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Improving of bread quality from frozen dough using ascorbic acid and α-amylase

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ABSTRACT

The study is aimed to investigate the effects of thawing-frozen processing, dough improver (e.g. ascorbic acid) and α-amylase on bread quality. The results indicated that the quality of bread was less changed in comparison with the control sample if frozen doughs were defrosted at room temperature for 30 minutes before fermentation at the conditions of 40°C, 2 hours and baking at 180-200°C for 22 minutes. The addition of ascorbic acid of 0.01%, α-amylase of 0.01% or their combination with the same content of 0.01% (based on flour weight) into doughs significantly improved dough strength and loaf volume.

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1 INTRODUCTION

Bread is one of the most widely consumed and important staple food in the world. Bread making technology is probably one of the oldest technologies that people have known. This technology has improved continuously by using new materials, ingredients and equipment to produce good quality bread. Involved in bread making, some ingredients are mandatory (flour, water, yeast) and optional (sugar, fat, emulsifiers, milk, etc.) (Umelo *et al.*, 2014). Supplementary enzymes (e.g. exogenous α-amylases, proteases, hydrolases for non-cellulosic polysaccharides, lipases and lipoxygenases) are added to improve bread quality (Gujral and Singh, 1999).

Fresh bread is one of popular bread types in the world, meeting market demands. It typically presents an appealing golden-brown crust, a pleasant roasted aroma, fine slicing characteristics, a soft and elastic crumb texture, and a moist mouth feel. However, fresh bakery products have a relatively short shelf life because during their storage, the staling process occurs. That, physical and chemical changes cause the loss of bread freshness by an increase in crumb hardness and a decrease in flavour and aroma, leads to loss of consumer acceptance. Vania and Zhou (2007) stated that two basic mechanisms in firming the crumbs are loss of moisture and starch retrogradation. These preservation problems, coupled with the complex processes involved in conventional bread making together with increasing market demands, have led to the necessity to find out efficient methods to produce superior bakery products while preventing undesirable changes and extending the shelf life.

Hence, the bakery industry has increasingly exploited the applications of freezing technology. Frozen dough technology has been developed since the early twentieth century (Sluimer, 2005). Currently, frozen dough is being used all over the world. This technique helps bakers or retailers provide fresh bread to their custumers at almost any time, resulting in economic advantages to the producers and increasing convenience for the users. Many studies related to frozen dough and the influence of such processes on the quality of bread have been published (e.g. Matuda *et al.*, 2005; Mohamed *et al.*, 2010). Although there are many advantages, frozen dough also exhibits some problems in the quality of the final products (loss of the dough strength; decrease in the carbon dioxide (CO_2) retention capacity; reduction in yeast activity; decrease in loaf volume; and deterioration in the texture of the final products). The quality of frozen dough bread is affected by dough formulation; quality, quantity and type of yeasts; dough mixing time (Rouille *et al.*, 2000); freezing rate; storage duration and thawing rate (Lu and Grant, 1999). These factors may act independently or synergistically to reduce yeast activity, which results in reduced CO_2 production, or to damage the gluten network which in turn results in poor CO_2 retention and poor baking performance (Lucas *et al.*, 2005). In addition, during the freezing time, reducing substances like glutathione from yeast, are released (Kline and Sugihara, 1968; Hsu *et al.*, 1979). That, glutathione cleaves disulphide bonds in the gluten network, results in dough weakening.

The addition of improvers in bread formulations may overcome these problems associated with frozen dough. Ascorbic acid is a very popular and widely used flour improver in bread products to eliminate oxidizing process (Joye *et al.*, 2009). It is an oxidizing agent that strengthens the gluten network by creating disulphide bonds to improve bread quality (e.g. keeping gas cells, softening crumb and increasing the bread volume) (Nakamura and Kurata, 1997). Moreover, it prevents the effect of glutathione forming in frozen-thawing process and lowers the requirement of mixing (Belitz and Grosch, 1999).

