Improvement of fermented dairy-plant concentrate technology

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Keywords:

Milk
Whey
Kernels
Peanut
Dairy-plant
Concentrate

Article history:

Received
16.08.2024
Received in revised form 18.10.2024
Accepted
31.12.2024

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DOI:
10.24263/2310-1008-2024-12-2-4

Abstract

Introduction. The global trend toward developing functional food products has spurred interest in creating fermented dairy-plant concentrates. These products balance nutritional and biological value by combining animal and plant proteins, offering enhanced functionality and meeting consumer demands for healthy, plant-based alternatives.

Materials and methods. The research involved experimental and analytical methods to determine optimal technological parameters. Sensory evaluation, physicochemical analysis, and statistical processing were applied to evaluate the quality of dairy-plant concentrates. The methods used include soaking, homogenization, pasteurization, fermentation, and analysis of whey-plant suspensions with varying ratios of dairy and plant components.

Results and discussion. The study established that the procedure of preparation of whey-plant suspensions involves soaking peanut (*Arachis hypogaea*) kernels for 480 minutes in a 5:1 ratio and homogenizing them for 4–5 minutes. Model samples of dairy-plant concentrates were prepared with whey-plant suspensions at ratios of 9:1, 4:1, 7:3, and 3:2. Results showed a decreasing trend in concentrate yield and increasing moisture content with higher proportions of whey-plant suspension. At a 9:1 ratio, the yield was 26.28%, decreasing to 21.8% at a 3:2 ratio. Simultaneously, the moisture content increased from 62.9% to 82.8%. The 4:1 and 7:3 ratios were identified as optimal, providing good functional and sensory properties. The water-holding capacity ranged from 59.1% at a 9:1 ratio to 76.2% at 3:2. Sensory analysis confirmed that concentrates with a 4:1 or 7:3 ratio had the most balanced texture, flavor, and appearance, closely resembling traditional milk-protein concentrates. The improved technology ensures consistent quality of fermented dairy-plant concentrates, allows for the use of plant components to enhance functional properties and enrich the amino acid profile, and provides the potential for their application as a base for other dairy products, including curd-based items.

Conclusions. The feasibility of using peanut kernels in dairy-plant mixtures has been demonstrated, addressing the issue of milk raw material shortages while enhancing the biological value of concentrates due to a more balanced amino acid composition.

Introduction

Current trends in expanding the range of dairy and protein products focus on creating nutritionally and biologically balanced products. Products with an optimized composition of essential nutrients are widely developed and introduced, which is ensured by selecting and combining proteins of animal and vegetable origin. The need to improve consumer properties, increase competitiveness, and ensure stable product quality requires rationalizing the composition and adjusting traditional dairy product technologies. The active use of plant-based milk is associated with both individual intolerances to lactose and/or milk casein in a large number of consumers and the popularization of vegetarianism and the physiological benefits of vegetable protein consumption, especially in geriatric nutrition (Rasane et al., 2013). The production of multicomponent milk and protein products is carried out using non-traditional raw materials of plant origin and various food additives (Slyvka et al., 2019). At the same time, there is a growing consumer interest in plant-based milk substitutes, which affects the market structure and encourages manufacturers to expand the range of dairy-plant products (Antoshchenkova and Kravchenko, 2022). These trends highlight the relevance of developing new technologies, particularly fermented dairy-plant concentrates, which combine the benefits of both components and meet modern consumer demands.

Each type of plant-based milk has its own characteristics in terms of compatibility with raw milk at the level of sensory properties. Today, there are many types of plant materials from which milk analogs are made. Some scientific papers attempt a general classification of these products, according to which five categories of beverages are distinguished, namely: (a) cereals: oat, rice, corn, and spelt milk; (b) legumes: soy milk, peanut-based milk, lupine, cowpea (Chinese asparagus beans); (c) nuts: almond, coconut, pistachio, hazelnut, and walnut milk; (d) seeds: sesame, sunflower, flax, hemp; (e) pseudo-cereals: milk from quinoa, amaranth, and tofu (Sethi et al., 2019).

Numerous studies have focused on soy milk (Kumari et al., 2022; Letizia et al., 2024; Zhang et al., 2023), as soybeans contain 35 to 52% high-value protein, 17 to 27% high-quality vegetable oils with a fatty acid composition, 18 to 25% various hydrocarbons, essential vitamins, and are a substitute for cow's milk (Al-Saedi et al., 2020; Osthoff et al., 2010). Cereals, oilseeds, nuts, tubers, and fruits are also used to produce plant milk, taking into account the properties of the plant ingredients (Lopes et al., 2020; Seong et al., 2022; Souza et al., 2020). The functional and technological properties of plant ingredients require additional research to produce plant milk with stable quality indicators during storage. However, it is necessary to investigate several technological problems to prepare plant milk as an alternative to cow's milk with stable sensory and physicochemical characteristics.

By using various extraction and processing methods, plant-based raw materials can be treated as dairy analogs and further fermented and/or prepared into fermented dairy analogs such as yogurt and cheese. In addition to selecting raw materials with appropriate flavor and nutritional properties, the extraction of such plant materials to create suitable ingredients is also critical to the development of a satisfactory plant milk analog. Extraction processes have a profound effect on the composition of the raw material, which then determines its behavior in the following stages of product development.

