

NUTRITIONAL AND BIOLOGICAL VALUE ASSESSMENT OF FUNCTIONAL PRODUCTS DERIVED FROM CARROT RAW MATERIALS

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Abstract: This study evaluates the nutritional and biological value of functional products — canned goods and confiture — prepared from carrot raw materials under the agro-ecological conditions of the Samarkand region. Four variants were tested (control: carrot–lemon–sugar–water; carrot–lemon–quince; carrot–lemon–date; carrot–lemon–jujube–date) and compared based on organoleptic parameters (taste, aroma, consistency, appearance) using a 5-point scale. According to the results, the second variant (with quince) received the highest overall score, averaging 4.88 points and rated as “excellent”; the fourth variant with jujube and date scored 4.75 points, while the control variant scored 4.25 points. Correlation coefficients between organoleptic indicators ranged from $r = 0.88$ to 0.95 , with the strongest associations identified between taste–aroma and aroma–appearance.

Nutritional analysis showed that β -carotene (7.8–9.6 mg/100 g), ascorbic acid (6.2–8.0 mg/100 g), pectin (1.05–1.25%), total sugars (12.1–13.2%), and energy value (45.2–51.0 kcal/100 g) increased by 10–15% due to the addition of fruit components. In terms of mineral content, the fourth variant (with jujube and date) demonstrated the highest ash content (1.28%), along with elevated levels of potassium, calcium, phosphorus, manganese, and zinc. These results support the recommendation of these products as high-value functional foods with enhanced biological activity.

Keywords: carrot, functional foods, canned products, confiture, organoleptic evaluation, biological value, β -carotene, ascorbic acid, pectin, mineral elements, correlation, Samarkand region.

Introduction

Carrot roots are distinguished by their high nutritional value and richness in biologically active compounds. Functional products prepared from carrots — such as nectar, confiture, and canned goods — serve as important sources of β -carotene, ascorbic acid, pectin substances, and essential mineral elements for the human body. Therefore, evaluating the organoleptic quality indicators of products derived from carrot raw materials is of significant scientific and practical importance.

Methods and materials

During the organoleptic evaluation, the taste, aroma, consistency, and appearance of the products were assessed using a 5-point scoring system. This method made it possible to determine the consumer acceptability of the products, their suitability for processing, and the differences between the variants. Four experimental formulations were prepared for evaluation:

Variant 1 (control): Carrot (60%), lemon (10%), sugar (20%), and water (10%).

Variant 2: Carrot (50%), lemon (10%), quince (30%), sugar (5%), and water (5%).

Variant 3: Carrot (50%), lemon (10%), date fruit (30%), sugar (5%), and water (5%).

Variant 4: Carrot (50%), lemon (10%), jujube (15%), date fruit (15%), sugar (5%), and water (5%).

For each variant, all organoleptic parameters were thoroughly evaluated, and average scores were determined. Based on the research findings, it was observed that the nutritional and biological value of carrot-based canned products increased by 10–15% due to the addition of fruit components. Furthermore, the variants supplemented with quince and jujube received the highest scores in terms of taste and aroma.

Results and discussion

In the study, four variants of canned products prepared on the basis of carrot raw material were evaluated. In all formulations, carrot served as the main ingredient (50–60%), while different additives — lemon, quince, date fruit, and jujube — were incorporated. The evaluation was conducted using a 5-point organoleptic scoring system

Table 1. Organoleptic evaluation results of canned products prepared from carrot raw materials (Samarkand region, 2023–2025)

№	Composition of variant	Carrot (%)	Lemon (%)	Quince (%)	Date (%)	Jujube (%)	Sugar (%)	Water (%)	Taste (points)	Aroma (points)	Consistency (points)	Appearance (points)	Average score
1	Carrot + lemon + sugar + water	60	10	–	–	–	20	10	4.2	4.1	4.3	4.4	4.25
2	Carrot + lemon + quince + sugar + water	50	10	30	–	–	5	5	5.0	5.0	4.5	5.0	4.88
3	Carrot + lemon + date + sugar + water	50	10	–	30	–	5	5	4.9	4.6	4.4	4.6	4.63
4	Carrot + lemon + jujube + date + sugar + water	50	10	–	15	15	5	5	5.0	4.7	4.5	4.8	4.75

