Ryazhanka with pumpkin puree and flax seeds

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Abstract

Introduction. The aim of this research was to study the influence of pumpkin puree and flax seeds addition on nutritional value, physicochemical and sensory properties of Ryazhanka.

Materials and methods. Ryazhanka samples were prepared with the addition of pumpkin puree and flax seeds. The titrated acidity was determined by the Turner method, and the active acidity was measured using pH-meter. The fat content was determined using Gerber's acid method, and sensory evaluations were conducted by an expert panel.

Results and discussion. Pumpkin puree and flax seeds were used in Ryazhanka preparation. It was shown that the addition of 4–8% flax seeds to Ryazhanka with 10% pumpkin puree reduced the titrated acidity to 64–70 °T and increased the active acidity to pH 4.6–4.7. Similarly, the addition of 4–8% flax seeds with 15% pumpkin puree reduced the titrated acidity to 61–68 °T and increased the active acidity to 4.6–4.7. When 20% pumpkin puree and 4–8% flax seeds were added simultaneously, the titrated acidity decreased to 60–65 °T, and the active acidity increased to 4.6-4.8. The optimal conditions for achieving physico-chemical stability in Ryazhanka were observed for samples added with 10% pumpkin puree and 4% flax seeds.

The addition of pumpkin puree (10%) and flax seeds (4%) to Ryazhanka resulted in increased content of water-soluble vitamins, such as 0.570 mg (184% increase) of vitamin C, 0.062 mg (295% increase) of vitamin B_1, 0.003 mg (2% increase) of vitamin B_2, and an increase in fat-soluble vitamins including vitamin E and β-carotene. Furthermore, the addition of flax seeds increased the content of polyunsaturated fatty acids, particularly the increase of omega-3 fatty acids from 0 to 0.80 g and omega-6 fatty acids from 0 to 0.20 g.

Comparing the control sample, the addition of pumpkin puree and flax seeds to Ryazhanka affected its shelf life at temperatures ranging from 0 to 6 °C, extending it to no more than 7 days.

Conclusions. The proposed recipe of Ryazhanka with pumpkin puree and flax seeds improves its nutrient composition, stabilizes its physicochemical parameters, enhances sensory properties, and expands the range of options to cater to the preferences of fermented milk drink consumers.

Introduction

Ryazhanka is a popular and traditional fermented milk drink in Ukraine. It is produced by fermenting curdled milk with pure cultures of the thermophilic lactic acid bacteria *Streptococcus salivarius* subsp. *thermophiles* (Aidarbekova and Aider, 2022). Improving the quality and expanding the range of fermented milk drinks (Buldo et al., 2021) requires the enhancement of preventive properties (Oh et al., 2014). This involves utilizing non-traditional raw materials (Tavares and Malcata, 2019), which is significant for Ryazhanka technology (Moreno-Montoro et al., 2018; Zhang et al., 2022). Application of natural plant additives including pumpkin and flax seeds in food products allows to enhance their nutritional value and supply the consumers with different valuable substances essential for health (Ivanov et al., 2021; Stabnikova et al., 2021).

Pumpkin is an innovative functional product that is used in various food products such as jelly, jam, marmalade, chutney, sauce, puree, juice, candies, bars, flakes, chips, cookies, cakes, halva, pickles, pies, and bread (Ahmad and Khan, 2019; Chikpah et al., 2022; Dhiman et al., 2009; Hussain et al., 2022; Montesano et al., 2018). It serves as a valuable raw material for the production of food products with therapeutic and preventive benefits. Pumpkin's rational composition of nutrients, nutraceuticals, and functional ingredients makes it an excellent choice to be added to Ryazhanka to improve its nutritional properties.

Since pumpkin crops are seasonal and prone to microbial spoilage and postharvest quality changes due to their high moisture content, they need to be dried or frozen to increase their shelf life and improve nutrient bioavailability (Akpinar et al., 2003; Korese et al., 2021; Monteiro et al., 2018; Ropelewska et al., 2022). Drying helps reduce moisture content and water activity to levels that significantly inhibit microbial, enzymatic, and chemical spoilage (Chikpah et al., 2022; Monteiro et al., 2018; Seremet (Ceclu) et al., 2016). Additionally, drying reduces the volume and weight of the product, resulting in reduced costs for packaging, transportation, and storage of agricultural food products, while also expanding its food supply applications. Therefore, innovative forms of processing pumpkin raw materials include powders, extracts, isolates, purees, biologically active substances, and functional food products. Pumpkin flour can be used as a supplement to cereal crop flour for producing bakery products, pasta, soups, instant noodles, mixtures for child feeding, natural dyes in pasta products, and flour mixtures (Ahmad and Khan, 2019; Dhiman et al., 2009; Hussain et al., 2022; Montesano et al., 2018). Moreover, dried pumpkin can be rehydrated and used to make stews and soups (Doymaz, 2007).

