LWT - Food Science and Technology 49 (2012) 96–101

Contents lists available at SciVerse ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Effect of the emulsifier sodium stearoyl lactylate and of the enzyme maltogenic amylase on the quality of pan bread during storage

Cristiane Rodrigues Gomes-Ruffi [a], Robison Henrique da Cunha [b], Eveline Lopes Almeida [c], Yoon Kil Chang [c], Caroline Joy Steel [c,*]

[a] Instituto de Tecnologia de Alimentos, Av. Brasil, 2880, Jardim Chapadão, CEP 13070-178, Campinas, São Paulo, Brazil
[b] AB Brasil Indústria e Comércio de Alimentos Ltda, Rua João Batista Figueiredo, 250, Jardim Brasil, CEP 13201-848, Jundiaí, São Paulo, Brazil
[c] Department of Food Technology, Faculty of Food Engineering, University of Campinas, P.O. Box 6121, CEP 13083-862, Campinas, São Paulo, Brazil

ARTICLE INFO

Article history:
Received 2 November 2011
Received in revised form
9 April 2012
Accepted 13 April 2012

Keywords:
Pan bread
Emulsifiers
Enzymes
Sodium stearoyl lactylate
Maltogenic amylase
Technological quality

ABSTRACT

Emulsifiers and enzymes are used as anti-staling agents in bakery products, providing increased shelf life, which is especially interesting for industrialized breads, such as pan bread. The objective of this study was to evaluate the effects of the emulsifier sodium stearoyl lactylate (SSL) and of the enzyme maltogenic amylase (MALTO) on the quality of pan bread during storage. A 2^2 complete factorial experimental design was followed and the Response Surface Methodology (RSM) was used to evaluate the influence of the addition of SSL (0–0.50 g/100 g flour) and MALTO (0–0.04 g/100 g flour) on bread quality parameters. A Control bread (without the addition of emulsifier or enzyme) was also prepared. Response surfaces and mathematical models were obtained for all the responses studied, showing the positive effect of the addition of SSL and MALTO on the increase of bread volume and the reduction of firmness, especially on Day 10. The breads with the highest total scores in the sensory evaluation were those with 0.43 g SSL/100 g flour + 0.03 g MALTO/100 g flour and with 0.50 g SSL/100 g flour + 0.02 g MALTO/100 g flour.

1. Introduction

Bread is composed basically of wheat flour, water, baker's yeast and salt (sodium chloride). However, other components are added in small quantities to improve dough characteristics during processing and the quality of the final product. These components can be vegetable shortenings, sugars, emulsifiers, oxidizing agents and enzymes (Matuda, 2004).

Bread staling is responsible for significant financial losses, both for consumers and for manufacturers. Staling corresponds to loss of freshness in terms of flavor, texture, moisture and other product characteristics (Si, 2001). The most widely used indicator of staling is the measurement of the increase of crumb firmness, which is the attribute most commonly recognized by consumers. The major theories on the staling mechanism, in summary, relate that the factors affecting bread staling during storage are: (1) starch retrogradation, especially amylopectin retrogradation, which plays an important role, but which alone is not responsible for bread staling; (2) gluten proteins and gluten–starch interactions also play an important role; and (3) moisture migration is also involved in staling (Lai & Lin, 2006).

Today, several anti-staling agents, such as emulsifiers and enzymes, are used in the breadmaking industry. They have different mechanisms of action, which can influence the properties of the product in different ways (Purhagen, Sjöö & Eliasson, 2011). In breadmaking, some emulsifiers are used to enhance dough stability; others are more specific for crumb softening (Sluimer, 2005). Some emulsifiers, such as sodium stearoyl lactylate (SSL) present both properties (Stampfli & Nersten, 1995). Dough strengtheners provide higher volumes and better crumb structure, while crumb softeners interact with flour components, retarding bread staling (Tamstorf, Jonsson & Krog, 1987). SSL is frequently used in the breadmaking industry, in particular in pan loaves. For white breads, the total amount of emulsifier ranges from 0.25 to 0.5 g/100 g flour (Sluimer, 2005).

