The influence of composite flour mixtures on *Saccharomyces cerevisiae* biotechnological properties and bread quality

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Abstract. Increased consumer attention to healthy nutrition imposed the need for the development of diverse products with partial supersedence of wheat in flour mixture. Both nutritional value and sensorial attribute of the bread primarily depend on the yeast biotechnological properties. The aim of the research was studying the influence of flour composite mixes from wheat, lentil and millet flours in different proportions on biotechnological properties of baker’s yeast. According to our data, multi cereal bread with 5-10% lentil/millet flour addition had better sensory qualities than traditional wheat bread. But introduction of 20% or 30% lentil or millet flour into the flour mixture had the best stimulating effect for the yeast growth. Thus, the addition of average volumes of lentil or millet flour was accompanied by an increase in yeasts’ rising power 5 times, while introduction of 40% lentil flour and complex three-component flour mixture formation reduced the specific growth rate of *Saccharomyces cerevisiae* by 1.5-2 times compared with the control. In addition, the best physico-chemical parameters were recorded in samples, containing 30% millet or 30% lentil flour.

1. Introduction

Increased consumer attention to healthy nutrition imposed the need for the emergence of a bakery industry of different products with healthful effects. It has resulted in the development of diverse products with partial supersedence of wheat in flour mixture. Specifically, the substitution of wheat with rye, oat, sorghum and millet in ratio 70:30 has positively influenced the fibre content, stiffness, elasticity and structure of final product [1]. There were many studies to reduce calories and increase the nutritional value of bread, in particular adding of green tea catechins, sorghum flour, crude malva nut gum, white bean extract, barley β-glucan-enriched flour, dietary fibre and wild grown fruits. Purple yam flour substitution for wheat flour has effected of in vitro starch digestibility of the bread: the content of rapidly and slowly digestible starch decreased with the addition of purple yam flour [2]. It has revealed, that enriching cereal products with legume flour gives nutritional advantages, for example improving amino acid balance and reducing the gluten content, but also changes the processability of semi-product and properties of final product (colour, texture, structure, and sensory acceptability) [3].

Formulations of new bakery products with increased nutritional values is trending the market, and sensorial attributes still need to be improved to reach a wider audience. To enhance sensorial attributes of breads, it is possible to combine different independent variables, as plant type of flour [4], plant saturation stage, including the addition of sprouted grains and seeds [5], fermentation and baking processes [6].

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Both nutritional value and sensorial attribute of the bread depend on many factors. But the bakery products quality is primarily determined by the yeast biotechnological properties. The yeast technological and functional role is loosening action with carbon dioxide, which gives the certain dough and final product properties, as well as production of ethanol and other molecules, involved in the formation of taste and aroma of bakery products. It is known, that, determining biotechnological properties cell enzymes are produced as a result of the substrates effects, in particular, the flour composite mixes proportion [2, 4, 5].

The aim of the research was studying the influence of flour composite mixes from wheat, lentil and millet flours in different proportions on biotechnological properties of baker's yeast. The objectives of the study included determining the specific growth rate and rising power of baker's yeast, as well as acidity, humidity, porosity and sensory properties of the finished product.

2. Materials and methods

All ingredients used in bread-making, including high-grade wheat flour, red lentil grain, millet grain, dried yeast, butter, salt and sugar, were obtained from a supermarket.

Lentil and millet whole grain flour was obtained using laboratory mill BRABENDER Quadrumat Junior (Germany) in the Laboratory of technology, standardization and certification of bakery. Dough was baked in a furnace UNOX (Italy) in the Scientific training technological laboratory for bakery and confectionery production. Acidity, humidity and porosity of the finished product were identified in the Scientific training laboratory to determine the quality of food and agricultural products. Microbiological studies were performed in the laboratory of the Department of Microbiology, biotechnology and chemistry.