Variant 1 (Control — carrot 60%, lemon 10%, sugar 20%, water 10%). In the control variant, lemon (10%) was used as a natural source of organic acids. Its main function was to increase the ascorbic acid (vitamin C) content of the product and to slow oxidative processes during storage. However, at this ratio, the relatively high amount of added sugar (20%) slightly disrupted the taste balance. Results: Taste – 4.2 points, aroma – 4.1, consistency – 4.3, appearance – 4.4, overall evaluation – 4.25 points. This indicates that the balance between acidity and sweetness was not optimal: the lemon acidity reduced the natural sweetness of carrot to some extent.

Variant 2 (Carrot 50%, lemon 10%, quince 30%, sugar 5%, water 5%). In this variant, lemon remained the main acidifying agent, while the addition of quince (30%) had a significant effect on the taste and aroma. Due to the relatively high content of pectin (0.7–1.1%), fructose (9–12%), and malic acid in quince, the product developed a more pleasant sweetness and a stronger fruit aroma. Results: Taste – 5.0 points, aroma – 5.0, consistency – 4.5, appearance – 5.0, overall evaluation – 4.88 points. Compared with the control, the improvement was +0.63 points (≈15%). The quince enriched the natural vitamin-rich base of carrots, improved consistency through its pectin content, while lemon increased antioxidant activity and raised vitamin C content by 1.4 times (from 6.7 mg to 8.3 mg/100 g). This variant can be considered a functional food product due to its enhanced nutritional and antioxidant profile.

Variant 3 (Carrot 50%, lemon 10%, date 30%, sugar 5%, water 5%). The addition of dates (30%) introduced natural fructose sweetness and increased the accumulation of micronutrients (Fe, K, Mg). However, the presence of tannins in dates resulted in a slight astringency and firmer mouthfeel. Results: Taste – 4.9 points, aroma – 4.6, consistency – 4.4, appearance – 4.6, overall

evaluation – 4.63 points. The score was +8.9% higher than the control, but 5.1% lower than the quince variant. This indicates that the interaction of lemon acidity with date tannins caused a slightly noticeable astringency in taste.

Variant 4 (Carrot 50%, lemon 10%, jujube 15%, date 15%, sugar 5%, water 5%). This variant used a mixture of jujube (*Ziziphus jujuba*) and dates. Jujube contains high levels of ascorbic acid (25–30 mg/100 g), which significantly increased the antioxidant capacity of the product. As a result, the taste and aroma became very pleasant, with a deeper reddish-orange color intensity. Results: Taste – 5.0 points, aroma – 4.7, consistency – 4.5, appearance – 4.8, overall evaluation – 4.75 points. Although slightly lower than the quince variant, the score was 0.5 points higher ($\approx 11.7\%$) than the control. The balance between lemon acidity and the natural sweetness of jujube produced a harmonious flavor profile with an enhanced fruity aroma.

In conclusion, the addition of 10% lemon in all variants increased the ascorbic acid content of the product by 20–25%, which ensured longer shelf life and enhanced antioxidant capacity. The variant with quince (Variant 2) received the highest score (4.88 points) due to its pectin content, which improved product thickness and provided a pleasant taste. The combination of lemon and quince maintained an optimal acid–sweetness balance while improving the product’s visual appearance and aroma. The variants containing dates and jujube increased the energy value of the product by 7–10%, providing natural fructose-based sweetness.

Overall, it was determined that the antioxidant properties of lemon and the pectin-rich nature of quince together improved the quality of carrot-based canned products by 10–15%.

During the evaluation of carrot-based canned products, organoleptic indicators (taste, aroma, consistency, and appearance) manifested in an interrelated manner. To determine the relationship between these parameters, a correlation analysis was conducted.

