EFFECT OF THE FERMENTATION METHOD ON INCREASING THE BIOAVAILABILITY OF IRON AND ZINC IN WHEAT GRAIN PROCESSING PRODUCTS AND POSSIBILITIES FOR OPTIMIZATION

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Wheat is one of the oldest crops in human history and is a major food source in many countries. Although it contains protein, fiber, vitamins and minerals, the bioavailability of micronutrients such as iron (Fe) and zinc (Zn) is relatively low. The main reason for this is the naturally occurring phytate (myo-inositol-hexaphosphate) compounds in wheat grains. Phytates form complex chelates with iron and zinc, making them insoluble in the intestine.

In recent years, iron and zinc deficiency has become a widespread problem worldwide, especially in populations that rely on cereal products. Therefore, it is urgent to improve technologies aimed at increasing the bioavailability of microelements in cereal products.

Milling (fermentation) is one of the most effective methods that significantly increases the bioavailability of iron and zinc in wheat grains and its processed products. During the milling process, the phytase enzyme is activated and phosphate groups are gradually separated from phytate molecules, as a result of which iron and zinc ions are released into a free state.[1]

This article discusses the biological mechanism, technological features and optimization possibilities of the milling process based on a broad scientific approach.

Sprouting is the process of increasing the moisture and temperature of grains or cereal products under controlled conditions to bring them to a biological activity close to germination. During the process, the following changes occur:

Activation of the phytase enzyme

Increase in proteolytic and amylolytic enzymes

Formation of organic acids

Decrease in pH level

Reduction in phytate breakdown[2]

As a result of this process, molecules that bind iron and zinc (phytate, oxalate) are broken down and microelements are absorbed in the intestine.

While iron is important for hemoglobin synthesis, oxygen transport, and oxidation-reduction processes, zinc is an important indicator in DNA synthesis, immune system activity, and enzyme activity. Therefore, increasing their bioavailability is important not only for nutritional quality, but also for health.

For grain sprouting, the most effective moisture content is in the range of 40–48%. If the moisture content is low, enzyme activity will not be sufficient; If it is high, an anaerobic environment will occur, causing a decrease in quality.

Extraction usually gives the best results at a temperature of 20–28°C. An increase in temperature increases phytase activity, but above 35°C there is a risk of enzyme denaturation.

2.3. Time factor

24–48 hours of extraction are optimal for iron and zinc bioavailability. Continuing for more than 72 hours will lead to excessive decomposition of organic matter and a decrease in sensory quality.

2.4. pH level

A pH of 5.0–5.8 during extraction creates an ideal environment for the phytase enzyme. A lower pH ensures faster decomposition of phytates.

The addition of lactobacteria, yeasts and phytase-producing microorganisms makes the process more efficient. This method can increase the solubility of iron and zinc several times, especially when used on an industrial scale.[3]

The phytate molecule has six phosphate residues and forms strong chelates with divalent cations such as iron and zinc. During digestion, the enzyme phytase:

cleaves the phosphodiester bond in myo-inositol phosphate breaks down the phytates and degrades them along the chain

phytate → inositol-pentaphosphate → inositol-tetraphosphate → inositol → phosphate,

as a result, iron and zinc ions are released from the chelated state.

Free microelements are ready for absorption in the intestine.

Advantages of sprouted wheat products

The bioavailability of iron and zinc increases by 30–70%.

The amount of easily digestible proteins increases.

The synthesis of substances belonging to the vitamin B group increases.

Antioxidant activity increases.

The glycemic index decreases.

Sensory (taste, smell, texture) properties improve.[4]
Automatic control of temperature, humidity, aeration stabilizes the process and ensures uniform quality.
The process can be accelerated by using additional phytase enzymes that activate phytates.
Bran is a source of phytase, and its rehydration enhances the absorption of iron and zinc.
The most effective regime is selected through mathematical modeling of the process (moisture-time-temperature triple model).
Social and practical significance
Reducing iron deficiency anemia in the population
Improving the nutrition of children and pregnant women
Increasing the production capacity of national functional foods
Application as a technology suitable for state programs on healthy nutrition[5]
In conclusion, studies show that the technology of fermentation significantly increases the bioavailability of iron and zinc in wheat grain and products made from it. The process increases the solubility of microelements through the activation of the phytase enzyme, the breakdown of phytates, and the increase in organic acids. High efficiency can be achieved by properly optimizing the fermentation conditions - temperature, humidity, time, pH, starter culture. This method has great potential in the production of functional foods and serves to reduce microelement deficiencies in the population.

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