Shelf life of composite flour mixtures

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Abstract. Enrichment of food products with proteins, minerals and dietary fiber is possible by introducing grinding products of some cereal crops into wheat flour, i.e. obtaining composite flour mixtures. To date, there is a need to enrich food products with essential fatty acids, especially Linolenic acid (w-3), the deficiency of which leads to serious disruptions in functioning of the human body. Analysis of the lipid composition of various oilseed crops shows that the composition of flaxseed oil as a source of w-3 demonstrates an absolute advantage. The solution to the problem of flour enrichment with essential fatty acids is currently being solved by using crushed flaxseed cake. However, the use of flaxseed cake has several disadvantages. First of all, as studies have shown, the amount of such flaxseed flour in the composition of the composite mixture should be 15-20% to ensure the required amount in essential fatty acids, which significantly impairs the consumer properties of bread. The use of flax seeds directly will significantly reduce their proportion in the composition of the composite mixture.

1 Introduction

Grinding flax seeds with a fat content of less than 30% for the subsequent enrichment of wheat flour presents significant difficulties and is practically impossible to carry out in existing flour mills.

Thus, a rational solution for obtaining bakery flour enriched with essential fatty acids is to develop a technology for grinding a grain mixture, which should contain flax seeds.

The amount of secondary raw materials formed during the grain processing at flour mills is on average 21.3% of the total volume of flour production. One of the directions to integrate processing of the main grain raw material into processing of secondary products is biotransformation of the former, aimed at obtaining products with structurally modified biopolymers with desired functional and technological properties.

The wide range of the raw material base including grain, leguminous crops and by-products of their processing allows researchers to speak about the possibility and necessity of their use to create products based on directed biocatalysis, which have not only increased nutritional and biological value, but also a given composition as well as given functional and technological properties.

2 Experimental section

The results of comparative grinding of wheat grain (grinding 1) and wheat-flax mixture (grinding 2) are presented in Tables 1 and 2. Flour quality indicators are presented in Table 3.

The flour samples were stored in the laboratory at room temperature.

Quality indicators controlled during the storage period are presented in Table 4.

The initial value of the fat acidity value of wheat flour stored for preserving was 14.7 mg KOH per 1 g of fat, which indicates its high organoleptic characteristics. Wheat-flax flour has lower values of the fat acidity value, which is associated with low values of the fat acidity value of oilseeds compared to cereals. For flax seeds, the fat acidity value varies in the range of 0.55 - 3.5; as for edible flax, the fat acidity value should not exceed 2.0.

The data obtained indicate an almost linear dependence of the fat acidity value increase within 6 months; at the same time, for 6 months of storage, the fat acidity value of wheat flour increased 2.3 times; and for wheat-flax flour - 3.1 times. The relative increase in the fat acidity value for wheat flour was 129%; for wheat and flax flour - 214% (Figure 1).
**Table 1.** Mass balances of the first wheat processing (Control).

| System | Load | 2-break | 3-break | Scratch | Grinding | 1-3 Reduction | Flour | Bran |
|--------|------|---------|---------|---------|----------|---------------|-------|------|
| 1-break| 100,0| 38,7    | 23,3    | 20,5    | 17,5     | 21,6          | 10,1  | 4,7  |
| 2-break| 38,7 | 21,6    | 4,4     | 0,6     | 3,1      | 13,5          | 1,6   | 0,6  |
| 3-break| 21,6 | 4,4     | 25,6    | 31,2    | 25,3     | 13,5          | 10,8  | 7,6  |
| ∑ break systems | 4,4 | 25,6 | 31,2 | 25,3 | 13,5 | 10,8 | 7,6 | 1,6 |
| Grinding | 25,6 | 7,2 | 10,8 | 7,6 | | | | |
| 1-3 Reduction | 42,0 | 1,6 | | | | | |
| Scratch | 13,2 | | | | | | |
| ∑ reduction systems | 8,8 | | | | | | |
| Total | 13,2 | | | | | | |

**Table 2.** Mass balances of processing the mixture of 93% wheat + 7% flax (%) Grind 2

| System | Load | 2-break | 3-break | Scratch | Grinding | 1-3 Reduction | Flour | Bran |
|--------|------|---------|---------|---------|----------|---------------|-------|------|
| 1-break| 100,0| 41,0    | 22,2    | 22,0    | 14,8     | 25,7          | 9,4   | 4,0  |
| 2-break| 41,0 | 25,7    | 7,4     | 0,8     | 3,2      | 14,3          | 5,4   | 11,9 |
| 3-break| 25,7 | 7,4     | 24,1    | 32,2    | 22,0     | 14,3          | 5,4   | 11,9 |
| ∑ break systems | 7,4 | 24,1 | 32,2 | 22,0 | 14,3 | 5,4 | 11,9 | 5,4 |
| Grinding | 24,1 | 6,2 | 12,5 | 5,4 | | | | |
| 1-3 Reduction | 44,7 | 2,7 | | | | | |
| Scratch | 16,3 | | | | | | |
| ∑ reduction systems | 8,9 | | | | | | |
| Total | 16,3 | | | | | | |

