

# Sensory and nutritional effects of citrus and pineapple enrichment in yogurt production

Sergey Boev<sup>1\*</sup>, Vladimir Trubnikov<sup>2</sup>, Sergei Grashkov<sup>2</sup>, and Dmitry Eskov<sup>2</sup>

<sup>1</sup>SouthWest State University, 94, 50 Let Oktyabrya str., Kursk, 305040, Russian Federation

<sup>2</sup>Kursk Agrarian University named after. I.I. Ivanov, 70, Karl Marx Street, Kursk, 305021, Russian Federation

**Abstract.** This paper explores the potential applications of pineapple and orange in yogurt production, examining their addition in various ratios and their impact on quality indicators. The study analyzed samples of enriched yogurt. Pineapple and orange enrichments were added in different proportions ranging from 2:1 to 3:1, meaning three parts pineapple and one part orange relative to the mass of the produced yogurt. To evaluate the obtained samples, researchers conducted organoleptic and other analyses. The results demonstrated that the addition of these components increased ash content and iron levels compared to the control sample. The highest concentration of the studied element was achieved with the addition of 15% pineapple and 5% orange. Based on the experimental results, it can be concluded that incorporating fruit components into the yogurt recipe increases ash content and, consequently, the elemental composition, as confirmed by the conducted studies. In terms of organoleptic properties, the best sample was the one with fruit components added in a 3:1 ratio (three parts pineapple and one part orange). This ratio proved optimal for enrichment in yogurt production.

## 1 Introduction

If statistics are to be believed, fermented dairy products have firmly entered our daily lives. Light and very beneficial for digestion, they easily combine with various products and have the ability to be enriched with different components containing a variety of vitamins and minerals. The interest in using various plant components in the production of fermented dairy products, including yogurt, as well as the possibility of enriching it and imparting new properties and flavor nuances, has been driven by many researchers for a variety of reasons. Primarily, this is related to obtaining a diverse flavor range of the product and improving its organoleptic and physicochemical parameters. For example, researchers Olaide Olawunmi Ajibola, Raymond Thomas, and Babatunde Femi Bakare present data indicating that "Preservation and processing of products play a vital role in suppressing food pathogens in fruits and vegetables prevalent in Malaysia. Lactic acid fermentation is generally a local bioprocess, one of the oldest forms and well-known among indigenous populations for food processing. The long shelf life of fermented vegetables and fruits increases their nutritional

---

\* Corresponding author: [boev.boss@yandex.ru](mailto:boev.boss@yandex.ru)

value and antioxidant potential. Fermented leaves and vegetables can be used as a potential source of probiotics since they host several lactic acid bacteria..." [1].

Other authors from Kazakhstan, Gaukhar Konuspayeva, Almagul Baubekova, Shynar Akhmetsadykova, and Bernard Faye, in their review article, propose protein enrichment of rice-based flour: "In domestic conditions, the most popular method for preserving such perishable products as milk was fermentation. The combination of both the diversity of animal species and the transition process from one ethnic group to another has led to a remarkable variety of fermented products such as ayran, kurt, irimshik, souzma, ryazhenka, простокваша (prostokvasha), tan, kefir, kumys, shubat, chal or khurmog. The physicochemical properties (when possible) and natural microbiota of lactic acid bacteria and yeasts responsible for spontaneous fermentation have been widely studied, highlighting high microbial diversity. In the future, deeper knowledge of this biological diversity could contribute to the sustainable consumption of traditional fermented dairy products" [2].

Literature sources also describe the application of ingredients in various aggregate states from components that are often production waste. Researchers Dana Elgeti and Sebastian D. Nordlone state that "in this study, freeze-dried microencapsulated powder of phenolic extract (MPE) from the peel of wild pomegranate fruits was used to enrich yogurt. Among various processing methods (T4), yogurt enriched with 2% MPE was recognized as the best based on sensory characteristics... This study suggests that the functional and antioxidant properties of yogurt can be significantly improved by enriching it with MPE without altering sensitivity while maximizing the preservation of biologically active compounds, allowing for commercial use. The study also showed that enriched yogurt has a higher content of phenolic compounds and antioxidant activity, which could open a new avenue for consuming functional foods" [3].