Enzymes play key roles in bread making. In recent years, enzyme usage in bread making has been increasing. Alpha-amylase is added to the dough in bread baking process to hydrolyse starch into small dextrins which can further be fermented by yeast. This increases the rate of fermentation. The starch hydrolysis also decreases the viscosity of the dough, thus improving its texture and increasing loaf volume by rising of dough (Ajita and Thirupathihalli, 2014). The enzyme is also used as an anti-staling agent to improve the shelf life and softness retention, and decrease oxidative reaction of baked goods (Kulp *et al.*, 1981; Van Dam *et al.*, 1992; Gupta *et al.*, 2003).

The study was conducted with the aim of determining the ability to use frozen dough for bread making. The effect of thawing time to frozen dough, the amount of ascorbic acid and α-amylase added to the formulation were investigated for improving the quality of the products.

2 MATERIALS AND METHODS

2.1 Materials

Wheat flour (11.5% protein) was provided from Hongha Company (Ninh Kieu district, Can Tho city). There was saf-instant dried yeast containing *Saccharomyces cerevisiae* and sorbitan monostearate (E491) from France. α-amylase from *Bacillus licheniformis* (Termamyl 120L-Type L, Novozymes A/S, Denmark), L-ascorbic acid (China) were supplied by Chemical and Scientific Technological Materials Joint Stock Company, Can Tho branch. Other materials such as sugar, condensed milk, butter and salt were prepared.

Procedures for bread making with constant formulation and summarized scheme are shown in Table 1 and Figure 1, respectively. Mainly used equipments in experiments including texture analyser (model TA-XT2i, England), freezer (Sanyo freezer MDF 236, Japan), and oven (Water Fall, Italia) came from Food Technology Department, College of Agriculture and Applied Biology, Can Tho University.

Table 1: Bread formulation for bread making

Ingredients	Amount (%) based on amount of wheat flour (100%)
Wheat flour	100
Water	45
Sugar	10
Condensed milk	7
Butter	5
Egg	3
Dried yeast (*)	1.25
Salt	0.35
Additives	0.3

(Thuy, 2011)

* *Dried yeast was activated in warm water at about 35°C before using*

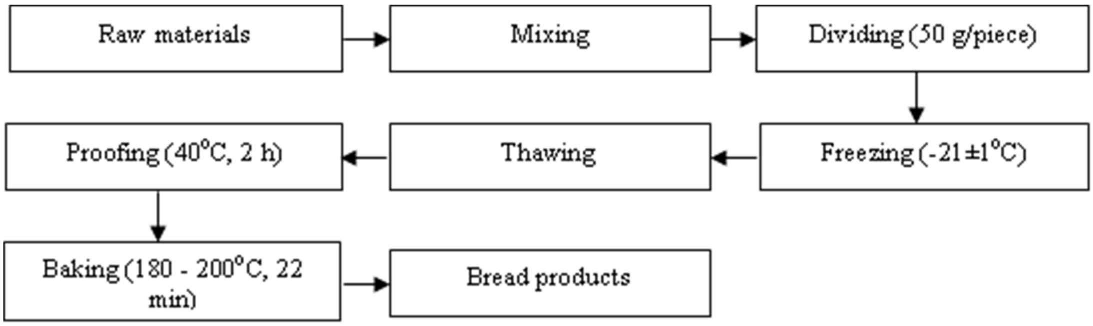


Fig. 1: Bread process flow diagram for frozen dough production

2.2 Experimental methods

2.2.1 Studying the effect of thawing time on texture and loaf volume of bread

The frozen doughs were thawed at room temperature for 20, 30, 40 and 50 minutes, and then fermentation process was carried out in a proof cabinet at 40ºC for 2 hours. The doughs were baked at 180 - 200ºC for 22 minutes. The products were kept at room temperature for 30 minutes before analysing. Fresh dough (non-frozen dough) was prepared as the control sample.

