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Study of Effect of Plant Additives on Baking Properties of Flour and Quality Indicators of Bakery Products

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1. SUMMARY

We studied functional properties of whole fenugreek seeds Trigonella foenum graecum L., black cumin seeds Nigella sativa, stevioside (steviosides) and their effect on organoleptic, physical, and chemical properties of bakery products made from wheat flour. Due to the wide range of useful components, fenugreek, black cumin, and stevioside possess hypoglycemic, antimicrobial, anti-inflammatory, anabolic, anticoagulant, and antioxidant properties. The aim of the work was to develop functional bakery products and to study quality indicators of white bread made from wheat flour with partial replacement of wheat flour with fenugreek seeds, black cumin seed flour, and replacement of sugar with stevioside. The following samples were under study: the control sample, samples with 2 and 2.5% fenugreek seeds, 1 and 1.5% black cumin seed flour in relation to the weight of wheat flour, as well as with the complete replacement of granulated sugar with stevioside.

2. Introduction

Using plant components in bakery products contributes to the expansion of variety of new-generation functional food products.

2.1. Fenugreek (Trigonella foenum graecum L.)

It is an annual herbaceous plant of *Fabaceae Lindl.* family with an upright subramose stem up to 40–70 cm high (***Figure 1***). Fenugreek blooms in June and July, the pod is 9-15 cm long, 3-5 mm thick, slightly hairy or without any hairs, containing 10-18 seeds. The seeds are yellowish, large, rhombic, with a peculiar nutty odor (***Figure 2***). The seeds ripen in August and September. Fenugreek originated in the eastern part of the Mediterranean and has been well known since ancient times as a valuable feeding, food and medicinal plant. It is grown in Southern and Central Europe, India, China, South Africa, Ethiopia, and America and used as an aromatic spice and as feed. In the CIS (Commonwealth of Independent States), it is cultivated in Ukraine and Kyrgyzstan.

According to the works of domestic and foreign scientists, this plant contains a wide range of useful ingredients.

Fenugreek seeds contain 20-30% of proteins rich in methionine, arginine, alanine, glycine, but poor in lysine, and up to 4% of peptides. The peptides contained in the seeds are of a cationic nature and have pronounced antimicrobial and fungicidal activity **[1]**.

Seeds contain up to 45-60% of carbohydrates characterized by a pronounced accumulation of galacturonic acid (more than 65% of the total composition), which is comparable with the well-known commercially produced citrus and apple pectins **[2]**.

The fatty oil content is 7–10%, with 65% of neutral lipids (of which oleic acid derivatives account for more than 17%), 28% of glycolipids, and 7% of phospholipids.

Fenugreek seeds are rich in steroidal saponins (up to 6%), namely, diosgenin, tigogenin, yamogenin, and their glycosides.

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Small amounts of trigonellin alkaloid (0.3%), nicotinic acid (3.5–18 mg%), phytosterols, bitter substances, essential oils (0.3%), tannins, vitamins A, B_1, C, minerals substances, etc., were found **[3]**.

A group of scientists conducted studies proving the antioxidant and antitumor properties of fenugreek. Most of these studies were performed in vitro on various tumor cell lines **[4], [5]**.

2.2. Black cumin (Nigella sativa)

Black cumin or otherwise known as black-caraway (*Nigella sativa*) is an annual herbaceous plant of the ranunculaceous family, 10–40 cm tall with an upright branching stem (***Figure 3***). It is cultivated around the world as a spice. *Nigella sativa* seeds are black in color and usually have a pyramidal shape. The seeds are 1.5–3 mm long, uniform in size, shape, and texture **[6]**.

Numerous of foreign studies of *Nigella sativa* have proved antioxidant, antidiabetic, immunomodulatory, hepatoprotective, anticancer, and other properties in its components **[7]**.

The antioxidant properties of *Nigella sativa* are explained by a large number of pharmacologically active quinones, such as thymoquinone, dithymoquinone, thymohydroquinone, and thymol. All of these compounds have pronounced antioxidant and antimicrobial properties, anti-inflammatory effects, boost the immunity, lower blood glucose, and stimulate digestion **[8]**.