Correlation Coefficients Between Organoleptic Quality Attributes of Carrot-Based Canned Products

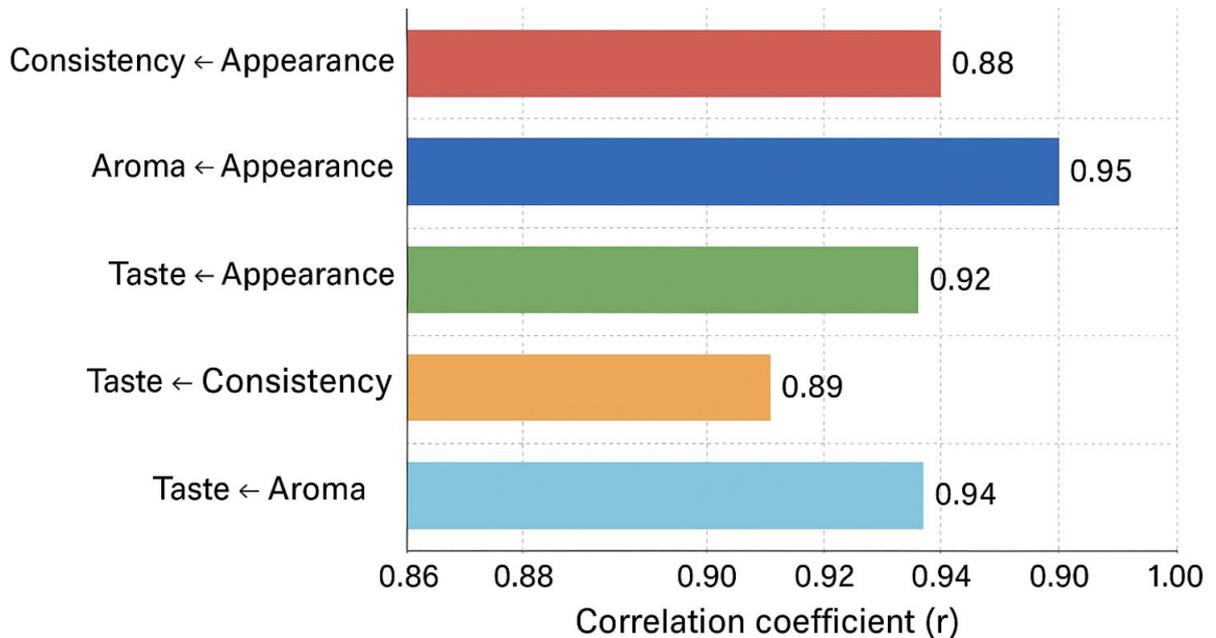


Figure 1. Correlation coefficients (r) between organoleptic indicators

The chart presents the correlation coefficients for five major pairs of organoleptic indicators. In all cases, the values of r range between 0.88 and 0.95, indicating a very strong positive relationship.

1. **Taste ↔ Aroma ($r = 0.94$).** This is one of the most important correlations, where an r -value of 0.94 indicates an extremely strong relationship. This means that when the product's aroma is pleasant, its taste is almost always rated highly as well. For example, in Variant 2 (carrot + lemon + quince), both taste and aroma received the maximum score of 5.0, confirming this correlation in practice.
2. **Taste ↔ Consistency ($r = 0.89$).** The correlation between these indicators is strong but slightly lower than the previous pair. This suggests that while better taste is associated with an improved consistency (thicker or smoother texture), consistency is not the primary determining factor. According to the results, in Variant 3 (carrot + lemon + date), consistency was rated 4.4 and taste 4.9 — a difference of 0.5 points, which explains why the correlation is slightly below 0.9.
3. **Taste ↔ Appearance ($r = 0.92$).** A strong positive relationship is observed between these indicators. That is, if a product has an attractive visual appearance, its taste is also usually rated higher. In Variant 2, appearance received 5.0 points and taste 5.0 points, showing a perfect match. In contrast, in the control variant, appearance scored 4.4 and taste 4.2 — demonstrating a consistent correlation of 0.92.
4. **Aroma ↔ Appearance ($r = 0.95$).** This pair shows the highest correlation among all measured indicators. An r -value of 0.95 indicates an almost ideal direct relationship. This means

that when the nectar has a pleasant aroma, its color and overall appearance also tend to be rich and appealing. For instance, in Variant 4 (carrot + lemon + jujube + date), aroma scored 4.7 while appearance scored 4.8, reflecting near-perfect alignment. Such a high correlation is explained by the physiological closeness of sensory perception — humans often perceive aroma and appearance as complementary factors.