In their studies, authors Ruta Gruskiene, Vera Lavelli, and Jolanta Sereikaite note the positive influence of inulin, which is a fructan predominantly biosynthesized in plants of the Asteraceae family. It is also found in edible vegetables and fruits such as onions, garlic, leeks, and bananas. For industrial production of inulin, chicory and Jerusalem artichoke are the primary raw materials. Inulin is used in food, pharmaceutical, cosmetic, and biotechnology industries. The combination of teff (10%) with grain sourdough (rice or buckwheat) enhanced the aroma of bread by intensifying fruity, grainy, and toasty notes [4].

In a review article by Vanessa D. Caprilesa, Fernanda G., José-Alfredo G. Areasa focuses on modern approaches used to increase nutrient content. This study utilizes natural resources with priority given to recyclable and renewable resources obtained from growing pinhao with the goal of using pulp, shells, and nuts as a source for adding biologically active compounds to yogurt while ensuring reasonable use of these natural resources [5].

Researchers conclude that "further studies are needed to improve or develop new nutrient-rich gluten-free bread (GFB) and assess them to understand or enhance their effectiveness as carriers of nutrient micronutrients and biologically active compounds" [5].

In their article, a group of researchers Md Wadud Ahmed, Md Sirajul Islam Khan, Aney Parven, Md Harunur Rashid, Islam Md Meftaul note that one major issue in production is "Vitamin A deficiency related to night blindness in children is a global public health problem that can be prevented or reduced by increasing dietary  $\beta$ -carotene intake. Enriching yogurt with  $\beta$ -carotene using pumpkin pulp (PF) could be a highly cost-effective public health initiative. The aim of this study was to analyze the immediate functional microbiological textural and sensory properties of yogurt enriched with PF to assess its suitability as a  $\beta$ -carotene enriched food product" [6].

Some researchers also note that "plant-based yogurt (PBY) represents an alternative for vegetarians flexitarians and people with dairy allergies. However how bacterial (cultural) variations may affect properties is still insufficiently studied. The aim of this study is to investigate physicochemical properties including texture rheological properties

microstructure and sensory characteristics of yogurt made from lupin and oat flakes influenced by adding commercial probiotics" [7].

Other researchers believe that "this study utilizes natural resources prioritizing recyclable and renewable resources obtained from growing pinhao aiming to use pulp shells and nuts as sources for adding biologically active compounds into yogurt ensuring reasonable use of these natural resources." Thus eight recipes for yogurts containing 5% to 10% by-products from pinhao were developed which were compared regarding their physicochemical nutritional functional properties antimicrobial activity and multi-element profile. Enriching acai yogurt with pinhao by-products did not significantly differ in protein lipid moisture or mineral salt content across all samples with pinhao by-products.

Promising results were obtained by scientists Thaís Marini Darlila Aparecida Gallina Elizabeth Harumi Nabeshima among others who used ultrafiltration technology (UF) to achieve protein concentration in skim milk for producing Greek-style probiotic yogurt... Ultrafiltration was also satisfactory for increasing mineral content especially calcium phosphorus and zinc. Probiotic bacteria maintained viability throughout refrigeration storage thus using ultrafiltered milk proved suitable for producing high-protein probiotic yogurts [8].

