final product adhered to research methods stipulated by sugar confectionery standards. The technological process followed the instructions outlined for sugar confectionery production.

The research was conducted at the “Plant Origin Products and Raw Materials Processing Technology” division of the Scientific Research Institute of Food Science and Biotechnology at the Armenian National Agrarian University.

Results and discussions

The research team sought to create an innovative marmalade by leveraging locally abundant and cost-effective raw materials. The primary focus was on preserving the heat-resistant vitamins present in these materials throughout the entire technological process. Pumpkin was chosen as a primary raw material due to its rich content of vitamins, minerals, assimilable membrane material, and other valuable substances. Its abundant chemical composition is complemented by its beneficial dietary properties.

An effort was made to procure marmalade samples by utilizing both singular pumpkin purees and a combination of sea buckthorn purees. Formulas were meticulously selected to yield optimal sensory attributes. Recognizing the potential functional value of marmalade from these raw materials, the study considered ingredient proportions and production technological modes.

Table 1. Chemical composition of the local pumpkin varieties*

Varieties	Names of indicators (%)				Vitamins (mg, %)	
	Total dry matter	Soluble dry matter	Pectinic matter	Dietary fiber	Total carotenoids	Vitamin C
Berkanush	7.7	6.8	0.6	1.2	4.5	6.7
Big-Max	4.7	4.31	0.8	1.5	2.2	5.6
Saporik	7.2	6.5	0.7	1.5	3.1	6.2

*Composed by the authors.

Experimental marmalade samples were prepared in two variations: one exclusively from pumpkin puree and another from a blend of pumpkin and sea buckthorn purees.

To obtain test samples of marmalade, the local Berkanush, Big-Max, and Saporik pumpkin varieties were examined, and their chemical composition is detailed in Table 1.

The study highlights that the Big-Max variety of pumpkin contains the highest concentrations of pectin substances and membrane material. Nevertheless, when conducting sensory assessments of experimental marmalade samples from each variety, the Berkanush variety emerged with the most favorable taste characteristics, along with its richness in carotenoids and vitamin C.

Sea buckthorn berries are identified as a concentrated source of natural biologically active substances. These berries encompass 10-19 % dry matter, with 7.3-11.3 % being soluble. The sugar content in sea buckthorn berries ranges from 2.5-3.6 %, including sucrose, glucose, and fructose. Pectin content in these berries varies between 0.3-1.2 %. On average, 100g of sea buckthorn berries provides up to 10 daily doses of vitamin C (approximately 1.05 mg), a substantial amount of vitamin E (7-18 mg), P (up to 1 mg), as well as vitamin B1 (0.35 mg), B2 (0.3), B6 (0.79), PP, and K (0.8-1.5 mg) (Morozova, 2011, https://health-diet.ru).

Marmalade was crafted using a base of mashed pumpkin. The agar was pre-soaked in a specialized bath with cold water to facilitate swelling. The extent of agar's swelling is contingent upon the specific type of agar used. Preliminary calculations suggest an approximate agar-to-water ratio of 1:4. Pre-sifted sugar was added to a cooking pot, and water was incorporated at a ratio of 1:4. Subsequently, agar, molasses, and the remaining specified raw materials in the recipe were introduced gradually. The mixture was cooked until it achieved a moisture content of 27-30 %. Finally, the cooked mass was strained with the assistance of gauze, ensuring a refined texture. The syrup, upon reaching a temperature between 71-73 ^{0}C, was cooled, and pumpkin puree was seamlessly incorporated into the mixture.

To obtain the pumpkin puree, the pumpkin was meticulously peeled, cut into pieces, steamed, and then skillfully mashed to achieve a smooth consistency. Simultaneously, a buckthorn puree was prepared. The relative proportions of pumpkin and sea buckthorn purees were deliberately selected, offering variations of 20:80, 50:50, and 80:20. After careful consideration, the 50:50 ratio was chosen from the samples prepared in three portions, as it exhibited the most optimal qualitative indicators. Additionally, a marmalade sample was prepared without the inclusion of sea buckthorn puree.