Overview of the latest research and publications

The development of dairy-plant products is a significant direction in the food industry, as they combine high nutritional value and meet the modern consumer's demand for healthy nutrition. Today, there is a need to create new food products that would not only expand the range but also have resource-saving technologies. One of the most promising ways to solve this problem is the rational use of by-products of dairy production with the combination of plant raw materials (Onopriichuk et al., 2022; Skuibida et al., 2022; Stabnikova et al., 2021). Researchers evaluated the characteristics of soybean grinding using different wet grinding systems and found that particle size had a significant impact on protein recovery in extracted milk, regardless of the type of grinder used (Vishwanathan et al., 2011). A study was conducted that showed that an acceptable vegan cheese analog can be made from mixtures of soy milk and cashew nut milk. This cheese analog can be a source of plant-based protein and potentially reduce the incidence of protein-energy malnutrition. It can also be a rich source of essential fatty acids (Oyeyinka et al., 2019).

It has been shown that the properties of tofu cheese depend on pretreatment, soaking and heating conditions of soybean seeds, and the type and concentration of coagulant. These factors affect the technological parameters of soybean processing and, accordingly, the quality of the resulting tofu cheese (Zhang et al., 2017). Some physicochemical, rheological, and sensory properties of plant-based and milk-based yogurts were studied. The quality indicators of plant-based yogurt had similar values to those of milk-based yogurt (Grasso et al., 2020).

Fermented beverages with cashew pulp were prepared with different whey concentrations of 10, 20, and 30%. Probiotic beverages with cashew fruit had physicochemical and microbiological stability when stored at 4 ± 2 °C for 28 days (Souza et al., 2020).

The kernels of *Arachis hypogaea* have a high nutritional value due to the presence of a significant level of proteins and fats that are easily digested. It should be noted that the fat (about 50%) of the peanut contains about 20% saturated and 80% unsaturated fatty acids, among which oleic and linoleic acids account for the largest share (Olajuyigbe et al., 2013). The protein composition of the kernels of *Arachis hypogaea* is represented by such proteins as albumin, globulins, and glutelins. The high biological value of the kernels of *Arachis hypogaea* proteins is associated with the content of 8 essential amino acids, which are necessary for human life but cannot be synthesized by the body, and 10 nonessential amino acids, which brings it closer to animal composition. Literature data indicate that the composition of the kernels of *Arachis hypogaea* protein is mainly represented by such amino acids as arginine, glycine, leucine, alanine, and methionine, while others are present in small amounts (Abdualrahm et al., 2013).

The vitamin composition of the kernels of *Arachis hypogaea* is characterized by a high content of vitamin E and B vitamins, the quantitative content of which is (mg/100 g): E - 6.93, B1 - 0.438, B2 - 0.098, B3 - 13.5, B5 - 1.4, B6 - 0.256, and B9 - 145. One of the functional components of the kernels of *Arachis hypogaea* is resveratrol, which has antioxidant, anticarcinogenic, and anti-inflammatory properties (Sales et al., 2013).

A rather significant group of substances in the chemical composition of the kernels of *Arachis hypogaea* is polyphenols, which are mainly represented by n-coumaric acid, ferulic acid, esterified derivatives of n-coumaric acid, hydroxybenzoic acid, and resveratrol (Lehnert et al., 2019). The above polyphenolic compounds have antioxidant properties that inhibit lipid oxidation. The analysis of the general chemical composition of the kernels of *Arachis hypogaea* shows a high content of biologically active substances, which makes it possible to recommend it for use in the technology of multicomponent milk and plant concentrates. The implementation of these measures is achieved through the improvement and scientific substantiation of the main technological processes.

However, oilseeds of the legume family, which includes the kernels of *Arachis hypogaea*, contain a high content of trypsin and chymotrypsin inhibitors. In general, enzyme inhibitors account for about 6% of the total protein content. The kernels of *Arachis hypogaea* contain both high and low molecular weight inhibitors. The inactivation or reduction of trypsin and chymotrypsin inhibitors has been described, and their effectiveness has been compared (Degon et al., 2021; de Jongh et al., 2020; Dubinina et al., 2017). It was found that all types of heat treatment can reduce the content of phytic acid by 3.8-24.7%, trypsin inhibitors by 15.6-61.2%, tannins by 6.7-68.5%, lectins by 75-100%, and improve protein digestibility by 21%. Autoclaving, boiling, roasting with salting, and deep-frying proved to be the most effective. These methods not only reduce the content of phytic acid, tannins, and lectins but also significantly inactivate trypsin and chymotrypsin inhibitors, thereby improving the nutritional value and digestibility of proteins.

It has also been confirmed that the kernels of *Arachis hypogaea* contain a fairly high amount of oxalic acid and copper salts. To create high-quality products based on the kernels of *Arachis hypogaea*, it is necessary to minimize the content of these toxic and antinutrient substances. To solve this problem, we used a physical method – hydrothermal treatment, namely cooking followed by roasting. Hydrothermal treatment simultaneously reduces oxalic acid and its salts, and salts of heavy metals, due to diffusion into the solution. In addition, heat treatment leads to the inactivation of trypsin and chymotrypsin inhibitors, which makes the kernel protein of *Arachis hypogaea* easier to digest. At the same time, roasting improves the sensory quality of the kernels (Dubinina et al., 2017).

Modern technologies for the production of dairy-plant concentrates involve the use of fruit and berry coagulants for protein precipitation. The application of organic acids derived from fruit and berry raw materials promotes the formation of protein-micellar complexes with improved functional and technological properties. This approach not only enhances the quality of the final product but also increases its biological value due to the natural content of vitamins and antioxidants present in the coagulant (Grek et al., 2020).