Flaxseed is rich in nutrients and offers various health benefits. It is known for being a rich source of omega-3 fatty acids, which can help reduce body fat levels and improve cardiovascular health (Marpalle et al., 2014). Flaxseed contains lipids (40%), protein (21%), dietary fiber (28%), ash (4%), and other soluble components such as sugars, phenolic acids, and lignans (approximately 6%) (Fitzpatrick, 2011). Therefore, incorporating flax seeds into the diet can be a beneficial addition for individuals seeking to improve their health. Moreover, flax seeds can serve as an innovative raw material in Ryazhanka technology.

The aim of this work is to enhance the nutrient composition of Ryazhanka by incorporating pumpkin puree and flax seeds, while further stabilizing the physicochemical parameters and improving the sensory properties of Ryazhanka.

Materials and methods

Materials

The main raw materials used for the production of Ryazhanka included high-grade and «Extra» grade whole cow's milk, cow cream, pure cultures of lactic acid bacteria

(*Streptococcus thermophilus, Lactococcus lactis*), pasteurized pumpkin puree (*Cucurbita moschata* Duchesne ex Poiret), and flax seeds (*Linum usitatissimum* L).

Ryazhanka samples were prepared according to the following compositions: control sample (sample 1) prepared using the classic recipe; samples 2–10, which were variations of Ryazhanka compositions with 10–20% pumpkin puree and 4–8% flax seeds.

Physicochemical and sensory analysis methods

The following methods were used to evaluate the physicochemical and sensory properties of Ryazhanka with pumpkin puree and flax seeds:

Taste, smell, color, appearance, and consistency analysis (ISO 6658:1985 Sensory analysis. Methodology. General guidance; ISO 6564:1985 Sensory analysis. Methodology. Flavour profile methods).

Determination of fat content by the gravimetric method (ISO 1211:1999 Milk. Determination of fat content. Gravimetric method).

Titratable acidity analysis (ISO/TS 11869:2012 Determination of titratable acidity).

Measurement of active acidity and pH using continuous pH measurement (ISO 26323:2009 Milk products. Determination of the acidification activity of dairy cultures by continuous pH measurement (CpH)).

The sensory evaluation was conducted using a scoring method, where highly qualified and experienced experts evaluated the sensory attributes of the Ryazhanka samples (Khareba et al., 2021; Kuzmin et al., 2021).

Calculation and analytical method

To determine the nutritional value and nutrient composition of Ryazhanka with pumpkin puree and flax seeds, a calculation-analytical method was employed. This method involves converting the data to 100 grams of plant raw material and combining the nutritional composition data with the database information (NatureClaim 2015-2023). The energy value of the samples was calculated using energy conversion coefficients and presented as kcal/100g by summing the percentage composition of fats, proteins, and total carbohydrate content multiplied by coefficients of 9, 4, and 4 respectively.

Results and discussions

Physicochemical parameters of Ryazhanka with pumpkin puree and flax seeds

The standard range for titratable acidity in Ryazhanka is 70-110 °T, while the active acidity should be within the range of pH 4.6-4.0. The control Ryazhanka prepared using the classical technology had a titratable acidity of 73 °T (Figure 1) and an active acidity of 4.56 pH (Figure 2).

The addition of 10-20% pumpkin puree to the Ryazhanka recipe resulted in a decrease in titratable acidity from 73 °T to 70–65 °T due to the presence of organic acids, primarily malic acid, in the pumpkin puree. The addition of 10% pumpkin puree increased the active acidity from pH 4.56 to pH 4.60. Addition of 15-20% pumpkin puree stabilized the active acidity at pH 4.62. However, it should be noted that the optimal range lies within the 10% pumpkin puree content. Increasing the pumpkin puree content to 15–20% led to a decrease in titratable acidity to 68–65 °T, which is below the standard value of 70 °T. Additionally, the increase in pumpkin puree content to 15-20% resulted in an increase in active acidity to pH 4.62, which exceeds the standard value of pH 4.6.

