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Effects of Hydrocolloids on Yeast Activity, Dough Rheology, and Quality of Frozen Mini-Baguettes during Storage

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Abstract

The study analyses the effect of adding certain hydrocolloids: guar gum, xanthan gum, and hydroxypropyl methylcellulose (HPMC) on baker's yeast, the properties of frozen dough, and the quality of mini-baguettes after storage at −18°C for 56 days. The control sample, without hydrocolloids, was compared with three variants formulated with each hydrocolloid. The results show that frozen storage progressively reduces the fermentative activity of the yeast; however, samples containing hydrocolloids maintain higher CO_2 production than the control. After 60 minutes, HPMC showed the highest fermentative activity after 60 min of fermentation at the end of frozen storage, while after 120 minutes, xanthan gum and guar gum provided the best long-term fermentative stability. From a rheological perspective, hydrocolloids improved dough stability, kneading tolerance, and water retention capacity. Xanthan gum had the strongest effect, increasing stability, resistance to extension, and the balance between elasticity and extensibility. HPMC produced moderate effects, while guar gum resulted in a stiffer dough. In the final product, the addition of hydrocolloids contributed to maintaining specific volume, reducing the increase in hardness, and preserving sensory acceptability. Xanthan gum stood out for volume stability and improved texture, while HPMC achieved the highest sensory scores after 56 days. In conclusion, hydrocolloids act as cryoprotective agents in frozen dough by limiting water mobility, protecting the gluten network, and maintaining yeast viability. The choice of hydrocolloid should be aligned with the technological objective: rheological stability and volume for xanthan gum, fermentative stability for guar/xanthan, and sensory acceptability for HPMC.

Keywords: *cryoprotective agents, fermentative activity, rheological stability, sensory acceptability*

1. Introduction

Frozen dough technology is one of the most important directions of development in the modern bakery industry due to the advantages it offers in technological process flexibility, distribution optimization, and shelf-life extension of bakery products. However, freezing and frozen storage processes induce complex structural and biochemical modifications in the dough matrix, directly affecting yeast viability and fermentative activity, as well as the rheological properties of the dough and the quality of the final product [1,2]. During freezing, the formation of ice crystals and their recrystallization during storage lead to damage to the yeast cell membrane and destabilization of the gluten network, reducing fermentation capacity and gas retention ability. These phenomena are reflected in a decrease in the specific volume of products, textural modifications, and reduced sensory acceptability

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of bread obtained from frozen dough [3,4].

The viability of *Saccharomyces cerevisiae* cells is considered one of the main limiting factors in frozen dough technology. Osmotic and mechanical stress generated by ice crystal formation causes damage to the cell membrane and loss of intracellular compounds, affecting the fermentative metabolism of yeast [2]. In addition, the reduction in available water and its migration during frozen storage influence enzymatic activity and gluten structure stability, intensifying the degradation of the technological properties of the dough [5]. The release of glutathione and other reducing compounds from damaged yeast cells contributes to the breaking of disulfide bonds in gluten and weakening of the protein network structure, thus diminishing the dough's ability to retain CO_2 produced during fermentation [6]. In this context, the use of hydrocolloids as cryoprotective agents has attracted considerable interest due to their ability to improve the structural and functional stability of frozen dough. Hydrocolloids are hydrophilic biopolymers capable of interacting with water, starch, and gluten proteins, influencing the rheological, thermal, and microstructural properties of dough. Among the most used hydrocolloids in frozen bakery products are xanthan gum, guar gum, carboxymethyl cellulose (CMC), hydroxypropyl methylcellulose (HPMC), pectin, and carrageenan [1,7]. Due to their high water-retention capacity, hydrocolloids reduce the amount of freezable water and limit the formation of large ice crystals, thereby protecting both the gluten structure and the integrity of yeast cells [4].

Numerous recent studies have demonstrated the beneficial effects of hydrocolloids on yeast fermentative performance and on the quality of products obtained from frozen dough [1] highlighted the role of hydrocolloids in reducing osmotic stress and stabilizing water in frozen food systems, contributing to increased survival of freezing-sensitive microorganisms. He and al., 2024 reported that the combined addition of hydrocolloids and enzymes in frozen whole wheat dough significantly improved yeast fermentative activity and bread volume while maintaining the textural properties of the final product [3]. Similarly, Liu X et al., 2020 [4] observed that hydrocolloids reduce microstructural damage produced during frozen storage of partially baked baguettes and contribute to maintaining the thermal and physical stability of the dough. Furthermore, Muadiad, T; & Sirivongpaisal, P., 2021 [8] demonstrated that hydrocolloid addition improves the rheological and structural properties of frozen dough supplemented with rice bran by reducing the negative effects of freeze–thaw cycles on dough structure.

