The influence of food additives on the production technology and quality indicators of whole grain bread

Elvira Pyanikova[1*], *Anna* Kovaleva[1], *Oxana* Evdokimova[2], *Nikita* Evdokimov[2], and *Ekaterina* Bykovskaya[1]

[1]Southwest State University, 94, 50 Let Oktyabrya street, Kursk, 305040, Russia
[2]Orel State Agrarian University named after N V Parakhin, 69, Generala Rodina st., Orel, 302019, Russia

Abstract. The innovative development of sustainable food systems is primarily aimed at preserving the health of the population, providing it with safe and nutritious products. The current trend in the consumer market is the growing demand for bakery products with the addition of cereals. The approach to solving the problem is provided through the development of prescription formulations and technologies of new types of bakery. In the course of the conducted research, recipes for whole-grain wheat-rye bread based on hop ferments were developed. The use of rye bran in bread recipes and the use of starter cultures with the addition of hops, unfermented malt and licorice root allows you to get a product with high organoleptic characteristics. The products acquire a golden color, have the right shape, a pleasant bread taste and smell. The use of the developed recipes of sourdough for bread has an effect on porosity, reduces the acidity and moisture content of the crumb, allows you to slow down the process of moisture loss during storage. Thanks to the components used in bread recipes, the content of dietary fiber, vitamins B1, B2, B9, E, PP, A and β-Carotene increases, bread is enriched with a number of macronutrients.

1 Introduction

Sustainable food systems play a key role in promoting health, equality and peace in the future. Improper nutrition often due to the lack of constant access to a sufficient amount of food of acceptable quality, harms human health. The issue of providing the population with high-quality products for preventive purposes, which makes it possible to provide the lack of necessary nutrients, and to form a stable immunity of citizens to various diseases, is urgent.

Bread is the main food that is consumed daily, and refers to mass consumption products [1]. Bread can act as an energy source and a carrier of vitamins and minerals [2, 3]. It is the most affordable product for fortification and enrichment with mineral supplements due to its relatively low price and accessibility to the population. Bread made from high-grade flour contains a small amount of vitamins B1, B2, PP, and vitamins A, C and D are practically

* Corresponding author: pyanikovaelvira@yandex.ru

absent in bread. The introduction of raw materials rich in these nutrients into the formulation makes it possible to make up for this deficiency.

Two of the most important details behind breads' success as a staple food are its simplicity in terms of ingredients and preparation, as well as the multiplicity of cereals that can be used to bake it [4].

Products from cereals and seeds are important components in human nutrition, ensuring the proper functioning of all body functions. Whole grains are important sources of nutrients, including dietary fiber, trace elements, some vitamins and antioxidant compounds. Their consumption, according to epidemiological studies, is associated with a reduced risk of many diseases, including cardiovascular diseases, obesity, type 2 diabetes and some types of cancer. The health effects of whole grains are mainly related to bran, as they contain essential nutrients [5].

Bakery products made of coarse flour improve metabolism [6], normalise weight [7], strengthen the body's immune system, they are able to make up for the deficiency of many vital substances for our body [8].

The purpose of the study was to conduct a comparative analysis of the effect of sourdough and prescription ingredients of whole grain bread on production technology and quality indicators.

2 Materials and methods

In recent years, the traditional production of sourdough bread has been popular due to the ever-growing consumer demand for more natural, delicious and healthy products [9]. Sourdough is an advanced fermentation method used for baking. The production of sourdough bread prepared with natural vegetable raw materials has a positive effect on the texture, taste, aroma, shelf life and nutritional value of wheat and rye bread [10-12].

For the developed recipes of whole-grain bread, sourdough was prepared using hop cones, licorice root infusion and unfermented malt.

Hop cones contain essential oil (up to 1.8%), polyphenolic compounds (2-5%) and from 5 to 26% bitterness (resinous substances). Among the resinous substances are: lupulin, humulenic acid, humulone, lupulone, etc. They also contain flavonoids (up to 0.85%), waxes, coumarins, tannins, aromatic compounds, B vitamins, choline, estrogen-like substances, alkaloid-like substance (humulin) [13, 14].