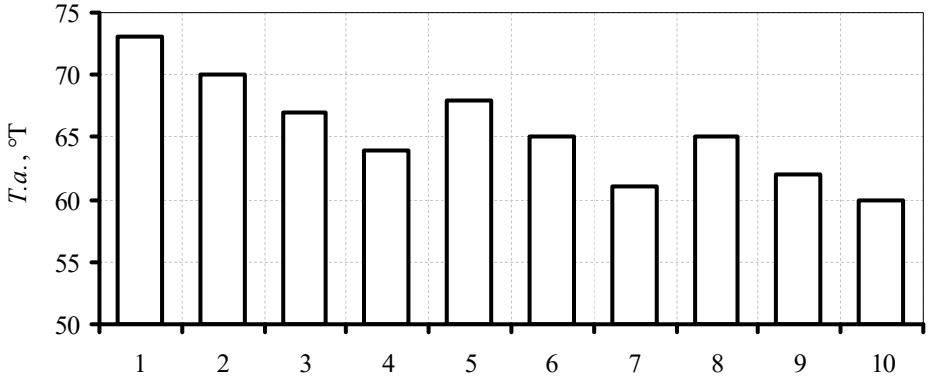


Figure 1. Dependence of the titratable acidity (*T.a.*) of Ryazhanka on the content of pumpkin puree and flax seeds:
1 – control sample; 2 – 10% pumpkin puree and 4% flax seeds; 3 – 10% pumpkin puree and 6% flax seeds; 4 – 10% pumpkin puree and 8% flax seeds; 5 – 15% pumpkin puree and 4% flax seeds; 6 – 15% pumpkin puree and 6% flax seeds; 7 – 15% pumpkin puree and 8% flax seeds; 8 – 20% pumpkin puree and 4% flax seeds; 9 – 20% pumpkin puree and 6% flax seeds; 10 – 20% pumpkin puree and 8% flax seeds

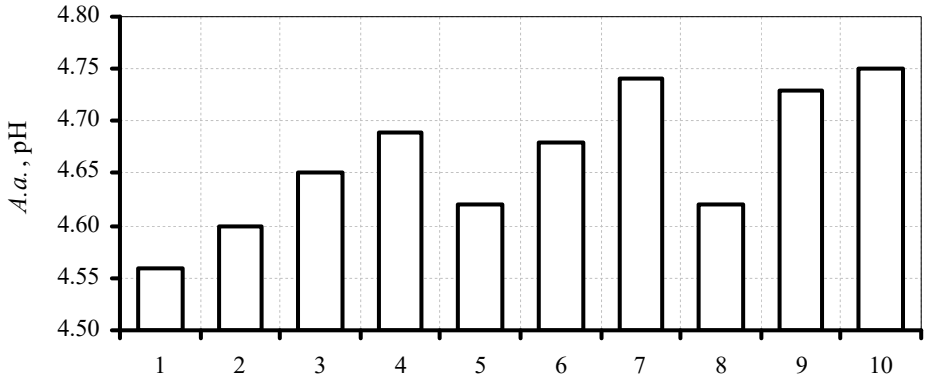


Figure 2. Dependence of active acidity (*A.a.*) of Ryazhanka on the content of pumpkin puree and flax seeds:
1 – control sample; 2 – 10% pumpkin puree and 4% flax seeds; 3 – 10% pumpkin puree and 6% flax seeds; 4 – 10% pumpkin puree and 8% flax seeds; 5 – 15% pumpkin puree and 4% flax seeds; 6 – 15% pumpkin puree and 6% flax seeds; 7 – 15% pumpkin puree and 8% flax seeds; 8 – 20% pumpkin puree and 4% flax seeds; 9 – 20% pumpkin puree and 6% flax seeds; 10 – 20% pumpkin puree and 8% flax seeds

Addition of flax seeds to Ryazhanka, which contains polyunsaturated fatty acids (omega-3 acids), has an impact on the reduction of titrated acidity and an increase in active acidity of the product, depending on the flax seed content. When adding 4–8% flax seeds to Ryazhanka along with 10% pumpkin puree, the titrated acidity of the product is reduced to 70–64 °T, while the active acidity increases to pH 4.60-4.69. Adding 4–8% flax seeds along with 15% pumpkin puree reduces the titrated acidity of Ryazhanka to 68–61 °T and increases the active

acidity to pH 4.62–4.74. Similarly, adding 4–8% flax seeds with 20% pumpkin puree reduces the titrated acidity of Ryazhanka to 65-60 °T and increases the active acidity to pH 4.62–4.75. However, the limiting range for the Ryazhanka recipe is the content of 4% flax seeds. Increasing the content of flax seeds to 6-8% leads to the following effects:

(a) a reduction in the titrated acidity of Ryazhanka to 67–64 °T when adding 10% pumpkin puree, to 65–61 °T when adding 15% pumpkin puree, and to 62–60 °T when adding 20% pumpkin puree, which is lower than the standard value of 70 °T;

(b) an increase in the active acidity to pH 4.65–4.69 when adding 10% pumpkin puree, to pH 4.68–4.74 when adding 15% pumpkin puree, and to pH 4.73–4.75 when adding 20% pumpkin puree, which exceeds the normalized value of pH 4.60.

Based on preliminary observations, it can be concluded that titrated and active acidity of Ryazhanka are inversely correlated, following a one-to-one relationship. An increase in titrated acidity by 1 °T leads to a decrease in the active acidity of Ryazhanka by 0.0151(Figure 3).