One of the promising directions in the food industry is the development of high-protein fermented beverages based on plant ingredients. Using protein sources such as chickpeas and flaxseed protein, combined with fermentation processes, allows for the creation of products with high biological value. These beverages exhibit improved sensory properties, reduced antinutritional factors, and enhanced protein digestibility. This technology facilitates the production of alternative products for consumers with lactose intolerance and those adhering to a plant-based diet (Novik et al., 2022).

The development of peanut-based milk alternatives has gained significant attention in recent years due to the growing demand for plant-based functional food products. Research shows that peanut milk possesses high nutritional value and functional characteristics, making it a promising alternative to traditional dairy products (Sakthi et al., 2020) studied the physicochemical, nutritional, and sensory properties of peanut milk. The results indicated that peanut milk has a balanced composition of proteins, fats, and carbohydrates, with high levels of unsaturated fatty acids, particularly oleic and linoleic acids. These properties enhance its nutritional profile and ensure good sensory acceptability.

The impact of processing methods such as autoclaving, roasting, and fermentation has been examined in numerous studies. These methods not only improved the physicochemical stability of peanut milk but also contributed to better emulsification properties and protein solubility. For example, it was demonstrated that pressure blanching preserved the sensory qualities of peanut milk and reduced undesirable bitterness, making it more appealing to consumers (de Albuquerque et al., 2015). Some studies explored the possibility of enriching peanut milk with bioactive compounds from other plant sources, such as guava and umbu. These enriched products exhibited enhanced sensory and functional properties, making them attractive to health-conscious consumers.

A review of the studies highlights the promising potential of peanut milk as a functional food product. Its high nutritional value, combined with technological advancements in processing and enrichment, positions peanut milk as a sustainable and health-promoting alternative to traditional dairy products. Further research is needed to optimize production methods and expand its applications in the food industry.

The fermentation of cowpea-peanut milk with *Lacticaseibacillus rhamnosus* enhances its nutritional and functional properties, producing a probiotic-rich beverage with significant antioxidant activity and essential amino acids (Chawafambira et al., 2022). The study suggests that such fermented plant-based milk alternatives could serve as viable options for health-conscious consumers, particularly in regions where dairy consumption is limited. This research contributes to the growing body of knowledge on plant-based fermented beverages, highlighting the potential of legumes such as cowpeas and peanuts in developing nutritious and functional dairy alternatives.

Considering the aforementioned characteristics, the kernels of *Arachis hypogaea* represent a promising plant-based raw material for the production of dairy-plant concentrates. It is crucial to account for the preliminary processing of *Arachis hypogaea* kernels to inactivate undesirable components and to determine the optimal inclusion level for achieving the best sensory and physicochemical properties of the product.

The aim of the present study is to improve the technology of fermented dairy-plant concentrates. To achieve this aim, the following tasks were defined: determination of the optimal conditions for obtaining whey-plant suspension from milk whey and kernels of *Arachis hypogaea*; determination of the physicochemical and sensory characteristics of fermented dairy-plant concentrates; establishing the optimal ratio for replacing cow's milk with whey-plant suspension in the production of fermented dairy-plant concentrates; improving the technology of fermented dairy-plant concentrates.

Materials and methods

Materials

The dairy-plant mixture was prepared from skimmed milk and whey-plant suspension in component ratios of 9:1, 4:1, 7:3, and 3:2, corresponding to suspension levels of 10%, 20, 30, and 40%. The active acidity of the suspension was 6.7±0.1 pH units, and the dispersed phase size ranged from 50 to 200 µm. Particles of this size are optimal for forming a uniform suspension, facilitating better fat emulsification and even protein distribution in the dairy-plant concentrate.

To obtain the whey-plant suspension, the peanut kernels were soaked in water at a temperature of 20±2 °C and left to swell for 360 to 660 minutes prior to mechanical processing. The kernels were then washed 2–3 times to remove insoluble residues through filtration. Next, the swollen kernels were mixed with curd whey in a ratio of 5:1, and the resulting mixture was homogenized using a disperser operating at 1000 rpm for 4 to 8 minutes. The obtained whey-plant suspension was filtered and then added to the prepared skimmed milk.

Methods

The yield (weight) was determined by the weight method: the sample was weighed after self-pressing the concentrate obtained from 1 l of the dairy-plant mixture.

The active acidity was determined potentiometrically using the universal ionomer EV-74.

The moisture content was determined by an accelerated method (using a «Quartz» device).

To determine the moisture content of the product, 150x150 mm newsprint bags (single or double layers) were rolled diagonally, the corners and edges were bent. The package was placed in a sheet of parchment slightly larger than the package, without wrapping the edges. The finished bags were dried on a «Quartz» apparatus for 3 min at a temperature of 150–152 °C.

The prepared bag was weighed with 5 g of the test product to the nearest 0.01 g. The product was distributed evenly over the entire surface of the bag. The bag with the sample was closed and placed in the device between the plates heated to 150–152 °C for 5 min.

The bags with dried samples were cooled in a desiccator for 3–5 min and weighed.

The moisture content of the product was determined by the formula:

$$W = \frac{(M - M_1)}{5} \cdot 100,$$

where W is the mass fraction of moisture, %; M is the mass of the bag with the sample before drying, g; M_1 is the mass of the bag with the sample after drying, g; 5 is the mass of the product, g.