Hop cones are rich in vitamins and minerals such as: vitamin E - 25 mg, vitamin PP – 3 mg, potassium - 749 mg, calcium - 273 mg, magnesium - 234 mg, phosphorus - 473 mg. They contain (per 100 g of product) 18.6 g of protein, 53.7 g of fat, 13 g of carbohydrates, 7 g of dietary fiber, the energy value is 609 kcal. The advantages of hop cones, which are the basis of the starter culture, are choleretic, hypnotic, soothing, anti-inflammatory, expectorant, antispasmodic effects, as well as increased appetite [15, 16].

In order to increase the mineral and vitamin composition of whole wheat bread, changes were introduced to the original bread recipe by reducing the amount of flour and increasing the amount of rye bran. Bran is a hard shell of grain, which is screened out during the production of flour. The chemical composition of bran includes organic and inorganic substances: the first include proteins (12.2 g), fats (3.4 g), carbohydrates (8.7 g), vitamins (B1 – 0.54 mg, B2 – 0.28 mg, PP – 2.07 mg), dietary fiber (43.6 g), enzymes and acids, The second group includes minerals (K – 1207 mg, Ca - 230 mg, Md – 448 mg, P – 310 mg, Fe – 10 mg, Mn – 6.98 mg, Cu – 759 mcg) and water.

Despite the fact that vitamin E in bran contains a small amount (1.5 mg), it is completely absorbed. A sufficient amount of iodine (60 micrograms) in the bran fibers allows you to normalise the hormonal background and adjust the thyroid gland. Bran normalises metabolic

processes in the body, increases blood flow, thereby stabilizing blood pressure, and cleanses blood vessels of plaques.

2.1 Technological process of preparation of whole wheat and rye bread

Stage 1. Preparation of starter cultures

1. Preparation of sourdough No. 1

1.1. Preparation of a decoction of hop cones on a water basis: boiling for 30 minutes, cooling and infusing for 24 hours.

1.2. Preparation of the extract from the broth: boiling the broth for 10 minutes, straining.

1.3. Obtaining a starter culture: brewing wheat flour of the highest grade with hop extract at a temperature of 95 °C, cooling to 60-65 °C, adding sugar, fermentation for 40 hours at 30-35 °C.

2. Preparation of sourdough No. 2

2.1. Preparation of a decoction of hop cones on a water basis: boiling in a water bath for 15-20 minutes, infusing for 10 hours, straining.

2.2. Obtaining a mixture from a decoction extract and wheat flour of the highest grade, aging at 30-35 °C for 30-40 hours.

2.3. Preparation of brewing from wheat flour and 2% unfermented malt at 65 °C for 3-4 hours. Combining the mixture and welding and holding for saccharification 32-33 °C for 14-16 hours. Mixing sugared tea leaves with 4% unfermented malt and aging for 6-9 hours at 32 °C and then 48 hours at a temperature of 27-30 °C.

3. Preparation of starter culture No. 3

3.1. Preparation of a water-based decoction of licorice root: boiling in a water bath for 30 minutes, cooling for 10 minutes, straining.

3.2. Preparation of a decoction of water-based hop cones in a water bath for 15-20 minutes, straining, cooling to 35-40 °C.

3.3. Preparation of the starter culture: combining a decoction of licorice root and a decoction of hop cones with wheat flour, holding for 36-48 hours at 30-32 °C.

The starter cultures are ready for further use when they increase in volume by 2-3 times, and the surface is covered with a layer of small bubbles.

Stage 2. Preparation of raw materials

Sifting flour, cleaning flour from metallomagnetic impurities, moving to the container.

Stage 3. Preparation of sourdough

The connection of hop starter culture with a part of water, sugar and flour, mixing. Adding a part of rye bran, bringing it to a homogeneous consistency. Fermentation at a temperature of 28-32 °C for 3-3.5 hours.