The main enzymes used in bakery products are amylases. Maltogenic amylase hydrolyzes α–1,4 glycosidic bonds. Maltodextrin, oligossaccharides and maltotriose are hydrolyzed mainly to produce maltose (Whitehurst & Law, 2002). Their precise mode of action is not clear (Goesaert, Bijttebier & Delcour, 2010). It has been described as an exoacting amylase with more pronounced endoaction at higher temperatures (Goesaert, Leman, Bijttebier, &

* Corresponding author. Tel.: +55 19 3521 3999; fax: +55 19 3289 3617.
E-mail address: steel@fea.unicamp.br (C.J. Steel).

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doi:10.1016/j.lwt.2012.04.014

Delcour, 2009). Maltogenic amylase does not affect dough rheological properties, as it has low activity at temperatures below 35 °C. Its greatest activity occurs at starch gelatinization temperature, as it is capable of hydrolyzing glycosidic bonds of gelatinized starch during baking. It is inactivated during the more advanced stages of baking, so it does not cause excessive hydrolysis of starch, producing low quantities of soluble dextrins (Gerrard et al., 1997; Whitehurst & Law, 2002). Compared to other enzymes, maltogenic amylase is unique in yielding significant softness to bread and maintaining a high level of crumb elasticity during storage, without affecting bread volume or crumb structure (Si & Drost-lustenberger, 2001).

The objective of this work was to evaluate the synergistic effect of the use of the emulsifier sodium stearoyl lactylate (SSL) and of the enzyme maltogenic amylase (MALTO) on pan bread quality during storage.

2. Material and methods

2.1. Material

Medium to strong strength commercial wheat flour (Bunge Alimentos, Tatuí, SP, Brazil) was used. It presented moisture, proteins (N × 5.7), lipids, ash and carbohydrates contents of 13.9 g, 10.8 g, 1.5 g, 0.7 g/100 g flour, respectively. Farinographic water absorption, stability, mixing tolerance index, maximum resistance to extension (135 min) and extensibility (135 min) were, respectively, 61.6 g/100 flour, 13 min, 46 BU, 654 BU and 154 mm, measured in a Brabender Farinograph, model 81 01 01, with a 300 g mixing vessel, at 63 rpm, and the Falling Number was 364 s.

The commercial emulsifier sodium stearoyl lactylate Grindsted SSL P 2522 (Danisco, Cotia, SP, Brazil) produced from refined fatty acids was used. It presented the following specifications, according to the supplier: 80 g SSL/100 g sample, ester value 145, alkaline index 185, acid value 70, lactic acid content 25.5 g/100 g sample and sodium content 4.5 g/100 g sample. The emulsifier contained calcium carbonate as anti-caking agent.

The commercial enzyme maltogenic α-amylase Spring Life (Granotec, Curitiba, PR, Brazil) was used. It had the following specifications, according to the supplier: maltogenic α-amylase enzymatic activity 6000 MGAU/g, fungal α-amylase enzymatic activity 5600 SKB/g and maximum moisture 8.0 g/100 g sample. The enzyme mixture contained starch as carrier agent, as well as anti-caking and free-flowing agents. Its optimum action pH is 4–6 and optimum action temperature 25–75 °C.

2.2. Methods

2.2.1. Bread formulation

The pan bread formulation used in this work was based on that proposed by Pisesookbunterng and D'Appolonia (1983) and was the following: wheat flour (100 g), water (61.6 g), salt (2 g), compressed baker's yeast (3 g), sugar (5 g), hydrogenated vegetable fat (3 g) and calcium propionate (0.2 g). SSL and maltogenic amylase (MALTO) were added to the formulation according to a 2^2 central composite rotational design (CCRD). The quantities added ranged from 0 to 0.50 g/100 g flour for SSL and from 0 to 0.04 g/100 g flour for MALTO. Eleven assays were conducted including four factorial points (2^2), four axial points (2 × 2) and three repetitions of the central point, as well as a Control sample without the addition of emulsifier or enzyme (Table 1).

Table 1
Experimental design matrix.

Assays	SSL	MALTO
1	−1 (0.073)	−1 (0.006)
2	+1 (0.427)	−1 (0.006)
3	−1 (0.073)	+1 (0.034)
4	+1 (0.427)	+1 (0.034)
5	−1.41 (0)	0 (0.020)
6	+1.41 (0.500)	0 (0.020)
7	0 (0.250)	−1.41 (0)
8	0 (0.250)	+1.41 (0.040)
9	0 (0.250)	0 (0.020)
10	0 (0.250)	0 (0.020)
11	0 (0.250)	0 (0.020)
Control	−1.41 (0)	−1.41 (0)

SSL = emulsifier sodium stearoyl lactylate; MALTO = enzyme maltogenic amylase. Values in brackets correspond to the quantities of sodium stearoyl lactylate and maltogenic amylase used in g/100 g flour.