The mechanisms through which hydrocolloids exert protective effects on yeast and dough structure are complex and depend on their chemical nature, molecular weight, and concentration. Some hydrocolloids increase the viscosity of the aqueous phase and reduce water-molecule mobility, thereby limiting ice recrystallization and osmotic stress on yeast cells, while others interact directly with gluten proteins and starch granules, thereby strengthening the dough structure [5,9]. At the same time, certain hydrocolloids can form protective structures around yeast cells, reducing mechanical damage caused by ice crystals and maintaining metabolic activity and CO_2 production capacity during frozen storage [1].

In recent years, researchers' interest has focused on identifying optimal combinations of hydrocolloids and their interactions with enzymes, emulsifiers, and other cryoprotective substances to improve frozen dough performance and yeast fermentative stability [2,7]. Recent studies have also highlighted the potential of natural additives and hydrocolloid-based formulations to improve fermentation stability, dough rheology, and final bread quality in frozen bakery products [10,11,12]. However, the effects of different types of hydrocolloids on yeast viability and metabolic activity are not yet fully elucidated, and the results available in the literature vary depending on dough formulation, freezing conditions, and storage duration.

Therefore, the objective of this study was to evaluate the effect of guar gum, xanthan gum, and HPMC on yeast fermentative activity, dough rheology, and quality characteristics of frozen mini-baguettes stored at −18 °C for 56 days.

2. Materials and methods

2.1. Materials

For the study tests, type 650 white wheat flour marketed by SC SAPTE SPICE SA (Iasi, Romania) was used.

The wheat flour used in this study was analysed in accordance with Romanian and international standard methods according to the International Association for Cereal Science and Technology

(ICC), and presented the following characteristics: moisture content: 14.1% (ICC 110/1); ash content: 0.65% (ICC 104/1); wet gluten: 29.2% (ICC 106/1); falling number: 416.5 s (ICC 107/1); deformation index: 2 mm (SR 90-2007).

For this study, the behaviour of fresh compressed baker's yeast packaged in 500 g packs and marketed by SC ROMPAK SRL (Pascani, Romania) was analysed.

The baker's yeast was analysed according to Romanian and international standard methods and presented the following characteristics with dry matter 35.15%, protein content in dry matter (N × 6.25) 46.3125%, fermentative activity after 60 minutes 855 mL CO_2, fermentative activity after 120 minutes 966 mL CO_2, trehalose content 16.87%.

Guar gum with the commercial name AG 20/50, produced by Agro Gums, India, extracted from *Cyamopsis tetragonolobus*, with a particle size of 200 mesh and viscosity between 5000 and 5500 cP, was used in the study.

The xanthan gum used was Grinstead Xanthan 200, produced by Danisco Dupont, Denmark, with a particle size of 200 mesh and viscosity between 1200–1600 cP.

The hydroxypropyl methylcellulose used was Methocel K4M, produced by Danisco Dupont, Denmark, with a viscosity between 3000 and 5600 cP. Recrystallized iodized extra-fine salt from the manufacturer Ginavidor, with a sodium chloride content of 99.5%, was used.

Tap drinking water with a hardness of 22°dH (ISO 6059:1984) was used.

Commercial ice cubes were used during testing.

The bakery improver Eka Excel Fresh was used during testing, composed of the following ingredients: enzymes – fungal alpha-amylase, fungal xylanase, bacterial xylanase, and lipase – and ascorbic acid, intended to correct the rheological parameters of the flour used. The improver was produced and marketed by SC ROMPAK SRL (Pașcani, Romania).

Manufacturing recipe:

Mini-baguettes weighing 72 g of dough were prepared according to the manufacturing recipe described in Table 1.

Sample identification:

Sample A1 – control sample, without hydrocolloid addition;

Sample A2 – mini-baguette sample with 0.3% guar gum addition;

Sample A3 – mini-baguette sample with 0.3% xanthan gum addition;

Sample A4 – mini-baguette sample with 0.3% HPMC addition.