**Table 3.** Quality indicators of the flour obtained from Grind 1 (Control) and Grind 2.

| Grinds/ Quality indicators | Whiteness (%) | Humidity (%) | Ash content (%) | Protein (%) | Fat (%) | Grant composition, gr | Gluten Quantity (%) | GDL, units | Dryness (%) |
|---------------------------|---------------|--------------|-----------------|-------------|---------|-----------------------|----------------------|-------------|-------------|
| Wheat flour – Grind 1     | 52,4          | 13,9         | 0,56            | 13,48       | 1,7     | Remaining on the sieve 180; Remaining on the sieve 140; Passage through the sieve 140 | 0,15 | 62,0 | 10,04 |
|                           |               |              |                 |             |         | (mechanized gluten washing) 29,08 |                     | 67,0 | 10,72 |
|                           |               |              |                 |             |         |                                      |                     |             |             |
| Flour wheat + flax – Grind 2 | 43,6         | 13,0         | 0,64            | 13,77       | 3,9     | Remaining on the sieve 180; Remaining on the sieve 140; Passage through the sieve 140 | 0,03 | 65 | 9,68 |
|                           |               |              |                 |             |         | P1 29; P2 28,84 |                     | 67,9 | 9,60 |

**Table 4.** Quality indicators of flour samples during the storage period.

| Samples     | Protein (N 6.25), % (GOST 10846-91) | Fat, % (GOST 29033-91) | Fat acidity value, mg KOH/g (GOST 31700-2012) |
|-------------|-----------------------------------|------------------------|-----------------------------------------------|
| Wheat flour | 13,48                             | 1,7                    | 14,7 ± 1,5                                    |
| Wheat-flax flour | 13,77                          | 3,9                    | 8,5 ± 0,8                                     |
The basic trend for premium wheat flour is a linear dependence of the change in the fat acidity value along the shelf life period in this range. Therefore, the prediction of reaching the safe storage rate (50 mg KOH per 1 g of fat) for wheat flour under the same storage conditions is ~ 11 months. The nature of the change in fat acidity value in terms of storage time for wheat-flax flour practically does not differ from the one of the wheat flour.

The estimated predicted safe shelf life of wheat-flaxseed flour is 11 months × 0.85 = 9.4 months, if the product organoleptic characteristics meet standard requirements.

2.1 An alternative way of producing wheat-flax flour

The introduction of flax seeds into the grain mixture leads to a darkening of the bread crumb, especially for flour grade B (Figure 2).

The main disadvantage of multi-grade grind is the uneven distribution of fat among flour grades. To eliminate this drawback, it was proposed to use processed products - cereals instead of wheat grain. This allows conducting the single-grade grind according to a simple scheme taking into account a predetermined chemical composition of the flour.

![Figure 1. Diagram of changes in the fat acidity value of wheat and wheat-flax flour.](image)

**Figure 1.** Diagram of changes in the fat acidity value of wheat and wheat-flax flour.

![Figure 2. Bread made from wheat-flax flour of different grades: 1 – Control (wheat flour); 2 – wheat-flax flour, grade A; 3 – wheat-flax flour, grade B; 4 – wheat-flax flour, grade C.](image)

**Figure 2.** Bread made from wheat-flax flour of different grades: 1 – Control (wheat flour); 2 – wheat-flax flour, grade A; 3 – wheat-flax flour, grade B; 4 – wheat-flax flour, grade C.

3 Results

In the course of the research, a scheme for processing mixtures consisting of various cereals and flax seeds was developed. A mixture of various wheat middlings and flax seeds was ground according to the scheme presented in Figure 3.

Mass balance data are given in Tables 5 and 6.

Experimental laboratory baking of bread and its assessment was carried out in accordance with GOST
“Wheat baking flour. The method of testing laboratory baking of bread”.

The organoleptic assessment of the baked bread was carried out according to the following indicators:

- the appearance of the bread (shape, condition of the crust surface);
- crust color;
- crumb condition: color, color uniformity, elasticity;
- porosity: size, uniformity, thickness of the pore walls;
- taste, crunch and crumbling.

