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STUDY OF THE EFFECT OF THE PRESSING METHOD ON INCREASING THE BIOAVAILABILITY OF IRON AND ZINC IN WHEAT GRAIN PROCESSING PRODUCTS

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Annotation: This study investigates methods to enhance the biological availability of iron and zinc in wheat grain products. The effectiveness of various processing technologies and nutritional supplements on mineral absorption was assessed. Results indicate that applying specific technological measures significantly improves the bioavailability of minerals in the products. The study is practically important for addressing micronutrient deficiency issues and producing fortified food products.

Keywords: Wheat grain, iron, zinc, bioavailability, nutritional supplements, processing technology, mineral absorption.

Аннотация. Данное исследование посвящено изучению методов повышения биодоступности железа и цинка в продуктах из пшеничного зерна. Оценивалась эффективность различных технологий переработки и пищевых добавок на усвоение минералов. Результаты показали, что использование специальных технологических приёмов значительно увеличивает уровень биодоступности минералов в продуктах. Исследование имеет практическое значение для решения проблем дефицита микронутриентов и производства обогащённых продуктов питания.

Ключевые слова: Пшеничное зерно, железо, цинк, биодоступность, пищевые добавки, технологии переработки, bioavailability.

Annotatsiya. Ushbu tadqiqot bug‘doy donidan tayyorlangan mahsulotlarda temir va ruh (safro) minerallarining biologik mavjudligini oshirish usullarini o‘rganishga qaratilgan. Ishda turli qayta ishlash texnologiyalari va oziqlanish qo‘shimchalari orqali temir va ruhning so‘rilish samaradorligi baholandi. Natijalar shuni ko‘rsatdiki, maxsus texnologik choralardan foydalanganda mahsulotlarda minerallarning bioavailability darajasi sezilarli darajada oshadi. Ushbu tadqiqot ovqatlanish sohasida mikronutrient yetishmovchiligi muammolarini hal qilish va sog‘lomlashtirilgan mahsulotlar ishlab chiqarishda amaliy ahamiyatga ega.

Kalit so‘zlar: bug‘doy doni, temir, ruh, biologik mavjudlik, oziqlanish qo‘shimchalari, qayta ishlash texnologiyasi, bioavailability.

INTRODUCTION

Food security, strengthening the health of the population and expanding the consumption of nutritious products have become one of the world's top priorities today. In particular, the deficiency of important microelements such as iron and zinc affects the health of millions of people globally. Especially in developing countries, iron deficiency is one of the main causes of

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anemia, and zinc deficiency causes a weakening of the immune system, slowing down developmental processes and a number of other physiological disorders. Therefore, enriching food products with microelements, increasing their bioavailability and using forms that are easily absorbed by the human body are of great scientific and practical importance.

Wheat grain and products derived from it occupy a key place in the diet of the population of Uzbekistan and many other countries. Widespread consumption of wheat products allows improving the health of the population by enriching them with microelements. However, in the natural state, most of the iron and zinc contained in wheat are bound to phytates, fibers and other compounds and are absorbed by the body in small quantities. Therefore, scientific research on increasing the bioavailability of these microelements has become one of the most relevant directions in recent years.

Technological methods used in the processing of wheat grain, such as enzymatic processing, the use of phytase enzyme, flour enrichment technologies, extrusion, fermentation, and the addition of microelements in the form of organic chelates to the flour composition, have been noted to be effective in increasing the bioavailability of iron and zinc. At the same time, modern processing technologies such as pre-soaking of grain, separation of flour into fractions, microgranulation, bioprocessing can also significantly improve the absorption of microelements. These methods are important in that they have a positive effect not only on bioavailability, but also on the taste, texture and storage properties of finished products.

Numerous studies on increasing the bioavailability of iron and zinc show that the chemical form of mineral additives, the solubility of their compounds, the structural composition of grains and flour, and each stage of the processing process significantly affect the level of assimilation of microelements. For example, iron in the form of ferrous sulfate, iron chelates, or nanoparticles has high bioavailability, while organic compounds of zinc (zinc lactate, zinc gluconate, etc.) are absorbed much faster. In this regard, the combination of highly efficient technological processes and properly selected mineral additives has an important scientific basis.

The relevance of studying this topic is that the possibility of widespread use of wheat products in the diet of the population requires that the process of their enrichment be economically feasible, convenient for practical use, and effective for the health of the population. Today, the world food industry sees the most effective way to combat microelement deficiencies precisely through the improvement of biofortification and processing processes. In accordance with the standards for food fortification recommended by international organizations, in particular, WHO and FAO, the availability and assimilation of iron and zinc in grain products should be sufficient.[1; 45, 78]

Scientific research is also being conducted in Uzbekistan to improve the quality of grain products and their fortification technologies. Research on increasing the bioavailability of microelements important for the health of the population allows strengthening national food security and strengthening the prevention of diseases associated with microelement deficiency.

In addition, further improvement of the technology for fortification of wheat products will serve to increase the competitiveness of the country's food industry, expand export opportunities, and provide the domestic market with quality products.

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From this point of view, this study is devoted to the scientific study of technological approaches aimed at increasing the bioavailability of iron and zinc in wheat grain processing products, and serves to analyze existing problems, assess the effectiveness of methods, and develop practical proposals. This topic is of high scientific and practical importance, and the results offer effective solutions for introducing innovative technologies in the food industry, producing healthier products, and combating micronutrient deficiencies among the population.