Stage 4. Preparation of the dough

Combining the sponge with the remaining parts of water, flour, crushed rye bran, mixing until smooth. Adding salt, sunflower oil, kneading until the gluten framework is fully developed. Mixing in 2 stages at different speeds: The 1st speed is 2 minutes (the rotation speed of the kneading organ is 60 rpm), the 2nd speed is 4 minutes (the rotation speed is 90 rpm). Fermentation for 120-150 min.

Stage 4. Cutting the dough

Cutting the dough into pieces of a given mass of 0.2 kg, molding (rounding the dough pieces), greasing the surface with vegetable oil, proofing the dough pieces in a special chamber for 90 minutes. at a temperature of 34-35 °C.

Stage 5. Baking

Baking bread at a temperature of 200-210 °C for 25-30 minutes.

Stage 6. Final

Room temperature cooling, packaging, storage, transportation.

3 Results and discussion

When analysing various recipes of sourdough bread, a method of making yeast-free sourdough bread was chosen as a control sample. The recipes of yeast-free bread (control sample and developed samples) are presented in Table 1.

Table 1. Recipes of sourdough and bread.

Ingredients	**Control sample**	**Sample No1**	**Sample No2**	**Sample No3**	**Sample No4**
Sourdough					
Rye flour, g	250	—	—	—	
Wheat flour of the highest grade, g	—	75	300	300	
Licorice root, g	—	—	—	30	
Sugar, g	—	20	—	—	
Drinking water, ml	250	450	1100	750	
Hops, g	—	80	15	50	
Unfermented malt, g	—	—	6	—	
Dough					
Ingredients	Control sample	Sample No1	Sample No2	Sample No3	Sample No4
Whole wheat flour, g	-	200	200	250	150
Wheat flour of the highest grade, g	2000	200	150	100	150
Rye flour, g	2000	—	—	—	—
Sugar, g	—	3	—	—	—
Food salt, g	—	5	5	5	5
Sea salt, g	25	—	—	—	—
Sunflower oil, ml	—	20	20	20	20
Drinking water, ml	—	250	300	300	250
Spring water, ml	1500	—	—	—	—
Rye bran, g	—	25	50	50	150
Starter culture control sample	200-250	—	—	—	—
Starter culture sample No. 1	—	50	—	—	50
Starter culture sample No. 2	—	—	50	—	—
Starter culture sample No. 3	—	—	—	50	—

The evaluation of the quality of bread samples by organoleptic indicators is carried out in accordance with the requirements of regulatory documents for the following indicators: appearance, condition of the crumb, taste and smell. For the organoleptic evaluation, a scale of the bread quality score was developed, in which the maximum number of points was assigned to each indicator - 5, the total amount of points was 40 points.

The evaluation of the qualitative indicators of baked bread samples was carried out using expert and organoleptic methods. The expert method is based on the fact that each of the 5 experts participating in the survey assigns a certain score to each of the criteria. Tasters, using their senses, assessed the quality of organoleptic indicators of the developed bread samples [17]. The average values of organoleptic indicators of the quality of bread samples are shown in Figure 1.

