EVALUATION OF THE IMPACT OF ADDITIVE COMBINATION ON THE QUALITY OF BAGUETTE AND HAMBURGER PRODUCTS MADE FROM FROZEN DOUGH

NGHIÊN CỨU ẢNH HƯỞNG CỦA TỔ HỢP PHỤ GIA ĐẾN CHẤT LƯỢNG BÁNH MÌ BAGUETTE VÀ BÁNH MÌ HAMBURGER LÀM TỪ BỘT NHÀO LẠNH ĐÔNG

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Abstract - The article presents the effectiveness of a combination of additives, including Hydroxypropyl Methyl Cellulose (HPMC), Sodium Carboxymethyl Cellulose (CMC), Glucose Oxidase (GOX) enzyme, and trehalose in improving the quality of Baguette and Hamburger bread made from frozen dough. The efficiency of the additive combination was monitored through volume measurements and sensory evaluations of the bread products after 1 day, 1 month, and 2 months of frozen dough storage. The research results indicate that the application of the additive formula has significantly improved the volume of both Baguette and Hamburger bread. The Baguette bread product was evaluated by the sensory panel to have a better taste profile than the control sample, allowing for frozen dough bread product storage for up to 2 months. The additive combination improved the volume of Hamburger bread, although the sensory panel did not recognize a significant difference.

Key words - Frozen dough; hedonic test; GOX, HPMC, DATEM, trehalose

Tóm tắt - Bài báo trình bày hiệu quả của tổ hợp các phụ gia bao gồm: Hydroxypropyl methyl cellulose (HPMC), Natri carboxymethyl cellulose (CMC), Enzyme glucose oxidase (GOX) và trehalose trong việc cải thiện chất lượng bánh mì Baguette và bánh mì Hamburger làm từ bột nhào lạnh đông. Hiệu quả của tổ hợp các phụ gia được theo dõi thông qua kết quả đo thể tích và đánh giá cảm quan sản phẩm bánh sau 1 ngày, 1 tháng, 2 tháng bảo quản lạnh đông bột nhào. Kết quả nghiên cứu cho thấy việc ứng dụng công thức tổ hợp phụ gia đã thực sự cải thiện được thể tích bánh mì Baguette và Hamburger; sản phẩm bánh mì Baguette đã được hội đồng cảm quan đánh giá cho điểm thị hiếu tốt hơn mẫu trắng, cho phép bảo quản sản phẩm bột nhào lạnh đông bánh mì đến 2 tháng. Tổ hợp phụ gia đã cải thiện thể tích bánh Hamburger nhưng không được hội đồng cảm quan nhận ra sự khác biệt.

Từ khóa - Bột nhào lạnh đông; phép thử thị hiếu; GOX, HPMC, DATEM, trehalose

1. Introduction

Bread is one of the most popular and widely used foods worldwide [1], [2] because of its convenience, sensory value and nutritional value. Bread production technology requires specific conditions, including yeast strains, space, specialized machinery and especially the experience of the producer. Therefore, making bread at home is not popular.

Bread shows its best sensory quality when it comes straight out of the oven. Their quality - flavor, crispness - does not remain the same as initially experienced and quickly decreases over time [3], [4]. If consumers bake their own bread, it will be easier to enjoy fresh, hot and delicious bread.

The technology of producing bread from frozen dough was developed to meet the demand for quick and instant bread-making [5]. In this process, the shaped dough is frozen and kept at freezing temperatures. Then, the dough is thawed, fermented, and baked. This method is time-efficient and does not require extensive space, sophisticated equipment, specific skills, or experience [6]. It can be applied on various scales, from restaurants and hotels to individual homes, allowing bread to be made in any quantity [7], [8].

Bread made from frozen dough, when stored for an extended period, encounters several issues such as the disruption of dough structure, smaller bread volume compared to those made from conventional dough, and quick staling and retrogradation of the bread [4]. Therefore, research to solve this problem is a huge topic and receives many conflicting opinions [9], [10]. To tackle some of the challenges with frozen dough, we conducted a study to determine the production process and identify suitable additive combinations for frozen dough, applying them practically to the production of Baguette and Hamburger bread. To evaluate the effectiveness of the additive combination in the production of Baguette and Hamburger bread from frozen dough, this research assesses product quality by examining bread volume and sensory evaluation at different frozen storage durations. This helps confirm the impact of the additive combination on the frozen storage process.