2.2.2. Bread production procedure

The production of pan breads followed the modified straight dough process. Batches of 3 kg wheat flour were made. The ingredients were mixed in a Hypo mixer (Indústria de Máquinas Hyppolito Ltda., Ferraz de Vanconcelos, SP, Brazil) until the dough reached complete gluten development. Mixing times and speeds of hook and bowl (clockwise and anti-clockwise movements, respectively) were: 2 min in slow speed (190 rpm hook and 50 rpm bowl) and 4 min in fast speed (380 rpm hook and 100 rpm bowl). Refrigerated water was used and final dough temperature was monitored so as not to exceed 30 °C. Immediately after mixing, doughs were divided into pieces of 450 ± 1 g and rounded. Then, they were left to rest for 15 min in a Climática Evolution proofer (Super Freezer, Pouso Alegre, MG, Brazil) at 30 ± 1 °C and 80 ± 1% RH. After this time, the pieces were molded in a Perfecta molder (Perfecta, Curitiba, PR, Brazil), put into pans and taken to the proofer at 37 ± 1 °C and 80 ± 1% RH for 120 min. After proofing, breads were baked in a Prática oven (Prática Technipan, Pouso Alegre, MG, Brazil) at a temperature of 190 ± 1 °C for 20 min. After baking, breads were depanned, cooled (for approximately 1 h), sliced (1.25 cm thick) in a Maquipão electric slicer (Maquipão, São Paulo, SP, Brazil), packaged in low-density polyethylene plastic bags, closed with twisted ties and stored at room temperature (approximately 26 °C) until analyses.

2.2.3. Bread evaluation

2.2.3.1. Specific volume. Pan bread apparent volume (V) was determined in mL by seed displacement, and mass (m), in grams, using a semi-analytic scale. Specific volume (SV) was calculated as the ratio (V/m). Specific volume determination was carried out 1 h after leaving the oven, in triplicate.

2.2.3.2. Firmness during storage. Bread firmness was determined on Days 1, 6 and 10 after baking, according to AACC Method 74-09.01 (AACC, 2010). Bread firmness is defined as the force required in grams-force for a compression of 25% of a sample of bread of 25 mm thickness. The values of bread firmness were obtained using a TA-XT2 texture analyzer (Stable Micro Systems, Haslemere, UK). Ten determinations (in 3 breads) of each assay were carried out.

2.2.3.3. Sensory evaluation. Four formulations, apart from the Control, were selected for sensory evaluation on Day 6 of storage. The evaluation was carried out using as basis the scoring system reported by El-Dash (1978). Scores were given for the following attributes: external characteristics (volume, crust color, shred and symmetry), internal characteristics (crust characteristics, crumb color, crumb structure and crumb texture), aroma and taste; totalizing a maximum of 100 points. This score was converted into a global concept determined as: very good (>90), good (80–90), regular (70–80) and detestable (<70) (Camargo & Camargo,

1987). The breads were evaluated by a team of 5 specialists in bakery products.

2.2.4. Statistical analysis

To evaluate the effect of the addition of different levels of SSL and of maltogenic amylase on pan bread quality during storage, an experimental design that permitted the analysis of the results through the Response Surface Methodology was used. The Statistica Software, version 7.0 (Statsoft Inc., Tulsa, OK, USA), was used and the results were evaluated through: (i) verification of significant effects ($P \leq 0.10$ or close values); (ii) Analysis of Variance (ANOVA); and (iii) Response Surface Methodology.

3. Results and discussion

3.1. Specific volume

Breads produced can be seen in Fig. 1. Bread specific volume was determined after cooling, on the same day as processing. The values for specific volume of the breads produced according to the experimental design varied from 5.65 to 6.53 mL/g, with 5.80 mL/g for the Control.

It was verified that the Control bread presented specific volume within the range found for the breads of the experimental design. Actually, only Assay 5, without the addition of SSL, presented lower specific volume (5.65 mL/g) than the Control. The importance of this emulsifier can be observed in the Response Surface (Fig. 2), generated by the mathematical model (Table 2) obtained from the experimental data. A greater effect of the emulsifier can be observed in relation to the enzyme, nevertheless it can be noted that both SSL and MALTO had a positive effect on specific volume.