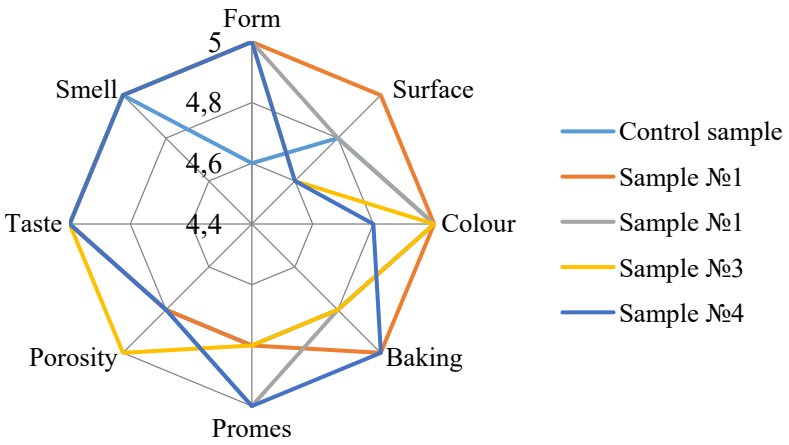

Fig. 1. Evaluation of organoleptic indicators of the quality of bread samples

In the course of the study, it was revealed that the best bread sample was No. 1, which received 39.6 points out of 40 possible. The tasters gave the maximum ratings to this sample according to such indicators as "shape", "surface", "colour", "baking", "taste" and "smell". The colour of the product is golden, the shape is rectangular without bulges, the surface is without large cracks and tears, without incisions and punctures. The crumb is baked and elastic, the product has a pleasant bread taste and smell, without foreign odors and tastes.

The bread sample No. 2 has a regular, rectangular shape. The surface is slightly rough. The colour of the product is dark golden. The crumb is baked and elastic, the porosity is uniform. No traces of non-kneading were observed. One taster noted that sample No. 2 had small explosions on the surface, for which he lowered his score. The smell and taste are pleasant, bread-like.

The bread sample No. 3 has a regular, rectangular shape, without prisms. The surface is slightly rough, slightly convex. The colour of the product is dark golden. The crumb is baked, the porosity is homogeneous. According to the "surface" indicator, two tasters noted the presence of cracks, according to the promes, one taster drew attention to the presence of inclusions in the form of lumps in the crumb. The smell and taste of the product are pleasant, bread-like.

The bread sample No. 4 has a rectangular, regular shape, with a convex upper crust. There is a slight roughness on the surface. The colour is light brown. The crumb is baked, not moist to the touch. There are no lumps and traces of non-kneading. The smell and taste are pleasant, bread-like. According to the "surface" indicator, two tasters noted the presence of mealiness, for which they lowered their scores. One taster noted that the colour of the bread has a greyish tint, and rated it 4 points. The taste and smell are pleasant, meet the requirements.

The developed samples of whole-grain sourdough bread were examined according to physico-chemical quality indicators (humidity, acidity and porosity). According to the indicator "humidity", all developed samples meet the requirements of regulatory documentation and do not exceed 50%. In samples No. 1 and No. 4, the humidity was 46% each, in samples No. 2 and No. 3 – 42% each.

According to the indicator "acidity", the samples of whole-grain bread do not exceed the norm and are for the sample №1 3.6 °, №2 – 3.2 °, №3 – 3.2 ° and No. 4 – 3,8 °. In sample No. 3, the value of this indicator is slightly higher than in the other three. This is due to the fact that it contains a greater amount of whole wheat flour.

According to the indicator "porosity": for sample No. 1, this indicator was 65%, for samples No. 2, No. 3 and No. 4 – 64% each.

There was also a study of the developed samples of whole-grain bread on starter cultures to establish expiration dates. To do this, the studied bread samples were stored in closed containers at room temperature and modes corresponding to standard bread storage conditions. After the allotted time, the analysis of physico-chemical parameters was carried out: humidity, acidity and porosity. As a result, it was found that the final changes in the acidity and porosity of the bread crumb have no significant difference from the beginning of this study, in contrast to the moisture content of the crumb, where there was a slight decrease in the values initially given. The moisture content of the crumb of sample No. 1 decreased by 1.5%, sample No. 2 – by 2.3%, samples No. 3 and No. 4 – by 3.1% after 72 hours. The most intensive process of moisture loss occurs in the first 24 hours of storage. At the same time, there were no significant differences in the nature of the process under consideration.