In the first step, flour composite mixes were prepared by mixing of wheat, lentil and millet flours in different proportions (table 1).

| Sample No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|-----------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
| Wheat flour | % | 100 | 0 | 0 | 90 | 80 | 70 | 60 | 90 | 80 | 70 | 60 | 90 | 80 | 70 |
| 100 | 5 | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 15 | 20 | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 30 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 40 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Lentil flour | | | | | | | | | | | | | | | | |
| 100 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 5 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 10 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Millet flour | | | | | | | | | | | | | | | | |
| 100 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 15 | 20 | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 30 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 40 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
Then, 0.06 g of baker's dry yeast was emulsified in 10 ml of saline with 0.06 g of flour composition and 1.12 g of sugar. Dilutions of 1:10² were prepared in a sterile physiological solution from all the samples, and 0.1 ml of each dilution was spread on the Saburo agar surface in 3 Petri dishes in parallel. After 1.5 h exposure at temperatures of 35±2°C, dilutions of 1:10⁴ were prepared, and 3 Petri dishes with Saburo agar were inoculated with 0.1 ml of each dilution. The inoculated Petri dishes were incubated in a thermostat within 48 h at 35±2°C. Then the yeast colonies were counted. Using the obtained data, the specific rate of yeast growth was calculated using the following formula:

\[ K_p = 2.303(lg a_2 - lg a_1)/(t_2 - t_1), \]

where

- \( a_1 \) – the yeast cells number at the first inoculation (CFU/ml),
- \( a_2 \) - the yeast cells number at the second inoculation (CFU/ml),
- \( t_1 - t_2 \) – time interval between inoculation (h).

In the second step, the yeast rising power was measured according to GOST 171-81 by the simple "ball" method. The dry yeast mass, corresponding to the weight of compressed yeast, was calculated by the formula:

\[ m = m_{pr}(100-W_{pr})/(100-W), \]

where

- \( m_{pr} \) – compressed yeast mass, g,
- \( W_{pr} \) – compressed yeast moisture, %,
- \( W \) – dried yeast moisture, %.

The float time of the prepared by a special method dough ball was multiplied by the empirical coefficient 3.5, and the resulting value was taken for the yeast rising power.

In the third step, we carried out baking of all bread samples and analysed their physico-chemical and organoleptic properties. Ingredients were: 215 g of the flour composite mixture, 12.5 g of sugar, 7.5 g of salt, 150 ml of water, and 12 ml of sunflower refined oil on 1 sample (500 g). The dough was prepared by the sponge method and baked in a furnace at temperatures of 160 °C (upper heater) and 220 °C (lower heater) for 30-40 min. Acidity, humidity and porosity of the finished product were identified in accordance with GOST 5670-96, GOST 21094-75 and GOST 5669-96, respectively (test protocol No 1246 from 21.05.2019). Bread organoleptic properties were determined in accordance with GOST 27842.

3. Results
Specific growth rate data for yeast in different flour compositions are presented in (table 2).

| Sample No | Flour composition               | Specific growth rate, CFU/h |
|-----------|---------------------------------|----------------------------|
| 1         | Wheat flour 100%                | 3.65±0.34                  |
| 2         | Lentil flour 100%               | 2.53±0.23                  |
| 3         | Millet flour 100%               | 2.62±0.25                  |
| 4         | Wheat flour 90% + Lentil flour 10% | 3.06±0.31                  |
| 5         | Wheat flour 80% + Lentil flour 20% | 3.47±0.32                  |
| 6         | Wheat flour 70% + Lentil flour 30% | 3.35±0.33                  |
| 7         | Wheat flour 60% + Lentil flour 40% | 2.35±0.22                  |
| 8         | Wheat flour 90% + Millet flour 10% | 2.58±0.25                  |
| 9         | Wheat flour 80% + Millet flour 20% | 3.30±0.31                  |
| 10        | Wheat flour 70% + Millet flour 30% | 3.52±0.33                  |
| 11        | Wheat flour 60% + Millet flour 40% | 3.28±0.32                  |
| 12        | Wheat flour 90% + Millet flour 5% + Lentil flour 5% | 3.02±0.30                  |
| 13        | Wheat flour 80% + Millet flour 10% + Lentil flour 10% | 2.79±0.26                  |
| 14        | Wheat flour 70% + Millet flour 15% + Lentil flour 15% | 2.69±0.26                  |
| 15        | Wheat flour 60% + Millet flour 20% + Lentil flour 20% | 2.01±0.20                  |

3
As it follows from the presented data in table 2, the best indicators of the specific growth rate were in samples 5 and 10 when 20% of lentil or 30% of millet flour was added into the flour mixture. Good results were obtained when 30% of lentil or 20% of millet flour was added into the flour mixture. It can be assumed, that the adding of medium-volume of other cereals flour to a wheat flour activates the yeast activity. The introduction of smaller amounts of flour admixture is probably not enough for this. The introduction of a large amount of lentil flour in flour composition and the formation of a complex three-component flour mixture adversely affected the growth of yeast.