The effect of SSL is probably due to its action as a dough strengthener. Dough strengthener emulsifiers are capable of forming liquid films of lamellar structure at the interface between gluten and starch. They improve the ability of gluten to form a film that retains the gas produced by the yeast (Krog, 1981), that consequently proportioned an increase in volume.

The effect of MALTO is due to the presence of fungal α-amylase in its composition, which supplies fermentable sugars for yeast growth and gas production mainly before the baking stage (Wong & Robertson, 2002). Also, amylase functionality in the increase of specific volume may also be related to the reduction of dough viscosity during starch gelatinization, thus prolonging oven rise (Goesaert, Slade, Levin, & Delcour, 2009).

However, it was observed that Assay 5, with the presence of 0.20 g MALTO/100 g flour and possibly an additional supply of fermentable sugars for gas production, did not present an increase in bread specific volume when compared to the Control, possibly due to the small amounts used.

It can also be observed, through Fig. 2, that varying the quantities of MALTO up to approximately 0.025 g/100 g flour has practically no effect on volume. This is also true for SSL, where the effect of the emulsifier is only observed at concentrations above 0.25 g/100 g flour. That is, there is a minimum amount of this additive (SSL) or processing aid (MALTO) that must be added to have an effect on specific volume. This might be because these compounds are not pure, but diluted with starch or other ingredients.

Another important observation is that, using higher quantities of SSL, close to 0.50 g/100 g flour, the quantity of MALTO (maltogenic amylase) had little effect on specific volume. This probably occurred due to two reasons: (1) The quantity of SSL added strengthened gluten to such an extent that it was not capable of expanding further (due to an increase in resistance) as a response to greater gas production at higher concentrations of MALTO. SSL causes the hydrophobic aggregation of the gluten protein and an increase in dough strength. However, there is an optimum amount of elasticity that yields the best volume, above which volume may decrease (Stauffer, 1990); or (2) There was the release of fermentable sugars due to the action of fungal α-amylase, but if this increase exceeds a certain limit, the increase in osmotic pressure of the dough may significantly inhibit fermentation, reducing the production of carbon dioxide and consequently bread volume (Maloney & Foy, 2003). Believing that reason (1) is correct, if the bread formulator opts for using a greater quantity of emulsifier (close to 0.50 g/100 g flour), little or no MALTO may be necessary to achieve better volume. In the case of this study, the Falling Number of the flour used was 364 s, close to the ideal range for bread production (200–300 s), indicating that the flour had a near to adequate amount of α-amylase to obtain good volume.

3.2. Firmness

Breads were submitted to analysis of instrumental texture, where firmness was evaluated on Days 1, 6 and 10 after processing, with the intention of observing the effect of the emulsifier SSL and of the enzyme MALTO on this response. The values for firmness of the breads produced following the experimental design varied from 0.79 to 1.32 N, with 1.21 N for the Control, on Day 1, from 1.24 to 2.18 N, with 2.37 N for the Control, on Day 6, and from 1.28 to 2.62 N, with 2.77 N for the Control, on Day 10.

It can be observed that, only on Day 1, firmness of the Control bread was within the range of values for firmness presented by the assays of the experimental design (with SSL and MALTO). On Days 6 and 10, the Control bread was firmer. The effect of the emulsifier and enzyme was more expressive as the storage period increased.

On Day 1, only Assay 5 presented greater firmness (1.32 N) than the Control. This assay was the only one that did not have SSL in its formulation. This fact was also observed with the specific volume of Assay 5 (SV of Assay 5 was lower than SV of the Control). We believe that the result for firmness can be a consequence of the result for specific volume (lower volume, greater firmness). On Day 1, it can also be observed that the formulation that presented the lowest firmness value was Assay 6 (0.50 g SSL/100 g flour + 0.02 g MALTO/100 g flour), with a value of 0.79 N, being also the one with the highest specific volume (6.53 mL/g). According to Faridi (1985), volume affects crumb firmness.

For volumes of equivalent mass, differences in volume generally imply differences in cell wall thickness and air cells size. To verify the effect of additives on bread firmness, it could be interesting to use lidded pans, for all loaves to present the same specific volume, thus removing this complicating factor from the analysis of their data. This procedure is highly recommended to all laboratories that are engaged in testing additives for their abilities to retard staling (Stauffer, 1990). As in our work we also wanted to evaluate the effect of the additives on specific volume, this procedure was not adopted.