After 72 hours, the acidity of the crumb in sample No. 1 decreased by 0.1°, samples No. 2, No. 3 and No. 4 had no changes in indicators. The porosity of the crumb after 72 hours in sample No. 1 decreased by 1%, in sample No. 2 – by 0.4%, in sample No. 3 – by 0.5%, in sample No. 4 – by 1%. The indicators of acidity and porosity of these samples correspond to the standards of GOST indicators after a given period of time.

The results of the determination of energy and nutrients in the studied bread samples are presented in Table 2.

Table 2. Chemical composition and nutritional value of whole wheat bread with the use of various starter cultures.

Food substances						
Nutrient	**control**	**№1**	**№2**	**№3**	**№4**	**norm**
	Quantity					
Energy value						
Caloric content, kcal	197	234	248	228	237	1684
Proteins, g	6.1	10.7	9	9.6	9.3	76
Fats, g	1.2	3.5	3.4	3.3	3.2	56
Carbohydrates, g	39.9	43.5	43.8	45.2	44.9	219
Dietary fiber, g	8.5	4	4	4.6	4.1	20
Water, g	41.6	35.3	37.8	38	36	2273
Vitamins						
Vitamin B1, mg	0.17	0.411	0.397	0.23	0.22	1.5
Vitamin B2, mg	0.08	0.252	0.287	0.08	0.08	1.8
Vitamin B4, mg	60	18.7	18.7	21	20	500
Vitamin B5, mg	0.6	0.82	0.536	0.46	0.6	5
Vitamin B6, mg	0.17	0.111	0.176	0.29	—	2
Vitamin B9, mcg	30	99	91	96	25	400
Vitamin E, mg	—	—	0.32	2.3	1.8	15
Vitamin K, mcg	—	—	1.3	—	—	120
Vitamin PP, mg	—	—	4.402	4.7	4	20
Vitamin H, mcg	—	—	—	2.15	—	50
Vitamin A, mcg	—	—	—	1	2	900
β-carotene, mg	0.006	0.001	—	0.005	0.012	5
Macronutrients						
Potassium, mg	242	141	227	185	224	2500
Calcium, mg	29	125	74	28	32	1000
Silicon, mg	7	—	—	2.2	2.2	30
Magnesium, mg	42	41	81	54	62	400

Sodium, mg	404	473	486	374	412	1300
Sulfur, mg	52	106.7	88	69	—	1000
Phosphorus, mg	130	129	185	136	118	800
Chlorine, mg	980	—	—	639	900	2300
Trace elements						
Iron, mg	3.6	3.6	3.07	3.6	4.3	18
Iodine, mcg	5.6	—	—	3.2	3.2	150
Cobalt, mcg	2	—	—	2.5	—	10
Manganese, mg	1.6	1.026	1.668	1.088	0.825	2
Copper, mcg	220	148	221	215	—	1000
Molybdenum, mcg	8	—	—	16	—	70
Selenium, mcg	5	28.8	31	16	18	55
Fluorine, mcg	35	—	—	14.5	14.5	4000
Chrome, mcg	2.7	—	—	3.3	—	50
Zinc, mcg	1.21	1.04	1.35	1.353	1	12

The energy value of the developed samples of whole-grain bread with the use of various ferments increased, compared with the control sample, in sample No. 1 – by 37 kcal, in sample No. 2 – by 51 kcal, sample No. 3 - by 31 kcal and sample No. 4 – by 40 kcal. Sample No. 2 has the highest caloric content – 248 kcal, and the control sample has the lowest – 197 kcal.

The largest amount of proteins and fats contains sample No. 1 (10.7 g and 3.5 g, respectively), and the smallest - the control sample (6.1 g and 1.2 g, respectively).

The use of 100 g of a control sample of bread allows you to meet the daily need for vitamin B1 – by 11.3%, vitamins B4 and B5 – by 12 %, silicon – by 23.3 %, phosphorus – by 16.3 %, iron – by 20%, cobalt – by 20%, manganese – by 80.5%, copper – by 22%, molybdenum – by 11.4%.

