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Comparison of pound cake baked in a two cycle microwave-toaster oven and in conventional oven

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A B S T R A C T

The industrial and domestic use of microwaves has increased considerably over the past few decades. New researches about the interaction of different ingredients with microwave energy, has provided insight that is helping to improve the quality of microwave-baked products. The aim of this work was to determine the best potency and baking time conditions for pound cake and apply the image analysis methodology to analyze the structure of pound cake baked in a two cycle microwave-toaster oven compared with a conventionally baked. Weight loss, density, water activity, moisture, luminosity and seven parameters of Image Analysis were measured as baking quality parameters. Optimal baking conditions for the two-cycle microwave-toaster oven were obtained using surface response analysis. The best baking conditions resulted in a low power for the first cycle (204 W for 120 s), a high power for the second cycle (937 W for 70 s), and a toasting time of 5:30 min at 200 °C. Image analysis showed a 7% reduction in the crumb cell number of the cake baked with microwaves as compared to the conventional. The two cycle microwave-toaster oven generated a product with a higher volume (11%) and higher luminosity (2%) than the conventional process. Both of them were equally preferred by consumers, scoring 4.6 (I like very much) in a hedonic sensory test.

1. Introduction

In bread baking process water, enzyme activity, starch, protein properties and heat are the main factors that determine bread quality. The bread texture is related to geometric and mechanical properties, which heavily depend on its cellular structure (Tan, Zhang, & Gao, 1997).

Due to the difficulty of describing bread crumb grain, baking technologists have normally only manually categorized experimental samples. Lately, with the rapid development of image-processing technology, several research groups have investigated the feasibility of adapting digital image analysis for crumb grain analysis (Gonzales & Butler, 2006).

The use of large-scale microwave processes is increasing. Recent improvements in the design of high-powered microwave ovens, reduced equipment manufacturing costs and electrical energy costs, offer a significant potential for developing new and improved industrial microwave processes (Vadivambal & Jayas, 2007). Nowadays industrial microwave dryers could be commercially viable for drying process in which short drying time and higher product yield is required. Also, food industries dealing with products that are susceptible to case hardening may consider microwave drying to be a good alternative in quality enhancement. Thus, there is a large market for microwave processed foods and one of the potentially important growth areas is microwave-baked products, however the improvement of quality of these microwave-baked products remains as the major task for researchers (Chavan & Chavan, 2010).

Two cycle microwave-toaster oven is a new technology that combines time saving of microwave heating and browning and crisping advantages of electric toaster. Some other combination

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heating methods have been studied as alternative to conventional heating, such as: infrared and hot air assisted microwave heating, halogen lamp and microwave combination oven (Datta & Ni, 2002; Ozge, Sumnu, & Sahin, 2004).

Conventional formulations of bread develop unacceptable textures when they are baked in microwave oven (Ovadia & Walker, 1996; Sánchez, Ortiz, Mora, Chanona, & Necoechea, 2008). The exterior parts of the bread are tough while inner parts are firm (Shukla, 1993). The reasons for firm texture in microwave-baked breads are: high moisture loss, interactions of microwave with gluten and high amylose leaching during baking (Higo & Noguchi, 1987; Shukla, 1993). The main difference between convection ovens and microwave ovens is the inability of the microwave ovens to induce browning on bread surface. Maillard reactions are responsible for the production of many flavored and colored compounds but the cool ambient temperature inside a microwave oven causes surface cooling of microwave-baked products and low surface temperature does not produce Maillard's reactions (Decareau, 1992, pp. 117–119).

Two cycles during baking process in microwave ovens, could eliminate the quality problems observed in microwave-baked products (Summu, 2001). First baking cycle could be applied with low potency and long time to improve internal cooking, while the second cycle could be performed with high potency and short time for contribute to the overall cooking. This baking process could generate great savings in time and energy (Sumnu & Sahin, 2005). Comparison of the effects of baking methods on quality parameters of bread will provide knowledge to understand the role of heating mechanism of different oven systems on final product quality.

A broad variety of sweet breads with different crumb characteristics can be produced. These types of breads (danish, puff pastry, pound cakes, cookies), along with white bread, are widely consumed in Mexico (32 kg annual per capita consumption). Sweet bread is one of the ten most consumed foodstuffs in daily meals (Grupo Bimbo. Annual report, 2003). Quality of sweet bread depends on the wheat flour characteristics, ingredients, as well as the baking process.