Loaves with stearoyl lactylate are characterized by a soft, fine crumb texture (Sluimer, 2005). Thus, we also wanted to verify if with the increase in volume given by SSL, bread crumb was maintained its “closed” characteristics. Interestingly, this did occur. In Fig. 1 and from the results of specific volume and firmness, it can be confirmed that the assays with the greater amounts of SSL (and the same amount of maltogenic amylase) presented higher specific volume and crumb with more closed alveoli, and surprisingly lower firmness (variation from Assay 1 to Assay 2, from Assay 3 to 4 and from Assay 5 to 6).

The responses obtained were analyzed statistically through the Response Surface Methodology, verifying the possibility of describing the effect of SSL and MALTO addition through

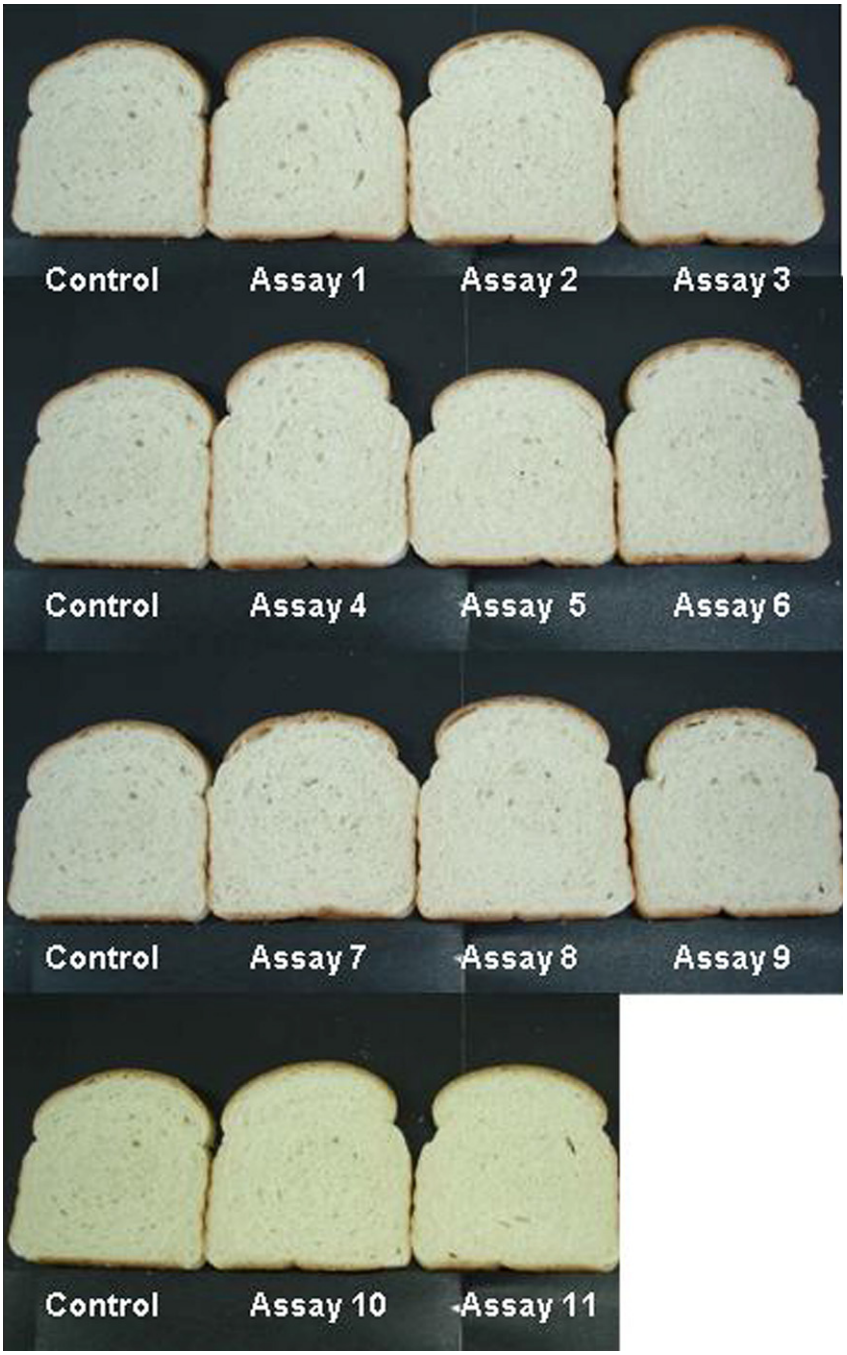

Fig. 1. Picture of experimental design breads versus control bread. Quantities of added SSL and maltogenic amylase in g/100 g flour, respectively, for each assay: Control: 0, 0; Assay 1: 0.073, 0.006; Assay 2: 0.427, 0.006; Assay 3: 0.073, 0.034; Assay 4: 0.427, 0.034; Assay 5: 0, 0.020; Assay 6: 0.500, 0.020; Assay 7: 0.250, 0; Assay 8: 0.250, 0.040; Assays 9, 10 and 11: 0.250, 0.020.

a mathematical model. The mathematical models, for use with coded variables, obtained for firmness on Days 1, 6 and 10 after processing, are presented in Table 2. Observing the equations and the response surfaces obtained from these equations (Figs. 3–5), it can be noted that both SSL and MALTO had a positive effect on bread texture (evidenced by their negative effect on firmness), with a greater effect of the emulsifier, but with a not negligible effect of the enzyme (especially taking into account the amounts used).