Table 1. Manufacturing recipe of mini-baguettes

Nr. Crt.	Material name	U.M.	Sample A_1	Sample A_2	Sample A_3	Sample A_4
			Ingredient quantities for 1000 g of dough			
1.	White wheat flour 650	g	620.35	619.19	619.19	619.19
2.	Fresh yeast	g	24.81	24.77	24.77	24.77
3.	Salt	g	12.41	12.38	12.38	12.38
4.	Bread improver	g	1.24	1.24	1.24	1.24
5.	Water	mL	248.14	247.68	247.68	247.68
6.	Ice	g	93.05	92.88	92.88	92.88
7.	Guar gum	g	-	1.86	-	-
8.	Xanthan gum	g	-	-	1.86	-
9.	Hidroxiproprilmethylcellulose (HPMC)	g	-	-	-	1.86

2.2. Methods of analysis

Analysis of yeast activity in mini-baguette dough after thawing

Yeast activity was determined using the Y55 Gastograph (Yucebas Machinery Analytical Equipment Industry, Turkey).

The analysis of yeast fermentative performance evaluates CO_2 production during the fermentation of a dough sample under standardized formulation, temperature, and humidity conditions. The method determines total or cumulative gas production over a predetermined period at a controlled temperature, expressed in mL.

For determining fermentative activity, 300 g dough samples were prepared separately according to the standardized method required by the Gastograph. These samples were not shaped into mini baguettes but were kept as bulk dough to ensure adequate

measurement conditions. The freezing of these samples followed the same thermal profiles applied to bun dough, ensuring comparability between fermentative activity measurements and the technological process.

3. Results and Discussion

3.1. Influence of Hydrocolloid Addition and Storage Time on Yeast Activity

In the experiments conducted, the selection of freezing–thawing parameters was based both on data reported in recent literature and on the results of previous research presented in section 2.2 of the "Materials and Methods" section. The selection of compressed baker's yeast was based on preliminary studies that highlighted superior fermentative performance and higher stability in frozen dough systems compared to other commercial forms of yeast [13,14].

Recent research has demonstrated that freezing and frozen storage processes induce significant structural and biochemical changes in the dough matrix, affecting yeast viability, rheological properties, and final product quality through the formation and recrystallization of ice crystals and the occurrence of osmotic stress [1,15,16]. In this context, hydrocolloids are considered efficient functional compounds for stabilizing frozen dough systems due to their water-retention capacity and ability to reduce water mobility within the dough matrix [1,17]. Recent studies have shown that xanthan gum, guar gum, and hydroxypropyl methylcellulose (HPMC) contribute to improving the structural and fermentative stability of frozen dough by limiting the formation of large ice crystals, protecting the gluten network, and reducing damage to yeast cells during frozen storage [4,5,15]. Liu et al. (2020) reported that the addition of hydrocolloids in partially baked baguette products stored frozen reduced microstructural damage and improved the thermal and physical stability of the dough [4]. Similarly, He et al. (2024) demonstrated that the use of hydrocolloids in combination with enzymes significantly improved yeast fermentative activity and the volume of products obtained from frozen dough [3]. In addition, Muadiad and Sirivongpaisal (2021) highlighted the positive effect of hydrocolloids on the rheological and structural properties of frozen dough through increased water retention and reduction of the negative effects produced by freeze–thaw cycles [8].

Based on the results reported in recent literature and preliminary experiments, hydrocolloids were used at a concentration of 0.3% relative to the flour quantity, a level considered appropriate for evaluating the cryoprotective effect on yeast fermentative activity and on the structural stability of frozen dough [5,7,10]. The results obtained regarding the fermentative activity of baker's yeast through Gastograph analysis are summarized in Tables 2 and 3.

The comparative analysis of yeast fermentative activity highlights the protective effect of hydrocolloids on yeast viability and fermentative performance during frozen storage of mini-baguette dough.

Table 2. Fermentative activity of yeast after 60 minutes of analysis in frozen mini-baguette dough during storage (mL CO_2)

Frozen dough sample	Storage time of frozen dough, [days]					
	0	7	14	28	42	56
Sample A1	625±3.5	581±4.4	528±3.6	525±3.6	511±3.6	403±3.6
Sample A2	639±3.6	607±3.6	530±3.6	525±3.0	513±3.6	440±3.6
Sample A3	629±3.6	611±3.6	525±3.6	520±3.6	509±3.6	439±3.6
Sample A4	750±3.6	688±3.6	577±3.6	555±3.6	504±3.6	494±3.6

p-values were determined by two-way ANOVA and indicate statistically significant differences between samples and frozen storage duration ($p < 0.05$). Values are expressed as mean ± standard deviation ($n = 3$). Yeast fermentative activity was determined using the Gastograph after 60 minutes and expressed in mL CO_2.