2. Materials and methods

2.1. Ingredient

Non Nuoc (NN) flour from Interflour Company (Da Nang City, Vietnam), Cat Tuong fresh yeast from Saf - Viet Company (Long An province, Vietnam), Anchor unsalted butter (New Zealand), Dutch Lady powdered milk (Vietnam), Vinamilk unsweetened fresh milk (Vietnam),

Tuong An cooking oil (Vietnam), salt, sugar, chicken eggs purchased locally in Da Nang - Vietnam.

The additives used are of analytical quality such as: Trehalose (Japan), Hydroxypropyl methylcellulose (HPMC) - brand Methocel K4M, (China), Mono and diacetyl tartaric acid esters of mono and diglycerides of fatty acids (DATEM) - Ervesa Datem 4000 brand (Turkey), Glucose oxidase enzyme (GOX) - Gluzyme Mono 10000 BG brand (Denmark).

2.2. Methods

- Sensory evaluation method: A hedonic test was used to evaluate the preference of consumer [11]. The test was performed on a panel of 60 consumers to find out their level of satisfaction and preference for the studied product. This test was held at the consumer's workplace.

Principle of the test: The consumers are invited to taste the product and score their preference and satisfaction levels using a predefined scale through terms describing the levels of satisfaction and preference:

1 – Dislike extremely
2 – Dislike very much
3 – Dislike moderately
4 – Dislike slightly
5 – Neither liked nor disliked
6 – Like slightly
7 – Like moderately
8 – Like very much
9 – Like extremely

Baguette bread was cut into 6 cm thick slices, Hamburger bread was cut into ¼ portions, coded with a set of random 3-digit numbers and tasted in random order. The product samples were placed on pre-numbered plates.

The evaluation panel consisted of untrained individuals guided in sensory evaluation through an instruction sheet.

- Volume measurement method: After cooling, the volume of bread was determined using the seed displacement method (AACC Method 10-05) [12] .

2.3. Process of producing Baguette and Hamburger bread from frozen dough

The dough included flour, fresh yeast, salt, sucrose, cooking oil, butter, eggs, milk powder, fresh milk and an optimal combination of additives with concentrations as shown in Table 1.

The salt, sugar, trehalose, HCMC, DATEM, GOX (if any) additives were dissolved in water or fresh milk according to each formula, and the mixture was frozen before being added to the mixing bowl (the frozen water component constitutes about 2/3 of the total water content). Subsequently, the flour mixture was kneaded for 18 minutes, and the temperature of the dough mass after kneading was maintained at 25±1°C. After kneading, the dough was divided into parts with a weight of 85 g, rounded (Particularly for Baguette bread used for sensory evaluation, it was divided into parts weighing 288g and shaped into long Baguette loaves). After shaping, the dough was wrapped, labeled, and stored at -20 ± 2°C. After 1 day, 1 month, 2 months of frozen storage, the dough was thawed and proofed at 35°C, 75% relative humidity for 60 minutes and baked at 180°C for about 18 minutes until the bread turns golden.

Table 1. *Recipe for producing Baguette and Hamburger (g)*

Ingredient	Baguette		Hamburger	
	Blank	**Optimal**	**Blank**	**Optimal**
Flour	1000	1000	1000	1000
Fresh yeast	60	60	60	60
Salt	12	12	20	20
Sugar	15	15	100	100
Cooking oil	20	20		
Butter			100	100
Egg	50	50	188	188
Milk powder			50	50
Fresh milk			425	485
Trehalose		1		1
HPMC		17.5		17.5
DATEM		5.4		5.4
GOX		0.027		0.027
Water	596	620		

The bread was cooled to room temperature for volume measurement and sensory evaluation using a hedonic test for each type of bread, including 7 samples (Blank and Optimal samples from frozen dough stored for 1 day, 1 month, 2 months, and 1 fresh market sample for control, denoted as Blank 2M, Optimal 2M, Blank 1M, Optimal 1M, Blank 1D, Optimal 1D, Market).

2.4. Statistical analysis

The volume of the bread was presented as the average value from independent experiments with three replicates. Differences were shown to be statistically significant at the 95% confidence level and analyzed by Minitab 16 (Minitab Inc. PA, US).

