Optimisation of frozen prebaked bread's manufacture

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Abstract
The quality of frozen prebaked bread is conditioned, besides the processing technology, by the establishment of an optimum recipe which contains those ingredients which can reduce to the minimum the negative effects of frozen and defrosting. In order to optimize the DATEM, α-amylase and xylanase additions in the manufacturing recipe of frozen prebaked bread a type 3^3 factorial optimization model was used. The finished products were analyzed regarding volume, porosity and elasticity.

Key words: frozen prebaked bread, factorial model optimization

Rezumat
Calitatea pâinii precoapte congelate este condiționată, pe lângă tehnologia de obținere, de stabilirea unei rețete optime care să conțină acele ingrediente care să minimalizeze efectele negative ale congelării şi decongelării. Pentru a optimiza adaosul de DATEM, α-amilaza şi xilanaza în rețeta de fabricație a pâinii precoapte congelate s-a utilizat un model factorial de tip 3^3. La produsele finite s-au analizat volumul, porozitatea şi elasticitatea miezului.

Cuvinte cheie: pâine precoaptă congelată, model de optimizare factorial.

1. Introduction

In order to prevent bread's short shelf live and to support the customer, the bread was traditionally manufactured at a small scale in un-modernized bakeries. As large scale production appeared, the demand for long term validity bread has increased. In part, this increase is satisfied through the use of various substances and agents that contribute to prolongation the validity term to a couple of days.

New technologies are used to satisfy this demand, thus, part baking technology is used for manufacturing fresh products at any hour. Prebaked bread is bread baked in moderate conditions which permit a second baking before consumption. Prebaked bread is deposited in various conditions and is re-baked in order to attain its final characteristics before being sold to the consumer or before being consumed.

The number of prebaked products is growing continuously. The first prebaked products (the French baguette, the bun and other breakfast pastry products) still have an important market share. Another product with an ever increasing outlet is Arabian bread. Italian bread types, ciabatta or focaccia, are also well known prebaked products. All these developments concerning prebaked products appeared on the foundation of a large and constant increase of their market share in many countries.

Prebaked bread is incompletely baked bread. After the incomplete baking process the prebaked bread has a stabile shape and volume, a partly formed crust of a very thin layer, little or without any colour. It is commercialized under this form, being subsequently transformed in a finished product, after the final bake. Generally, the nutritional characteristics of normally baked bread are superior than those of prebaked bread.

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In order to improve the quality of prebaked bread, some experiments were made to perfect its manufacturing recipe through an addition of various ingredients.

This paper shows own researches concerning a type 3^3 factorial optimization model for optimizing the addition of three ingredients in the manufacturing recipe of prebaked bread.

2. Materials and methods

The researches were done within S.C. Pambac S.A. Bacau on an existing technological line for obtaining pastry products.

The raw materials and manufacturing recipe used for obtaining the prebaked bread needed for experiments were: flour 650 – 1 kg; bakery yeast – 1.9%; salt – 1.7%; water – 55%.

In order to improve prebaked bread quality the addition of three ingredients was experimented: DATEM (0.2%; 0.4%; 0.6%), α-amylase (0.5, 0.8 and 1g/100 kg flour) and xylanase (4, 6 and 10 g/100 kg flour).

The technological characteristics of obtaining frozen prebaked bread require the following operations: pre-baking, cooling, frozen, defrosting and final baking. Following repeated experiments this optimum possibility was reached: pre-baking ¾ of baking time followed by quick cooling, quick frozen and slow defrosting. Pre-baking is made in order to coagulate proteins and to gelatinize starch. Knowing the traditional baking duration in the classic procedure for a 0.300kg bread is 16 minutes, in the experiments - for obtaining prebaked bread - the baking process was interrupted at ¾ of baking duration, 12 minutes.

The pre-baking temperature used was 190…200°C, inferior to that used in the classic process: 220…230°C.

