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SCIENTIFIC SUBSTANTIATION OF THE USE OF PLANT PROCESSING DERIVATIVES FOR ENRICHMENT OF FERROUS MILK DRINKS

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Abstract

Derivatives from plant processing are generally classified as industrial waste. Despite their biological properties, they are mostly recycled or used in the production of animal feed. Given the rapid growth of the world's population and the increased interest of consumers in plant foods, it is advisable to use plant by-products as nutritional supplements with certain functional properties. The purpose of the study is to substantiate the possibility of using sesame flour and rice bran as fillers in the production of fermented milk drinks. Formulas were developed for fermented milk drinks enriched with sesame flour in the amount of 2 % and rice bran – 1 %. The amount of additives was determined taking into account the optimal organoleptic indicators. The study showed that the addition of additives increased the content of dietary fiber in a product enriched with rice bran, up to 0.3 %, and up to 0.7 % in a fermented milk drink with sesame flour. The antioxidant properties of a fermented milk drink enriched with sesame flour were studied. Antioxidant properties were determined by the level of DPPH radical scavenging activity. The results of the study showed that the highest DPPH radical scavenging activity (1.82 mg/ml) was observed in the enriched sample on day 7 of storage. On the 14th day of storage in the control sample, the activity decreased to 1.55 mg/ml, while in the sample with sesame flour its value was at the level of 1.75 mg/ml. Thus, it can be argued that the investigated plant by-products can be used as additives to increase the content of dietary fiber and increase the shelf life of products.

Keywords: vegetable by-products, derivative processing, industrial waste, sesame flour, rice bran.

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1. Introduction

Given the rapid growth of the world's population and the increased interest of consumers in plant foods, the consumption of vegetables, berries and grains has increased. According to the latest data from the World Food and Agriculture Organization (FAO), over the past decades, the world production of fruits, vegetables and cereals has reached very high levels. The demand for food will continue to grow [1].

In the process of processing vegetable raw materials, a large number of by-products are formed that are not used in the production process and are classified as industrial waste [2].

The remains of raw materials and materials formed during the production process and not lost their consumer value can be used as food additives or a source of valuable nutrients. The larger the volume of production, the more derivative products and waste are generated [3].

Despite the fact that secondary material resources contain a large number of bioactive components, most of them are used for animal feed or must be disposed of by composting and incineration. Innovations in the field are focused on using plant by-products as natural antioxidants, preservatives and nutritional supplements. Husk, bran and germ are the main industrial waste products of cereals. Such waste can be recycled and turned into value-added products [4].

Wastes from the processing of vegetable raw materials are among the most used in the world. Food waste is now considered as a cheap source of valuable components, since existing technologies make it possible to withdraw target compounds and use them within the food chain as functional additives in various products [5].

Since industrial waste contains useful nutrients that can be extracted and used in various products, some researchers use the term "by-product" or "co-product" to refer to food waste [6].

After extraction of sesame oil, a fat-free sesame meal is formed, containing 50 % protein, high calcium content (1.5 g/100 g), and crude fiber (10.8 g/100 g). Cake is a type of by-product commonly discarded or used as animal food in the form of sesame flour [7].

Sesame flour contains phenolic compounds that exhibit antioxidant, antimutagenic and antimicrobial activity [8, 9]. Other nutraceutical compounds present in sesame flour are lignans and some minerals such as: potassium (4.6–5.3 g/kg), phosphorus (1.7–2.3 g/kg) and magnesium (0.018–0.052 g/kg) [10].

Another valuable material is rice bran. The processing of coarse rice produced to produce milled edible rice produces by-products including rice husk (20 %), rice bran and germ (10 %) [11].

It is known that rice flour contains higher polysaccharides-cellulose, mucous membranes, hemicelluloses, pectin substances, which can act as functional substances. At the same time, rice flour is a source of vitamins and minerals; its use can significantly increase the nutritional value of baby food dairy products [12].