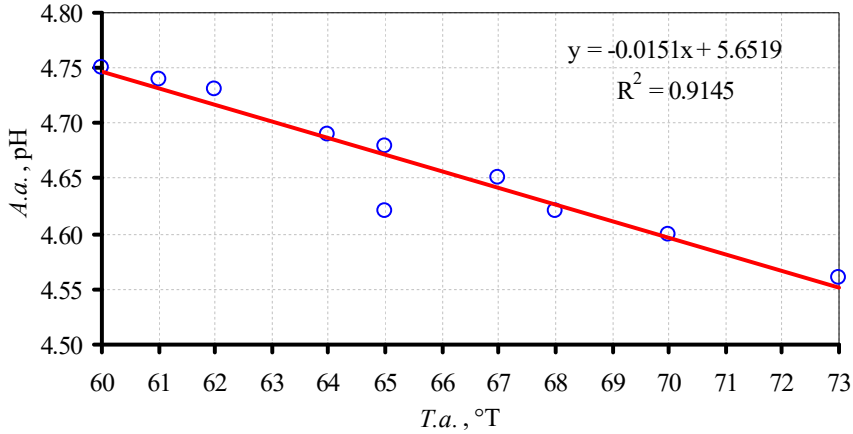
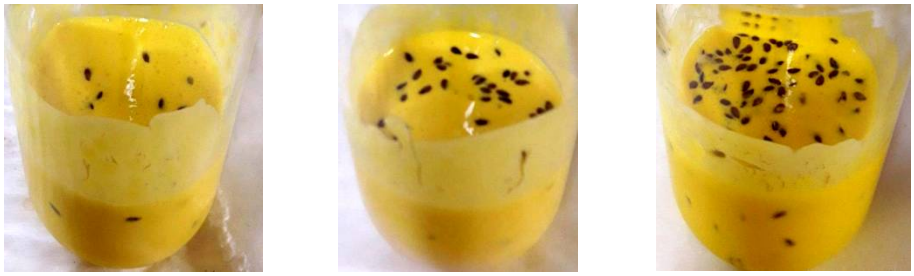


Figure 3. Dependence of active acidity (*A.a.*) on titratable acidity (*T.a.*)

The addition of pumpkin puree and flax seeds has an impact on the titrated and active acidity of Ryazhanka, as these ingredients contain organic acids that can alter the acid-base balance of the final product. The optimal values of titrated and active acidity for Ryazhanka are achieved with the simultaneous addition of 10% pumpkin puree and 4% flax seeds, which sets a limit on increasing the content of these ingredients. Furthermore, the addition of pumpkin puree and flax seeds can have a positive effect on the nutritional value and sensory characteristics of Ryazhanka, including its appearance, consistency, taste, aroma, and color.

Sensory evaluation of Ryazhanka with pumpkin puree and flax seeds

The sensory evaluation of Ryazhanka with 10% pumpkin puree and 4% flax seeds is shown in Figure 4a. Figure 4b represents the sample with 15% pumpkin puree and 6% flax seeds, while Figure 4c illustrates Ryazhanka with 20% pumpkin puree and 8% flax seeds.



a b c

Figure 4. Ryazhanka with different amounts of pumpkin puree and flax seeds:
a – 10% pumpkin puree and 4% flax seeds;
b – 15% pumpkin puree and 6% flax seeds;
c – 20% pumpkin puree and 8% flax seeds

Based on the results of the point assessment, profilograms were constructed (Figure 5-6).

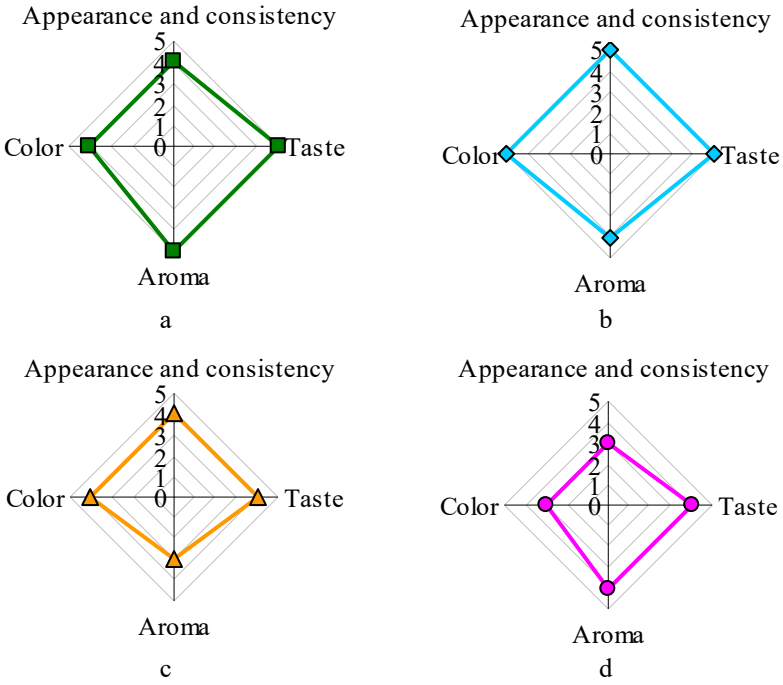


Figure 5. Profilograms of sensory indicators of the quality of Ryazhanka depending on the content of pumpkin puree and flax seeds:
a – control sample; b – 10% pumpkin puree and 4% flax seeds; c – 10% pumpkin puree and 6% flax seeds; d – 10% pumpkin puree and 8% flax seeds