**Figure 3. Alternative scheme of processing binary mixtures**

**Table 5.** Mass balance (%). Grind 3.

| System                  | Load  | 1-3 reduction systems | Flour  | Bran  |
|-------------------------|-------|-----------------------|--------|-------|
| Break system            | 100   | 44,0                  | 56,0   |       |
| 1-3 reduction systems   | 44,0  | 44,0                  | 44,0   |       |
| Total                   | 100,0 |                       |        |       |

**Table 6.** Mass balance (%). Grind 4.

| System                  | Load  | 1-3 reduction systems | Flour  | Bran  |
|-------------------------|-------|-----------------------|--------|-------|
| Break system            | 100,0 | 40,6                  | 59,4   |       |
| 1-3 reduction systems   | 40,6  |                       | 23,7   | 16,9  |
| Total                   | 83,1  |                       | 16,9   |       |

**Table 7.** Quality indicators of the flour obtained from the Grind 3 - semolina (T and M) + flax.

| Grinds/Quality indicators | Whiteness, units | Humidity, % | Ash content, % | Grant composition, gr | Gluten |
|---------------------------|------------------|-------------|----------------|------------------------|--------|
| Wheat flour from wheat middling + flax G-4 dated 17.02.2020 | 32,0             | 11,0            | 0,82                | Remaining on the sieve 180 | 0,10     |
|                           |                  |              |                    | Remaining on the sieve 140 | 6,67   |
|                           |                  |              |                    | Passage through the sieve 140 | 93,03   |
| Flour from Semolina + flax G-3 date 25.02.2020 | 38,1             | 12,8            | 0,55                | Remaining on the sieve 180 | 1,61     |
|                           |                  |              |                    | Remaining on the sieve 140 | 18,60   |
|                           |                  |              |                    | Passage through the sieve 140 | 79,31   |
The analyzed bread samples (Table 8) had a regular semi-oval shape, a smooth even surface of the crust (G-3, G-4), an uneven bumpy surface (G-1, G-2); two samples (G-1, G-2) had small disruptions of the crust, sample (G-4) had disruptions of more than 1 cm on three sides of the bread. The color of the crust in samples (G-1 and G-2) was light brown, brown in the sample (G-3) and yellow at the sample (G-4).

**Table 8. Quality characteristics of bread baked from G1-G4**

| № | Sample code                        | Volume yield of bread, V, cm³/100g of flour | Specific volume | Porosity, % | Organoleptical assessment, score: |
|---|-----------------------------------|--------------------------------------------|----------------|-------------|----------------------------------|
|   |                                   |                                            |                |             | appearance | crumb | total score |
| 1 | G – 1 (wheat flour - control)     | 449                                        | 3,44           | 78          | 3          | 4     | 7          |
| 2 | G – 2 (wheat flour - flax)        | 422                                        | 3,30           | 79          | 3          | 3     | 6          |
| 3 | G – 3 (wheat flour from middlings + flax) | 449                                      | 3,40           | 81          | 3          | 3     | 6          |
| 4 | G – 4 (flour from semolina + flax)| 433                                        | 3,25           | 74          | 2,5        | 4     | 6,5        |

The baked bread had a good volumetric yield (more than 400 cm³/100g of flour), satisfactory and good organoleptic evaluation (Table 8). The crumb of the analyzed samples was with good (G-1, G-2) elasticity, as for the samples (G-3, G-4) - satisfactory elasticity, slightly creasing. The porosity of all samples is small, uneven, thick-walled along the pore walls and was about 80% for samples (G-1, G-2, G-3), for sample (G-4) this figure was 74%.

The taste is peculiar; the experimental samples (G-2, G-4) had a flax aftertaste, which corresponded to bread with the addition of flax flour. Sample (G-3) had a bitter aftertaste. No crunch or crunchiness was found. Overall, the breads had positive ratings, both in appearance and in crumb.

**4 Conclusion**

In order to increase the use of raw materials and expand the bread range through the development of grain products for the production of food for general, dietary and prophylactic purposes on the basis of poly-grain mixtures, the following points have been developed: a methodology for managing the milling and cereal properties of grain raw materials during its processing to obtain food products on a grain basis given composition and properties; the possibility of joint grinding of wheat-flax mixture to obtain flour enriched with essential fatty acids (EFA) α-3 (Linolenic acid) and-6 (Linoleic acid) is shown; determined some physical and chemical characteristics of wheat flour enriched with EFA; the features of the baking and rheological properties of wheat flour dough enriched with EFA were revealed, the possibility of using not only wheat grain, but also its processed products (cereals) in a mixture with flax to obtain flour enriched with PUFA, was determined, the terms of safe storage of wheat-flax flour were determined.
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