Researching the possibility of using recycled apple raw materials to create functional food products

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Abstract. When developing products for healthy and functional nutrition, much attention is currently paid to domestic raw materials of natural origin: fruit, vegetables, cereals and their processed products. In our region, one of these types of raw materials is apple. Apples are a source of nutrients for the human body: vitamins, minerals, organic acids, dietary fiber and pectin. They are the raw material for a large number of fruit and berry products, fillings for flour confectionery products, juice drinks, kissels, etc. During the production of these products, the so-called «secondary raw materials» remain, which are formed as a result of grinding, peeling, squeezing, grating, pressing and other technological operations. The study investigated the effect of addition of apple pomace in dried, crushed to a powdery state, and thawed (after deep freezing) form on the fermentation activity of yeast and the technology of wheat bread production with the addition of buckwheat flour. It has been established that the quality of the finished bread depends on the type of additive: fresh-frozen apple pomace improves the porosity and taste of bread to a greater extent.

1. Introduction

One of the innovative directions in the processing of agricultural raw materials is the creation of functional and specialized products. Such products can be used in personalized nutrition for certain groups of people. Recently, scientists from many countries have found new sources of functional compounds, such as dietary fiber and biologically active compounds. Apple pomace is a by-product obtained after the production of apple juice. Researchers have previously assessed their potential to increase the nutritional value of foods, in particular cereals and / or baked goods [1-4]. These by-products are rich sources of dietary fiber (35-60%) [5]. Apple pomace is also a rich source of polyphenols, which contribute to its antioxidant capacity [6]. Wastes from the production of apple juice (pomace), which have a fairly high content of protopectin, are one of the most promising types of pectin-containing raw materials for our country. Apple pectin is obtained from marketable or dried apple pomace, which is formed when juice is squeezed from apples. The amount of pomace formed during the squeezing of juice from apples is, mass. % of the mass of raw materials: from cultivated varieties - 28-36, from wild varieties - 40. The gelatinous ability of apple pomace pectin after 3 hours of storage of raw materials decreases by 37%, and after 48 hours - by 69% [7]. Therefore, the shelf life of fresh apple pomace should not exceed 2 hours, but it can be increased by deep freezing.
Secondary raw materials (SRM), in comparison with fresh apples, contain a higher amount of fiber and a lower amount of soluble pectin substances. The most suitable apple variety is «Renet Simirenko» [8]. If you use dried apple pomace powder and freshly frozen pomace as a functional additive, you can get a functional product with desired structural and mechanical properties, with improved vitamin and mineral composition and reduced calorie content. On average, from 1 kg of apples of medium juiciness, 280-300 g of pomace is obtained. At the same time, the juice extracted is a little more than 600 g.

Dietary apple fibers of pomace, normalizing good intestinal function, help maintain normal weight. People with problems of the cardiovascular system are also advised to consume products with apple pomace, because the substances that make up their composition help to cleanse the blood. The staple food in many diets is wheat bread. It is one of the main sources of daily energy. Bread composition is the result of several factors, including wheat genotypes, agronomic processing, environmental conditions, flour composition, bread baking conditions and product storage [9]. The dynamic development of the bakery products market with a functional focus requires manufacturers to expand their range of products. One of the directions for the development of the range and the creation of new types of products is the enrichment of wheat bakery products with various types of flour and other fortifiers. Apple pomace acts as such a fortifier.

In addition to the benefits for the human body, apple pomace has a direct impact on the technological process of the production of bakery products.

The physiological state and biochemical activity of the yeast used, which is capable of fermenting sugars with the formation of alcohol and carbon dioxide, is of great technological importance in bakery production. The structure of semi-finished products, volume and shape of finished products largely depend on them [10-12].

2. Materials and methods
To determine the effect of the herbal supplement on the state and activity of baker’s pressed yeast, a number of studies were carried out. The lifting force of the pressed yeast was determined by the accelerated method. Counting the number of cells of microorganisms under a microscope was carried out using a Tom-Goryaev camera. The method is as follows: yeast is counted in liquid substrates after preliminary dilution with water. Cell counting begins after 3-5 minutes after filling the chamber. This time is enough for the cells to settle and place them in one plane. A digital electron microscope with 4x magnification was chosen for the yeast cell counting. Counting was done in 10 large grid squares. To obtain a reliable result, the total number of counted cells of microorganisms must be at least 600.