Hedonic scores of the test were analyzed according to ANOVA with 2 factors (sample and tester) using Minitab 16 software, plotted with Microsoft office Excel 2016 software. Different letters represented significant differences ($\alpha = 0.05$) according to Tukey test.

3. Results and Discussion

3.1. Effect of additive combination on the Baguette bread volume and sensory quality

After each freezing storage period of the dough for 1 day, 1 month, and 2 months, samples of frozen dough for 85g Baguette were thawed, proofed, baked, and their volume was measured. The results of measuring the volume of Baguette bread samples from frozen dough stored for different durations are presented in Table 2.

Table 2. *Baguette volume (ml) over different storage periods*

Baguette	1 day	1 month	2 months
Blank	$255^{b} \pm 10.82$	$196^{b} \pm 23$	$166^{b} \pm 26.6$
Optimal	$399^{a} \pm 11.0$	$309^{a} \pm 13.0$	$275^{a} \pm 10.2$

(Different letters in the same column represent significant differences at $p < 0.05$)

After checking the volume of the Baguette bread samples, proceed to defrost the 288g Baguette dough samples shaped into long loaves, proof, bake (as shown in Figure 1) and conduct a sensory evaluation of the products.

Table 3 presents the results of the 2-factor ANOVA of sensory evaluation scores for the Baguette bread products using Minitab software.

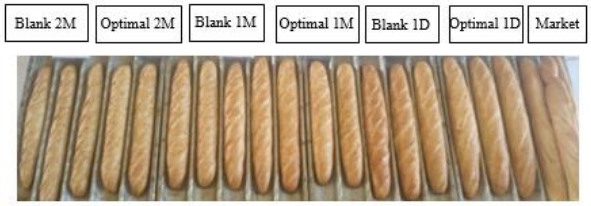

Figure 1. *Baguette Bread Product for Sensory Evaluation*

Table 3. *ANOVA summary of taste scores for Baguette bread samples*

Source	Degrees of freedom	Sum of squares	Mean of Squares	Variance Ratio (F)	P value	Standard F value
Tester	59	361.283	6.123	3.56	0.000	1.359
Baguette sample	6	254.095	42.349	24.6	0.000	2.12
Error	354	609.333	1.721			
Total	418	1223.656				

The F-value for the group of Baguette samples is 24.6, which exceeds the critical F-value of 2.12 [13]. Therefore, different Baguette samples significantly impact the hedonic scores of the product. The p-value for the group of Baguette samples is lower than 0.05, indicating that the differences among samples are statistically significant at a 5% significant level [11].

Similarly, the F value of the group of testers is 3.56, which is greater than the table standard F of 1.359 [13], demonstrating that different testers also affect the hedonic score of the product. The p value of the tester group is less than 0.05, so leading to the conclusion that different testers assign scores significantly different at the 5% level [11].

Based on the results in Table 3, it can be concluded that the sensory scores depend on both the factors of the bread sample and the tester.

The average hedonic scores of 60 testers are presented in Figure 2. Different letters represent significant differences ($p<0.05$) according to Tukey's test.

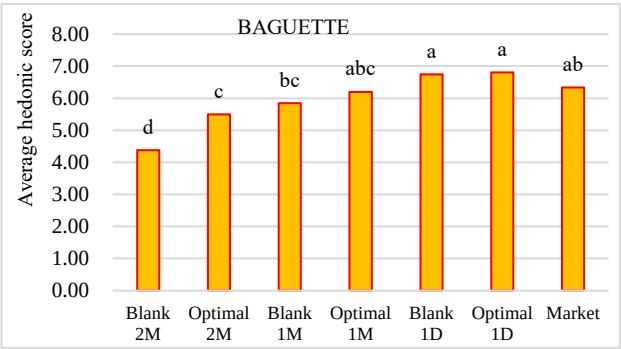

Figure 2. *Average hedonic scores of Baguette bread samples (Different letters represent significant differences ($p<0.05$)).*

The results of measuring bread volume indicate that the optimal Baguette bread sample consistently exhibits better volume than the blank sample throughout the frozen dough storage process of up to 2 months. This demonstrates the effective impact of the combination of additives, including trehalose, HPMC, DATEM, and GOX, on the frozen dough storage process of Baguette bread dough.