LITERATURE REVIEW AND RESEARCH METHODOLOGY

Scientific research on increasing the bioavailability of iron and zinc has highlighted the effectiveness of various technological approaches in many sources. International studies show that a high content of phytate in cereal products sharply reduces the absorption of iron and zinc. In studies conducted by WHO, FAO, and a number of scientific centers on food biotechnology, the use of the phytase enzyme has been recognized as one of the most effective strategies for increasing the bioavailability of micronutrients. Also, scientific work on the use of mineral chelates, nanoparticles, organic salts, and fermentation processes shows that this direction is a promising path. In the works of Uzbek and foreign scientists devoted to approaches such as grain bioprocessing, extrusion, and microgranulation, it is emphasized that each stage of the technological process directly affects the absorption of micronutrients.[2; 22,49]

The methodology of this study is based on the principles of systematic analysis of existing scientific foundations, step-by-step implementation of experimental and testing processes and comparative evaluation of the results. At the first stage, the mineral composition, phytate content, fiber content and available bioavailability indicators of wheat grain and flour obtained from it are determined by laboratory methods. At the second stage, various technological processing methods are used - fermentation, phytase addition, extrusion, ion exchange technology and organic chelate additives. At the third stage, the solubility, absorption indicators and bioavailability indices of iron and zinc in the obtained samples are evaluated based on internationally recognized in vitro models. The collected data are statistically analyzed and differences in the effectiveness of the methods are identified. Through this methodological approach, the most optimal technological solutions for increasing the absorption level of microelements in wheat products are determined.

ANALYSIS AND RESULTS

During the study, the effect of various technological methods on the absorption of iron and protein in wheat grain and products made from it was studied in depth. Initially, the amount of minerals in the raw grain, the percentage of phytate compounds and bioavailability indicators were analyzed in laboratory conditions. The initial results showed that the absorption rate of iron in the natural state of wheat grain is on average 6–8%, and in the protein - around 10–15%, which is not high enough for the human body. Complexes associated with phytates were noted as the main factor preventing the transition of mineral ions to the free form.

In the second stage of the study, samples were analyzed in which the phytase enzyme was used. As a result of the phytate-degrading properties of phytase, the solubility of iron and protein increased significantly. In flour samples treated with phytase, the iron bioavailability increased on average to 22–25%, and in the case of the spirit - to 28–32%. This confirms the effectiveness of the enzymatic method and is consistent with the data presented in the international literature.[3; 56,84]

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At the next stage, the effect of fermentation technology was studied. During the fermentation process using lactic acid bacteria, phytates were broken down, organic acids were formed, and the solubility of mineral ions increased. It can be seen that the absorption of iron in fermented flour samples reached up to 30%, and in the case of the spirit - up to 35–38%. This method not only increases the bioavailability, but also has a positive effect on the taste, texture and nutritional value of the finished products.

The extrusion technology was also analyzed separately. This process, carried out under high temperature and pressure, changes the structural structure of the grain and causes the destruction of compounds bound to mineral substances. Although the iron absorption in the extruded samples increased to 18–20%, and in the spirit to 22–25%, these indicators were slightly lower than in the variants using fermentation or phytase. However, the advantage of extrusion is its ease of use in industry and improvement of the physicochemical properties of the product.

Another area of research was the study of the effectiveness of mineral supplements in the form of organic chelates. Samples with the addition of compounds such as ferrous gluconate, ferrous lactate, and spirit gluconate had high bioavailability indicators. The absorption rate of iron chelates was up to 45–48%, and spirit showed a result of more than 50%. Organic chelates are characterized by good solubility and rapid absorption by the body. However, the high cost of such supplements may limit their widespread use.

At the final stage of the methodology, the effectiveness of combinations of different methods was assessed. Samples pre-treated with phytase and then fermented showed the highest results. The absorption of iron in the combined method reached 52–55%, and in the spirit - up to 60%. This confirmed that the integrated use of technological processes is the most effective approach. The combined methods also improved the organoleptic characteristics of the product, which made it more attractive to consumers.[5; 19,44]

Statistical analysis of the data obtained during the study also confirmed the reliability of the results. Using variance analysis methods, it was found that the differences between the methods were significant ($p < 0.05$). In particular, samples treated with fermentation and phytase showed high efficiency in terms of bioavailability.[6; 70, 96]

Although enrichment with mineral additives gives high results, it was noted that it has some limitations in terms of economic efficiency.

Overall, the results of the study suggest that the most appropriate approach to increase the bioavailability of iron and zinc in wheat grain products is to use a combination of enzymatic digestion, bioprocessing, and organic chelation methods. This not only significantly increases the absorption of minerals, but also improves the quality and nutritional value of the finished products. The results serve as a practical basis for further improving biofortification processes in the food industry.

CONCLUSION

Increasing the bioavailability of iron and protein in wheat grain processing products is one of the most important tasks facing the modern food industry. The analyzes conducted during the study showed that phytates, fibers and other compounds naturally present in wheat significantly

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hinder the absorption of microelements by the body. Therefore, the use of various technological processing methods to increase the bioavailability of minerals is scientifically and practically relevant.

As a result of such methods as treatment with the phytase enzyme, fermentation, extrusion and the use of mineral additives in the form of organic chelates, a sharp increase in the solubility and absorption of iron and protein was observed. In particular, the combination of the fermentation process with the use of phytase showed the highest efficiency. These methods not only improved bioavailability indicators, but also changed the organoleptic and technological properties of the finished products in a positive direction.

The results of the study indicate that the enrichment of wheat products can reduce the health problems associated with iron deficiency and iron deficiency in the population. Also, by introducing additional technological steps into the production processes, it is possible to strengthen national food security, expand the range of fortified products, and increase industrial competitiveness. In general, the proposed approaches to increase the bioavailability of iron and iron create a solid scientific basis for the production of biofortified products in the future.

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