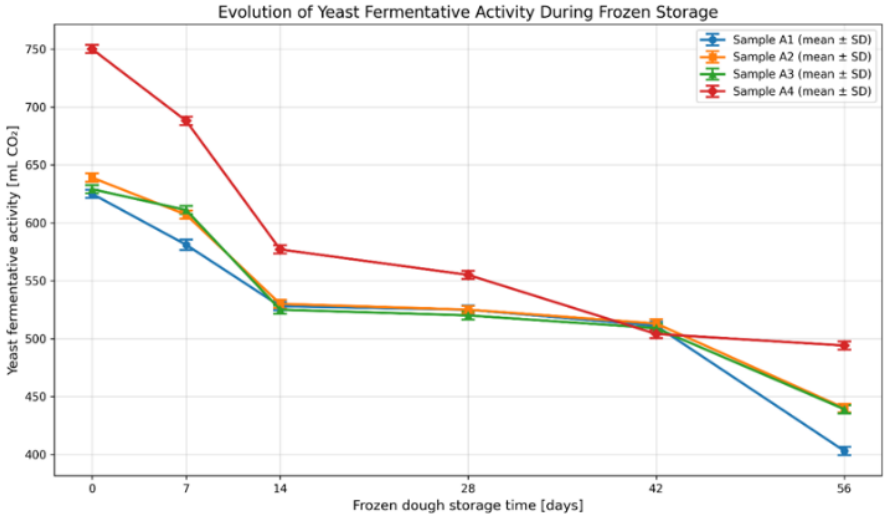

Figure 1. Evolution of yeast activity, after analysis at 60 minutes, during the storage of mini baguette dough

Yeast fermentative activity, determined using the Gastograph after 60 minutes and expressed in mL CO_2, was significantly influenced both by the duration of frozen storage at −18 °C and by the type of hydrocolloid added to the dough formulation. Analysis of variance (two-way ANOVA) revealed statistically significant effects ($p < 0.05$) of the studied factors and their interaction on the fermentative activity of the dough.

The control sample (A1), without hydrocolloid addition, showed the most pronounced reduction in fermentative activity during frozen storage. The volume of CO_2 produced decreased from initial values of approximately 625–629 mL to only 399–406 mL after 56 days of storage. This decrease may be attributed to the progressive deterioration of Saccharomyces cerevisiae cells because of ice crystal formation and osmotic stress associated with the freezing process.The addition of 0.3% guar gum (A2) resulted in a moderate improvement in fermentative stability compared to the control sample. After 56 days of storage, fermentative activity values were higher than those observed for A1, indicating a cryoprotective effect of guar gum on yeast cells. This behaviour may be explained by the ability of guar gum to increase water retention and reduce water mobility in the dough system, thus limiting the formation of large ice crystals. In the case of sample A3, which contained 0.3% xanthan gum, fermentative activity remained at slightly higher values than in sample A2 throughout the frozen storage period. Xanthan gum likely contributed to stabilizing the gluten network and reducing the negative effects of freeze–thaw cycles on yeast viability by increasing the viscosity of the aqueous phase and enhancing its hydration capacity.

The best results were obtained for sample A4, formulated with 0.3% HPMC (hydroxypropyl methylcellulose). This sample showed the highest values of CO_2 production throughout the frozen storage period, maintaining values of approximately 490–497 mL CO_2 after 56 days, significantly higher compared to the other samples. The superior effect of HPMC may be associated with its water-binding properties and its ability to form a protective structure around yeast cells and gluten components, reducing damage caused by water crystallization during freezing.

The results obtained demonstrate that the addition of hydrocolloids contributes to maintaining the fermentative activity of frozen mini-baguette dough, the cryoprotective effect varying depending on the type of hydrocolloid used. Among the hydrocolloids studied, HPMC showed the highest efficiency in preserving yeast fermentative activity during frozen storage at −18 °C, followed by xanthan gum and guar gum. These results confirm that hydrocolloids can improve the biological and technological stability of frozen dough by reducing the negative effects of thermal and osmotic stress on yeast cells.

