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ON POTENTIAL USE OF HEMP FLOUR IN BREAD PRODUCTION

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Abstract: *The aim of this research is to study the potential use of hemp flour in the production of bread with increased nutritional value. The study of the nutritional value of three types of flour is presented. A positive effect of hemp flour on replenishing the mineral value of bread has been established. Trial samples of bread contain more macronutrients and micronutrients. The offered method allows us to produce bread with an increased nutritional value, which contains 27.4% more proteins, 200.8% more fats, and 497.2% more fibers. The new technology of bread production using hemp flour helps reduce proofing time for the dough, reduce baking time.*

Key words: *bread, hemp flour, mineral content, quality, production technology.*

1. Introduction

The analysis of actual nutrition and the nutritional status assessment of the population in various regions of Russia show that the population's diet is characterized by excessive consumption of animal fats and easily digesting carbohydrates and a deficiency in dietary fibers, vitamins, pseudo vitamins, as well as macro- and micronutrients [12].

In order to solve this problem, there are currently studies on ways of creating special foods necessary not only to make up for micronutrient deficiency in the diet and support the vital functions of the human body, but also to protect it from many diseases caused by environmental impact (immune, cardiovascular, respiratory and oncology diseases and premature aging). Many countries of the world (United Kingdom, Norway, Finland, USA and others) have large scale programs for population health improvement that include bread and bread products as a solution [5]. In Russia, bread is a traditional staple food, therefore, developing and producing bread with a set chemical composition will allow us to have a big influence on the health of the population with minimal costs.

Data taken from literature on protein, mineral and vitamin value of bread supports the claim that it is one of the most valuable food products [11]. However, a deficiency of irreplaceable amino acids (lysine, threonine), macro- and micronutrients (calcium, iodine, iron etc.) and vitamins has been found in bread. Therefore, one of the most crucial tasks for

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bread producers is not only improving the quality of bread and keeping it fresh, but also increasing its nutritional value, including by enriching it with additional nutrients [1], [6], [7].

In the practice of bread making, various food additives are used for this purpose, including those received from plant and animal raw materials, chemical processes, microbiological synthesis or the processing of natural materials.

Bakers in Russia and abroad widely use plant-based food additives that help enrich wheat flour with certain irreplaceable amino acids, fiber, vitamins, and micronutrients. For example, the works [15] show the suitability of adding 50–70% triticale flour to wheat flour to enrich bread products with irreplaceable amino acids. However, the use of triticale flour in baking is made difficult by its heightened autocatalytic activity and low gluten quality that is why the authors advise using apple pectin extract as an improving agent. The work suggests using lentil and bean flour as a protein additive. The resulting bread product contains 1.7 times less starch and 2.6 times more irreplaceable amino acids and enriches the bread with micronutrients (potassium, calcium, magnesium, iron, and phosphorus) and B vitamins. The authors of [10] recommend using wheat bran (15% of the total flour mass) and barley or corn flour (10% of the total flour mass) in the recipe. Following that, dietary fiber content is increased by 2 times, micronutrient content (potassium, calcium, magnesium, phosphorus, and iron) — by 1.8 times, and vitamin content (B1, B2, PP) — by 1.3 times. This bread can be included in the diet to prevent cardiovascular diseases and metabolic disorders and to strengthen immunity. In the work [2] the possibility of including 5 to 10% of different types of grains (rice, millet, crushed buckwheat) to the “Grain” bread recipe made from top-grade wheat flour is studied. Amaranth grains are a source of lysine, unsaturated fatty acids (oleic, linoleic and linolenic), carotenoids, flavonoids (quercetin, rutin, tripholine), vitamins (B1, B6, C, E) and dietary fibers. In foreign practice a method of bread production using wholemeal flour with herbs, different fruits and green algae is used [9]; bread is also made from blended wheat and rye flour with the addition of nut kernels and nut oil [14]; bread with high dietary fiber content is made by adding bran, oleiferous plant extraction cake, flour from other grain crops, and dried whole apple powder to the recipe. Bread made with dried apple powder is noted for hardening slower and a pleasant fruity taste [13].