The effect of the emulsifier was greater than that of the enzyme, and as for specific volume, the effect of SSL can be noted only above a determined concentration. Up to 0.25 g SSL/100 g flour firmness is equal to or greater than the Control bread, except if a determined quantity of MALTO is added. If up to 0.25 g SSL/100 g flour is added to the formulation, at least 0.01 g MALTO/100 g flour must be added to have an effect on softness, in comparison to the Control.

It can be observed that the response surfaces for firmness on the three different days of storage presented the same trend, with only a displacement of the surfaces along the *Z*-axis, showing the increase in firmness during shelf-life. It can also be observed that the response surface of Day 10 (Fig. 5) presents a plain with greater inclination or slope, showing a greater effect of the additives to retard crumb hardening as storage progresses.

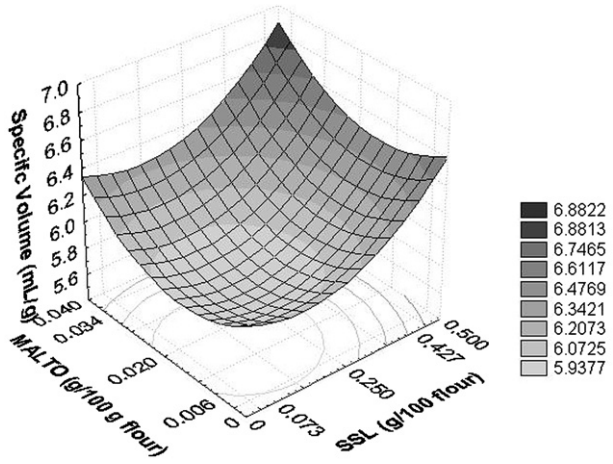

Fig. 2. Response surface for the response specific volume as a function of the concentrations of sodium stearoyl lactylate (SSL) and maltogenic amylase (MALTO).

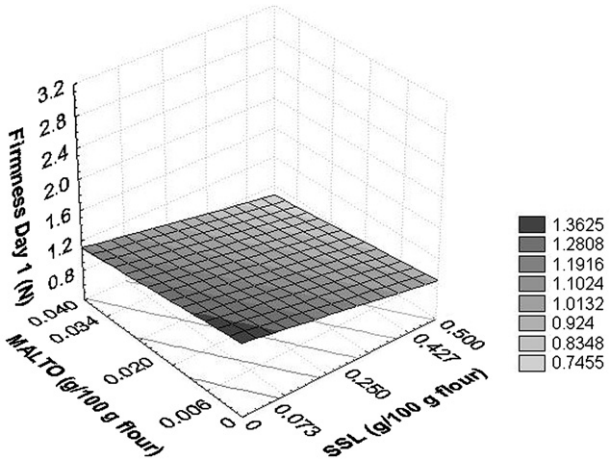

Fig. 3. Response surface for the response firmness on Day 1 after processing as a function of the concentrations of sodium stearoyl lactylate (SSL) and maltogenic amylase (MALTO).

