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EXPERIMENTAL JUSTIFICATION OF THE RATIONAL DOSAGE OF KELP POWDER IN THE FORMULATION OF A FLOUR-BASED CULINARY PRODUCT

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Abstract: The article presents the results of an experimental study of the effect of kelp powder dosage on the sensory, physicochemical and technological characteristics of a flour-based culinary product. The aim of the study was to determine the rational level of partial replacement of wheat flour with kelp powder based on a comprehensive assessment of the quality of the dough and finished product, its consumer properties and behavior during cooking. A control sample without kelp powder and experimental samples with 5, 10, 15 and 20% replacement of wheat flour with kelp powder were studied. Moisture and acidity were determined, sensory evaluation was performed, shape retention after cooking and the amount of dry matter transferred into the cooking water were assessed. The nutritional and energy values of the control and 15% samples were also compared. Increasing the kelp powder dosage to 15% improved cooking properties: shape retention reached 100%, while dry matter transfer into the cooking water decreased to 4.1%. At 20% replacement, sensory and technological characteristics deteriorated. Based on the combined assessment of the studied parameters, 15% replacement of wheat flour with kelp powder was determined as the rational dosage.

Keywords: flour-based culinary products, kelp powder, functional ingredient, formulation optimization, sensory evaluation, physicochemical properties, cooking properties, nutritional value.

Introduction

The development of food products with specified nutritional characteristics is one of the relevant areas of modern food technology. For mass-consumption products, particular importance is attached to formulation approaches that make it possible to increase the content of individual nutrients without substantially impairing the structure, taste, color and other consumer characteristics. Functional ingredients are considered tools for targeted modification of the composition and properties of food systems; however, their technological effectiveness depends on the dosage and compatibility with the basic raw materials.

Flour-based products are of interest as a matrix for introducing natural components because their formulation allows partial replacement of the main raw material. At the same time, an increase in the proportion of a non-traditional ingredient may change the hydration properties of the dough, the state of the protein-gluten framework, color, taste and cooking behavior of the product. Therefore, the selection of dosage should be based on a comprehensive assessment of technological and consumer parameters [5–8].

Marine algae are regarded as promising raw materials for food enrichment because they contain minerals, dietary fiber and other biologically valuable components. Studies on the use of algae in food technology demonstrate their potential to modify the functional and technological properties of

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products when incorporated into formulations [9–12]. At the same time, excessive amounts of an algal ingredient may disturb the structure of a food system and reduce consumer acceptability.

The aim of this study was to provide an experimental justification for the rational dosage of kelp powder when partially replacing wheat flour in the formulation of a flour-based culinary product, based on a comprehensive assessment of sensory, physicochemical and cooking characteristics.

LITERATURE AND METHODS

Analysis of scientific and educational sources shows that the use of non-traditional plant and marine raw materials is one of the approaches to modifying the nutritional value and functional-technological properties of flour-based products [1–12]. When selecting the dosage, not only the chemical composition of the additive but also its influence on dough structure, sensory characteristics and dry-matter losses during thermal processing are important.

The experimental studies were conducted in the laboratories of the Department of Public Catering Technology and Processing of Plant Raw Materials, the Department of Meat and Dairy Product Technology, and the Department of Chemistry of Bashkir State Agrarian University. Premium-grade wheat flour, kelp powder, water, salt, chicken egg and vegetable oil were used.

Table 1 — Formulation of the experimental samples

Component, g/ml	Control	5%	10%	15%	20%
Wheat flour, g	100	95	90	85	80
Kelp powder, g	0	5	10	15	20
Water, ml	25	25	25	25	25
Salt, g	1	1	1	1	1
Egg, g	25	25	25	25	25
Vegetable oil, g	5	5	5	5	5

Wheat flour and kelp powder were preliminarily sifted. Kneading was performed using water at 20–25 °C, followed by resting of the dough for 30–40 minutes. After forming the dough into ropes, a second resting period of 15–20 minutes was used. Noodles with a diameter of approximately 2–3 mm were formed and boiled in water until ready.