The difference between the parallel determinations did not exceed 0.5%.The final result was the arithmetic mean of three parallel determinations.

The water-holding capacity was determined by the Grau-Hamm gravimetric method in the modification of A.A. Alekseev, based on determining the amount of water released from the product during light pressing, which is absorbed by filter paper. The water-holding capacity of the product was determined by the formula:

$$HWC = \frac{a - b}{a} \cdot 100,$$

where HWC is moisture holding capacity, %; a is the amount of moisture in the product by weight, mg; b is the amount of moisture released from the product sample, mg, is determined by the difference in weight before and after pressing.

$$a = \frac{0.3 - W_W}{100} \cdot 100,$$

where 0.3 is product weight, mg; W_w is the mass fraction of moisture in the product, %.

Results and discussion

Selection of technological parameters of pre-processing of peanut kernels

At the first stage of the research, thermal treatment of peanut kernels was carried out. This is a crucial step in the technological process, ensuring the inactivation of enzyme inhibitors such as trypsin and chymotrypsin. These antinutritional substances negatively affect protein digestion, reducing their bioavailability and assimilation by the body. It is hypothesized that thermal treatment at a temperature of 120 ºC for 30–35 minutes effectively reduces the content of enzyme inhibitors to a safe level while maintaining the high functional and technological properties of the proteins. This temperature regime also promotes the breakdown of antinutritional substances such as phytic acid and tannins, further enhancing the sensory and physicochemical properties of the product. Thus, the conditions for preliminary thermal treatment not only improve the nutritional value of peanut kernels but also ensure their safety for use in the production of dairy-plant concentrates.

The main objective in processing plant raw materials for subsequent combination with cow's milk is to obtain a homogeneous and stable whey-plant suspension with dispersed phase particles ranging from 50 to 200 µm. To determine the optimal parameters for the preliminary preparation of *Arachis hypogaea* kernels, the influence of technological parameters, namely soaking and grinding durations, on their sensory characteristics was evaluated using a 5-point scale, as shown in Table 1.

Table 1

Influence of technological parameters of preliminary processing of peanut kernels on their sensory characteristics

Duration, min		Score	Duration, min		Score
Soaking	Grinding		Soaking	Grinding	
360	4	3	480	8	4
360	5	3	540	3	4
360	6	4	540	5	4
360	7	4	540	6	5
360	8	3	540	7	5
420	4	3	540	8	4
420	5	3	600	4	3
420	6	4	600	5	4
420	7	4	600	6	5
420	8	3	600	7	5
480	4	3	600	8	4
480	5	4	660	4	3
480	6	5	660	5	4
480	7	5	660	6	3
480	8	4	660	7	3

The analysis of the results showed that the duration of soaking and grinding of peanut kernels significantly affects their sensory properties. The highest average scores were obtained with a soaking duration of 480 minutes, where the ratings ranged from 6 to 8 points. Soaking for 360 and 420 minutes yielded slightly lower results, particularly for sensory characteristics. Regarding the grinding duration, optimal results were achieved with a duration of 4–5 minutes, where the scores consistently ranged from 4 to 5 points. Increasing the grinding time beyond 6 minutes did not lead to a significant improvement in the scores. The obtained results correlate with the studies of (Siva Sakthi et al., 2021), which examined the comparative effects of different processing methods, such as soaking and roasting, on the properties of the resulting plant mixture. Thus, the best results for the preliminary preparation of *Arachis hypogaea* kernels are achieved with soaking for 480 minutes and grinding for 4–

5 minutes, ensuring optimal sensory properties for further processing and use in the technology of dairy-plant concentrates.

Determination of the optimal ratio of skimmed milk and dairy-plant suspension in mixtures for precipitation

The next stage of the research involved determining the optimal replacement level of skimmed milk with whey-plant suspension in fermentation mixtures. To achieve this, the yield, physicochemical, and sensory properties of the resulting dairy-plant concentrates were evaluated. Model samples were prepared using skimmed milk and whey-plant suspension in component ratios of 9:1, 4:1, 7:3, and 3:2, corresponding to suspension levels of 10%, 20%, 30%, and 40%, respectively. The active acidity of the suspension was 6.7±0.1 pH units. The selection of the optimal replacement level was based on maintaining the standard physicochemical parameters characteristic of milk-protein concentrates, which can serve as a base for producing various types of curd products. Acid-rennet technological regimes were applied for the production of both traditional fermented milk-protein concentrates (control) and dairy-plant concentrates.

The research results (Figure 1) revealed a trend of decreasing yield and increasing moisture content in the obtained dairy-plant coagulates as the proportion of whey-plant suspension with *Arachis hypogaea* kernels increased.

