Modern American Journal of Business, Economics, and Entrepreneurship
ISSN (E): 3067-7203
Volume 2, Issue 4, April, 2026
Website: usajournals.org

TECHNOLOGY FOR FORMING THE FUNCTIONAL PROPERTIES OF RYE BREAD BASED ON PREBIOTIC COMPONENTS

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Abstract
The article investigates the effect of using inulin-containing raw materials in conventional bread-making technology on the aromatic properties of bakery products. Experiments were carried out on rye–wheat and wheat breads, and the amount of aroma-forming compounds was evaluated through carbonyl compounds binding with sodium bisulfite. The results showed that all samples with added inulin preparations had higher levels of aromatic compounds than the control samples. Partial hydrolysis of inulin during baking and the active participation of formed fructose and fructans in Maillard reactions enriched the aromatic profile. A lower degree of polymerization of inulin preparations increased aroma-forming compounds, with the highest values observed for P95 and GR preparations. These findings confirm the scientific and practical suitability of using inulin-containing raw materials to improve the organoleptic and functional properties of bread product

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Keywords: Inulin, functional bread, aroma-forming compounds, rye–wheat bread, prebiotics.

Introduction

At present, ensuring healthy nutrition in strengthening the health of the population in the Republic of Uzbekistan is considered one of the important socio-economic tasks. The deficiency of dietary fiber and biologically active substances in the diet is leading to the widespread occurrence of metabolic and gastroenterological diseases. Therefore, the development and implementation of functional food products is regarded as an urgent scientific and practical issue.

The inclusion of prebiotics, probiotics, and other physiologically active components in the composition of functional food products is of great importance in normalizing intestinal microflora, improving metabolism, and supporting the general functional state of the organism. Scientific studies confirm the high effectiveness of inulin and other fructans among prebiotic substances. Inulin-containing plant raw materials, including chicory and Jerusalem artichoke, are considered promising sources under the conditions of Uzbekistan. .[1,3,5,]

Bread and bakery products are the main food products consumed daily by the population, and increasing their nutritional and biological value has broad social significance. In this regard, the introduction of inulin-containing raw materials into the technology of bakery products makes it possible to improve their functional properties and comprehensively enhance product quality. This direction has urgent scientific and practical significance for the food industry. .[4,5,6,7]

Literature Review

Scientific sources widely describe the prebiotic properties of inulin and other fructans, their positive effect on intestinal microflora, and their role in increasing the biological value of food products. Studies have noted that the inclusion of inulin-containing raw materials in the composition of bakery products not only enriches the nutritional composition of the product, but also affects organoleptic indicators, particularly aromatic properties, through chemical and physical

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changes occurring during dough preparation, fermentation, and baking processes. .[2,4,6,8]

The literature indicates that in conventional bread-making technology, during the baking process, as a result of the increase in temperature in the surface layers of the dough piece, oxidation-reduction reactions occur between reducing sugars and amino acids, polypeptides, and proteins. These processes proceed with the formation of melanoidins, shaping the color, smell, and taste of the bread crust. At the same time, scientific sources emphasize that the amount of aroma-forming carbonyl compounds in the crust of freshly baked bread is higher than in the crumb.

Scientific studies have reported that inulin undergoes partial acid hydrolysis during baking, resulting in the formation of low-molecular compounds such as fructans and fructose. These hydrolysis products actively participate in Maillard reactions and accelerate the formation of aroma-forming substances. The literature also explains that a decrease in the degree of polymerization of inulin and oligofructose increases the intensity of their hydrolysis and influences the formation of aromatic compounds. .[1,3,5,]

Although some results are presented in existing sources regarding the use of inulin-containing raw materials in conventional bread-making technology, their effects on the rheological properties of dough, fermentation processes, and the formation of the aromatic profile have not been sufficiently analyzed in a systematic manner. This situation necessitates the experimental study of the use of inulin-containing components in conventional bread-making technology.

Materials and Methods. Research Results

The results of the conducted experiments made it possible to determine that the use of inulin-containing raw materials in conventional bread-making technology has a significant effect on the aromatic properties of the product. The amount of aroma-forming compounds was evaluated through the quantity of carbonyl compounds binding with sodium bisulfite, and this method makes it possible to quantitatively characterize the aromatic profile of bread.

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Table 1 Effect of the Addition of Inulin-Containing Raw Materials on the Aromatic Indicators of Bread

Sample Name	Amount of Aroma-Forming Compounds, ml (in 0.1 N iodine solution)	Change Compared to Control, %
Rye–wheat bread (control)	16.6	—
Rye–wheat bread + 3.0% HP	22.5	+35.5
Rye–wheat bread + 3.0% GR	24.5	+47.6
Rye–wheat bread + 3.0% P95	24.6	+48.2
Wheat bread (control)	11.3	—

According to the data of Table 1, the amount of aroma-forming compounds increased in all experimental samples with added inulin-containing preparations compared to the control samples. A similar trend was also observed in wheat bread samples. While the amount of aroma-forming compounds in the control sample was 11.3 ml, this value increased to 13.0 ml with the addition of 3.0% HP, to 14.1 ml with the addition of 3.0% GR, and to 15.2 ml with the addition of 3.0% P95. As a result, the relative increase in the amount of aromatic compounds was recorded within the range of 14.7–34.2%.