The number of cells in 1 cm³ of the initial suspension is determined by the formula

\[ M = a \times 1000 / (h \times S \times n)^{\frac{1}{3}}, \]

where \(a\) – is the average number of cells in a grid square; \(h\) — chamber depth, mm; \(S\) – is the area of the grid square, mm²; \(n\) – is the dilution of the original suspension; 1000 mm³= 1 cm³ [13].

When preparing nutrient mixtures, the powder and frozen pomace were poured with water at a temperature of 35 °C and mixed in order to ensure a more complete extraction of soluble substances. The yeast was kept at 33–35 °C for 30 min. The lifting force of the yeast improved and decreased from 12 (no activation) to 7 min. Studies have shown that increasing the dose of raw apple is unnecessary, because this biological index of activated yeast is not significantly improved. As a result of yeast processing by adding frozen apple pomace and apple pomace powder, the \(\alpha\)-glucosidic activity of yeast changes and this process takes 90 minutes. Since apple pomace contains a significant amount of mono-saccharine and sucrose, a change in the vital activity of the yeast cell occurs. To increase the biological activity of pressed yeast cells, they were dissolved in water with apple pomace introduced into it. Powder in the amount of 0.35–0.375% of the flour mass in the dough was poured with water (8–10%) at 34–35 °C and stirred intensively for 3–5 min. Pressed baker's yeast was added to the resulting mixture, stirred until a homogeneous suspension was formed, and kept for 30–60 min. at a temperature of 33–34 °C [14].
3. Results
The formula was used to determine the number of cells in 1 cm³ of the initial suspension:

- for the control sample:
  \[ M_{K} = 31.9 \cdot 1000 / (0.1 \cdot 0.04 \cdot 1000)^{-1} = 7975 \text{ cells/cm}^3 \]
- for a sample with the addition of apple pomace powder:
  \[ M_{1} = 66.8 \cdot 1000 / (0.1 \cdot 0.04 \cdot 1000)^{-1} = 16700 \text{ cells/cm}^3 \]
- for a sample with the addition of fresh frozen apple pomace:
  \[ M_{2} = 61.6 \cdot 1000 / (0.1 \cdot 0.04 \cdot 1000)^{-1} = 15400 \text{ cells/cm}^3 \]

From the obtained calculations, it can be concluded that the introduction of apple raw material helps to accelerate the growth of yeast cells. This action can be used to activate yeast and shorten the process.

Taking into account the favourable influence of apple raw material on the vital activity of yeast cells, it was proposed to change the recipe (table 1): replace sugar with apple raw material; reduce the amount of wheat flour by replacing it with buckwheat flour and apple raw materials (table 2).

| Table 1. Recipe for a control sample of wheat bread. |
|---------------------------------------------------|
| Raw material composition | Rate (net) per serving |
|--------------------------|------------------------|
| Baking wheat flour, g    | 160                    |
| Water, ml                | 110                    |
| Yeast, g                 | 5.5                    |
| Vegetable oil, ml        | 10                     |
| Sugar, g                 | 5                      |
| Salt, g                  | 2.5                    |

| Table 2. Originally developed recipe and norms of raw material. |
|---------------------------------------------------------------|
| Raw material composition | Rate (net) per serving |
|--------------------------|------------------------|
|                          | Apple pomace powder    | frozen Apple pomace   |
| High-grade baking flour  | 120                    | 120                   |
| Buckwheat flour          | 40                     | 40                    |
| Pressed yeast            | 5.5                    | 5.5                   |
| Water, ml               | 150                    | 145                   |
| Vegetable oil, ml       | 10                     | 10                    |
| Apple pomace             | 10                     | 5                     |
| Salt, g                  | 2.5                    | 2.5                   |

When developing a recipe for wheat bread with buckwheat flour and apple pomace, a standard production technology was used without fermentation.