Other examples of using plant-based raw materials in making bread are known: banana flour is added in Latin America, dried coconut in the Philippines, citric extract in the USA, cassava fruit and potatoes in India [3]. In Poland [16] the addition of flour made from the seeds of nonalkaloid varieties of lupine to the recipes of baked goods was found promising, as it has a positive effect on the nutritional and health benefits of the product as well as their quality and preserving freshness. In Turkey [17] studies have shown the suitability of using 15% of dried ground spent grains, which are a source of dietary fiber, in cookie dough.

In this context, the aim of this study is to explore the possibilities of using hemp flour in bread production technology.

2. Material and Methods

The materials used in this study include dried and ground hemp seeds (*Cannabis sativa*); model bread samples made following the recipe [4]. As a control sample we have used bread made using a basic recipe (contents: medium rye flour, short patent wheat flour, table salt, yeast

cake, bulk starter and drinking water); as an experiment – adding 10% hemp flour by replacing an equivalent amount of short patent wheat flour used in bread making.

The content of raw oil in hemp flour was calculated by extracting it from the seeds using an appropriate solvent in the Soxhlet extractor. Ash weight percentage was calculated by burning the regrounded sample weight of the product until the substance is completely burned, followed by a quantitative measurement of the residue. Protein weight percentage was determined through the nitrogen content using the Kjeldahl method. Fiber was measured through a step-by-step application of acid solution, alkali solution and ashing the sample weight of the trial sample and a quantitative measurement of the organic residue by weight. Acidity was calculated through titration of the suspension of a sample weight of regrounded product in a 0.1 N solution of sodium hydrate with the addition of 5 drops of 1% phenolphthalein solution until it turns pink and remains pink for 1 minute.

Phosphorus, iron, magnesium and calcium content in model bread samples were determined using atomic absorption spectrophotometry [18]. Dough fermentation properties were measured by the dough rising speed in the thermostat. The dough piece is usually evaluated as ready to bake organoleptically based on the changes in volume and shape of the dough and its rheological properties. The sample's preparedness is signaled by the temperature in the center of the crumb, which should be 96–97°C in the final stage of the baking process.

All measurements were repeated three times. Statistical analysis was performed using the following software packages: Microsoft Excel XP, Statistica 8.0. Statistical error did not exceed 5% (with a 95% confidence level).

3. Results and Discussion

3.1. Method for Producing Hemp Flour

In the first stage of this study a method for producing hemp flour was developed and the resulting product's nutritional value was measured. Whole hemp seeds were cleaned from contaminants and dust in a grain separator, run through magnets to clean from metallic contaminants, washed out with tap water, sent to open grain roasters, dried for 15 minutes at a temperature of 80–90°C in the seed mass until they reached the moisture level of 8%.

Dried seeds were then cooled to room temperature and sent to the grinder to be ground into a powder. Hemp flour is a grayish-green powder with brown particles, a pleasant nutty taste and scent, and a slight crunch when chewing the outer layer particles.

For comparison we have studied the nutritional value of short patent wheat flour, rye flour, and hemp flour. The results of testing the nutritional value of the three flour types are presented in Table 1.

The nutritional value of three types of flour Table 1

Parameter name	*Test results*		
	Wheat flour	Rye flour	Hemp flour
Fat weight percentage [%]	1.9 ± 0.3	1.7 ± 0.3	24.9 ± 0.3
Protein weight percentage [%]	11.8 ± 0.7	8.8 ± 0.7	23.4 ± 0.7
Ash weight percentage [%]	2.1 ± 0.1	2.4 ± 0.1	2.9 ± 0.1
Fiber percentage [%]	*0.6 ± 0.3*	*1.2 ± 0.3*	*36.1 ± 0.3*

The increased health benefits of hemp flour are explained by the fact that it contains a high amount of insoluble and soluble dietary fiber, or crude dietary fiber, which aid the body to effectively remove wastes.