The aim of this work was to determine the best potency and baking time conditions for pound cake and apply the image analysis methodology to analyze the structure of pound cake baked in a two cycle microwave-toaster oven compared with a conventionally baked.

2. Materials and methods

2.1. Pound cake formulation

Pound cake was prepared using commercial wheat flour containing 9.98 g of moisture, 12.0 g of protein, 28.1 g of wet gluten, and 0.22 g of ashes per 100 g of flour (results obtained using the methods described by the American Association of Cereal Chemists International (AACC), 2000. Further, 80 mL of water, 60 g of sugar, 40 g of fresh eggs, 32 g of butter, 8.0 g of whole milk powder, 8.0 g of corn dextrin, 2.0 g of powdered yeast and 1.0 g of sodium chloride, were used per 100 g of flour. Batted dough method was used to obtain two different batches of pound cake. Butter, sugar, corn dextrin, milk powder, salt and baking powder were batted for 15 min in a kitchen-aid heavy-duty electric mixer (Model K5SS, Benton Harbor, MI, USA). Then, the other ingredients were added and batted for 5 min until a homogeneous mix was obtained. Approximately 45 g of dough was placed in molds (30 × 21 cm) of six cavities with a lower diameter 5.5 cm, upper diameter 7 cm, and high 4 cm (TEFAL silicon oven-proof mold, Group SEB-Mexico-USA). The amount of batter in each mold was determined based on the development characteristics during baking, as well as the volume of the final product.

2.2. Conventional baking

Conventional baking was performed in a commercial electrical oven Henry Simon Limited swing electrical oven (London, Cheshire, UK), at 180 °C for 35 min. Approximately 45 g of dough was placed in molds (30 × 21 cm) with six cavities of a lower diameter 5.5 cm, upper diameter 7 cm, and high 4 cm (TEFAL silicon oven-proof mold, Group SEB-Mexico-USA). The oven was preheated to the set temperature before placing the dough samples into it. Pound cakes were cooled down at room temperature (20–22 °C), during 1 h and placed in sealed plastic containers until analysis.

2.3. Two cycles microwave-toaster oven

Two cycle microwave-toaster oven (Toast & Bake Microwave Oven, multifunction 1000 W, 2450 MHz, Samsung MT1099STD, Bangkok, Thailand) with 10 power levels was used to bake the pound cake. This oven is equipped with an internal electrical heater used to toast the surface of the pound cakes. There are no previous reports about the pound cake baking conditions in a two-cycle microwave-toaster oven, for this reason, the first step in this research, was to determine the potency and baking time conditions for pound cake. The experimental design was a rotable central composite design of four factors: low power (LP) and long time (LT) for cycle one and high power (HP), and short time (ST) for cycle two, (Montgomery, 2006, chap. 6 and 9). Each of these factors was analyzed at two levels. Factors and levels used are shown in Table 1, a total of thirty samples were run according with Table 2. Selected responses were lower density, maximum water activity and optimum luminosity. These responses were expressed individually for each microwave baking cycle as a function of independent variables. Data were analyzed by multiple regression analysis, reporting analysis of variance, lack of fit test, effect of each variable and regression analysis, in order to adjust the variables to a mathematical model. The experimental order design and data analysis was obtained from the Design-Expert 7.0 for Windows-software, for design of experiments (Stat-Ease Inc., Minneapolis, USA). Response surface plots were generated with the same software.

The response variables measured on freshly-baked product were evaluated as follows:

2.4. Density

Density was determined with the mass/volume formula, being product mass as weighed in an analytical balance an hour after baking. The volume of each cake was obtained by the rape seed displacement method (AACC, 2000).

2.5. Crumb water activity (Aw)

Aw was measured with a HygroPalm Aw1 (Alpha Controls & Instrumentation, Canadian Industries) instrument in the AwE

Table 1
Response surface experimental design.

Factor	Code	Levels		
		−1	0	+1
Low power (W)	LP	204	292	380
Long time (s)	LT	120	180	240
High power (W)	HP	772	875	978
Short time (s)	ST	47	60	73