In their research group authors Harsh Kumar Shivani Guleria Neetika Kimta Eugenie Nepovimova Rajni Dhalaria Daljeet Singh Dhanjal Nidhi Sethi Suliman Y. Alomar Kamil Kuca write that "the ultimate goal of every nation is achieving zero hunger levels while ensuring health and well-being for its population. However such issues persist daily in poor countries especially rural areas. Currently there is an increasing demand for fruit consumption due to its potential health benefits. Surprisingly the most common by-product for them is pomace which is produced in millions of tons usually discarded as waste after processing or consumption. Even food produced from these types of raw materials can contribute towards achieving the goal of eradicating hunger worldwide. With these advantages scientists have begun evaluating the nutritional value of various fruit pomaces as well as the chemical composition of various biologically active components which have significant health benefits and can be used to create diverse food products with notable nutraceuticals and functional potential" [9].

Some Russian researchers besides applying various components for enriching yogurt suggested producing the product using goat's milk noting that goat's milk has recently taken a significant share in the diet of adults and children since compared to cow's milk it is easily digestible in the gastrointestinal tract. Given that goat's milk fat represents one important component of this product studying its characteristics opens up wide opportunities for researching human health benefits.

The authors previously studied the possibility of using aronia powder as an enrichment component. The results show the effectiveness of using aronia powder in making goat's milk yogurts. The results indicate that aronia powder increases micro- and macroelement content in products.

In her research M.A. Zaikina proposes enriching yogurt with a mixture of two plant components noting during her work that "it is advisable to introduce a mixture of aronia powder and hawthorn at the fermentation stage followed by post-fermentation since adding plant supplements at the fermentation stage positively affects taste aroma and appearance in goat's milk-based yogurt" [10].

A.G. Kaluzhskih showed possibilities for using plant raw materials particularly white bean flour for enriching yogurts: "The results showed that based on organoleptic and physicochemical indicators it was concluded that it is advisable to add 5% bean flour relative to the mass of dairy base into yogurt recipes" [11].

Some studies explore using fruits from rowan trees including common rowan berries and black rowan berries: Researchers concluded from their work that "the introduction of rowan powder into recipes increased iron content in yogurt; iron levels increased proportionally

with rowan powder concentration in experimental samples; higher iron content was found in samples with 15% replacement of milk with black rowan" [12].

## 2 Materials and methods

The standard recipe was improved by adding pineapple and orange. The ingredients were introduced in quantities of 5–15% of the milk's weight immediately after fermentation.

Table 1. Recipe for yogurt with orange and pineapple for 100g.

Raw	Weight, gr		
	Sample No. 1	Sample No. 2 5% - orange 10% - pineapple	Sample No. 3 5% - orange 15% - pineapple
Milk, 3.2%	85	85	85
Starter	3	3	3
Orange	-	5	5
Pineapple	-	10	15

The ratio of components is 1:2 and 1:3, with orange having a constant value in both samples (5% orange and 10%, 15% pineapple, respectively). The orange components are less compared to pineapples due to excessive oxidation of the product and whey production.

To increase shelf life, fruit components are added after fermentation.

According to the recipes presented in Table 1, samples of enriched yogurt were produced, and their quality indicators were investigated.

During organoleptic studies, quality indicators were determined in accordance with current regulatory documents.

### 2.1 Organoleptic characteristics of samples

Organoleptic indicators include the appearance of finished products, consistency, color, taste, and smell.

Organoleptic indicators are determined after the product has cooled and are applied according to the regulatory documentation for yogurts. General technical conditions. Enriched yogurts must be manufactured in accordance with the requirements of this standard and the standardization document under which the product of a specific name is made, following the recipe and technological instructions, as well as comply with the regulatory legal acts of the state in which this product is in circulation.

Indicators such as appearance, consistency, and color are controlled by inspecting the entire obtained product. Organoleptic indicators are controlled through the senses (smell, touch, sight).

According to organoleptic indicators, fermented milk products must meet the presented requirements.

When assessing the appearance of the product, attention is paid to the correct consistency of added components. The color of the product should be uniform, milk-white.

The taste and smell should correspond to the given type of product. When chewing, the product should have a lactic acid taste, fruit pieces should have their characteristic taste, and the smell should be fermented milk with a citrus aroma.

Table 2 presents the organoleptic quality indicators of yogurt enriched with berry and fruit additives.