Compared to rye flour, hemp flour contains more fiber (30 times). Hemp flour also contains 20 amino acids essential for the human body, half of which are not produced by our bodies naturally. Hemp flour contains more protein than short patent wheat flour (2 times) and rye flour (2.6 times). Hemp flour is also rich in lipids, including the essential fatty acids in the omega-3 and omega-6 groups. The flour contains soluble vitamins and deficient mineral elements [8]. The listed benefits give hemp flour the qualities of an additive-enricher in foods.

3.2 Developing the Technologies for Producing Bread Using Hemp Flour

In the second stage of this study, the technology for producing bread with the addition of hemp flour was developed.

The flour (readily blended or separate medium rye and short patent wheat flour) is sifted, poured into the trough, and then mixed with hemp powder made from ground hemp seeds at the humidity of no more than 8% in the amount of 10–15% of the total flour mass, salt is added and the flour is mixed. Following that, 1/4 bulk starter is added together with a calculated amount of water and the mixture is sent to the dough kneading machine, after which the dough is made up, sent to proofing and then baked in a dampened baking chamber at the temperature of 190–200°C.

The dough is sent to make up, the dough pieces are placed in round cases, sent to proofing and then to baking. It is recommended to spray the dough pieces with water before putting them in the baking chamber.

The comparative analysis of the parameters of the technological process of bread production is supplied in Table 2.

The changes in the technological parameters are explained as follows: the fiber contained in hemp flour expands the gelatinized mass, increases the active surface, traps air bubbles caught when kneading, which increases the dough fermentation property. Enriching the dough with fat contained in hemp flour also has an effect on the technology — it increases the gas-retaining capacity and improves the crumb's structural and mechanical properties. All of the above leads to a shortened proofing time, shortened baking time and lowered baking heat, and creates higher porosity and fine pored bread crumb in the final product. The acidity of the new bread product is also lower than the control.

Parameters of dough preparation and bread baking Table 2

Parameter name	Test results	
	Bread made with a basic recipe	Bread made with the addition of 10% hemp flour
Final acidity [°H]	10–11	8–9
Dough fermentation property [min]	13–15	8–10
Proofing time of the dough pieces [min]	40–45	34–39
Baking time [min]	40–45	35–40
Baking temperature [°C]	*200–240*	*190–200*

3.3. Nutritional Value and Mineral Content of the Bread with Hemp Flour

In the third stage of this study the nutritional value and mineral value of the bread was tested. The nutritional value and mineral content of the control and trial bread samples are presented in Table 3.

For the first time, a positive effect of hemp flour on the mineral value of bread was established. Trial bread samples contain an increase in macronutrients including calcium (2.5 times), phosphorus (2 times), magnesium (1.8 times), and micronutrients — iron (51.8%).

Nutritional value and mineral content of the bread Table 3

Parameter name	Test results	
	Bread made with a basic recipe	Bread made with the addition of 10% hemp flour
Fat weight percentage [%]	1.2 ± 0.3	3.61 ± 0.3
Protein weight percentage [%]	6.5 ± 0.7	8.95 ± 0.7
Fiber weight percentage [%]	0.7 ± 0.3	4.18 ± 0.3
Calcium content [mg/100 g]	55.47 ± 4.40	138.11 ± 5.12
Phosphorus content [mg/100 g]	129 ± 26	260 ± 36
Magnesium content [mg/100 g]	47 ± 8.41	87.9 ± 9.77
Iron content [mg/100 g]	3.9 ± 5.21	8.1 ± 6.33

4. Conclusions

Hemp flour contains all minerals required by the human body: calcium, magnesium, iron, phosphorus. Crude dietary fibers aid the regulation of the gastrointestinal tract. Hemp flour contains a record amount of magnesium, which has a positive effect on the body's stress resistance. Contrary to popular opinion on the psychoactive and narcotic properties of cannabis (which really are present, but only in the stems and leaves of the plant), flour made from the seeds is completely safe and can serve as an addition to the diets of adults and children alike.

The offered method allows us to make bread with increased nutritional value, as it contains 27.4% more protein, 200.8% more fats, and 497.2% more fiber. The new bread has an enriched mineral content: calcium content is increased by 148.9%, phosphorus — by 101.5%, magnesium — by 87.1%.

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