Table 3. Fermentative activity of yeast after 120 minutes of analysis in frozen mini-baguette dough during storage (mL CO_2)

Frozen dough sample	Storage time of frozen dough, [days]					
	0	7	14	28	42	56
Sample A1	846.0±10.0	812.0±11.0	798.0±9.0	759.0±8.0	761.0±10.0	730.0±9.0
Sample A2	860.0±12.0	826.0±10.0	817.0±11.0	809.0±9.0	800.0±8.0	782.0±10.0
Sample A3	865.0±14.0	823.0±12.0	820.0±10.0	819.0±9.0	800.0±9.0	802.0±8.0
Sample A4	878.0±15.0	836.3±13.0	817.0±12.0	802.0±9.0	750.0±9.0	745.0±11.0

p-values were determined by two-way ANOVA and indicate statistically significant differences between samples and frozen storage duration ($p < 0.0001$). Values are expressed as mean ± standard deviation ($n = 3$). Yeast fermentative activity was determined using the Gastograph after 120 minutes and expressed in mL CO_2.

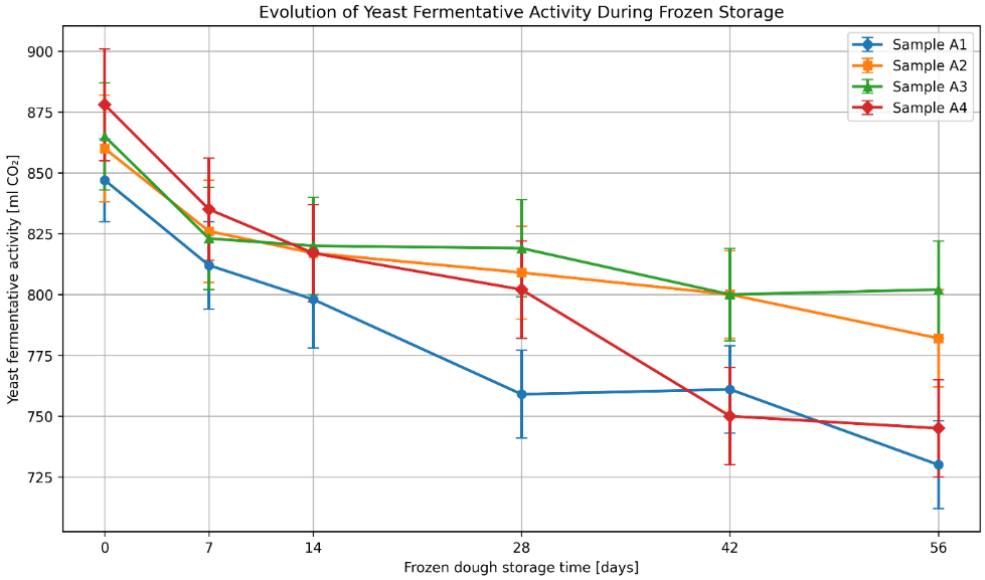

Figure 2. Evolution of yeast activity, after analysis at 120 minutes, during the storage of mini baguette dough

Two-way ANOVA statistical analysis demonstrated that both hydrocolloid addition and frozen storage duration significantly influenced the fermentative activity of baker's yeast in mini-baguette dough stored at −18 °C ($p < 0.0001$). For all analysed variants, a progressive decrease in fermentative activity during storage was observed, highlighting the negative effect of prolonged freezing on yeast metabolic activity. However, the intensity of this reduction varied depending on the type of hydrocolloid used in the dough formulation.

The control sample (A1), prepared without hydrocolloid addition, recorded the most pronounced decrease in fermentative activity during storage, suggesting lower resistance of yeast cells to freezing stress in the absence of compounds with cryoprotective effects. In contrast, samples containing hydrocolloids maintained higher fermentative activity values throughout the storage period, confirming the protective role of these compounds on yeast viability and functionality in frozen dough systems.

Among the analysed hydrocolloids, xanthan gum (A3) showed the best capacity to maintain yeast fermentative activity during frozen storage, with values remaining relatively stable even after 56 days. Guar gum (A2) also exhibited a favourable protective effect, although slightly lower compared to xanthan gum. The sample containing hydroxypropyl methylcellulose (A4) showed the highest initial fermentative activity; however, during prolonged storage, a more pronounced decrease was observed compared to samples A2 and A3.

The significant interaction between dough

formulation and storage duration indicates that the efficiency of hydrocolloids depends on the freezing period. Overall, the results suggest that the use of hydrocolloids, especially xanthan gum, contributes to improving the stability of yeast fermentative activity during frozen storage and may help maintain the technological performance and quality of frozen mini baguette dough.

3.2. Influence of Hydrocolloid Addition and Storage Time on the Specific Volume of Mini-baguettes

The variation in specific volume of mini-baguettes containing hydrocolloids during storage is presented in Figure 3.