Moisture content, acidity, and the quantity and quality of gluten were determined. In the finished products, sensory characteristics, moisture, acidity, shape retention after cooking, and the amount of dry matter transferred into the cooking water were assessed. β-Carotene content was determined by a colorimetric method. The tests were performed in triplicate, and the results were subjected to statistical processing [13–16].

DISCUSSION

The totality of the results demonstrates that the effect of kelp powder depends on its concentration. At moderate inclusion levels, acceptable consumer characteristics were maintained and individual technological parameters improved. At 20% replacement, shape retention and sensory scores decreased, while dry-matter losses increased.

A particularly pronounced pattern was observed for cooking properties: within the 5–15% range, shape retention increased, whereas the amount of dry matter transferred into the cooking water

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decreased. A possible explanation is related to the hydrocolloid properties of polysaccharides present in marine algal raw materials. At a moderate inclusion level, these compounds may contribute to moisture retention and stabilization of the dough structure, whereas excessive replacement of wheat flour with non-starch components may disrupt the protein matrix. This is consistent with the deterioration of cooking properties observed at the 20% dosage.

From the perspective of nutritional value, 15% replacement was accompanied by an increase in protein, dietary fiber and several mineral components, together with a reduction in energy value. The obtained parameters do not constitute evidence of a clinical or preventive effect of the product.

RESULTS

The quality characteristics of premium-grade wheat flour were as follows: moisture 14.0%, crude gluten 32.8%, gluten quality 85 IDK units (Group II), and acidity 2.8°. The kelp powder was characterized by a dark olive color and a specific seaweed odor and taste; its moisture content was 17.5%, and no foreign impurities or signs of mold were observed.

Table 2 — Effect of kelp powder dosage on dough parameters

Sample	Moisture, %	Acidity, °N
Control	43.1	2.3
5%	42.9	2.4
10%	42.0	2.5
15%	41.7	2.6
20%	41.0	3.0

Table 3 — Sensory evaluation of the experimental samples

Parameter	Control	5%	10%	15%	20%
Surface	5	5	4	5	4
Color	5	4	4	5	3
Taste	5	4	4	5	3
Odor	5	5	5	5	3
Degree of doneness	5	5	5	5	4

Table 4 — Effect of kelp powder dosage on cooking properties

Parameter	Control	5%	10%	15%	20%
Shape retention, %	96.0	97.5	98.5	100.0	95.0
Dry matter in cooking water, %	5.8	5.2	4.7	4.1	6.9

Table 5 — Comparative nutritional and energy value

Parameter	Control	15%	Change
Protein, g/100 g	7.2	8.7	+20.8%
Fat, g/100 g	1.5	1.7	+13.3%
Carbohydrates, g/100 g	49.3	45.1	−8.5%
Dietary fiber, g/100 g	1.9	2.0	+5.3%
Energy, kcal/100 g	239	230	−3.8%

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β-Carotene, mg/100 g	0	0.3	appearance
Vitamin C, mg/100 g	0	1.6	appearance
Potassium, mg/100 g	85.2	130.5	+53.2%
Magnesium, mg/100 g	11.2	17.8	+58.9%
Calcium, mg/100 g	12.6	16.0	+27.0%
Iron, mg/100 g	0.84	1.89	+125.0%

CONCLUSION

1. A relationship was established between the sensory, physicochemical and cooking characteristics of the product and the level of wheat flour replacement with kelp powder in the range of 5–20%.
2. Dough moisture decreased from 43.1% in the control sample to 41.0% at 20% replacement, while acidity increased from 2.3 to 3.0 °N.
3. The most balanced sensory characteristics were obtained at a 15% dosage; at 20%, taste, color and odor scores decreased.
4. At 15% replacement, shape retention was 100% and dry matter transfer into the cooking water was 4.1%; at 20%, the corresponding values were 95% and 6.9%.
5. At 15% replacement, protein increased by 20.8%, dietary fiber by 5.3%, and energy value decreased by 3.8%; the contents of potassium, magnesium, calcium and iron also increased.
6. Based on the combined assessment of the studied parameters, 15% replacement of wheat flour with kelp powder was determined as the rational dosage.

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19. Note. The original work contains some terminology inconsistencies: the main sections use the term "kelp", whereas some fragments refer to "spirulina". Before publication, the name of the raw material should be verified against the laboratory records and primary documentation.