At present, most of the rice husk produced is not used for any other applications due to its high silicon content and rapid degradation by bacteria. However, rice bran is a very rich source of γ-oryzanol, ferulic acid, phytosterols, tocols, γ-aminobutyric acid and phytic acid. These biocomponents have cardiometabolic protective properties [13].

Rice bran protein is a kind of high-quality protein, has the appropriate amino acid composition and high biological effect, the content of lysine reaches 5.8 g/100 g. According to a study [14], defatted rice bran contains (% dry base): carbohydrates (43.5–54.3 %), proteins (14.1–18.2 %), fats (1.6–20.9 %), ash (12.8–15.3 %), fiber (8.4–10.5 %).

Every year, 90 % of rice bran produced in the world is used cheaply as feed for cattle and poultry, and the rest is used to extract rice oil [15].

Given the organoleptic, physical and chemical properties of sesame flour and rice bran, it is advisable to use them as food additives in the production of fermented milk drinks. Sour-milk drinks contain all the nutrients the body needs, except for dietary fiber. The introduction of additives containing dietary fiber will make the fermented milk drink balanced in composition.

Thus, the aim of research is to substantiate the possibility of using sesame flour and rice bran as fillers in the production of fermented milk drinks.

To achieve this aim, it is necessary to solve the following objectives:

– develop a recipe for fermented milk drinks enriched with sesame flour and rice bran;

– investigate the content of dietary fiber in fermented milk drinks enriched with sesame flour and rice bran;

– investigate the antioxidant properties of fermented milk drinks enriched with sesame flour.

2. Materials and methods

2. 1. Sample preparation

Milk with a fat content of 2.5 % was used to prepare the studied samples. Milk pasteurized at 90–92 °C with holding for 2–3 min and cooled to temperature fermentation 20–22 °C. Fungal leaven was used for leavening in the amount of 2 % to the mass of milk. Part of the milk was used to prepare a suspension of defatted sesame flour (**Fig. 1, *a***), rice bran (**Fig. 1, *b***). For this, the additive was added to the milk in a ratio of 1:10 at a temperature of 90 °C, thoroughly mixed for 10 minutes. The resulting suspension was added to pasteurized milk before fermentation.

a *b*

Fig. 1. Derivatives of plant processing: *a* – sesame flour; *b* – rice bran

Through preliminary studies [16, 17], the optimal amount of sesame flour and rice bran additives was determined, at which the organoleptic and physicochemical properties of the finished product were preserved.

The formulation of the studied samples is presented in **Table 1**.

Duration of fermentation was 9 hours. Fermentation was carried out by the tank method. The finished product was thoroughly mixed, cooled to 8 °C and left to ripen for 12 hours. After ripening, antioxidant properties were studied and dietary fiber content was determined. The research was carried out for 28 days.

Table 1

Recipe of the studied samples of fermented milk drinks

Raw	Amount of raw materials, %		
	Control sample	Sample 1	Sample 1
Cow's milk	100.0	99.0	98.0
Rice bran	–	1.0	–
Defatted sesame flour	–	–	2.0
Sourdough	2.0	2.0	2.0

2. 2. Determination of dietary fiber content

Dietary fiber was measured according to official AOAC method 991.43 [18]. Dried samples were digested with heat stabilized α-amylase, protease and glucosidase to remove protein and starch. After precipitation with ethanol and filtration, the residue was washed with ethanol and acetone, dried and weighed, which was the total dietary fiber residue.

The total dietary fiber content of the sample was calculated by subtracting the respective protein, ash, and reagent blanks from the dietary fiber residue. For the test, a dietary fiber determination system (CSF6, Italy) was used.

Determination of dietary fiber (DF, g/100 g):

$$TDF=\{[(R_1+R_2)/2]-P-A-B\}/[(M_1+M_2)/2]\times 100, \quad (1)$$

where R_1 and R_2 are the masses of residues (mg) for duplicate samples; P and A are the masses (mg) of protein and ash, respectively, determined for the first and second residues; B is empty weight (mg); M_1 and M_2 are the weights (mg) of the samples.