2.3. Stevioside

Stevioside is a glycoside from an extract of plants of the genus Stevia. It was extracted by French chemists M. Bridell and R. Livier in 1931. Stevia *(Stevia rebaudiana)* is a perennial herbaceous, annually flowering plant of the genus *Stevia*, which includes more than 180 species, of the family *Compositae (Asteriaceae)* **[9]**.

Stevioside has several advantages over sucrose:

- Coefficient of sweetness of the powder is 180 units;
- Low energy value;
- Solubility;
- Much softer sweetness than sucrose;
- Enhanced sweetness when combined with salts and organic acids;
- Absence of darkening in case of prolonged heat treatment;
- Not digested by microorganisms;
- Stability at high temperatures (100 °C) and in a wide pH range of 3-9 **[10]**.

Numerous studies have shown that regular consumption of stevioside leads to the decrease of radionuclides and cholesterol content in the body, better cell regeneration and blood coagulation, inhibition of neoplasm growth, strengthening of blood vessels, and restoration of lipid, protein, and water-salt metabolism. Stevioside prevents the development of hypoglycemic and hyperglycemic conditions, and significantly reduces the dose of insulin for diabetics. Stevioside has antioxidant activity, immunomodulating, and bactericidal properties **[11]**.

3. Materials and methods

As the basis we used the formula of white bread made from premium wheat flour. Whole fenugreek seeds, black cumin seed flour and stevioside, which replaced the granulated sugar from the control sample, were used as additives. Fenugreek seeds and black cumin seed flour were added to the test samples in the following concentrations: 2% of fenugreek seeds and 1% of black cumin seed flour by weight of wheat flour (sample 1) and 2.5% of fenugreek seeds and 1.5% of black cumin seed flour by weight of wheat flour (sample 2). In samples 1 and 2, the specified amount of granulated sugar was replaced with stevioside.

Fenugreek seeds were soaked in water at 98-100 °C for 10 minutes. Then the water was drained and the seeds were added to the dough. The obtained samples were stored at (18±3) °C.

The studies were carried out not later than 14 hours after the end of baking. The finished product was tested for such organoleptic indicators as color, smell, taste, and appearance. The mass fraction of moisture was determined by drying a sample of the product at elevated temperature and atmospheric pressure. The relative error of the method is 0.5% with a confidence probability of p = 0.95.

The acidity of the bread was determined by neutralizing the acid contained in the sample with sodium hydroxide in the presence of phenolphthalein until a pink color appeared.

The porosity was determined by calculating the ratio of the pore volume of the crumb to the total volume of the crumb, expressed as a percentage.

The mass fraction of gluten flour was determined by washing the gluten from the dough manually and then weighing it.

The gluten viscoelasticity was evaluated by the indicators of the IDK-3M (Gluten Deformation Meter) device. The tests were carried out in accordance with the manual.

The gluten extensibility was determined with a ruler.

The yeast rising power was determined by floating up a ball of dough **[12]**.

All measurements were carried out in three replications. Statistical analysis was performed using Microsoft Excel XP and Statistica 8.0 software package. The statistical error of the data did not exceed 5% (at 95% confidence level).

4.Results and discussions

4.1. Study of Effect of Plant Ingredients on Baking Properties of Flour, Gluten, and Starch

Wheat flour of the highest grade with partial replacement of medium rye flour was selected as the object of study. The characteristics of the rye-wheat flour are presented in ***Table 1***.

At the first stage, we studied the effect of fenugreek, black cumin flour, and stevioside on the quality indicators of gluten in rye-wheat flour (***Table 2***).

The introduction of enriching ingredients in a ratio of 1:3 per 100 g of flour led to an insignificant change in the content of crude gluten in rye-wheat flour compared to the control sample, which did not significantly affect its quality.

Yeast rising power is presented in ***Table 3***.

According to ***Table 3***, the rising power of baker's yeast with plant ingredients increased, compared to the control sample, due to a large amount of nutrients in the plant ingredients (B vitamins, minerals, sugars etc.).

Indicators of extensibility and viscoelasticity of gluten are given in ***Table 4***.

The results obtained indicate that it is possible to use black cumin, fenugreek, and stevioside to improve the properties of dough, in particular when using a weak flour.