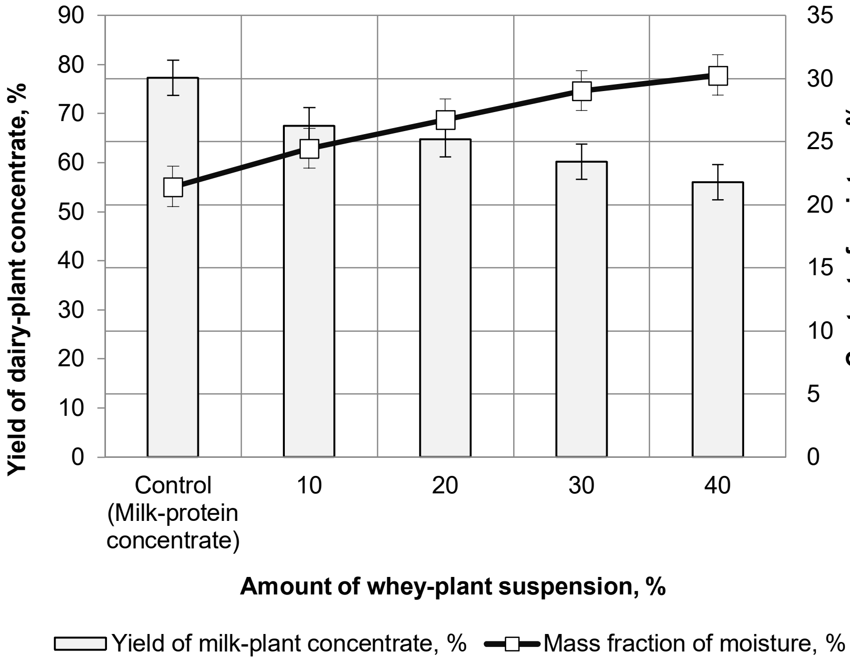

Figure 1. Yield and content of moisture in dairy-plant concentrates

The research results indicate that as the proportion of whey-plant suspension in mixtures with milk increases from 9:1 to 3:2, there is a trend of decreasing yield of dairy-plant concentrates by 5.37–11.17% compared to the control sample (milk-protein coagulate), which uses only dairy raw materials. This reduction is attributed to the decrease in the total protein mass fraction in the mixtures due to the replacement of a portion of the milk with whey-plant suspension containing peanut kernels. At a 9:1 ratio, the concentrate yield is 26.275%, which is 12.5% lower than the control sample (30.05%). With a further increase in the suspension proportion, the yield decreases to 21.8% at a 3:2 ratio, reflecting a 27.5% reduction.

Regarding the mass fraction of moisture, an increase is observed from 62.9% to 82.8% with a higher proportion of whey-plant suspension. For instance, at a 9:1 ratio, the moisture content is 67.9%, which is 12.9% higher than the control sample (60.1%). At a 3:2 ratio, this indicator reaches a maximum of 82.8%, demonstrating the ability of plant components to retain more moisture. This also affects the product's consistency: at a 9:1 ratio, the concentrate has a more cohesive texture, while at a 3:2 ratio, the samples exhibit a smooth, paste-like consistency, with the self-pressing process taking longer.

Analyzing the graph depicting the water-holding capacity of dairy-plant concentrates (Figure 2), a clear dependence of this parameter on the ratio of milk to whey-plant suspension can be observed. The control sample, made from dairy raw materials, demonstrates a water-holding capacity of 72.5%, serving as a benchmark.

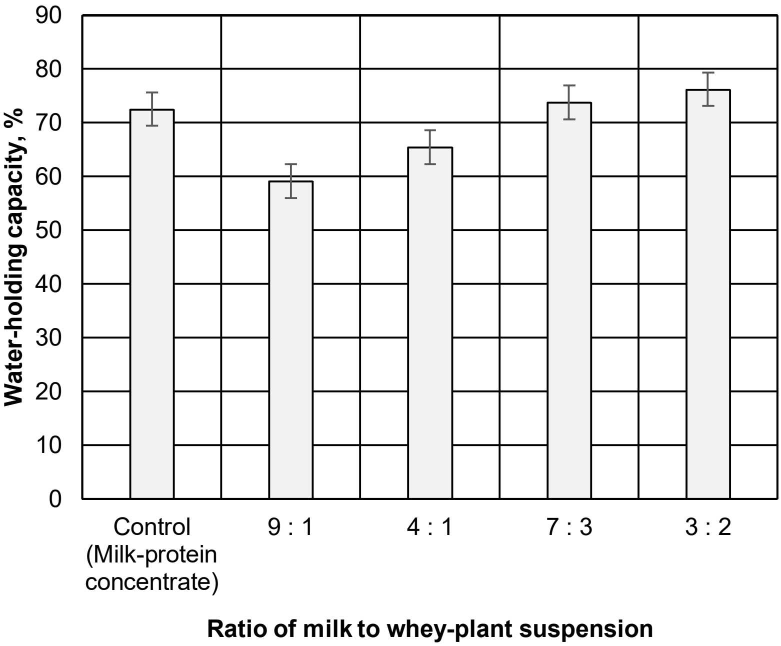

Figure 2. Water-holding capacity of dairy-plant concentrates

With an increasing proportion of whey-plant suspension, the water-holding capacity shows a rising trend. At a 9:1 ratio, this indicator decreases to 59.1%, which is 13.4% lower than the control. For samples with a 4:1 ratio, the water-holding capacity increases to 65.4%, only 7.1% less than the control. At a 7:3 ratio, the value reaches 73.8%, exceeding the control by 1.3%. The maximum water-holding capacity is observed at a 3:2 ratio, reaching 76.2%, which is 3.7% higher than the control sample.

The optimal ratios for producing dairy-plant concentrates are 4:1 and 7:3. At a 4:1 ratio, the water-holding capacity is close to the control sample, ensuring good functional and sensory properties of the product. The 7:3 ratio provides an even higher water retention level (73.8%) without significantly compromising the product's texture. Although the 3:2 ratio demonstrates the highest water-holding capacity (76.2%), it may result in an excessively paste-like consistency, which could be undesirable under certain consumption conditions.