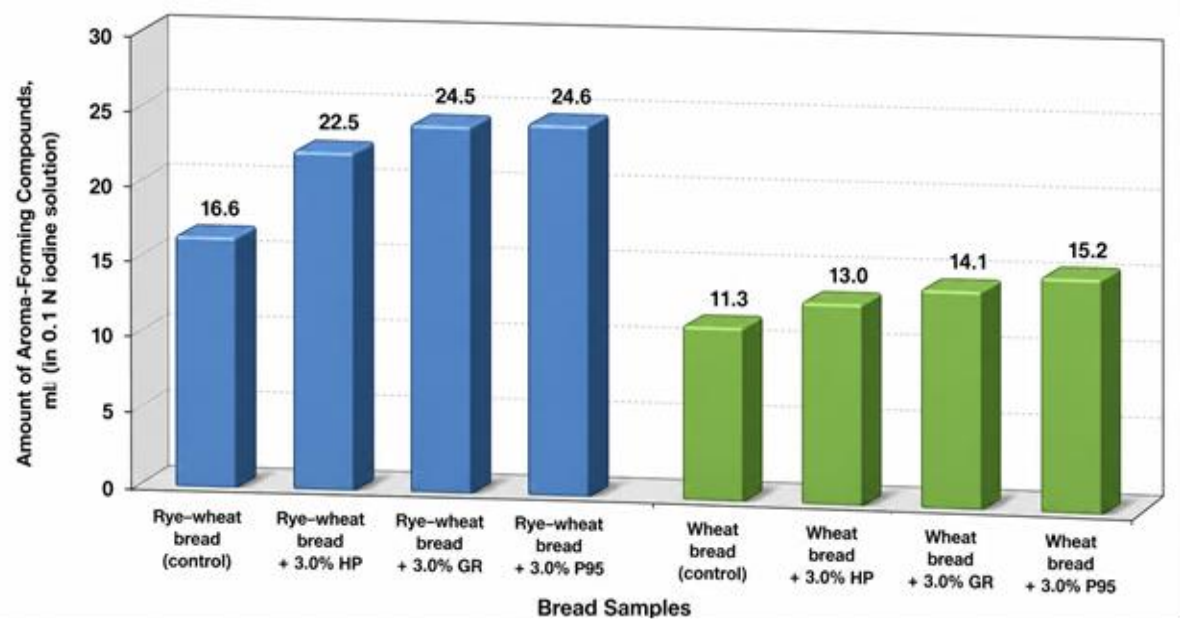

Figure 1. Effect of Inulin-Containing Raw Materials on the Amount of Aroma-Forming Compounds in Bread

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These regularities are clearly reflected in the bar chart presented in Figure 1. As can be seen from the graph, the samples with added inulin-containing preparations showed higher aromatic activity than the control samples in all cases. At the same time, the amount of aroma-forming compounds in rye–wheat breads was higher than in wheat breads, which is explained by the carbohydrate–protein complex of rye raw materials and the relatively intensive course of enzymatic processes. .[1,3,5,]

The obtained results indicate that inulin-containing raw materials actively participate in the chemical changes occurring during the baking process. It is known that during baking, the temperature in the surface layers of the dough piece rises above 100 °C, which together with the acidity of the medium leads to partial acid hydrolysis of inulin. As a result of hydrolysis, inulin molecules undergo depolymerization, forming fructans and monomer fructose.

The formed fructans and fructose, as reducing sugars, interact with amino acids, polypeptides, and proteins, accelerating Maillard reactions. During these reactions, melanoidins and aroma-forming carbonyl compounds are formed. The research results show that as the degree of polymerization of inulin preparations decreases, the intensity of their hydrolysis increases and the process of aromatic compound formation becomes stronger. In particular, the highest values of aromatic compounds were recorded when P95 and GR preparations were used.

The analysis of the obtained results shows that the data presented in the table and graph confirm that the use of inulin-containing raw materials in conventional bread-making technology enriches the aromatic profile of the product. The observed changes are explained by the active participation of low-molecular carbohydrates formed as a result of partial hydrolysis of inulin during baking in Maillard reactions. This condition not only improves the consumer properties of bread, but also demonstrates the technological feasibility of using inulin preparations. .[6,8,10]

Conclusion

As a result of the research, it was determined that the use of inulin-containing raw materials in conventional bread-making technology increases the amount of aroma-forming compounds in bakery products. The partial hydrolysis of inulin

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during baking and the participation of the formed fructose and fructans in Maillard reactions accelerate the formation of aromatic compounds and melanoidins. As the degree of polymerization of inulin preparations decreases, the amount of aromatic compounds increases, which was especially evident when P95 and GR preparations were used. The obtained results confirm that the use of inulin-based additives makes it possible to improve the organoleptic and functional properties of bakery products.

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