This phenomenon can be attributed to the role of trehalose in yeast cells, where it serves as a vital energy source and participates in their metabolic activities. Trehalose also protects biological molecules within yeast cells and contributes to the structure of the dough. Furthermore, trehalose acts as a defense mechanism against unfavorable environmental factors such as dryness, heat, cold, or nutrient deficiency. Additionally, trehalose possesses the ability to absorb and retain water, thereby reducing the osmotic pressure on yeast cells [14], [15]. These functions effectively enhance the survival capacity of yeast cells during freezing processes, leading to improvements in both volume and sensory quality of the bread.

GOX is an oxidizing agent that produces hydroperoxide (H_2O_2) as an intermediate reaction product. These hydroperoxides react with free thiols (–SH groups) found in glutathione (released from autolytic yeast), cysteine, peptides, proteins and with phenolic compounds in arabinoxylan, forming disulfide bonds in the resulting gluten network, thus increasing the elasticity of the gluten network. This, in turn, enhances the ability to retain carbon dioxide, thereby increasing volume [16].

Hydroxypropyl methylcellulose is a water-soluble fiber. The etherification of the hydroxyl groups of cellulose has increased the water solubility of HPMC and introduced some affinity for non-polar phases in the dough. Therefore, in a multiphase system like bread dough, this multifunctional property allows the dough to maintain homogeneity, protect, and sustain the stability of the emulsion during the bread-making process [4], [17].

In a frozen dough system for bread, Hydroxypropyl Methylcellulose (HPMC) forms interfacial films at the gas-liquid interface of the bubbles, providing stability to the gas bubbles against expansion and other changes. As the temperature increases during the baking process, HPMC forms a gel by interacting with the polymer chains, creating a network structure. This imparts strength to the dough during expansion and protects against volume loss.

HPMC is highly hydrophilic, and it can bind with the water present in the system, reducing the likelihood of complex formation between polymers present in the bread. Unlike proteins or starch polysaccharides, HPMC molecules do not aggregate at low temperatures. Therefore, the presence of HPMC does not lead to a redistribution of water in the dough, preventing part of the dough degradation [4]. All the above reasons make it possible for HPMC to improve the quality of bread from frozen dough through frozen storage cycles lasting up to 2 months.

DATEM is an anionic oil-in-water emulsifier used to improve bread quality. When mixed into dough, it interacts with gluten proteins to form the glutein – DATEM – gliadin complex [18]. This strengthens the dough structure and enhances gas retention.

Additionally, DATEM has the ability to interact with

starch. It prevents water movement from the gluten network to the starch, reinforcing the dough and preventing starch retrogradation and the staling of the final bread. Therefore, bread with added DATEM can have a larger volume and a softer texture compared to samples without added emulsifier.

For samples of bread made from frozen dough stored for 1 day or after 1 month, the preference level of the testers for the optimal sample and the blank sample showed no significant difference, and this preference level was also not significantly different from that of fresh bread from the market. With freezing time up to 1 month, the reduction in bread volume, as well as the staling of the blank sample, remained acceptable to the testers. Therefore, both the blank and optimal samples were deemed equally acceptable as fresh bread from the market.

For samples of bread from frozen dough after 2 months of freezing, their sensory scores were lower than fresh bread from the market, indicating significant staling [19]. However, the difference in sensory scores between the optimal sample after 2 months and fresh market bread was not too large (5.5 compared to 6.3). Meanwhile, the sensory score of the blank sample dropped below the average (4.38). This suggests the effectiveness of the combination of additives in the extended freezing process up to 2 months.

It could be concluded that the optimal additive combination formula can be used to produce frozen Baguette dough and can be stored frozen for 2 months.

3.2. Effect of additive combination on the Hamburger bread volume and sensory quality

Like Baguette bread, the Hamburger dough undergoes each stage of freezing for 1 day, 1 month, and 2 months, followed by defrosting, proofing, baking the Hamburger, and measuring the volume. The results of measuring the volume of Hamburger samples from frozen dough stored for different periods of time are shown in Table 4.

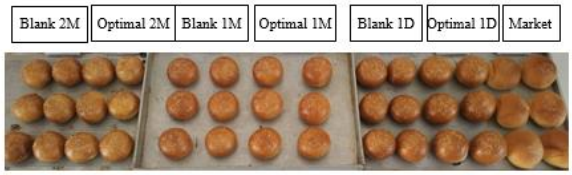

Figure 3. *Hamburger Bread Product for Sensory Evaluation*

After checking the volume of the Hamburger Bread samples, proceed to thaw the Hamburger Bread dough samples, proof, bake the bread (product as shown in Figure 3), and conduct a sensory evaluation of the product. Table 5 presents the results of the two-factor ANOVA analysis for the sensory evaluation scores of the Hamburger Bread product using Minitab software.