**Table 2.** Organoleptic evaluation of finished yogurt.

Indicator	Characeristic		
	Sample No. 1	Sample No. 2 5% - orange 10% - pineapple	Sample No. 3 5% - orange 15% - pineapple
Appearance	Thick, without foreign inclusions	Thick, with visible inclusions of fruit components	Thick, with visible inclusions of fruit components
Taste	Lactic-sour	Lactic-sour, pieces of fruit have a weak characteristic taste	Lactic-sour, pieces of fruit have a clearly expressed characteristic taste
Smell	Lactic-sour, with a characteristic smell	Sour-milk, with a citrus aroma	Sour-milk, with a citrus aroma
Color	Milky-white	Milky-white	Milky-white
Consistency	Moderately thick, without foreign components	Moderately thick, with particles of added components	Moderately thick, with particles of added components

As the data presented in Table 1 show fermented milk products enriched with fruit and berry raw materials meet the indicators of current standards. In sample No. 2, we added 5% orange and 10% pineapple, while in sample No. 3, the ingredients were added in the following amounts: 5% orange and 15% pineapple.

All samples of the obtained enriched yogurt were examined for key indicators.

The results of organoleptic studies, reflected in Table 2, show that the obtained samples of enriched yogurt correspond to the normative organoleptic indicators. However, with an increase in the amount of additives, replacing 15% of milk with pineapple yields the best organoleptic indicators of taste and aroma compared to samples with lower concentrations. The sample containing 5% orange and 15% pineapple replacement proved optimal for the studied indicators. The pronounced fruit flavor demonstrates an optimal combination of fruit ingredients, which saturate the product with the most pleasant range of taste sensations and the maximum possible amount of vitamins.

### 3 Results and discussion

Results of nutritional value determination. The indicator of nutritional value characterizes an important property of the product - the presence and quantity of nutrients necessary to meet the physiological needs of humans and energy value.

The obtained results of the nutritional value of the best sample (Sample No. 3), determined based on the results of organoleptic studies, are presented in Table 3.

**Table 3.** Nutritional value per 100g of finished product.

Nutrient	Quantity
Caloric content	94 kcal
Proteins	2.8 g
Fats	3.5 g
Carbohydrates	15 g
Water	76.81 g
Ash	0.56 g

The nutritional value of the product is higher due to the addition of plant-based components to the original product, which increases the overall value of the product.

The chemical composition of food products is an indicator of the potential value of food products. Its effect on the human body depends on the type of yogurt mixture consumed. However, it should be noted that the number of chemical composition indicators cannot reflect the full diversity and significance of yogurt's impact on the human body, as chemical analyses cannot detect certain aspects of yogurt's influence.

The added plant components themselves have a high content of vitamins and microelements. Adding these components to the product allows for expanding the list of beneficial properties. Table 4 presents the chemical analysis of the studied sample of the obtained fruit yogurt.

**Table 4.** Chemical analysis of the studied fruit yogurt.

Nutrient	Quantity, mg	Norm, mg	% of the norm
Vitamin A, RE	26.7	27	9.6
Vitamin B1, thiamine	0.046	1.5	2.4
Vitamin B2, riboflavin	0.28	1.8	10
Vitamin B4, choline	49	500	9.6
Vitamin B5, pantothenic	0.382	5	7.4
Vitamin B6, pyridoxine	0.07	2	3
Vitamin B9, folates	9.73	400	2.3
Vitamin B12, cobalamin	0.582	3	17.3
Vitamin C, ascorbic	0.84	90	0.9
Vitamin D, calciferol	0.07	90	0.8
Vitamin E, alpha tocopherol, TE	0.086	15	0.6
Vitamin H, biotin	4.352	50	8.5
Vitamin K, phylloquinone	0.3	120	0.2
Vitamin PP, NE	1.78	20	8.6
Potassium, K	203	2500	7.6
Calcium, Ca	168.2	1000	17
Magnesium, Mg	17.2	400	4.5
Sodium, Na	65	1300	4.8
Sulfur, S	65	1000	6.5
Phosphorus, P	114.2	800	15.7
Chlorine, Cl	124	2300	5.7
Iron, Fe	0.23	18	0.9
Iodine, I	11.9	150	7.8
Cobalt, Co	1.2	10	12
Manganese, Mn	0.0073	2	0.4
Copper, Cu	11	1000	1.1
Molybdenum, Mo	6	70	8.6
Selenium, Se	2.5	55	4.5
Fluorine, F	24	4000	0.6
Chromium, Cr	2.4	50	4.8
Zinc, Zn	0.46	12	4
Omega-3 fatty acids	0.038	from 0.9 to 3.7	4