Comparing equations obtained for firmness on Days 1, 6 and 10 (Table 2), an increasingly greater effect of the emulsifier and enzyme tested can be observed, showing their importance in maintaining softness of packaged breads. Through this, it can be said that after one day there was practically no aging. As from Day 6, the aging process was more advanced (the tendency of amylose and amylopectin molecules to re-crystallize was greater) and SSL and MALTO presented a retarding effect. Thus, in those breads where SSL formed complexes with starch molecules and/or the enzyme reduced the molecular weight of these starch molecules, the effect of crystal formation (retrogradation) due to their approximation or with proteins was lower, resulting in lower firmness.

Comparing the firmness of the Control bread and of the breads of the experimental design during the storage period, it was observed that the firmness that the Control bread presented on Day 1 after processing, was presented by Assay 6 only on Day 10 of storage or that the firmness that the Control bread presented on Day 6 after processing was presented by Assay 5 only on Day 10 of storage. From this analysis, the effectiveness of SSL and/or MALTO in reducing bread firmness, extending softness for a longer storage period, was clearly observed.

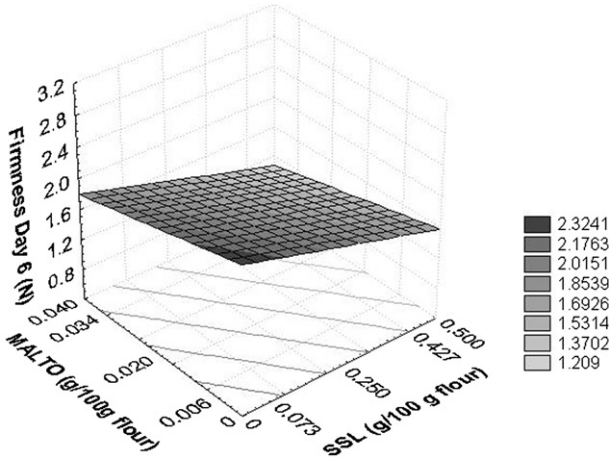

Fig. 4. Response surface for the response firmness on Day 6 after processing as a function of the concentrations of sodium stearoyl lactylate (SSL) and maltogenic amylase (MALTO).

3.3. Sensory evaluation

The four formulations, apart from the Control (without emulsifier or enzyme), selected for the sensory evaluation on Day 6 of storage were: Assay 2 (0.43 g SSL/100 g flour + 0.01 g MALTO/100 g flour), Assay 4 (0.43 g SSL/100 g flour + 0.03 g MALTO/100 g flour),

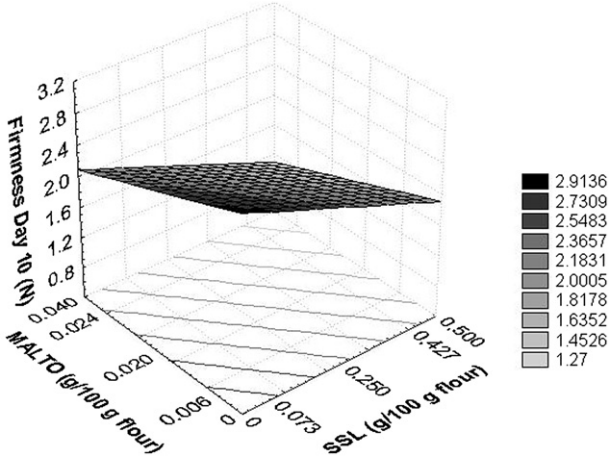

Fig. 5. Response surface for the response firmness on Day 10 after processing as a function of the concentrations of sodium stearoyl lactylate (SSL) and maltogenic amylase (MALTO).

Table 2
Coded models for specific volume and firmness on Days 1, 6 and 10 after processing as a function of the quantities of the sodium stearoyl lactylate and maltogenic amylase (the coded values of the independent variables must be used).

Parameters	Coded model
Specific volume =	$5.88 + 0.19\ SSL + 0.15\ SSL^2 + 0.10\ MALTO + 0.15\ MALTO^2$ ($r^2 = 0.76$; Fcalc/Ftab = 1.46; $P \leq 0.10$)
Firmness (day 1)=	$1.03 - 0.16\ SSL - 0.09\ MALTO$ ($r^2 = 0.81$; Fcalc/Ftab = 5.28; $P \leq 0.10$)
Firmness (day 6)=	$1.76 - 0.26\ SSL - 0.19\ MALTO$ ($r^2 = 0.85$; Fcalc/Ftab = 6.17; $P \leq 0.10$)
Firmness (day 10)=	$2.01 - 0.36\ SSL - 0.29\ MALTO$ ($r^2 = 0.96$; Fcalc/Ftab = 13.16; $P \leq 0.10$)

SSL = coded value ($-\alpha$ to $+\alpha$) of the quantities of sodium stearoyl lactylate; MALTO = coded value ($-\alpha$ to $+\alpha$) of the quantities of maltogenic amylase; r^2 = regression coefficient; Fcalc = calculated F; Ftab = tabled F.