Thus, the ratios of 4:1 and 7:3 are optimal for producing dairy-plant concentrates with high technological and consumer qualities.

To determine the optimal dosage of whey-plant suspension for the production of dairy-plant concentrate, a sensory evaluation was conducted, as presented in Table 2.

Table 2

Sensory characteristics of dairy-plant concentrates

<table>
<tr><th rowspan="2">Ratio of skimmed milk to whey-plant suspension</th><th colspan="3">Sensory Characteristics of the Concentrate</th></tr>
<tr><th>Consistency and appearance</th><th>Taste and aroma</th><th>Color</th></tr>
<tr><td>9 : 1</td><td rowspan="3">Uniform, soft, spreadable</td><td rowspan="2">Clean, fermented milk-like, with a mild peanut taste and aroma</td><td rowspan="2">Slightly noticeable light cream color, uniform throughout the mass</td></tr>
<tr><td>4 : 1</td></tr>
<tr><td>7 : 3</td><td>Clean, fermented milk-like, with a slight peanut aroma</td><td>Cream-colored, uniform throughout the mass</td></tr>
<tr><td>3 : 2</td><td>Uniform, slightly liquid, floury</td><td>Clean, fermented milk-like, with a pronounced peanut taste and aroma</td><td>Overly pronounced, rich yellowish-cream color, uniform throughout the mass</td></tr>
</table>

The analysis of the sensory characteristics of dairy-plant concentrates, presented in the table, confirms the optimality of the 4:1 and 7:3 ratios. At a 4:1 ratio, the concentrate is characterized by a uniform, soft, and spreadable consistency. Its taste and aroma are clean, fermented milk-like, with a slight peanut aroma. The color is cream and uniform throughout the mass, indicating a balanced combination of dairy and plant components that ensures high consumer qualities of the product. The 7:3 ratio also demonstrates similar positive characteristics. The consistency is uniform and spreadable, while the taste is clean, fermented milk-like, with a slight peanut aroma. The color is uniformly cream. This option provides a high water-holding capacity (73.8%) and a good balance between texture and flavor. In contrast, the 9:1 ratio shows a less pronounced peanut aroma and a weak cream color, indicating an insufficient contribution of the plant component. The 3:2 ratio, while having the highest water-holding capacity (76.2%), is characterized by a slightly liquid, floury consistency and an overly saturated yellowish-cream color, which may affect the perception of the final product. Thus, the sensory evaluations support the previous conclusions regarding the optimality of the 4:1 and 7:3 ratios, as they provide the best balance between texture, taste, aroma, and appearance of the concentrates.

Improvement of the technology for the production of fermented dairy concentrates

Based on the conducted research, the technology for producing fermented dairy-plant concentrates was improved. Initially, a dairy-plant mixture is prepared using skimmed milk and whey-plant suspension at the optimal ratio of 4:1 or 7:3. Pasteurization of the prepared dairy-plant mixture is carried out at an optimal temperature of 74–76 °C with a holding time of 20–30 seconds. This regime ensures the coagulation of thermolabile whey proteins, thereby increasing the yield of the dairy-plant protein concentrate. The pasteurized dairy-plant mixture is then cooled to 28–30 °C during the warm season and 30–32 °C during the cold season before being sent for fermentation. The aforementioned temperature regimes are optimal for the development of key starter microorganisms, ensuring active acid production from the beginning of the fermentation process, primarily mesophilic lactic streptococci. The fermentation of the dairy-plant mixture lasts 6–8 hours. To accelerate the fermentation process, a symbiotic starter culture, made from mesophilic and thermophilic streptococci in a 1:1 ratio, is used. The temperature of the dairy-plant mixture is set at 38 °C during the cold season and 35 °C during the warm season, reducing the fermentation time to 4–4.5 hours. For the production of the milk-protein base using the acid-rennet method, calcium chloride and milk-clotting enzymes are added to the milk along with the starter culture. Calcium chloride is added at a rate of 400 g of anhydrous salt per 1000 kg of the mixture in the form of a solution with a mass fraction of calcium chloride of 30–40%. During the production of the milk-protein base using the acidic method, the dairy-plant mixture is fermented until the curd reaches an acidity of 75–85 °T, and for the acid-rennet method, 61–65 °T. After fermentation, steps are taken to expedite whey removal: the curd is cut into cubes approximately 2 cm on each side using special wire knives. The cut curd is left undisturbed for 40–60 minutes to increase acidity and facilitate more intensive whey separation. Whey is then partially removed. For protein coagulation using the acidic method, the curd is heated to 36–40 °C with a holding time of 15–20 minutes to enhance and expedite whey removal.

For final whey removal and obtaining a milk-protein base with a standard moisture content, the curd undergoes self-pressing, followed by forced pressing. The pressed concentrate is cooled to 3–8 °C to stop lactic fermentation and prevent further acidity increase. The dairy-plant protein concentrate is then cooled in a refrigeration chamber to 2–4 °C.

Conclusions

The feasibility of using peanut (*Arachis hypogaea*) kernels in dairy-plant mixtures has been demonstrated, addressing the issue of milk raw material shortages while enhancing the biological value of concentrates due to a more balanced amino acid composition. Based on the assessment of the influence of technological parameters on the sensory properties of the kernels, the optimal preparation involves soaking *Arachis hypogaea* kernels for 480 minutes in a 5:1 ratio and homogenizing them for 4–5 min.