Thus, the obtained data proves a positive effect and the advisability of using plant ingredients to improve the baking properties of flour, which without doubt will have a positive effect on the quality of products.

Table 4 shows that the gluten of flour with the introduction of plant ingredients was medium in extensibility. Such gluten has good elasticity and is considered the best in quality. Bread baked from such flour has a good quality. The dough does not spread and kept its shape well.

An important technological factor in bread baking is the aptitude and biochemical activity of quick-acting (instant) dry yeast Saccharomyces cerevisiae, capable of fermenting sugars with the formation of alcohol and carbon dioxide. The yeast viability and rising power preconditions the structure for semi-finished products, the volume and shape of the finished bakery products. In this concern, it is necessary to study the effect of plant ingredients on the quality indicators of baker's yeast.

The characteristics of the sample of baker's pressed yeast are presented in ***Table 5***.

The rising power of yeast was determined using the accelerated method, by floating up a ball of dough, which was kneaded with fenugreek and black cumin seed flour to 7 g of flour. We measured the time elapsed from the moment the ball was immersed until it floated up. The obtained results are given in ***Table 6***.

According to ***Table 5***, adding plant ingredients increased the rising power of baker's yeast, compared to the control sample, which is partially due to the presence of a large amount of nutrients in the plant ingredients.

Thus, sample 1 compared to the control sample saw a 28.3% increase in rising power, sample 2 compared to the control sample – 23.9%, sample 3 compared to the control sample – 17.2%. The table suggests that the more plant ingredients are introduced, the longer the rising power is in action.

4.2. Organoleptic, Physical, and Chemical Characteristics of Finished Products

Figures 4 and 5 show the appearance and condition of the crumb of all samples. The results of organoleptic evaluation are given in ***Table 7***.

The test samples had the normal appearance, well developed porosity, elastic crumb, pleasant spicy and nutty flavor without any bitterness, good coloring of the crust, despite the replacement of granulated sugar with stevioside. Fenugreek seeds, evenly distributed in the test samples, were visible on the cut. However, due to the introduction of black cumin seed flour, the crumb of the test samples possessed a gray color, which consumers may find unappealing. In prospect, the gray color of the crumb can be neutralized by additional components in the bread recipe. In addition, stevioside has a sweet aftertaste, which can also affect the choice of consumers. Therefore, it makes sense to reduce the amount of stevioside in the recipe.

In samples 1 and 2, compared with the control sample, there was a decrease in moisture by 0.7 and 1.3%, an increase in acidity by 0.4 and 0.6 degrees, and a decrease in porosity by 1 and 3%, respectively (***Table 8***).

A decrease in moisture can be explained by the high moisture absorbing power of black cumin seed flour.

The amount of water added to the dough should be increased.

The increase in acidity of the test samples is associated with the presence of organic acids and polyunsaturated fatty acids in fenugreek seeds and black cumin seed flour.

The porosity of the test samples was within acceptable limits and exceeded the minimum for this type of bakery product by several points. The decrease in the porosity of the test samples, as compared with the control sample, can be explained by several reasons: firstly, a decrease in the mass fraction of gluten in the dough because of the additives and loss in wheat flour mass, and secondly, changes in the structural and mechanical properties of gluten under the influence of the introduced additives, which is of interest for further research.

We chose the best samples and determined optimal dosages of whole fenugreek seeds and black cumin seed flour: 1% black cumin seeds and 2% fenugreek to the mass of flour for pan bread made from premium flour.

5. Conclusions

Organoleptic, physical and chemical studies proved that a bakery product with the addition of fenugreek, black cumin flour and stevioside had a high nutritional value and meets most people's physiological needs.

We also studied physical and chemical properties of plant ingredients, and proved their positive effect on the quality indicators of flour, baker's yeast, and the structural and mechanical properties of the dough, such as strengthening of gluten and increase in gassing ability.

The following samples were under study: the control sample, samples with 2 and 2.5% fenugreek seeds, 1 and 1.5% black cumin seed flour in relation to the weight of wheat flour, as well as with the complete replacement of granulated sugar with stevioside. As the results of physical and chemical studies, test samples showed a slight decrease in moisture and porosity, and an increase in acidity.

6. Acknowledgement

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