In comparison with the control sample, bread sample No. 1 surpasses it in content and degree of satisfaction in such nutrients as: vitamin B1 (27.4%), vitamin B5 (16.4%), phosphorus (16.1%), manganese (1.3%). Thanks to the introduction of enriching raw materials (hop cones and rye bran) sample No. 1 is enriched with such nutrients as B2, B9, PP, calcium, selenium, which allow meeting the daily requirement by 14%, 24.8%, 28%, 12.5%, 52.4%, respectively.

The use of enriching raw materials (hop cones, unfermented malt and rye bran) in the recipe of whole wheat bread (sample No. 2) increases the content of a number of nutrients that meet the daily need for vitamins B1 – by 26.5%, B2 – by 15.9%, B9 – by 40.3%, PP – by 22%, magnesium – by 20.3%, phosphorus – by 23.1%, iron – by 17.1%, manganese – by 83.4%, copper – by 22.1%, selenium – by 56.4%, zinc – by 11.3%.

When using 100 g of bread with sourdough containing a decoction of licorice root (bread sample No. 3), satisfaction of daily needs is provided in vitamins B1 - by 15.3%, B4 – by 12.2%, B6 – by 14.5%, E - by 15.3%, PP – by 23.5%, magnesium – by 13.5%., phosphorus – by 17%, chlorine – by 27.8%, iron – by 20%, cobalt – by 25%, manganese – by 54.4%, copper – by 21.5%, molybdenum – by 22.9%, zinc – by 11.3%.

When using hop starter culture and an increased amount of rye bran in the recipe, compared with bread sample No. 1, bread sample No. 4 satisfies the daily need for vitamin B1 – by 14.7%, vitamin E - by 12%, vitamin PP – by 20%, as well as minerals: magnesium – by 15.5%, phosphorus - by 14.8%, iron - by 23.9%, manganese – by 41.3%. Compared with sample No. 1, there were minor changes, so an increase in the amount of rye bran did not affect the change in nutritional value.

4 Conclusions

In the course of the conducted research on the development of recipes for whole wheat bread on various ferments, the following conclusions were made:

- the components introduced into the formulation (hop cones, licorice root, unfermented malt, rye bran) make it possible to reduce the time and temperature parameters in comparison with the traditional technology of producing whole wheat bread: the dough was kneaded in two stages at different speeds (for 2 minutes with a rotation speed of the kneading organ 60 rpm and 4 minutes with a rotation speed of 90 rpm); fermentation took place at a temperature of 28-32 ° C, the fermentation time averaged 2.5-4 hours; the duration of proofing was 1.5 hours at a temperature of 35° C and humidity 75%; the baking duration was 25-30 minutes at a temperature of 200-210 ° C;
- the use of hop starter culture (sample No. 1) in the bread recipe has a positive effect on the organoleptic characteristics of whole-grain bread: the product acquires a golden colour, has the right shape, pleasant bread taste and smell;
- the use of hop starter culture (sample No. 1) affects the porosity of whole grain bread (it becomes more developed), reduces the acidity and moisture of the crumb in comparison with the control sample of bread;
- the use of enriching components in bread ferments (hops, unfermented malt and licorice root) allows you to slow down the process of moisture loss during storage and does not affect other physico-chemical parameters of bread;
- according to the results of the conducted studies of the developed samples of whole-grain bread according to organoleptic and physico-chemical indicators, the best and recommended for implementation is sample No. 1;
- the caloric content of the developed recipes of whole wheat bread, in comparison with the control sample, increases slightly – by 13.5-20.5%;
- the content of dietary fiber in 100 g of the developed samples of whole wheat bread allows you to meet the daily requirement by 25%;
- the content of B vitamins: B1, B2, B9, in comparison with the control sample, increases several times;
- the largest amount of vitamins (B1, B2, B4, B5, B6, B9, E, PP, A and beta Carotene) and macronutrients (potassium, calcium, silicon, magnesium, sodium, sulfur, phosphorus) is contained in bread sample No. 3.

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