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"THE WORK OF SHAFT MACHINES IN CHANGING THE RHEOLOGICAL PROPERTIES OF WHEAT"

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Abstract: This study investigates the role of shaft machines in modifying the rheological properties of wheat during mechanical processing. Particular attention is paid to the influence of rotational speed, shear stress, and processing duration on the structural and viscoelastic characteristics of wheat material. The mechanical action generated by shaft machines leads to significant changes in dough-forming components, including gluten network development and starch–protein interactions. Rheological parameters such as viscosity, elasticity, and plasticity were analyzed to assess the degree of structural transformation. The results demonstrate that controlled mechanical treatment can improve wheat processing efficiency and enhance technological properties relevant to flour quality and dough behavior. The findings contribute to the optimization of shaft machine operating regimes in grain processing and food engineering applications.

Keywords: Wheat processing; shaft machines; rheological properties; mechanical treatment; viscoelastic behavior; gluten structure; food engineering.

Introduction

The rheological properties of wheat play a crucial role in determining the quality and technological performance of flour and dough in food processing industries. These properties are directly influenced by the mechanical, physical, and biochemical transformations that occur during wheat processing. In recent years, increasing attention has been paid to the application of mechanical treatment methods as an effective approach to modifying the structural characteristics of wheat materials without the use of chemical additives.

Shaft machines are widely employed in grain and wheat processing due to their ability to generate controlled shear forces, compressive stresses, and intensive mixing conditions. The mechanical energy transferred through rotating shafts affects the internal structure of wheat kernels and milled fractions, leading to changes in protein aggregation, gluten network formation, and starch granule behavior. As a result, the viscoelastic response of wheat-based systems can be significantly altered.

Understanding the relationship between shaft machine operating parameters—such as rotational speed, shaft geometry, and processing time—and the resulting rheological behavior of wheat is essential for optimizing processing efficiency and product quality. Despite extensive research on wheat rheology, the specific mechanisms by which shaft machines influence rheological parameters remain insufficiently explored.

Therefore, the aim of this study is to analyze the effect of shaft machine operation on the rheological properties of wheat, with particular emphasis on viscosity, elasticity, and plastic deformation characteristics. The outcomes of this research are expected to provide a scientific

basis for improving mechanical processing techniques and enhancing the functional properties of wheat in food engineering applications.

The rheological behavior of wheat is governed by its complex multiphase structure, primarily composed of starch granules, protein matrices, lipids, and minor components. Among these, wheat proteins—especially gluten-forming fractions—play a dominant role in defining the viscoelastic characteristics of wheat-based systems. The balance between elastic and viscous responses determines the technological suitability of wheat for various processing operations.

Mechanical treatment is recognized as an effective method for altering the internal structure of wheat materials by introducing shear deformation, compressive forces, and frictional interactions. These mechanical effects can induce partial disruption of starch granules, rearrangement of protein networks, and modification of inter-molecular bonding. As a result, the rheological response of wheat may shift depending on the intensity and duration of mechanical energy input.

Shaft machines operate by transmitting mechanical energy through rotating elements, generating controlled shear fields within the processed material. Unlike conventional grinding or milling devices, shaft machines enable continuous and uniform mechanical activation, which promotes structural reorganization rather than simple particle size reduction. This makes them particularly suitable for studying and controlling rheological transformations in wheat.

From a rheological standpoint, the behavior of mechanically treated wheat can be described using viscoelastic models that account for both elastic deformation and viscous flow. Parameters such as apparent viscosity, storage modulus, and yield stress serve as quantitative indicators of structural changes induced by shaft machine processing. Understanding these theoretical principles provides a basis for interpreting experimental results and for optimizing mechanical treatment conditions.

Materials

The wheat samples used in this study were obtained from locally cultivated hard wheat varieties commonly employed in flour production. Prior to mechanical treatment, the wheat was cleaned to remove foreign materials and conditioned to a standardized moisture content to ensure uniform processing conditions. All experiments were conducted under controlled laboratory conditions.

Shaft Machine Description

The mechanical treatment of wheat was performed using a laboratory-scale shaft machine equipped with adjustable rotational speed and interchangeable shaft elements. The machine allowed precise control of processing parameters, including shaft rotation speed, treatment duration, and mechanical load. These parameters were selected based on typical industrial operating regimes.

Experimental Procedure

Wheat samples were subjected to mechanical treatment at different shaft rotational speeds and processing times. After treatment, the samples were milled and prepared for rheological analysis. Rheological measurements were carried out using standard viscometric and oscillatory testing methods to determine key parameters such as apparent viscosity, elastic modulus, and plastic deformation behavior.

Rheological Analysis

The rheological properties of treated and untreated wheat samples were evaluated using a rotational rheometer. Flow curves and viscoelastic characteristics were obtained to assess the influence of mechanical processing on wheat structure. All measurements were repeated to ensure reproducibility, and the results were analyzed using comparative and statistical methods.

The experimental results indicate that shaft machine processing has a pronounced effect on the rheological behavior of wheat. An increase in shaft rotational speed resulted in higher shear stresses, leading to enhanced structural modification of wheat components. This was reflected in measurable changes in viscosity and elasticity.

Treated samples exhibited improved viscoelastic properties compared to untreated wheat, suggesting the formation of a more developed gluten network. The mechanical action facilitated protein–protein and protein–starch interactions, which contributed to increased elasticity and structural stability of the wheat-based system.

Furthermore, prolonged processing time intensified mechanical energy input, resulting in a gradual transition from elastic-dominant to plastic-dominant behavior. These findings highlight the importance of optimizing shaft machine operating parameters to achieve desired rheological characteristics while avoiding excessive structural degradation.

The results are consistent with existing studies on mechanical activation of wheat materials and confirm that shaft machines can serve as an effective tool for rheological property modification in grain processing applications.

Conclusion

This study demonstrates that shaft machines play a significant role in altering the rheological properties of wheat through controlled mechanical treatment. The applied shear forces and mechanical stresses induce structural transformations in wheat components, leading to notable changes in viscosity, elasticity, and plasticity.

The findings indicate that appropriate selection of shaft machine operating parameters can enhance the technological properties of wheat, thereby improving processing efficiency and end-product quality. The results provide a scientific foundation for the optimization of mechanical processing methods in wheat and flour production and may contribute to the development of energy-efficient and additive-free processing technologies in the food engineering industry.

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