Yogurt contains: easily digestible protein, fat, vitamins, carbohydrates containing the necessary amount of carbohydrates, calcium, and phosphorus, which regulate blood pressure and strengthen bone tissue. According to regulatory requirements, milk quality is determined as follows.

Organoleptic indicators:

- Appearance
- Consistency
- Taste and smell

Physicochemical indicators:

- Fat content
- Milk protein content
- Dry non-fat milk solids
- Acidity
- Total sugar (calculated as invert sugars)
- Phosphatase
- Temperature at production

Microbiological indicators include the number of milk microorganisms and lactic acid bacteria in 1 g of product at the end of shelf life.

## 4 Conclusion

As a result of the conducted research, the previously stated objectives were successfully achieved. The theoretical and experimental studies carried out, along with their verification under laboratory conditions, confirmed the effectiveness of using pineapple and orange in the production of enriched yogurt. The best samples based on the obtained indicators were those with 5% orange and 15% pineapple. The practical significance of this research allows for the practical application of the results in the production of enriched yogurt.

The yogurt sample enriched with 5% orange and 15% pineapple relative to the mass of milk can be recommended for inclusion in the diets of various age groups, taking into account individual functional characteristics.

## References

1. O.O. Ajibola, O.A. Oyewole, O.A. Oyedeji, A.A. Oyeyinka, *Food Sci. Hum. Wellness* **12**, 1493 (2023).
2. G. Konuspayeva, B. Faye, G. Loiseau, *Int. Dairy J.* **137**, 105514 (2023).
3. Hamida, M.S. Bouheroum, A. Laiadi, S. Bennadja, M. Ghanmi, B. Satrani, A. Hakkou, *S. Afr. J. Bot.* **151**, 413 (2022).
4. R. Gruskiene, R. Krivorotova, P. Sereikaite, *Carbohydr. Polym.* **327**, 121670 (2024).
5. M.S. Fiebig, L.D. Pinto, G.L. Nunes, C.R. Menezes, C.R.F. Souza, W.P. Oliveira, *Food Res. Int.* **192**, 114813 (2024).
6. M.W. Ahmed, M.S. Rahman, M.M. Rahman, M.A. Khaleque, M.A. Alam, *Heliyon* **9**, e15039 (2023).
7. D. Dhakal, B. Adhikari, M. Subedi, C.J. Barrow, B. Adhikari, *Food Hydrocoll.* **156**, 110353 (2024).
8. T. Marini, L.M. Paucar-Menacho, A.C. Conti-Silva, *NFS J.* **29**, 16 (2022).
9. H. Kumar, S. Jain, K. Prakash, S. Sharma, S. Mishra, *Curr. Res. Food Sci.* **9**, 100791 (2024).
10. A.G. Kaluzhskikh, *Technol. Food Process. Ind. AIC - Healthy Food* **3**, 18 (2021).
11. M.A. Zaikina, *Proc. Voronezh State Univ. Eng. Technol.* **83**, 204 (2021).
12. A.G. Belyaev, S.G. Boev, N.S. Baroyan, *Technol. Food Process. Ind. AIC - Healthy Food* **4**, 15 (2019).