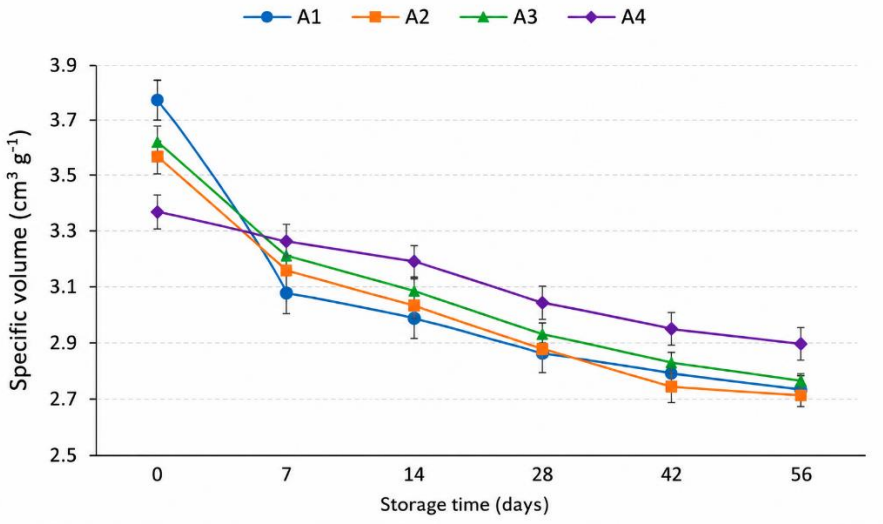

Figure 3. Evolution of the specific volume of minibags during storage

As can be observed, the initial specific volume increases with hydrocolloid addition. The same trend is maintained after 7 days of storage. After 14 days of storage, a general decrease in specific volume is observed for all samples, although the decrease is more pronounced at high substitution levels. Thus, sample A4 reached a measured specific volume of 3.94 cm³/g compared to sample A1, whose measured specific volume was 4.13 cm³/g, suggesting a higher sensitivity of the dough structure with high hydrocolloid content to freezing stress.

At 28 and 42 days of storage, sample A3 showed the best specific volume values, a result suggesting the existence of an optimal substitution level (15%) that provides structural stability and good CO_2 gas retention capacity during storage.

After 56 days of storage at −18 °C, all samples recorded decreases in specific volume; however, the differences became more evident: sample A3 maintained a high value of 4.52 cm³/g, while the specific volumes of mini-baguettes corresponding to samples A1, A2, and A4 decreased to 3.83 cm³/g, 3.96 cm³/g, and 3.81 cm³/g, respectively.

Sample A3 showed the best specific volume values, suggesting that the addition of 0.3% xanthan gum provided improved structural stability and gas retention during frozen storage. This demonstrates that the addition of 0.3% xanthan gum ensured the best long-term storage stability.

3.3. Influence of Hydrocolloid Addition and Storage Time on Mini-baguette Hardness

The results obtained through textural analysis are represented in Figure 4.

The results obtained through textural analysis highlight a progressive increase in dough hardness during frozen storage, a phenomenon associated with structural modifications induced by water recrystallization and degradation of the gluten network.

The addition of hydrocolloids significantly influenced the rheological behaviour of the dough, with the samples presenting distinct variations in hardness. Sample A3 recorded the lowest hardness values and the smallest increase over time, indicating a superior capacity for water retention and protection of the dough structure.

In contrast, sample A1 showed the greatest increase in hardness, suggesting reduced efficiency of the stabilization system.

Among the analysed variants, the hydrocolloid used in sample A3 demonstrated the best efficiency in

maintaining the textural properties of frozen dough, as evidenced by low hardness values and moderate increases during storage. This behaviour suggests superior water-retention capacity and protection of the gluten network against freezing-induced degradation.

By comparison, the other variants showed either more pronounced increases in hardness (A1), greater variability (A2), or higher initial values (A4). These results confirm the essential role of hydrocolloids in maintaining the rheological properties of dough subjected to freezing.