Recognizing sea buckthorn's high ascorbic acid content, the inclusion of sea buckthorn puree was carefully considered when formulating the invert sugar solution. This involved calculating the necessary amount of citric acid, taking into account that the total acids in the mixture would amount to 1 %, and the pH would fall within the range of 3.2 to 3.4.

The two purees were premixed to ensure a uniform distribution of the mass. The mixture was brought to a boil for approximately 5 minutes and then concentrated under vacuum to achieve a dry matter content of 70-74 %. When molding the final mass, the temperature was maintained at 69-70 ^{0}C. The moisture content of the mass during molding was regulated to be between 28-30 %. The gelatinization process lasted for a duration of 15-20 minutes.

To eliminate excess moisture from the marmalade and induce the formation of a crystalline crust on the outer layer, the marmalades underwent a drying process. In laboratory conditions, drying was carried out using a specialized convective dryer at temperatures ranging from 50 to 55 ^{0}C for a duration of 20 minutes. Subsequent to the drying phase, the marmalades were cooled to temperatures between 20 and 25 ^{0}C, achieving a moisture level of 18-21.5 %. They were then carefully removed from the silicone molds.

The technological scheme of the product preparation unfolds as follows:

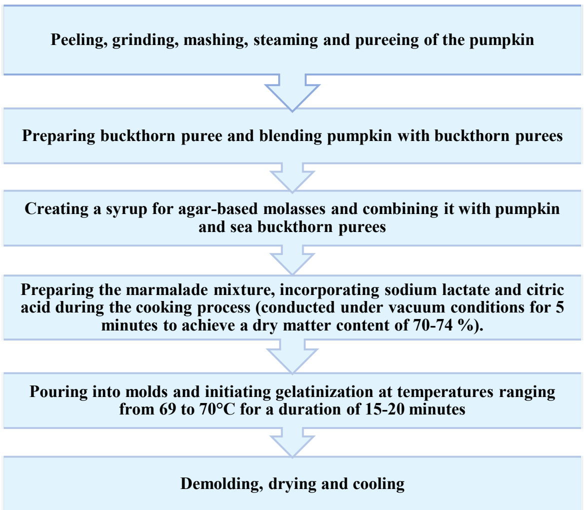

Figure. Technological scheme of marmalade with pumpkin and sea buckthorn puree (*composed by the authors*).

Given that the taste characteristics of pumpkin vary from other fruits typically employed in marmalade production, it was crucial to initially assess the sensory indicators of the new variant. This evaluation is presented in Table 2.

The physicochemical indicators of marmalade play a crucial role in determining its quality. The standards for moisture, acidity, and reducing sugars are established by regulatory guidelines. Failure to meet these standards can have a considerable impact on the safety, shelf life, and overall quality of the product.

The research results on physicochemical indicators yielded the values, presented in Table 3.

Table 3. Physicochemical indicators of the control sample and new types of marmalades*

Name of indicator	Characteristics		
	Control sample	**Pumpkin puree product**	**A product created by combining pumpkin and sea buckthorn purees**
Moisture content, % (Maximum)	21.5	20.0	18.0
Soluble sugars content, % (Maximum)	25.0	25.8	26.0
Acidity, pH	8.1	8.4	5.2
Insoluble ash in 10% HCl solution, % (Maximum)	0.05	0.05	0.05

*Composed by the authors.

Table 2. Sensory indicators of the control sample and new types of marmalades*

Name of indicator	Characteristic		
	Control sample	**Pumpkin puree product**	**A product created by combining pumpkin and sea buckthorn purees**
Taste, smell, color	Characteristic of the product with this name, without additional flavors and odors	The product exhibits a more distinct pumpkin flavor, free from extraneous tastes and odors. It has a bright yellow color with the presence of pumpkin particles	Blended with distinct pumpkin and slightly acidic flavors, without off-flavors and odors. The color is yellowish-carmine, with the presence of pumpkin particles
Composition	Jelly-like	Solid jelly-like	Solid jelly-like
Form	In the form of a mold used for the given product. It maintains stability and shows no signs of damage	In the form of a mold used for the given product. It maintains stability and shows no signs of damage	In the form of a mold used for the given product. It maintains stability and shows no signs of damage
Surface	Smooth and shiny	Smooth and non-expressive shine	Smooth and shiny
Taste Score 20 points	19.1	17./6	18.9

*Composed by the authors.