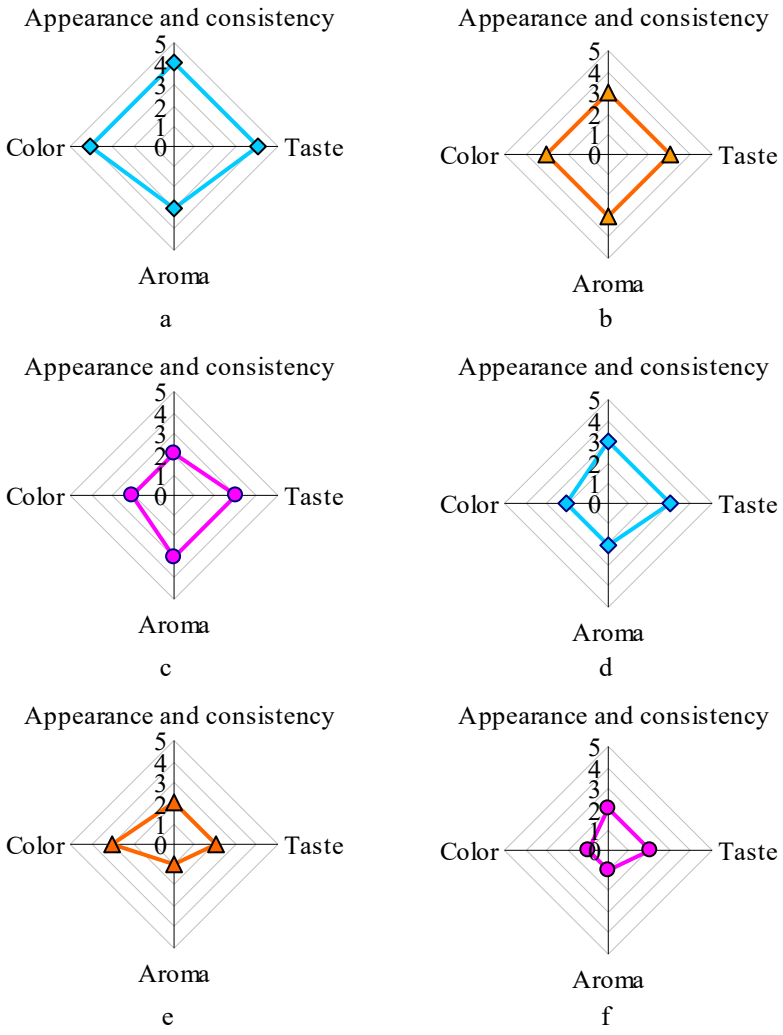


Figure 6. Profilograms of sensory indicators of the quality of Ryazhanka depending on the content of pumpkin puree and flax seeds:
a – 15% pumpkin puree and 4% flax seeds; b – 15% pumpkin puree and 6% flax seeds; c – 15% pumpkin puree and 8% flax seeds; d – 20% pumpkin puree and 4% flax seeds; e – 20% pumpkin puree and 6% flax seeds; f – 20% pumpkin puree and 8% flax seeds

Profile analysis revealed that Ryazhanka with the addition of 10% pumpkin puree and 4% flax seeds exhibited the highest sensory indicators (Figure 5b), with an average score of 4.75 points.

Evaluation of the sensory properties of the samples showed that the addition of up to 10% pumpkin puree and 4% flax seeds to Ryazhanka resulted in improved sensory parameters. The addition of pumpkin puree contributed to a soft, sweet, and pleasant aroma in Ryazhanka, while flax seeds added crunch, texture, and a natural flavor. These findings

are consistent with a study by Mousavi et al. (2019), which demonstrated the positive effects of flax seeds on the sensory properties of yogurt, particularly its texture and taste. Flax seeds imparted a richer flavor and aroma to the yogurt and improved its texture by forming a gel structure. However, it should be noted that flax seeds contain polysaccharides that can increase viscosity and affect the texture of fermented dairy products (Fitzpatrick, 2011). Therefore, to achieve the desired consistency of Ryazhanka with flax seeds, strict adherence to the prescribed their amount in the recipe and close control over the production process are necessary.

Increasing the content of pumpkin puree over 10% and flax seeds over 4% negatively impacts the quality of Ryazhanka. The average sensory index decreased from 3.75 to 1.50 points with a deterioration in appearance, texture, taste, aroma and color. A higher amount of pumpkin puree leads to an overly pronounced pumpkin flavor in the final product, resulting in excessively expressive color in Ryazhanka. Similar results were observed when adding sea buckthorn to Ryazhanka in amounts of 2.5, 5.0 and 7.5% (Ge et al., 2022). The authors found that samples with higher sea buckthorn content exhibited a more red-yellow color.

