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Effect of sodium chloride on the viscoelastic properties and baking performance of soft wheat dough

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Abstract
This study investigates the impact of varying sodium chloride concentrations on the viscoelastic properties and baking performance of soft wheat dough. By examining the dough's rheological behavior and the resultant bread's quality under different salt concentrations, this research aims to elucidate the mechanisms by which sodium chloride influences gluten network formation and baking outcomes. The results indicate that optimal sodium chloride content not only enhances dough strength and stability but also improves the volume and texture of the baked bread. These findings can aid in optimizing salt levels for better health profiles without compromising product quality.

Keywords: Sodium Chloride, Soft Wheat Dough, Viscoelastic Properties, Baking Performance, Gluten Network, Salt Reduction.

Introduction
Soft wheat flours are commonly used in the baking industry due to their lower protein content, which is suitable for products like cakes and pastries. However, the addition of sodium chloride (salt) plays a crucial role in modifying the properties of dough made from soft wheat. This study focuses on the dual role of sodium chloride in influencing the viscoelastic properties of dough and its subsequent effects on the quality of baked goods. Sodium chloride is known to strengthen the gluten network, enhance flavor, and extend shelf life. Understanding its impact on soft wheat dough is essential for achieving desired product characteristics while potentially reducing sodium content.

Objective
The main objective of this study is to investigate the influence of sodium chloride concentrations on the viscoelastic properties of soft wheat dough and to determine how these changes affect the overall baking performance and quality of the bread produced.

Materials and Methods
Soft wheat flour was mixed with water, yeast, and varying concentrations of sodium chloride (0%, 1%, 2%, and 3% based on flour weight). The viscoelastic properties of the dough were analyzed using a rheometer to measure elasticity and extensibility. Dough samples were baked under controlled conditions. The volume, crumb structure, and texture of the bread were evaluated. Standard chemical and physical methods were used to assess the gluten content, moisture levels, and protein interactions within the dough.

Results

Table 1: Rheological Properties of Soft Wheat Dough at Different Sodium Chloride Concentrations

Sodium Chloride (%)	Elasticity (Pa)	Extensibility (mm)
0	500	50
1	650	55
2	800	60
3	780	48

Note: Elasticity is measured in Pascals (Pa) and extensibility in millimeters (mm). Higher elasticity indicates a stronger dough, and greater extensibility indicates a more stretchable dough.

Table 2: Baking Performance and Bread Quality at Different Sodium Chloride Concentrations

Sodium Chloride (%)	Bread Volume (cm^3)	Crumb Texture Score (1-5)	Overall Bread Quality Score (1-10)
0	350	2	4
1	400	3	6
2	450	4	8
3	420	3	7

Note: Bread volume is measured in cubic centimeters (cm^3). The crumb texture score ranges from 1 (poor) to 5 (excellent), and the overall bread quality score from 1 (poor) to 10 (excellent).

The rheological data showed that increasing sodium chloride concentration up to 2% significantly improved the dough's elasticity and resistance to deformation. Breads baked from dough with 2% sodium chloride exhibited the highest volume and optimal texture. However, further increase in sodium chloride concentration to 3% resulted in diminished baking performance, indicating an optimal threshold for salt addition in soft wheat dough.

Discussion
The results presented in Tables 1 and 2 provide significant insights into the effects of sodium chloride on the viscoelastic properties of soft wheat dough and the consequential impacts on baking performance. This discussion explores these findings, emphasizing their

relevance to dough formulation and baking quality. The elasticity measurements demonstrate a clear increase with the addition of sodium chloride up to 2%, indicating that sodium chloride plays a crucial role in strengthening the gluten network. This enhancement likely arises from the ability of salt to tighten the gluten structure by reducing repulsive charges between protein molecules, thus promoting closer interaction and stronger bonds. The peak in elasticity at 2% salt suggests an optimal concentration for achieving a robust gluten network conducive to superior baking properties. However, the decrease in elasticity at 3% sodium chloride alongside reduced extensibility points to an over-strengthening of the dough. At this concentration, the excessive ionic strength may be leading to a gluten network that is too tight, restricting the expansion capabilities of the dough and thus negatively impacting the gas retention and stretching required during fermentation and baking. The bread volume data correlates well with the rheological properties, where a maximum volume is observed at 2% sodium chloride. This volume increase can be attributed to the enhanced gas-holding capacity of a stronger gluten network, as suggested by the improved elasticity measurements. The optimal network structure at this concentration likely facilitates better leavening during proofing and baking, resulting in a lighter, airier bread structure. The decline in volume and overall bread quality at 3% sodium chloride, despite a relatively high elasticity, supports the idea that an overly rigid gluten network can be detrimental, confirming the trend seen in the decrease of dough extensibility. Furthermore, the crumb texture scores, which peak at 2% and then diminish, highlight the importance of balanced dough properties. While strength is necessary, excessive firmness can lead to a denser, less desirable bread texture. These findings hold significant implications for the baking industry and health-related food reformulation. Optimizing sodium chloride levels not only enhances the structural and sensory attributes of bread but also offers a pathway to reduce sodium content without sacrificing quality. This is particularly relevant in the context of global health guidelines recommending lower sodium intake. Moreover, understanding the role of sodium chloride in dough properties aids in troubleshooting and refining baking processes, enabling bakers to produce consistently high-quality products under varying conditions and formulations. In conclusion, the study underscores the critical balance required in sodium chloride concentration to optimize both the viscoelastic properties of soft wheat dough and the overall quality of the baked bread. These insights can guide future research and practical applications in baking science, focusing on the development of healthier and equally satisfying wheat-based products.

Conclusion

The research conducted on the effect of sodium chloride on the viscoelastic properties and baking performance of soft wheat dough has yielded crucial insights. The study established that the addition of sodium chloride up to 2% by weight enhances the rheological properties of the dough, notably improving its elasticity and extensibility. This optimal salt concentration contributes significantly to the formation of a robust gluten network, which in turn supports better gas retention during fermentation, leading to an increase in bread volume and improvement in crumb texture. However, exceeding this concentration to 3% begins to have a detrimental effect on dough performance. The over-strengthened gluten network at higher salt levels restricts dough expansion and negatively impacts the overall texture and volume of the bread. These findings highlight the delicate balance required in salt addition, underscoring the importance of precise formulation in the baking process to achieve desired outcomes. This study not only advances our understanding of the functional roles of sodium chloride in dough but also has practical implications for the baking industry. By optimizing salt levels, bakers can improve the quality and consistency of soft wheat bread while also addressing health concerns associated with sodium intake. Future research could explore alternative strategies for dough enhancement that reduce sodium content without compromising product quality, contributing to healthier food options for consumers. In summary, the research confirms the critical role of sodium chloride in determining the physical properties of dough and the quality of bread, providing a scientific foundation for its application in baking and for potential sodium reduction initiatives in food production.

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