From the analysis of physicochemical indicators, it is evident that the two experimental samples of marmalade not only met the standards, but also exhibited superior physicochemical characteristics.

Based on laboratory research and calculations, the production composition of the new product was formulated for a one-year period according to finished products (Table 4). Component calculations were performed using established technological calculation methods (Skobelskaya, 2021; Pavlova, 2002).

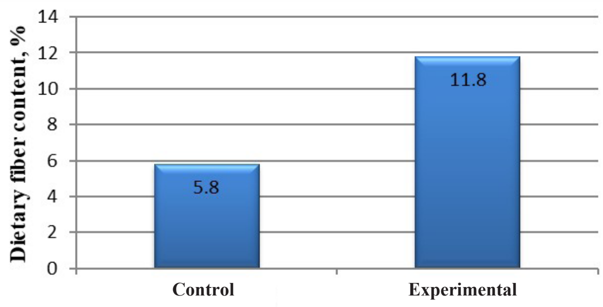

Diagram. The Dietary fiber content in the new marmalade product *(composed by the authors)*.

Table 4. Composition of marmalade made with pumpkin and buckthorn puree*

Name of indicator	Amount of dry matter, %	Based on the yearly calculation of the final product in kilograms	
		By weight	By dry matter
Sugar	99.85	580.2	579.1
Molasses	78.0	260.0	202.8
Agar	85.0	9.0	76.5
Pumpkin puree + sea buckthorn puree (50:50 ratio)	10.0	152.0	12.0
Citric acid	99.0	9.0	0.8
Sodium lactate	50.0	10.0	5.0
Total	-	1020.2	876.2
Yield	82	1000.0	820.0

*Composed by the authors.

One of the objectives in developing new marmalade products is to enhance dietary fiber content using alternative raw materials. The human body typically requires 25-30 g of dietary fibers per day (Chernikov, 2019). Pumpkin contains 1.5 % of dietary fiber in 100 g, while sea buckthorn can have up to 10 % in the same quantity. The nutritional value of 100 g marmalade includes 6 % dietary fiber. Theoretically, it can be inferred that the new product should have an increased content of dietary fibers since they are not significantly degraded during reheating. To experimentally determine the dietary fiber content in marmalade, a corresponding experiment was conducted, and the results are presented in Diagram. As shown in Diagram, the dietary fiber content in the control sample was 5.8 %, while in the samples prepared with a mixture of pumpkin and sea buckthorn puree, it reached 11.8 %. In other words, the food fiber content in the new product has doubled, providing the product with added functional significance. The data of the research result related to microbiological indicators are presented in Table 5.

Table 5. Microbiological indicators of the control sample and new types of marmalades*

Names of indicators	Characteristics				
	Mesophilic aerobic and facultative anaerobic microorganisms (CFU/g), no more	Intestinal coliform bacteria (coli forms) are not allowed in the food mass (g/cm³)	Pathogen, including Salmonella, weight of food (g), in which it is not allowed: 25 g	Molds (CFU/g), no more	Yeasts, (CFU/g), no more
Permissible levels	$1x10^3$	1.0	Not allowed	100	50
Control sample	$1x10^3$	1.0	Not detected	Not detected	Not detected
A Product made with pumpkin puree	$1x10^3$	Not detected	Not detected	Not detected	Not detected
A product made with a blend of pumpkin and sea buckthorn purees	$1x10^3$	Not detected	Not detected	Not detected	Not detected

*Composed by the authors.