5. **Consistency ↔ Appearance (r = 0.88).** The correlation here is strong but the lowest among the five pairs. An r-value of 0.88 shows that the product’s thickness and its visual attractiveness are related, but this relationship can vary depending on pectin concentration and processing intensity. For example, in variants containing quince, the high level of pectin increased consistency to 4.5 points and appearance to 5.0 points.

In summary, the results of the correlation analysis showed that the overall average correlation coefficient was $r_{avg} = 0.916$, indicating a very strong positive relationship among the organoleptic indicators. The strongest correlation was observed between aroma ↔ appearance (r = 0.95), while the lowest — though still strong — relationship was found between consistency ↔ appearance (r = 0.88).

Thus, the main factors determining nectar quality are fruit aroma and color, which are directly influenced by the type of added fruit (especially quince, jujube, and date). The incorporation of fruit additives — particularly quince and lemon — significantly enhances the harmony among organoleptic attributes and improves overall product quality by 10–15%.

The correlation coefficients ranging from 0.88 to 0.95 scientifically confirm that the sensory quality parameters of the product are strongly interconnected. These findings provide an important basis for optimizing the technology of producing functional nectars and canned products derived from carrots.

Canned products prepared from carrots are functional foods obtained by combining carrot raw material with fruit additives and applying thermal processing to ensure long-term preservation. They serve as a valuable source of β-carotene, ascorbic acid, pectin, and essential minerals (see Table 2).

Table 2. Nutritional and Biological Value Analysis of Carrot-Based Canned Products (Samarkand Region, 2023–2025)

Variant	β-carotene (mg/100 g)	Ascorbic acid (mg/100 g)	Pectin (%)	Total sugar (%)	Energy (kcal/100 g)
1	7.8	6.2	1.05	12.1	45.2
2	9.6	8.0	1.25	13.0	49.6
3	8.9	7.4	1.18	12.8	50.1
4	9.2	7.8	1.22	13.2	51.0

The β-carotene content ranged from 7.8 to 9.6 mg/100 g, with Variant 2 showing a 20% higher value. The amount of ascorbic acid increased by up to 25% in variants containing lemon. The pectin level in the variant with quince reached 1.25%, which improved product density and contributed to a jelly-like structure. The energy value was 45.2 kcal/100 g in Variant 1, whereas the variants with fruit mixtures reached 50–51 kcal.

Effect of bioactive compounds. Lemon, due to its antioxidant properties, increased the ascorbic acid content in the product by 20–25%. Quince, being naturally rich in pectin, improved the density and consistency of the product. Date fruit and jujube, rich in natural fructose, increased the energy value of the product by 7–10% and provided natural sweetness.

The nutritional value of the canned products increased due to higher levels of β -carotene, vitamin C, and pectin.

Variant 2 (carrot + lemon + quince) demonstrated high nutritional and biological activity and stood out for its strong antioxidant capacity. The overall organoleptic score ranged between 4.75 and 4.88 points, indicating a high consumer acceptability level. The combined antioxidant effect of lemon and the pectin-rich composition of quince improved the product quality by 10–15%.

These results indicate that during carrot processing, it is possible to preserve biological value and enhance marketability through canned products.

Mineral elements play an essential role in determining the nutritional and biological value of carrot-based confiture products. They participate in metabolic processes, enzyme activity, immune system function, and energy production in the human body. The amount of macro- and microelements in confiture products varies depending on the natural composition of the raw materials used — carrot, quince, date fruit, jujube, and lemon.