An increased level of flax seed can introduce a bitter aftertaste that may be undesirable to some consumers, thus caution is advised when incorporating this ingredient. This finding was supported by Mousavi et al. (2019), who reported a decreasing trend in sensory scores, including taste, mouthfeel, appearance, and overall acceptance, in samples containing high amounts of flaxseed. Higher amount of flax seeds alter the texture of Ryazhanka, making it thicker and reducing its sweetness. The oil content in flax seeds can also impart a slightly oily texture to Ryazhanka. The addition of flax seeds generally enhances the nutritional value of Ryazhanka due to their beneficial elements, such as omega-3 fatty acids.

Recipe development

Based on the conducted research, a recipe was developed incorporating the most successful combination of components for Ryazhanka with pumpkin puree (10%) and flax seeds (4%), as shown in Table 1.

Table 1

Ryazhanka with pumpkin puree and flax seeds

Raw material	Component amount (kg)	Percentage (%)
Pasteurized milk	859.98	85.998
Leaven	0.02	0.002
Pumpkin puree	100	10
Flax seeds	40	4
Total	1000	100

The production of Ryazhanka using this proposed recipe will result in a product enriched with biologically valuable substances, improved sensory properties, and an expanded range of this fermented milk beverage.

Justification of raw material processing technology

In addition to pumpkin, other plant materials such as garlic, black pepper, and basil leaves can be added to the Ryazhanka recipe. These ingredients have been shown to have

immune-strengthening properties (Ahmad et al., 2022). The use of spicy-aromatic plant raw materials in the restaurant industry has been proven to enhance the biological value and antioxidant capacity of dishes, thereby improving their sensory properties (Khareba et al., 2021; Kuzmin et al., 2021; Shevchenko et al., 2022).

Flax seeds are particularly valuable as a raw material. Various flax seed products, including whole flax seeds, ground meal, and extracted oil or mucilage, can be used in food preparation (Kajla et al., 2015). These products have been suggested as nutritional additives in a variety of dietary items, such as baked cereal products, ready-to-eat cereals, fiber bars, salad toppings, meat extenders, bread, muffins, and spaghetti (Singh et al., 2011; 2012).

Nutritional and energy value

Calculated nutritional and energy value of Ryazhanka with pumpkin puree and flax seeds is shown in Table 2.

Table 2

Calculated nutritional and energy value of Ryazhanka with pumpkin puree and flax seeds per 100 g of the finished product

Indicator	Control sample – Ryazhanka*	Ryazhanka with 10% pumpkin puree and 4% flax seeds**	+/-
Nutritional value			
Proteins, g	2.7	3.1	0.4
Fats, g	2.5	2.9	0.4
Carbohydrates, g	4.0	4.2	0.2
Energy (calorie) value			
Calorie content, kcal	49.30	55.30	6.00
Energy value, kJ	206.41	231.53	25.12
Vitamins			
C, mg	0.310	0.880	0.570
B_1, mg	0.021	0.083	0.062
B_2, mg	0.127	0.130	0.003
E, mg	0.000	0.010	0.010
β-carotene, mg	0.000	0.051	0.051
Minerals			
K, mg	141.00	172.30	31.300
Ca, mg	123.00	117.80	-5.200
Mg, mg	15.00	32.20	17.200
Na, mg	47.00	42.90	-4.100
Fatty acids			
Omega-3, g	0.00	0.80	0.800
Omega-6, g	0.00	0.20	0.200

*The nutritional composition of Ryazhanka, according to the manufacturer's quality certificate, indicates a fat content of 2.5% per 100 g.

**Recalculation for 86 grams of Ryazhanka with the addition of 10 grams of pumpkin puree and 4 grams of flax seeds, based on the combined nutritional data from the database (NatureClaim 2015-2023).

A comparison of the nutritional value, energy content, vitamin and mineral content, and fatty acid composition was conducted for 100 g of the control sample product – Ryazhanka and Ryazhanka with the addition of 10 g of pumpkin puree (10%) and 4 g of flax seeds (4%).

The addition of 10% pumpkin puree and 4% flax seeds to Ryazhanka compared to the control resulted in an increase in protein by 0.4 g (15%), fats by 0.4 g (16%), and carbohydrates by 0.2 g (5%). This led to a 6.00 kcal (12%) increase in calorie content and a 25.12 kJ (12%) increase in energy value. The presence of proteins in pumpkin puree and essential amino acids (Ezzat et al., 2022) confirms these findings. Additionally, *Cucurbita moschata* Duchesne ex Poiret contains 5.0-7.0% total sugars.