Table 4. *Hamburger volume (ml) over different storage periods*

Hamburger	**1 day**	**1 month**	**2 months**
Blank	315 ^{b} ± 14.2	242 ^{b} ± 9.1	236 ^{b} ± 5.0
Optimal	385 ^{a} ± 7.0	290 ^{a} ± 5.0	242 ^{a} ± 10.2

(Different letters in the same column represent significant differences (p<0.05))

Table 5. *ANOVA analysis of hedonic scores for Hamburger bread samples*

Source	**Degrees of freedom**	**Sum of squares**	**Mean squared**	**Variance correlation (F)**	**P value**	**Standard F value**
Tester	59	289.133	4.901	3.42	0.000	1.359
Hamburger sample	6	4.795	0.799	0.56	0.763	2.12
Error	354	506.633	1.431			
Total	419	800.562				

The F value of the group of Hamburger samples is 0.799, which is less than the reference standard F value of 2.12 [13], indicating that different Hamburger samples do not have significant effects on the hedonic score of Hamburger products. The p value of the Hamburger sample group is greater than 0.05, leading to the conclusion that the different samples are not significant at the 5% level [11].

Similarly, the F value of the group of testers is 4.901, which exceeds the reference standard F value of 1.359 [13], indicating that different testers have varying effects on the hedonic score of Hamburger products. The p value of the tester group is less than 0.05, suggesting that the testers' scores are significantly different at the 5% error level [11].

From the results in Table 5, it shows that hedonic scores depend on tester factors but do not depend on sample factors.

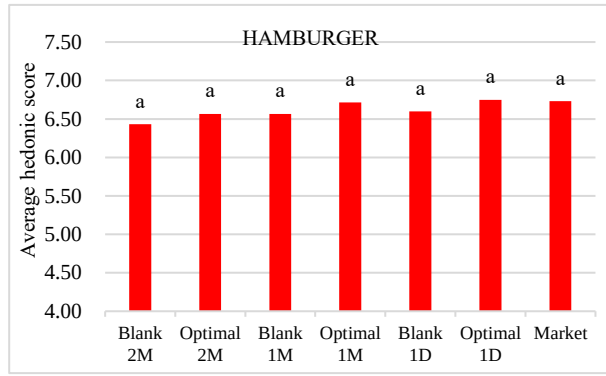

Figure 4. *Average hedonic scores of Hamburger bread samples (Different letters represent significant differences (p<0.05))*

The average hedonic scores of 60 testers are presented in Figure 4, where different letters represent significant differences (p<0.05) according to Tukey's test.

Although there is a noticeable difference in the volume measurement of Hamburger bread between the Blank and optimal samples after the same freezing dough preservation periods of 1 day and 1 month, the testers still find it challenging to perceive the difference through sensory evaluation.

The volume of the optimal Hamburger sample consistently exceeds that of the blank sample during the frozen storage of Hamburger dough for up to 2 months, demonstrating the enhancing effect of the additive combination trehalose, HPMC, DATEM, and GOX on the quality of Hamburger bread, similar to Baguette bread [14] [15] [16] [17] [18]. However, despite all 7 Hamburger samples having the same sensory preference group, this may be attributed to both the blank and optimal samples

containing high levels of butter, milk, and eggs in their composition. These ingredients help the bread retain numerous air bubbles, resulting in a soft, smooth, and uniform texture for Hamburger bread [20]. Additionally, the bread is cut into quarters for tasting, making it challenging for the testers to discern the differences.

To summarize, the optimal additive combination improved the volume of Hamburger bread, although the sensory panel found it difficult to recognize the difference between Hamburger samples.

4. Conclusion

The article has confirmed that applying the optimal additive formula to the production of Baguette and Hamburger dough improves the quality (volume) of Baguette and Hamburger bread. The Baguette bread product was evaluated by the sensory panel to have a better hedonic score than the blank sample after being frozen for 1 day, 1 month and 2 months, allowing frozen bread dough products to be preserved for up to 2 months. While the optimal additive combination improved Hamburger volume but no difference was detected by the sensory panel.

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