After examination of microbiological indicators, it has been established that the obtained samples comply with the requirements set forth in the Technical Regulation of the Customs Union on Food Safety (“TR TS”) 021/2011.

Conclusion

Based on the research findings, it is evident that local varieties of pumpkin and sea buckthorn can serve as novel raw materials in sugar confectionery.

Additionally:

A potential method and the optimal way to utilize pumpkin and sea buckthorn have been established.

The content of dietary fiber in the finished product was assessed.

The study demonstrated the feasibility of excluding colorants and other additives in products crafted from the selected raw materials.

The study revealed an increase in the nutritional fiber content of the product manufactured using the developed technology and portions.

The utilization of pumpkin and sea buckthorn purees in the production of sugar confectionery, as cost-effective and locally sourced ingredients, proves highly effective and facilitates the expanded utilization of local raw materials.

References

1. Chernikov, A. (2019). Fiber 5th element of a healthy diet//Tomsk, - 84 p. (in Russian).
2. Council directive 2001/113/EC of 20 December 2001 relating to fruit jams, jellies and marmalades and sweetened chestnut purée intended for human consumption. Official Journal of the European Communities.
3. Emelike, N.J.T., Akusu, O.M. (2019). Quality Attributes of Jams and Marmalades Produced from Some Selected Tropical Fruits // Journal of Food Processing & Technology. - V. 10 (5). doi: 10.4172/2157–7110.1000790.
4. Kalidas Shetty, Dipayan Sarkar (2020). Functional Foods and Biotechnology Biotransformation and Analysis of Functional Foods and Ingredients/1st Edition. Pub. LocationBoca Raton, - pp. 5-9 http://dx.doi.org/10.1201/9781003003793.
5. Magomedov, G.O., Lobosova, L.A., Zhurahova, S.N. (2017). Jelly - fruit marmalade of increased food value with juice from sea buckthorn berries // Technology and technology of food production - № 3, - pp. 50–54 (in Russian).
6. Morozova, E.I. (2011). Medicinal properties of buckthorn, sea buckthorn, rose hip. - Donetsk. OOO “PKF” “BAO”, -240 p. (in Russian).
7. Navnidhi Chhikara, Anil Panghal and Gaurav Chaudhary (2022). Functional Foods/Scrivener Publishing (LLC), - 2-6 p. http://dx.doi.org/10.1002/9781119776345.
8. Pavlova, N.S. (2000). Collection of basic recipes of sugar confectionery products - SPb. GIORD, - pp.160-176.
9. Skobelskaya, Z.G. (2021). Technology of confectionery products. Calculation recipe. Textbook / izd., ster.- Saint-Petersburg, - 84 p. (in Russian).
10. Tefikova, S.N., Nikitin, I.A., Kondratyev, N.B., Semenkina, N.G. (2018). Expansion of the assortment of jelly-shaped marmalade based on vegetable puree // Vestnik of the Voronezh State University of Engineering Technologies. V. 80. № 2, - pp. 165–174 (in Russian) http://dx.doi.org/10.20914/2310-1202-2018-2-165-174.
11. Zubchenko, A.V. (1999). Technology of confectionery production. Voronezh, - 432 p.
12. https://health-diet.ru/base_of_food/sostav/240.php (accessed on 10.06.2023).
13. https://yandex.ru/patents/doc/RU2630236C1_20170906 (accessed on 14.06.2023).
14. http://agroecoarm.com/wpcontent/uploads/2016/07/%D5%89%D4%BB%D5%89%D4%BD%D4%B1%D5%86-Sea-buckthorn-Hippophae.pdf (accessed on 21.05.2023).
15. https://calorizator.ru/product/vegetable/pumpkin-1 (accessed on 22.05.2023).
16. https://pcgroup.ru/blog/laktat-natriya-vazhnejshij-dlya-pischeproma-i-kosmeticheskoj-industrii-reaktiv/ (accessed on 19.09.2023).

Accepted on 26.09.2023
Reviewed on 01.12.2023