2.2.2 Studying the effect of ascorbic acid and α-amylase addition on texture and loaf volume of bread made from frozen dough

The levels of ascorbic acid and α-amylase were 0.01, 0.02 and 0.03%; and 0.005, 0.01 and 0.015% (w/w, based on flour weight), respectively. After thawing at the optimum condition (from previous experiment results), the dough was baked as demonstrated in Figure 1. Bread texture and loaf volume were further analysed.

2.2.3 Analytical methods

Texture profile analysis

Texture profile analysis was conducted using a texture analyser (model TA-XT2i, England) equipped with a 25 kg load cell, a cylindrical aluminum probe of 25 mm diameter and a test speed of 1 mm/s to measure compression force. The thickness of bread slice is 25 mm. The maximum compression force needed to compress the sample to 40% of its original thickness (10 mm). The value of compressive strength (gram-force) was recorded at the time when the structure is broken (Figure 2).

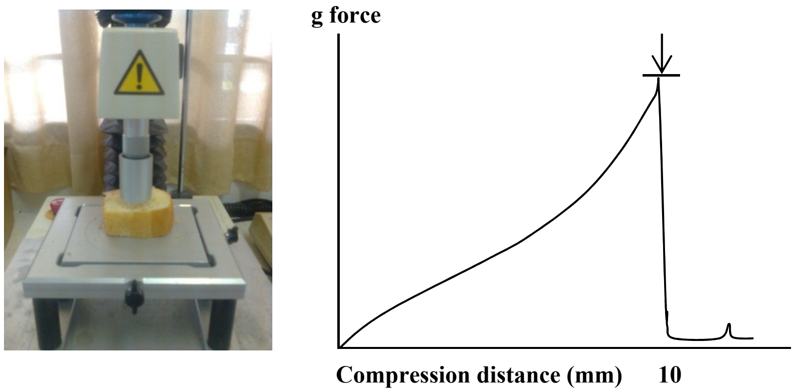
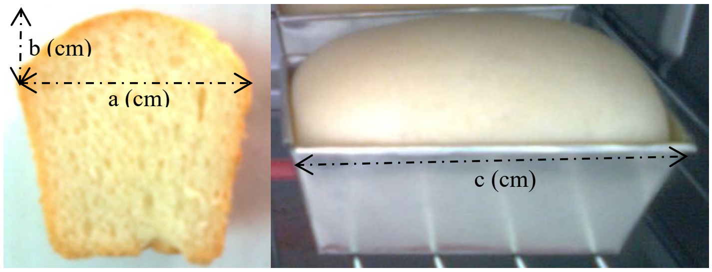


Fig. 2: Texture analyser and compressive force curve

Loaf volume measure

Loaf volume (cm^3) was relatively measured based on the volume of pan (124 cm^3) and the volume of part located out to the pan (Figure 3). Loaf volume was calculated in the following equation (1).

$$\text{Loaf volume } (cm^3) = 124 + (a \times b \times c) \qquad (1)$$



(A) **(B)**

Fig. 3: The pan for bread baking with (A) bread slice and (B) fermented bread before baking

Sensory evaluation

Sensory evaluation was performed by 10 fixed panelists, and the quality of bread was judged using scoring method for the score of 5 points from 1 (very bad), 2 (bad), 3 (fair), 4 (good) and 5 (very good). Sensory qualities including color, texture and taste were evaluated.

2.2.4 Statistical analysis

All the experiments were carried out in triplicate, and the results are expressed as means. Statistical analyses were performed using Statgraphics Centurion v.15.2.11.0. The analysis of variance was performed by ANOVA procedure with Least significant difference test for determining the differences of means. P values of less than 0.05 were regarded as significant.

3 RESULTS AND DISCUSTION

3.1 Effect of frozen dough thawing time on bread texture and loaf volume

The frozen dough was defrosted at room temperature in different time periods. After fermentation step, it was baked during 22 minutes at 180-200ºC. The bread was cooled at room temperature, and the data was recorded. The effects of thawing time on texture and volume of bread are presented in Table 2.