2. 3. Determination of the antioxidant properties of fermented milk drinks enriched with sesame flour

Analysis of information sources showed that sesame flour has antioxidant properties. Given this fact, a study was made of the antioxidant properties of fermented milk drinks with the addition of sesame flour.

Antioxidant properties were determined by the level of DPPH radical scavenging activity. To determine the radical scavenging activity of DPPH, 1 g aliquots of each sample were diluted 1:9 (sample: anhydrous ethanol). The solvent was centrifuged at 4000 rpm for 10 minutes in an L550 centrifuge.

Next, 2 ml of the supernatant was placed in Eppendorf tubes with 2 ml of an aqueous solution of 9.0 mmol/l $FeSO_4$, 2 ml of a salicylic acid ethanol solution of 6 mmol/l, and 2 ml of an aqueous solution of 1 mmol/l of H_2O_2. The reaction mixtures were homogenized and heated in a water bath at 37 °C for 30 minutes. The curve was plotted using a standard solution of vitamin C, the optical density was determined on a Thermo Fisher Evolution 300 spectrophotometer at 510 nm.

3. Results

3. 1. The results of the determination of dietary fiber in fermented milk drinks

Instead of food fibers in sour-milk drinks enriched with low-fat sesame boar and rice whiskers, it is shown in **Table 2**

Table 2

The content of dietary fiber in different samples

Samples	Control sample	Samples added with 1 % RB	Samples added with 2 % DSC
Content of fiber, %	–	0.3	0.7

The introduction of RB and DSC has significantly improved the dietary fiber content of fermented milk drinks. With an increase in the amount of additives added, the fiber content increases.

3. 2. The results of the study of the antioxidant properties of fermented milk drinks enriched with sesame flour

When studying antioxidant properties, it is necessary to construct a standard curve expressing the relationship between absorption values and vitamin C content (mg/ml). A standard curve was prepared using a vitamin C standard solution and absorbance was read using a spectrophotometer (Thermo Fisher Evolution 300, USA) at 517 nm. The data are shown in the following **Table 3.**

The standard curve expresses the relationship between absorbance values and vitamin C content (mg/ml) shown in **Fig. 2.**

Table 3

Relationship between absorption value and vitamin C content (mg/ml)

Absorption	Vitamin C content (mg/ml)
0.441	0.015
0.393	0.025
0.343	0.035
0.29	0.045
0.251	0.055

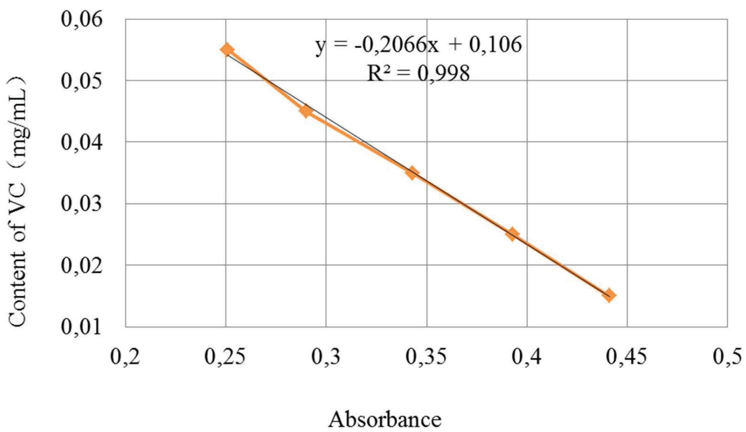

Fig. 2. Standard curve showing absorption between absorption values and instead of vitamin C

When determining the antioxidant capacity of the samples, the diluted sample showed an absorbance value according to the experimental method, the absorbance value reflected the antioxidant capacity of the diluted sample according to the standard formula:

$$y=-0.2066x+0.106, \quad (2)$$

where y is the absorption value; x is the vitamin C content (mg/ml) and the dilution factor and volume, the absorbance value will be converted to vitamin C equivalent in mg.