The addition of pumpkin puree and flax seeds to Ryazhanka increased the content of water-soluble vitamins: C by 0.570 mg (184%), B_1 by 0.062 mg (295%), and B_2 by 0.003 mg (2%). It also increased the content of fat-soluble vitamins: E by 0.010 mg and β-carotene by 0.051 mg. *Cucurbita moschata* Duchesne ex Poiret contains vitamin C, 4.8–7.6 mg/100 g, as well as vitamins B_1, B_2, E, and carotenoids. The addition of pumpkin puree and flax seeds to Ryazhanka increased the content of minerals: K by 31.3 mg (22%) and Mg by 17.2 mg (115%) due to the presence of minerals in pumpkin. However, replacing Ryazhanka with pumpkin puree and flax seeds led to a decrease in the content of such minerals as Ca by 5.2 mg (-4%) and Na by 4.1 mg (- 9%).

Pumpkin fruits are rich in phenolic substances, including phenolcarboxylic acids and flavonols (Chikpah et al., 2022; Hussain et al., 2022), essential oils (Hussain et al., 2022), dietary fibers (Ahmad and Khan, 2019; Ezzat et al., 2022; Montesano et al., 2018), polysaccharides and pectin (Ezzat et al., 2022), peptides (Hussain et al., 2022), and phytosterols (Ezzat et al., 2022).

Flax seed (*Linum usitatissimum* L.) has a unique nutrient profile due to its oil content, ranging from 29% to 45% of the seed (Fitzpatrick, 2011; Marpalle et al., 2014). It is high in polyunsaturated fatty acids (73% of total fatty acids), moderate in monounsaturated fatty acids (18%), and low in saturated fatty acids (9%). Linoleic acid constitutes approximately 16% of total fatty acids (Morris, 2001), and flax seed oil's main nutritional advantage is its high level of α-linolenic acid (50-60%), an essential omega-3 fatty acid (Fitzpatrick, 2011; Morris, 2001). Adding flax seeds to Ryazhanka increased the content of omega-3 fatty acids from 0 to 0.80 g and omega-6 fatty acids from 0 to 0.20 g (Table 2). Flax seed mucilage, which constitutes about 20% of the flax seed, contains gum-like polysaccharides (Fitzpatrick, 2011). Flax seed also contains approximately 1-2% total phenolic compounds (Fitzpatrick, 2011).

The addition of pumpkin puree to the Ryazhanka enriches it with biologically active compounds that exhibit a wide range of biological activities: antioxidant, immunomodulatory, anti-inflammatory, antibacterial, antiviral, cardioprotective, hepatoprotective, cytoprotective, antidiabetic, anticancer, anti-aging, and prebiotic effects (Chikpah et al., 2022; Ezzat et al., 2022; Hussain et al., 2022; Yang et al., 2007). These properties make it useful to improve human health in current post COVID 19 period (Hussain et al., 2022).

Flax seed can be used in Ryazhanka technology as an additional ingredient to improve the nutritional value and texture of the product. Flax seed is a rich source of dietary fiber, omega-3 and omega-6 fatty acids, lignans, and other beneficial substances that can enhance the health benefits of Ryazhanka.

Sensory evaluation of Ryazhanka

The sensory indicators of Ryazhanka with an optimal content of pumpkin puree (10%) and flax seeds (4%) are presented in Table 3.

Table 3

Sensory evaluation of Ryazhanka with pumpkin puree (10%) and flax seeds (4%)

Indicator	Research results of Ryazhanka according to a new recipe
Appearance and consistency	Homogenous, with a broken clot, pumpkin puree and flax seeds evenly distributed throughout the mass
Taste	Sour milk, with a pronounced taste of pumpkin puree
Aroma	Clean, sour milk with a pronounced smell of pumpkin
Color	Uniform throughout the mass: light yellow

The impact of 4% flaxseed on the sensory characteristics of Ryazhanka is limited. The presence of mucilage in flax seeds increases the viscosity of Ryazhanka, resulting in reduced fluidity and increased resistance to destruction. Using more than 4% flaxseed can lead to the formation of a thick consistency that may be unpleasant for consumers. Hence, the optimal amount of flax seeds in Ryazhanka should be restricted to 4%. Similarly, the content of pumpkin puree should be limited to 10% as it affects the pleasant taste, aroma, and creaminess of Ryazhanka. Exceeding the 10% threshold may alter the consistency of the product.

Research of physicochemical parameters

There is a need to study the influence of pumpkin puree and flax seeds on the quality and properties of Ryazhanka, including the duration of storage. The study of physico-chemical indicators was carried out based on the indicators of the mass fraction of fat and titrated acidity in two parallel tests. The final result was taken as the arithmetic mean of two parallel tests.

The results of changes in the titrated acidity of the control sample (Ryazhanka) and Ryazhanka with the addition of 10% pumpkin puree and 4% flax seeds during storage are shown in Figure 7.

The results from Figure 7 show that on the first day of the study, Ryazhanka with 10% pumpkin puree and 4% flax seeds had a titrated acidity of 72 °T. Over the storage period, the titrated acidity increased to 86 °T on the 4th day, 100 °T on the 6th day, and 107 °T on the 7th day. These findings are in line with data reported by Dan et al. (2019), Huang et al. (2020), and Zhang et al. (2022).