It has been established that the partial replacement of skimmed milk with whey-plant suspension in ratios of 4:1 and 7:3 allows the production of dairy-plant concentrates with high physicochemical and sensory properties, comparable to milk-protein concentrates (control).

The improved technology ensures consistent quality of fermented dairy-plant concentrates, allows for the use of plant components to enhance functional properties and enrich the amino acid profile, and provides the potential for their application as a base for other dairy products, including curd-based items.

References

Abdualrahm M.A.Y. (2013), Chemical, in-vitro protein digestibility, minerals and amino acids composition of edible peanut seeds (*Arachis hypogaea* L.), *Science International*, 1(6), pp. 199–202, https://doi.org/10.5567/sciintl.2013.199.202

Al-Saedi N., Agarwal M., Ma W., Islam S., Ren Y. (2020), Study on effect of extraction techniques and seed coat on proteomic distribution and cheese production from soybean milk, *Molecules*, 25(14), 3237, https://doi.org/10.3390/molecules25143237

Antoshchenkova V., Kravchenko, Y. (2022), Current trends in milk production and consumption in the world in the conditions of globalization, *Economic Analysis*, (32(2)), pp. 7–14, https://doi.org/10.35774/econa2022.02.007

Chawafambira A., Jombo T.Z., Mkungunugwa T. (2022), Effect of *Lacticaseibacillus rhamnosus* Yoba fermentation on physicochemical properties, amino acids, and antioxidant activity of cowpea-peanut milk, *Journal of Food Quality*, 2022, pp. 1–10, https://doi.org/10.1155/2022/3192061

de Albuquerque E.M.B., Almeida F.A.C., Gomes J.P., Alves N.M.C., da Silva W.P. (2015), Production of "peanut milk" based beverages enriched with umbu and guava pulps, *Journal of the Saudi Society of Agricultural Sciences*, 14(1), pp. 61–67, https://doi.org/10.1016/j.jssas.2013.07.002

Degon J.G., Zheng C., Elkhedir A., Yang B., Zhou Q., Li W. (2021), Effect of microwave pre-treatment on physical quality, bioactive compounds, safety risk factor, and storage stability of peanut butter, *Oil Crop Science*, 6(3), pp. 137–144, https://doi.org/10.1016/j.ocsci.2021.07.006

de Jongh H.H.J., de Jong G.A.H., Apostolovic D., Taylor S.L., Baumert J.L., Koppelman S.J. (2020), Effect of heat treatment on the conformational stability of intact and cleaved forms of the peanut allergen Ara h 6 in relation to its IgE-binding potency, *Food Chemistry*, 326, 127027, https://doi.org/10.1016/j.foodchem.2020.127027

Dubinina A.A., Lenert S.O., Khomenko O.O., Cherevychna N.I. (2017), *Study of the chemical composition and the quality assessment of peanut varieties adapted for cultivation in Ukraine*, KhDUHT, Kharkiv.

Grasso N., Alonso-Miravalles L., O'Mahony J.A. (2020), Composition, physicochemical and sensorial properties of commercial plant-based yogurts, *Foods*, 9(3), 252, https://doi.org/10.3390/foods9030252

Grek O., Pshenychna T., Tymchuk A., Savchenko O., Ochkolyas O. (2020), Research of quality indicators in protein-blueberry concentrates, *Potravinarstvo Slovak Journal of Food Sciences*, 14, pp. 156–163, https://doi.org/10.5219/1255

Kumari M., Kokkiligadda A., Dasriya V., Naithani H. (2022), Functional relevance and health benefits of soymilk fermented by lactic acid bacteria, *Journal of Applied Microbiology*, 133(1), pp. 104-119, https://doi.org/10.1111/jam.15342

Lehnert S.O., Khomenko O.O., Dubinina A.A., Malyuk L.P., Skyrda O.Y., Radchenko A.E. (2019), Development of peanut quality criteria for determination of its rational use, *Science and Innovation*, 15(5), pp. 23–33. https://doi.org/10.15407/scine15.05.023

Letizia F., Fusco G.M., Fratianni A., Gaeta I., Carillo P., Messia M.C., Iorizzo M. (2024), Application of *Lactiplantibacillus plantarum* LP95 as a functional starter culture in fermented tofu production, *Processes*, 12(6), 1093, https://doi.org/10.3390/pr12061093

Lopes M., Pierrepont C., Duarte C.M., Filipe A., Medronho B., Sousa I. (2020), Legume beverages from chickpea and lupin, as new milk alternatives, *Foods*, 9(10), 1458,