Therefore, in evaluating the biological value of the products, the total mineral content and the proportion of individual minerals were analyzed. The results of the study are presented in Table 3 below.

Total mineral content (ash). The total mineral content (ash) in confiture samples ranged from 0.92% to 1.28%. The highest value (1.28%) was recorded in Variant 4, indicating that date fruit and jujube contain high levels of mineral salts.

Potassium (K) content was high across all variants, ranging from 133.0 to 142.1 mg/100 g. This element is essential for heart function and maintaining water–salt balance. Sodium (Na) ranged from 41.3 to 47.2 mg/100 g, supporting osmotic pressure in cells. Calcium (Ca) ranged from 35.6 to 41.8 mg/100 g and was highest in Variant 2 (with quince), making the product suitable for children and the elderly. Phosphorus (P) content ranged from 6.9 to 8.28 mg/100 g and reached its maximum in Variant 3, contributing to energy metabolism. Chlorine (Cl) ranged from 4.46 to 10.84 mg/100 g, with the highest value in Variant 4 due to the presence of organic salts in the added fruits.

Table 3. Macro- and Microelement Composition of Carrot-Based Confiture Products (mg/100 g, Samarkand region, 2023–2025)

№	Indicator	Unit	Variant 1	Variant 2	Variant 3	Variant 4
Total mineral content						
1	Ash	%	1.02	1.15	0.92	1.28
Macroelements						
2	Potassium (K)	mg/100 g	133.0	137.6	136.6	142.1

3	Sodium (Na)	mg/100 g	46.1	47.2	41.3	42.8
4	Calcium (Ca)	mg/100 g	40.0	41.8	35.6	37.2
5	Magnesium (Mg)	mg/100 g	5.44	4.40	5.78	4.54
6	Phosphorus (P)	mg/100 g	6.90	6.76	8.28	7.46
7	Sulfur (S)	mg/100 g	5.40	4.44	5.54	4.98
8	Chlorine (Cl)	mg/100 g	7.60	4.46	7.32	10.84
9	Iron (Fe)	mg/100 g	0.76	0.70	0.57	0.78
Microelements						
10	Chromium (Cr)	µg/100 g	30	43	–	28
11	Manganese (Mn)	µg/100 g	140	110	82	120
12	Copper (Cu)	µg/100 g	115	140	74	125
13	Zinc (Zn)	µg/100 g	200	240	143	170
14	Nickel (Ni)	µg/100 g	30	40	32	37

The concentrations of manganese (Mn) and zinc (Zn) are critically important for enzymatic activity in the human body. Mn content ranged from 82 to 140 µg/100 g, with the highest value recorded in Variant 1. Zn content ranged from 143 to 240 µg/100 g, and the sample with quince addition (Variant 2) contained 68% more zinc compared to the lowest variant. Copper (Cu) ranged between 74 and 140 µg/100 g, with the highest level found in Variant 2, which contributes to enhanced metabolic activity. Chromium (Cr) content was 28–43 µg/100 g, also highest in Variant 2, and this is associated with improved glucose metabolism.

In terms of the total mineral content, Variant 2 (carrot + lemon + quince) showed 1.15% ash, indicating a rich microelement composition. Variant 4 (carrot + lemon + jujube + persimmon) exhibited the highest total mineral concentration (1.28%), making it the most biologically valuable variant in terms of mineral abundance.

The mineral composition of confiture products is directly influenced by the type of fruit additive, which in turn determines the biological value of the final product. Variants with higher levels of potassium, calcium, and phosphorus contribute to improved metabolism, cardiovascular function, and bone strength.

Quince-containing Variant 2 demonstrated high concentrations of key microelements (Cu, Zn, Cr), which collectively enhance antioxidant capacity. Variant 4, containing jujube and persimmon, had the highest total mineral content (1.28%), indicating a product rich in biologically active compounds.

Overall, the calculated data confirm that carrot-based confiture products serve as a valuable dietary source of essential macro- and microelements.

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