Table 3
Scoring obtained in the sensory evaluation of internal, external, taste and aroma characteristics of breads.

Characteristics evaluated		Maximum value	Assays				
			Control	2	4	6	8
External characteristics	Volume (SV × 3)	20	17.8	19.2	19.7	20.0	19.0
	Crust color	10	5.5	5.5	9.0	8.0	7.5
	Shred	5	4.0	4.0	4.0	4.0	4.0
	Symmetry	5	3.5	2.5	2.5	2.5	2.0
Internal characteristics	Crust characteristics	5	2.0	3.5	2.0	2.5	4.0
	Crumb color	10	7.5	7.5	7.5	7.5	7.5
	Crumb structure	10	6.5	7.0	8.0	9.0	6.5
	Crumb texture	10	4.5	5.5	8.0	9.0	7.0
Aroma and taste	Aroma	10	8.5	8.5	8.5	8.5	8.5
	Taste	15	11.0	12.5	12.5	11.0	11.0
Total score		100	70.8	75.7	81.7	82.0	77.0

Control: without emulsifier or enzyme; Assay 2: 0.43 g SSL/100 g flour + 0.01 g MALTO/100 g flour; Assay 4: 0.43 g SSL/100 g flour + 0.03 g MALTO/100 g flour; Assay 6: 0.50 g SSL/100 g flour + 0.02 g MALTO/100 g flour; Assay 8: 0.25 g SSL/100 g flour + 0.04 g MALTO/100 g flour. SSL = sodium stearoyl lactylate; MALTO = maltogenic amylase.

Assay 6 (0.50 g SSL/100 g flour + 0.02 g MALTO/100 g flour) and Assay 8 (0.25 g SSL/100 g flour + 0.04 g MALTO/100 g flour), which were those with best results for specific volume and texture. It can be seen that they are the assays with the highest amounts of SSL. The results obtained in the evaluation of bread quality of these 5 formulations through the scoring system described by El-Dash (1978), carried out by a team of 5 specialists in bakery products, are presented in Table 3.

It can be observed that all breads from the assays of the experimental design were better evaluated than the Control. The parameters that most contributed to this were the lower scores for volume and crumb texture of the Control. The best total scores, 81.7 and 82 (good, according to Camargo & Camargo, 1987), were obtained for the breads of Assays 4 and 6, with 0.43 g SSL/100 g flour + 0.03 g MALTO/100 g flour and 0.50 g SSL/100 g flour + 0.02 g MALTO/100 g flour, respectively, corroborating the results of specific volume and instrumental texture. It can be observed that the individual characteristics in which these two assays received higher scores than the other assays and the Control were: volume (specific volume × 3), crust color, crumb structure and crumb texture.

The results for specific volume are in accordance with those presented in Fig. 1. Assays 4 and 6 presented slightly higher volumes than the others two assays evaluated sensorially.

Gómez et al. (2004) report that products elaborated with SSL exhibit marked improvement in crumb structure. The resulting loaves are characterized by a soft, fine crumb structure (Sluimer, 2005). This can be observed in Fig. 1.

Relating the sensory results for crumb texture with the instrumental firmness on Day 6 (day of the sensory analysis), it can observed that Assay 6 presented the lowest firmness amongst the assays evaluated sensorially. Assay 4 also presented a low value for firmness, but not lower than Assay 8. According to Alasino et al. (2011), SSL helps in maintaining the tearing quality. These authors also verified that the increase of the concentration of SSL produces a beneficial effect on the sensory attributes of bread, including crumb texture score.

4. Conclusion

In general, it can be concluded that breads with added SSL and maltogenic amylase presented an increase in volume and a reduction in firmness on Days 1, 6 and 10 of storage, as well as good acceptance regarding the sensory attributes evaluated. This study presents precise dosage values for practical application in white pan bread. Further research could include the use of combined emulsifier and enzyme in other bakery products, including fiber-enriched products, cakes, etc., where an increase in shelf-life is technologically and economically important.

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