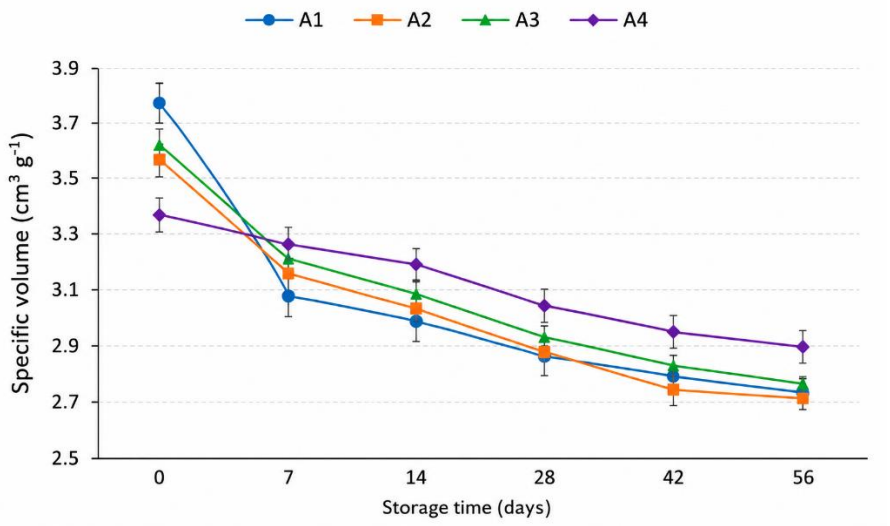

Figure 4. Influence of storage time on the hardness of mini-baguettes

3.4. Influence of Hydrocolloid Addition on the Sensory Characteristics of Mini-baguettes

The analysis of overall acceptability highlights a gradual decrease in sensory scores for all mini-baguette samples during frozen storage up to 56 days; however, the magnitude of this decrease was significantly influenced by hydrocolloid addition.The control sample (A1) recorded the most pronounced decrease in overall acceptability, from 8.67 to 7.00, indicating a faster degradation of sensory quality during storage. In contrast, the samples containing hydrocolloids (A2–A4) showed superior maintenance of acceptability, confirming their beneficial effect on product stability (Table 4).

Table 4. Overall acceptability of mini-baguettes during storage

Frozen dough sample	Storage time of frozen dough, [days]					
	0	**7**	**14**	**28**	**42**	**56**
Sample A1	8.67	8.17	8.17	7.50	7.33	7.00
Sample A2	8.67	8.50	8.33	8.00	7.83	7.17
Sample A3	8.33	8.50	8.50	8.00	7.83	7.67
Sample A4	8.33	8.50	8.50	8.20	8.00	7.83

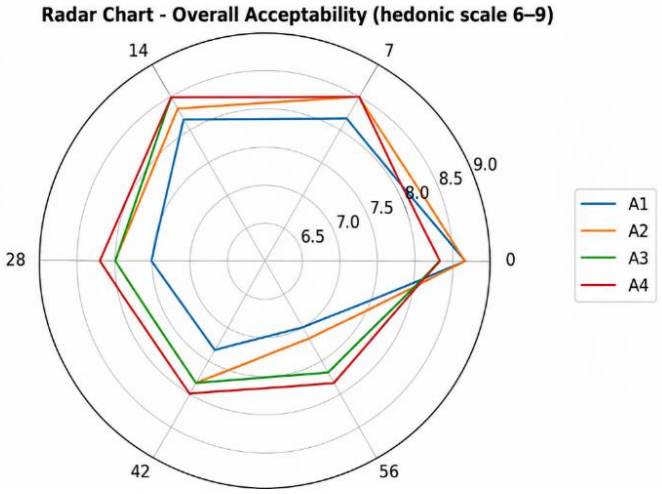

Figure 5. Synthesis of sensory results for mini-baguettes samples analyzed according to the storage duration of the frozen dough

Among the analysed variants, sample A4 (HPMC) demonstrated the best preservation of sensory quality, maintaining the highest score after 56 days (7.83), followed by sample A3 (xanthan gum, 7.67) and sample A2 (guar gum, 7.17). These samples also presented higher values during intermediate storage stages, indicating slower degradation compared to the control.

The results indicate that hydrocolloid addition contributes to improving and maintaining the overall acceptability of frozen mini-baguettes, most likely through effects on water retention, crumb structure stability, and limitation of staling phenomena. HPMC stood out through the most pronounced protective effect on sensory quality, followed by xanthan gum, while guar gum showed a positive but less pronounced effect.

3.5. Correlations Between Yeast Fermentative Activity and the Specific Volume of Mini-baguettes To evaluate the influence of frozen storage on the technological properties of mini-baguette dough, yeast fermentative activity and the specific volume of the final product were analyzed during storage at −18 °C. Yeast fermentative activity was determined using the Gastograph after 60 and 120 minutes and expressed in mL CO_2, while the specific volume of mini-baguettes was used as an indicator of structural quality and gas-retention capacity in the dough.