Rising power data for yeast in different flour compositions are illustrated in figure 1.

![Figure 1. Yeasts’ rising power.](image)

As illustrated in figure 1, in samples 5 and 10 (20% lentil or 30% millet flour added) the yeasts’ rising power had the best results. Good results were obtained when 30% of lentil or 20% of millet flour was added into the flour mixture. Accordingly, the dough maturation time in these samples is reduced. This is due to an increase in the quantity and activity of yeast.

Physico-chemical properties of bread crumb, baked from different flour compositions, are presented in table 3.

| Sample No | Acidity, % | Humidity, °T | Porosity, % |
|-----------|------------|--------------|-------------|
| 1         | 43.5±2.2   | 1.5±0.1      | 68.0±3.5    |
| 2         | 42.5±2.1   | 5.0±0.2      | 50.0±2.6    |
| 3         | 34.5±1.5   | 2.0±0.1      | 51.0±2.5    |
| 4         | 35.0±1.6   | 2.0±0.1      | 70.0±3.4    |
| 5         | 36.5±1.8   | 2.0±0.1      | 62.0±3.1    |
| 6         | 35.0±1.4   | 3.0±0.1      | 65.0±3.2    |
| 7         | 38.5±1.6   | 2.5±0.1      | 63.0±3.1    |
| 8         | 37.0±1.8   | 3.5±0.1      | 56.0±2.3    |
| 9         | 39.0±1.8   | 7.0±0.2      | 56.0±2.2    |
| 10        | 35.5±1.6   | 2.5±0.1      | 63.0±3.2    |
| 11        | 40.5±1.9   | 2.0±0.1      | 54.0±2.4    |
| 12        | 40.5±2.1   | 2.5±0.1      | 62.0±3.1    |
| 13        | 37.0±1.7   | 2.0±0.1      | 65.0±3.3    |
| 14        | 39.0±1.9   | 1.5±0.1      | 65.0±3.2    |
| 15        | 37.5±1.6   | 2.5±0.1      | 67.0±3.4    |
As it follows from the data in table 3, bread with millet and lentil flour addition had a moisture content of 4.5% - 8.5% lower than classic wheat bread sample. For three-component bread, a tendency to reduce the moisture content of the bread crumb with an increase of addition flour was noted. Lentil flour introduction had almost no effect on the bread crumb acidity. But the acidity of the bread crumb decreased with the increase of millet flour in the composition. The acidity of three-component bread crumb did not significantly vary with the change in flour composition. The bread crumb porosity decreased slightly in the two composite samples and increased in the three composite samples with increasing of added flour. In general, the best physico-chemical parameters were recorded in samples, containing 30% millet or 30% lentil flour.

The data of organoleptic properties determination in bread from different flour compositions are illustrated in figure 2 - 4.

![Figure 2](image)

**Figure 2.** Organoleptic bread properties with millet flour addition.

As shown in figure 2, bread from millet flour had satisfactory organoleptic properties, but its consistency and taste had not been attractive to tasters. The best indicators had the bread with 10 and 20% millet flour addition.

![Figure 3](image)

**Figure 3.** Organoleptic bread properties with lentil flour addition.

As shown in figure 3, bread from lentil flour had satisfactory organoleptic properties too, but its taste had not been attractive to tasters. The best sensory characteristics had the bread with 10 lentil flour...
addition.

Figure 4. Organoleptic bread properties with lentil and millet flour addition.

As it is shown in figure 4, multi cereal bread with small amount of lentil and millet flour addition (5-10%) had even better sensory qualities than wheat bread. However, the increase of added flour volume in flour composition significantly reduced the acceptability of bread.

4. Conclusion

Thus, introduction of 20% or 30% lentil or millet flour into the flour mixture had the best stimulating effect for the yeast growth. Introduction of 40% lentil flour and complex three-component flour mixture formation reduced the specific growth rate of \textit{Saccharomyces cerevisiae} by 1.5-2 times compared with the control. The addition of average volumes (20-30%) of lentil or millet flour was accompanied by an increase in yeasts’ rising power 5 times and improvement of physico-chemical parameters of bread crumb compared to controls. Multi cereal bread with 5-10% lentil/millet flour addition had better sensory qualities than traditional wheat bread. Our data correlate with the results of other researchers showing the positive effect of complex flour compositions on the yeast biotechnological properties and the quality of baked bread [7, 8].

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