After oven placement a 1 minute steaming process was made in order to prevent premature formation of crust and to subsequently obtain a shiny and uniformly coloured crust. Quick cooling was made in a acclimatized environment to a temperature of 4…6°C for 30–35 minutes, and quick frozen at a temperature of -30…-35°C, for 120–130 minutes. The products underwent a slow defrozen, of 100–110 minute duration, at a 28…30°C temperature. After defrosting, the products were baked in the rotary oven for 4 minutes at 220…230°C.

The bread final product was determined for volume, porosity and core elasticity compared with the control samples.

3. Results and discussions

In the first stage of research, 3 independent variables were applied: DATEM quantity (x_1), α-amylase quantity (x_2) and xylanase quantity (x_3).

The components considered and the variation levels of their concentration in the environment are shown in table 1.

The response functions pursued are volume (y_1), porosity (y_2), elasticity (y_3). The factorial model type 3^3 coefficients were determined and polynomial equations were obtained (1)

In order to simplify the models and also to eliminate the terms with minimal influence, the t-student test was made by repeating the experiment three times in the central coordination point (0, 0, 0). The values obtained from the supplementary tests are shown in table 2.

Finally, after neglecting insignificant coefficients, the models obtained were obtained (2).

Table 1. Concentration of ingredients added in frozen prebaked bread's manufacturing recipe

Independent variable	Reduced variable	Variation level			Δx_i	$x_{i\,med}$
		-1	0	+1		
DATEM quantity[%]	x_1	0.2	0.4	0.6	0.2	0.4
α-amylase quantity [g/100kg flour]	x_2	0.5	0.8	1	0.25	0.75
Xylanase [g/100kg flour]	x_3	4	6	10	3	7

$$y_1=347 + 7.61x_1 + 11.22x_2 + 0.38x_3 – 11.16x_1x_2 + 1.16x_1x_3 + 8.00x_2x_3 – 18.38x_1^2 – 7.89x_2^2 + 20.39x_3^2 – 10.12x_1x_2x_3$$

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$$y_2=84.06 + 0.08x_1 + 0.277x_2 - 0.166x_3 - 0.47x_1x_2 - 0.10x_1x_3 + 0.3x_2x_3 - 1.20x_1^2 - 0.87x_2^2 + 0.17x_3^2 + 0.53x_1x_2x_3 \quad (1)$$

$$y_3=77.28 - 2.93x_1 + 1.22x_2 + 0.98x_3 + 1.46x_1x_2 + 1.51x_1x_3 + 1.57x_2x_3 + 2.39x_1^2 - 0.30x_2^2 + 1.14x_3^2 + 0.84x_1x_2x_3$$

Table 2. Values of supplementary tests

Response function	y_1^0	y_2^0	y_3^0	y_{med}
Volume (y_1)	354	331	360	348
Porosity (y_2)	84.2	83.4	84.8	84.0
Elasticity (y_3)	78.9	77	78,1	78

$$y_1 = 347 + 7.61x_1 + 11.22x_2 - 11.16x_1x_2 + 8.08x_2x_3 - 18.38x_1^2 - 7.89x_2^2 + 20.39x_3^2 - 10.12x_1x_2x_3$$

$$y_2=84.06 + 0.277x_2 - 0.166x_3 - 0.47x_1x_2 + 0.3x_2x_3 - 1.20x_1^2 - 0.87x_2^2 + 0.17x_3^2 + 0.53x_1x_2x_3$$

$$y_3=77.28 - 2.93x_1 + 1.22x_2 + 0.98x_3 + 1.46x_1x_2 + 1.51x_1x_3 + 1.57x_2x_3 + 2.39x_1^2 + 1.14x_3^2 + 0.84x_1x_2x_3$$

In order to visualize these effects, a graphic representation in a three-dimensional space is used.