https://doi.org/10.3390/foods9101458
Novik A., Lapytska N., Lystopad T., Boychenko P., Savchenko A. (2022), Development of the technology of a high-protein fermented drink on a plant basis, *Biota. Human. Technology*, 1(2), pp. 93–105, https://doi.org/10.58407/bht.2.22.7
Olajuyigbe F.M. (2013), Optimized production and properties of thermostable alkaline protease from *Bacillus subtilis* SHS-04 grown on groundnut (*Arachis hypogaea*) meal, *Advances in Enzyme Research*, 01(04), pp. 112–120, https://doi.org/10.4236/aer.2013.14012
Onopriichuk O., Grek O., Tymchuk A. (2022), Influence of malt properties on the indicators of milk-protein concentrates, In: O. Paredes-López, O. Shevchenko, V. Stabnikov, V. Ivanov (Eds.), *Bioenhancement and Fortification of Foods for a Healthy Diet*, pp. 179-202, CRC Press, Boca Raton, London, https://doi.org/10.1201/9781003225287-12
Osthoff G., Hugo A., van Wyk P., de Wit M., Meyer S. (2010), Characterization of a spray-dried soymilk powder and changes observed during storage, *Food Science and Technology International*, 16(2), pp. 169–178, https://doi.org/10.1177/1082013209353236
Oyeyinka A.T., Odukoya J.O., Adebayo Y.S. (2019), Nutritional composition and consumer acceptability of cheese analog from soy and cashew nut milk, *Journal of Food Processing and Preservation*, 43(12), e14285, https://doi.org/10.1111/jfpp.14285
Rasane P., Jha A., Sabikhi L., Kumar A., Unnikrishnan V.S. (2013), Nutritional advantages of oats and opportunities for its processing as value added foods - a review, *Journal of Food Science and Technology*, 52(2), pp. 662–675, https://doi.org/10.1007/s13197-013-1072-1
Sakthi T.S., Meenakshi V., Kanchana S., Vellaikumar S. (2020), Study on standardisation and quality evaluation of peanut milk by different processing methods, *European Journal of Nutrition & Food Safety*, pp. 60–72, https://doi.org/10.9734/ejnfs/2020/v12i530228
Sales J.M., Resurreccion A.V. A. (2013), Resveratrol in peanuts, *Critical Reviews in Food Science and Nutrition*, 54(6), pp. 734–770, https://doi.org/10.1080/10408398.2011.606928
Seong G.U., Kim J., Kim J., Park S., Cho J.H., Lee J.Y., Lee S.B., Shin D., Park D.S., Moon K.D., Kang J.W. (2022), Quality characteristics of plant-based rice milk prepared with different rice varieties, *Korean Journal of Food Preservation*, 29(3), pp. 395–406, https://doi.org/10.11002/kjfp.2022.29.3.395
Sethi S., Tyagi S.K., Anurag R.K. (2016), Plant-based milk alternatives an emerging segment of functional beverages: A review, *Journal of Food Science and Technology*, 53(9), pp. 3408–3423, https://doi.org/10.1007/s13197-016-2328-3
Siva Sakthi T., Meenakshi V., Kanchana S., Sampathrajan V., Mastanjevic K., Strossmayer J.J. (2021), Effect of different processing methods on the nutritional composition and antinutritional factors of peanut milk, *Madras Agricultural Journal*, 108(1-3), pp. 101-106, https://doi.org/10.29321/maj.10.000492
Skuibida V., Onopriichuk O., Tymchuk A., Soloviov N., Grek O. (2022), Quality indicators of multicomponent dairy-vegetable concentrates, *Ukrainian Food Journal*, 11(2), pp. 247-258, https://doi.org/10.24263/2304-974X-2022-11-2-5
Slyvka N.B., Bilyk O.Y., Mikhailytska O.R., Nagovska V.O. (2019), Improvement of technology of curd products with succade from pumpkin, *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies*, 21(92), pp. 47–

52, https://doi.org/10.32718/nvlvet-f9209
Souza F.R.M., Santos N.G.S., Padilha D.M.M., Bezerra D.S., Felipe M.B.M.C., Ramalho H.M.M. (2020), Probiotic fermented milk drink added with cashew pulp (*Anacardium occidentale*): Formulation, physicochemical, microbiological and sensory characteristics, *Research, Society and Development*, 9(8), e990986753, https://doi.org/10.33448/rsd-v9i8.6753
Stabnikova O., Marinin A., Stabnikov V. (2021), Main trends in application of novel natural additives for food production, *Ukrainian Food Journal*, 10(3), pp. 524–551, https://doi.org/10.24263/2304-974X-2021-10-3-8
Vishwanathan K.H., Singh V., Subramanian R. (2011), Wet grinding characteristics of soybean for soymilk extraction, *Journal of Food Engineering*, 106(1), pp. 28–34, https://doi.org/10.1016/j.jfoodeng.2011.04.002
Zhang Q., Wang C., Li B., Li L., Lin D., Chen H., Liu Y., Li S., Qin W., Liu J., Liu W., Yang W. (2017), Research progress in tofu processing: From raw materials to processing conditions, *Critical Reviews in Food Science and Nutrition*, 58(9), 1448–1467, https://doi.org/10.1080/10408398.2016.1263823
Zhang X., Zhang C., Xiao L., Wang S., Wang X., Ma K., Ji F., Azarpazhooh E., Ajami M., Rui X. (2023), Effects of *Lactiplantibacillus plantarum* with different phenotypic features on the nutrition, flavor, gel properties, and digestion of fermented soymilk, *Food Bioscience*, 55, 103026, https://doi.org/10.1016/j.fbio.2023.103026

Cite:

UFJ Style

Onopriichuk O., Skuibida V. (2024), Improvement of fermented dairy-plant concentrate technology, *Ukrainian Journal of Food Science*, 12(2), pp. 117–130, https://doi.org/10.24263/2310-1008-2024-12-2-4

APA Style

Onopriichuk, O., & Skuibida, V. (2024). Improvement of fermented dairy-plant concentrate technology, *Ukrainian Journal of Food Science*, *12*(2), 117–130. https://doi.org/10.24263/2310-1008-2024-12-2-4