DPPH radical scavenging activity is the most common method for measuring the antioxidant capacity of natural extracts. The antioxidant properties of fermented milk drinks are shown in **Fig. 3.**

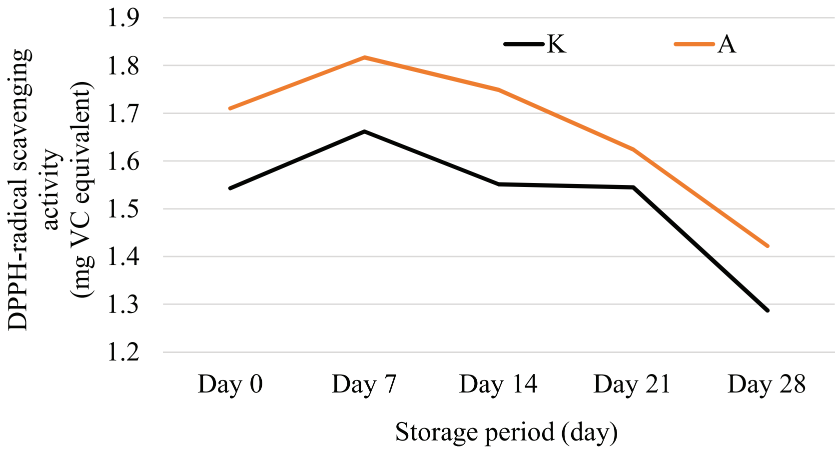

Fig. 3. DPPH-radical scavenging activity in test samples

It was found that the introduction of sesame flour significantly increased the levels of scavenging activity of DDPH radicals. High antioxidant activity was observed on the 7th day of storage.

4. Discussion

Sesame and rice derivatives contain dietary fiber. Their introduction into the composition of a fermented milk drink increases the content of dietary fiber. The rice bran-enriched drink contains 0.3 % dietary fiber. In a fermented milk drink with sesame flour – 0.7 %. Their addition to fermented milk drinks in a small amount allows to balance the product for all the nutrients necessary for the body. Similar results were obtained by other researchers who studied the influence of vegetable raw materials on the content of dietary fibers in fermented milk products [19]. Previous studies have also demonstrated that kefir as a probiotic [20, 21] and dietary fiber had a potential prebiotic effect [22, 23]. Dietary fibers have high water-retaining properties, which positively affect the preservation of the structure of the product during storage, prevents the separation of whey.

The results of the study showed that the highest DPPH radical scavenging activity (1.82 mg/ml) was observed in the enriched sample on day 7 of storage. On the 14th day of storage in the control sample, the activity decreased to 1.55 mg/ml, while in the sample with sesame flour its value was at the level of 1.75 mg/ml. This indicates that some antioxidant components in sesame flour improve the antioxidant properties of fermented milk drinks [8, 9]. The antioxidant properties of sesame flour are explained by the high level of sesamol [24]. Sesame oil has antioxidant capacity [25], part of it remains in sesame cake. Therefore, sesame flour is made from pomace, able to exhibit an antioxidant effect, increasing the shelf life of the product.

A limitation of this study may be the storage and preparation before use of the by-products. It is very important to prepare a quality suspension, without lumps, to form a uniform texture of the fermented drink. To do this, it is necessary to include a tank equipped with a paddle or propeller agitator in the production scheme.

The study involved the production of a fermented milk product such as kefir. It is planned to consider the possibility of using by-products (sesame flour and rice bran) in the production of yoghurts, curd desserts and milkshakes.

5. Conclusions

A recipe for fermented milk drinks enriched with sesame flour and rice bran has been developed. Such products contain all the necessary nutrients: proteins, fats, carbohydrates, minerals, vitamins, dietary fiber.

Increasing the content of dietary fiber in fermented milk drinks can increase their functional properties. Dietary fiber has a positive effect on the development of probiotic microflora, improves the functioning of the human gastrointestinal tract.

The use of sesame flour as an additive in the production of fermented milk drinks can increase the shelf life of the product. This is due to the antioxidant activity of the supplement.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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The study was performed without financial support.

Data availability

Manuscript has no associated data.

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