Based on the research results, it can be concluded that the addition of 10% pumpkin puree and 4% flax seeds influences the titrated acidity of Ryazhanka compared to the control sample. However, the experimental sample did not reach the upper limit of normalized titrated acidity (110 °T) during the 7-day storage period. Therefore, the shelf life of Ryazhanka with 10% pumpkin puree and 4% flax seeds, stored at temperatures between 0 and 6 °C, is determined to be no more than 7 days.

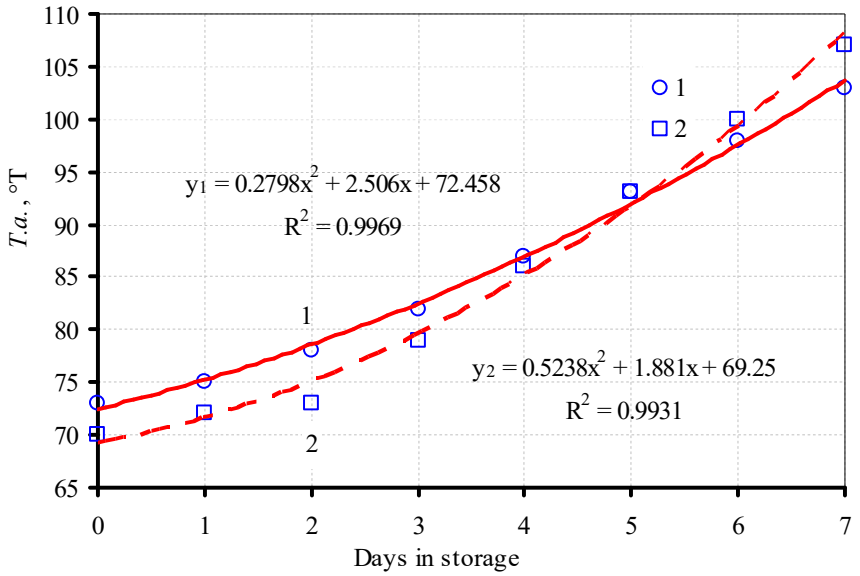


Figure 7. Changes in the titrated acidity of Ryazhanka with pumpkin puree and flax seeds during storage:
1 – a control sample made according to the traditional recipe; 2 – sample according to the developed recipe with pumpkin puree (10%) and flax seeds (4%)

Similar findings were observed in a study on fermented baked milk with sea buckthorn, where the authors noted a slight impact of sea buckthorn on the initial acidity of the samples. Over the subsequent 21 hours, the trends in titrated acidity of sea buckthorn fermented baked milk were comparable (Ge et al., 2022). These results align with the indicators highlighted in another study by Samilyk and Helikh (2020), which examined the addition of strawberry powder, candied beetroot, and strawberry jam to a yogurt recipe. The authors found no negative effects on the fermentation process and no significant increase in titrated acidity.

Conclusions

1. The effect of pumpkin puree and flax seeds addition on the active and titrated acidity of Ryazhanka was studied. The results showed that adding 4-8% flax seeds and 10% pumpkin puree reduced the titrated acidity to 64-70 °T and increased the active acidity to pH 4.60–4.69. Similarly, adding 4-8% flax seeds and 15% pumpkin puree reduced the titrated acidity to 61–68 °T and increased the active acidity to pH 4.62–4.74. Furthermore, adding 4–8% flax seeds and 20% pumpkin puree decreased the titrated acidity to 60–65 °T and increased the active acidity to pH 4.62–4.75.
2. The optimal conditions for modifying the content of pumpkin puree and flax seeds in Ryazhanka to stabilize the physicochemical parameters were determined to be 10% pumpkin puree and 4% flax seeds.
3. It was determined that an increase in titrated acidity by 1 °T leads to a decrease in the active acidity of Ryazhanka by 0.0151 pH – an inverse correlation.

4. Based on the results of a study of the sensory indicators of Ryazhanka with pumpkin puree and flax seeds in comparison with Ryazhanka made according to traditional technology, it was established that the addition of 10% pumpkin puree and 4% flax seeds provides pleasant sensory properties, in particular with a uniform light yellow color, the taste and smell of pure sour milk with a pronounced taste of pumpkin.
5. When calculating the nutritional and energy value of the new type of Ryazhanka, an increase in the amount of proteins, fats, and carbohydrates was established by 15%, 16%, and 5%, respectively. The energy value of Ryazhanka with pumpkin puree and flax seeds increased by 12% compared to Ryazhanka made according to the traditional recipe.
6. Adding pumpkin puree and flax seeds to Ryazhanka affected the titrated acidity, and based on the research findings, the shelf life of Ryazhanka at temperatures between 0 °C and 6 °C was determined to be no more than 7 days.
7. The recipe of Ryazhanka with pumpkin puree and flax seeds was developed taking into account the quality indicators that meet the requirements of consumers and the needs of the production chain. This research enables the expansion of fermented milk product varieties and increases the production and consumption of Ryazhanka with enhanced health benefits.

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