Table 2: Effect of thawing time on compressive strength and loaf volume

Thawing time (min)	Compressive strength (gram-force)	Loaf volume (cm^3)
Control	235.88^{c}	98.28^{c}
20	209.76^{b}	76.32^{a}
30	229.05^{bc}	86.76^{ab}
40	214.10^{b}	93.96^{bc}
50	159.71^{a}	79.92^{a}

Data are presented as mean of triplicate analyses
Different letters denote significant differences ($p<0.05$) between thawing time

There were significant differences in compressive strength and loaf volume of bread from frozen-and-thawed dough and non-frozen dough. Compressive force on bread made from the frozen dough decreased from 235.88 gram-force (control sample) to 159.71 gram-force (sample with 50 minutes of thawing time). Frozen dough defrosted for 30 minutes kept the structure (229.05 gram-force) better than the others. The loaf volume got the best value when frozen dough was defrosted in 40 minutes (93.96 cm^3 in comparison with 98.28 cm^3 of the control sample). If frozen dough was defrosted in short time (20 minutes) or long time (50 minutes), the quality of bread could not be kept as the control. A possible explanation for the quality loss involves the changes in dough texture as a result of water transport during storage from the hydrated gluten to the ice phase (Bot and de Bruijne, 2003). During baking, the gluten does not rehydrate, thus affecting the yield stress of the starch paste and the baking performance of the dough (Vania *et al.*, 2007). Another reason is the liberation of glutathione from yeast during dough freezing, leading to the reduction of gluten cross linking (Kline and Sugihara, 1968). According to Gelinas *et al.* (1995), ice crystalisation contributed to the weakening of gluten network and the reducing CO_2 retention, so to the volume of final product made from frozen-and-thawed dough.

The changes in compressive force and volume of bread made from defrosted dough at room temperature in 30 - 40 minutes were lowest (in comparison with the control). Therefore, optimum condition or thawing time of 30 minutes was chosen for the next experiments.

3.2 Effect of ascorbic acid and α-amylase addition on bread quality

The using of singular or multiple improvers affected the quality of bread made from frozen dough. The data on the effects of ascorbic acid and α-amylase on bread quality are shown in Table 3.

Table 3: Effect of ascorbic acid and α-amylase on compressive strength and loaf volume

Ascorbic acid (%)	α-amylase (%)	Compressive strength (gram-force)	Loaf volume (cm^3)
0	0	234.02^{a}	79.38^{a}
	0.005	246.60^{ab}	88.02^{bcd}
	0.01	274.43^{cde}	92.34^{cd}
	0.015	269.71^{cd}	88.02^{bcd}
0.01	0	259.66^{bc}	84.24^{b}
	0.005	258,.8^{bc}	84.78^{ab}
	0.01	326.19^{h}	103.68^{e}
	0.015	273.35^{cde}	102.60^{e}
0.02	0	262.61^{bc}	86.94^{bc}
	0.005	284.69^{def}	91.26^{bcd}
	0.01	317.54^{gh}	93.42^{cd}
	0.015	304.91^{fg}	90.72^{bcd}
0.03	0	265.71^{bcd}	89.10^{bcd}
	0.005	283.62^{de}	94.50^{d}
	0.01	314.01^{gh}	92.88^{cd}
	0.015	292.34^{ef}	89.64^{bcd}

Data are presented as mean of triplicate analyses
Different letters denote significant differences (p<0.05) between the content of ascorbic acid and α - amylase

There was remarkable improvement in compressive force and loaf volume of the samples which were supplied ascorbic acid (0% of α-amylase) compared with control sample. However, the increasing of ascorbic acid content from 0.01% to 0.03% did not show significant difference in compressive strength (259.66, 262.61 and 265.71 gram-force, respectively) and loaf volume (84.24, 86.94 and 89.10 cm^3, respectively). Hence, adding 0.01% ascorbic acid to the dough formula gave positive effect on texture and volume of bread. The same result was reported by Kenny et al. (1999).