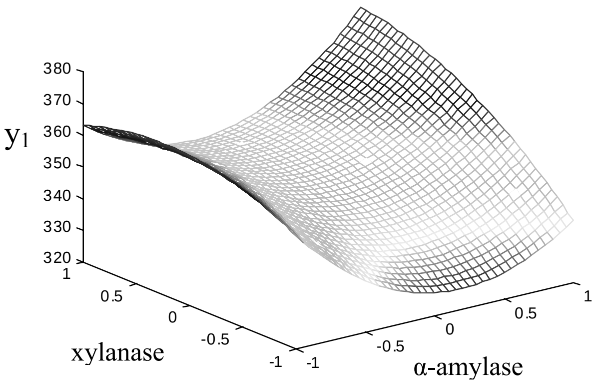

Figure 1. The combined effect of α-amylase and xylanase quantity over volume

Concerning products' volumes (y_1 model), DATEM addition has a positive effect. A favourable effect over volume can also be obtained through α-amylase addition and through the combined effect of α-amylase and xylanase.

y_1

xylanase

Datem

Figure 2. The combined effect of DATEM and xylanase quantity over volume

y_1

α-amylase

Datem

Figure 3. The combined effect of DATEM and α-amylase quantity over volume

The positive effect combined between the studied variables (α-amylase and xylanase) can be observed over the product's porosity, fact shown in figure 4.

y_2

xylanase

α-amylase

Figure 4. The combined effect of α-amylase and xylanase quantity over porosity

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y_2

xylanase Datem

Figure 5. The combined effect of DATEM and xylanase quantity over porosity

y_1

α-amylase Datem

Figure 6. The combined effect of DATEM and α-amylase quantity over volume

From the analysis made concerning the products' porosity, we've seen that the addition of α-amylase and the combined effect of α-amylase and xylanase are positive.

A favourable effect over porosity can also be obtained in the case of a combined addition of DATEM, α-amylase and xylanase.

y_3

α-amylase xylanase

Figure 7. The combined effect of α-amylase and xylanase quantity over elasticity

From Figure 7 it could be seen that both α-amylase and xylanase have a positive effect on elasticity, a greater effect being obtained when combining the two.

y_3

xylanase Datem

Figure 8. The combined effect of DATEM and xylanase quantity over elasticity

y_3

α-amylase Datem

Figure 9. The combined effect of DATEM and α–amylase quantity over elasticity

Concerning the product's elasticity (y_3), the combined addition of α-amylase and xylanase has a significant positive effect compared to an individual addition.

The intensity of ingredient addition over the final product's elasticity varies, favourably, in the following order: α-amylase and xylanase combination, DATEM and xylanase combination, DATEM and α-amylase combination and DATEM, α-amylase and xylanase combination.

The optimization of developed models was made through derivate annulment method.

Table 3 shows the optimum values of the three parameters used in the experiments.

Table 3. Optimum values of the three physical parameters of the finished product

Response function	Reduced values			Real values		
	x_1	x_2	x_3	DATEM [g/100 kg]	α-amylase [g/100 kg]	xylanase [g/100 kg]
Volume	0.037	0.626	-0.118	400	0.90	6.64
Porosity	-0.027	0.216	0.306	390	0.78	7.91
Elasticity	0.957	0.037	-1.09	590	0.75	3.73

Cumulating the results obtained and making their average, we can say that the best results are obtained with a quantity of 0.46% DATEM, 0.8 g α-amylase/100 kg flour, 6.09 g xylanase/100 kg flour.

4. Conclusions

The obtainment of quality prebaked bread is conditioned by the raw materials and ingredients used in the manufacturing recipe.

The optimization models used through a factorial program of 27 experiments have led to the establishment of the following components which optimize the finished product's sensorial quality:

- for volume: DATEM – 400 g/100 kg, α-amylase – 0.90 g/100kg flour; xylanase – 6.64 g/100kg flour;
- for porosity: DATEM – 390 g/100 kg, α-amylase – 0.78 g/100kg flour; xylanase – 7.91 g/100kg flour;
- for elasticity: DATEM – 590 g/100 kg, α-amylase – 0.75 g/100kg flour; xylanase – 3.73 g/100kg flour.

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