According to the standard technology, samples of bread were baked, in which a number of shortcomings were revealed in such operations as fermentation, proofing and baking, which affected the organoleptic characteristics and acidity of the bread. As a result of test production of bread, using the recipe presented in table 2, during the evaluation it was found that the bread has an oblong-oval shape, not glutinous without imprints. The surface of the bread has small cracks, no visible tears, no pricks or cuts. The colour of the bread in the sample with apple pomace powder is yellow. Bread with fresh frozen pomace has a light yellow-grey colour. The crumb is baked, not wet to the touch, after pressing it takes its original shape. No lumps and traces of impurities. The porosity is undeveloped, without voids, compacted. The bread has a pronounced smell and taste of buckwheat, and the aftertaste also retained an acidic taste for a long time. The smell is characteristic of buckwheat. In terms of organoleptic
characteristics, the bread made according to the recipe presented does not meet the requirements of GOST R 58233–2018.

Thus, it was necessary to make adjustments to the technological process of bread production with the addition of apple raw materials, reducing the time for kneading the dough to 2 minutes. Initially, for a sample with freshly frozen apple pomace, thawed apple pomace was pre-soaked in a mixture of vegetable oil and warm water (water temperature 28–30 °C). With stirring, the mixture was brought to a uniform consistency. It stood for 2-3 minutes. At the same time, the whole amount of flour, salt, yeast was mixed for 2 minutes. Then the prepared mixture was added to the dough. After kneading, the dough was fermented in a rotating hopper with a cone-shaped bottom for 5–7 minutes. In this case, the dough temperature rose to 30 °C. Then the kneading was carried out, after which the fermentation process continued for another 5–7 minutes. In the classical method of the technological process, two portions are provided without fermentation. The buckwheat flour used in the recipe has a low gluten content. Therefore, the dough was kneaded only once. To increase the acidity of the bread and reduce the fermentation process, a larger amount of yeast and apple raw materials are introduced into the recipe. This made it possible to reduce the fermentation process by 1 hour 45 minutes from the standard 2 hours. Next, bread was moulded with a weight of 150 g each. Semi-finished products for proofing were placed in a special chamber for 20 minutes. The bread proofing process was carried out at a temperature of 34–35 °C. As a result, the dough increased in volume. Before baking, the surface of the semi-finished products was sprinkled with flour. Bread was baked in baking ovens at 195–205 °C. The baking time was 20 minutes. The baked bread was gradually cooled at room temperature.

The optimal content of all components in the samples with apple pomace powder and fresh frozen apple pomace in baked bread was determined experimentally. In the course of research, when baking pilot batches of samples, the optimal ratios of components were established in terms of organoleptic and physicochemical indicators.

In the first sample, 50 g of premium wheat flour was replaced by 20 g of buckwheat flour and 30 g of apple pomace powder, respectively, and the amount of water was increased by 10 ml. In the second sample, 50 g of premium wheat flour was also replaced with 20 g of buckwheat flour and 30 g of freshly frozen apple pomace, respectively, the amount of water was reduced by 35 ml and brought to 110 ml, the rest of the components in the recipe did not change. These ratios were chosen because there is no deterioration in the consumer properties of bread: the products are given functional properties and good taste [15].

4. Conclusion
During the research on the development of recipes for bakery products with the addition of apple raw materials, the following conclusions were made:

- SRM, which are apple pomace powder and fresh frozen pomace, represent a biologically valuable additive;
- the studied SRM increase the fermentation activity of yeast by 1.5-1.8 times;
- the amount of yeast must be increased to 3-4%, in contrast to the 1-2% introduced in the control sample;
- the degree of influence of apple products on the technological process and the quality of bread depends on the type of product introduced into the dough (apple powder or frozen pomace) and its amount;
- apple products stimulate (apple powder or frozen pomace) the dough fermentation process;
- apple pomace reduces the duration of the maturation of the dough and the proofing operation;
- the quality of the finished product depends on the type of additive: freshly frozen apple pomace improves the porosity and taste of bread to a greater extent.
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