The addition of α-amylase without ascorbic acid to the doughs resulted in improvements in the volume and texture of the products. In comparison with the control sample (79.38 cm^3), the present of 0.005% α-amylase improved the volume of bread made from frozen dough (88.02 cm^3). However, increasing α-amylase content from 0.005% to 0.015%, the increase of loaf volume (88.02, 92.34 and 88.02 cm^3, respectively) was not observed in term of statistical significance. The addition of 0.005% α-amylase did not affect compressive force (246.60 gram-force comparing to 234.02 gram-force for control sample). The amount of 0.01 and 0.015% led to a significant increase of compressive force (274.43 gram-force and 269.71 gram-force, respectively). The results indicated that the amount of α-amylase of 0.01% was sufficient to improve bread quality from frozen dough.

However, a single improver did not solve all the problems related to bread quality lost from frozen dough. The combination of them gave more effective results. As shown in Table 2, the combination of ascorbic acid and α-amylase gave better results. The content of 0.01% ascorbic acid and 0.01% α-amylase had a positive effect on bread quality. The maximum of compressive force (326.19 gram-force) and loaf volume (103.68 cm^3) were obtained in these conditions. These values had considerable difference from the values of the control sample and individual ascorbic acid or α-amylase treated samples.

Bread quality was evaluated in terms of colour, texture and taste by 10 panelists. The data on the effects of ascorbic acid and α-amylase on bread sensory properties are presented in Table 4. The products accepted by customers should be scored from 4 downwards. That means the quality of products is evaluated well by panelists.

Table 4: Effect of ascorbic acid and α-amylase on sensory properties of products

Ascorbic acid (%)	α-amylase (%)	Sensory quality		
		Colour	Texture	Taste
0	0	3.5^{abc}	2.9^{a}	3.0^{a}
	0.005	3.2^{a}	3.2^{abc}	3.4^{b}
	0.01	3.9^{cd}	3.8^{ef}	3.6^{bc}
	0.015	3.9^{cd}	3.5^{cde}	3.8^{cd}
0.01	0	3.3^{ab}	3.5^{cde}	3.4^{b}
	0.005	3.9^{cd}	3.4^{cde}	3.6^{bc}
	0.01	4.2^{d}	4.3^{g}	4.3^{e}
	0.015	3.6^{abc}	3.5^{cde}	3.5^{bc}
0.02	0	3.9^{cd}	3.1^{ab}	3.5^{bc}
	0.005	3.9^{cd}	3.2^{abc}	3.8^{cd}
	0.01	4.7^{e}	3.3^{abc}	3.5^{bc}
	0.015	3.7^{bc}	4.0^{fg}	4.4^{e}
0.03	0	3.7^{bc}	3.5^{cde}	3.7^{bc}
	0.005	4.3^{de}	4.4^{g}	3.8^{cd}
	0.01	3.9^{cd}	3.8^{ef}	4.1^{de}
	0.015	4.2^{d}	3.6^{def}	3.5^{bc}

Data are presented as mean of triplicate analyses
Different letters denote significant differences (p<0.05) between the content of ascorbic acid and α - amylase

The most acceptable bread was the one with 0.01% ascorbic acid and 0.01% α-amylase which had a fine taste, brown colour, good aroma and fresh appearance. The given scores for this sample were 4.2 for colour, 4.3 for texture and 4.3 for taste. Control sample received lower scores on colour (3.5/5), texture (2.9/5) and taste (3/5) because of lost quality during freezing storage of dough.

4 CONCLUSIONS

In this study, the effects of thawing time, ascorbic acid and α-amylase addition on quality of bread made from frozen dough were evaluated. The dough freezing-thawing process in bread making affects the texture and volume of final product. The thawing time of 30 minutes at room temperature minimised changing of the compressive strength and loaf volume of bread in comparison with a control sample (non-frozen dough). The presence of 0.01% ascorbic acid and 0.01% α-amylase improved the quality of bread made from the frozen dough, removing the negative effects of that process conditions.

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