The study aimed to compare the control sample, without hydrocolloid addition, with samples formulated with 0.3% guar gum, 0.3% xanthan gum, and 0.3% hydroxypropyl methylcellulose (HPMC), to highlight the protective effect of hydrocolloids on yeast activity and on the quality parameters of the final product during frozen storage

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Table 5. Influence of frozen storage duration on yeast fermentative activity and specific volume of the final product

Sample	Specific volume [cm^3/g]	Yeast activity after 60 minutes [ml $CO_{2]}$	Yeast activity after 120 minutes [ml $CO_{2]}$
Sample A1	3.08±0.37	527.80±72.58	771.00±40.80
Sample A2	3.06±0.34	542.50±61.70	805.80±29.20
Sample A3	3.09±0.29	544.40±60.66	816.30±25.83
Sample A4	3.19±0.17	594.90±96.96	790.20±53.67

ANOVA analysis (p-value): specific volume p = 0.963; yeast activity after 60 minutes p = 0.970; yeast activity after 120 minutes p = 0.199.

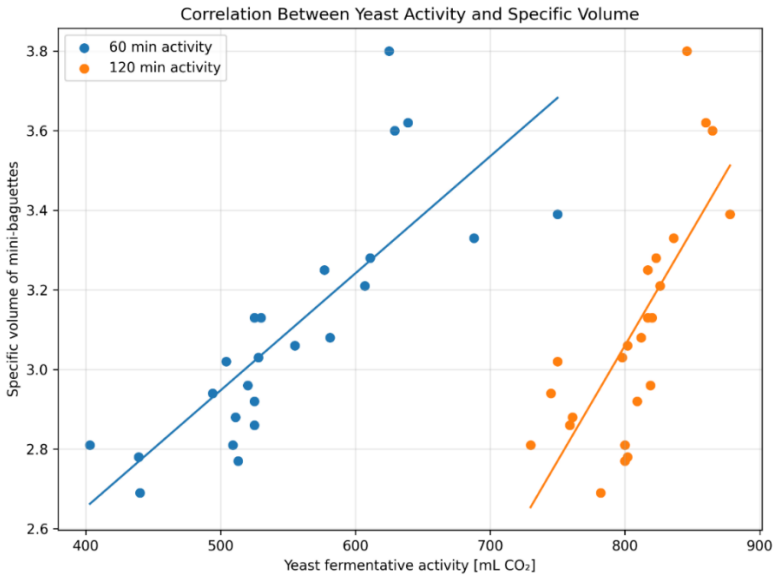

Figure 6. Correlations between yeast activity and specific volume of mini-baguettes

The results presented in the table and graphical analysis indicate that frozen storage caused a gradual reduction in both yeast fermentative activity and the specific volume of mini-baguettes. However, samples containing hydrocolloids presented higher values compared to the control sample, suggesting a beneficial effect on dough structure stability and on maintaining yeast metabolic activity during freezing.

ANOVA statistical analysis highlighted that the differences between samples were not statistically significant for specific volume ($p = 0.963$), fermentative activity after 60 minutes ($p = 0.970$), and fermentative activity after 120 minutes ($p = 0.199$). Nevertheless, the observed trends indicate that the use of hydrocolloids, especially xanthan gum and HPMC, may contribute to maintaining higher yeast activity values and improving the technological properties of frozen dough.

The positive correlation between fermentative activity and specific volume suggests that maintaining yeast viability and activity during frozen storage directly influences proofing capacity and the final quality of the bakery products.

4. Conclusion

The present study demonstrated that the addition of hydrocolloids improved the stability of frozen mini-baguette dough during storage at −18 °C for 56 days. Although yeast fermentative activity decreased progressively in all samples during frozen storage, doughs containing hydrocolloids maintained higher activity than the control sample, confirming their cryoprotective role.

Among the tested hydrocolloids, HPMC was the most effective in preserving fermentative activity after 60 minutes of fermentation and maintaining sensory acceptability, while xanthan gum showed the best long-term stability of fermentative activity after 120 minutes and contributed to improved textural properties and specific volume. Guar gum also exerted a positive protective effect, although less pronounced than xanthan gum and HPMC.

Overall, the results indicate that hydrocolloids can be successfully used as functional ingredients to improve the technological performance and quality stability of frozen bakery products by reducing the detrimental effects of frozen storage on yeast activity and dough structure.

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Conflicts of interest / Competing interests: The authors declare no conflict os interest.

Ethics approval: Not applicable

Availability of data and material: The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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