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Quality and microbial characteristics of part-baked Sangak bread packaged in modified atmosphere during storage

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ABSTRACT

The effect of part-baking and modified atmosphere packaging (MAP) on quality and microbial stability of part-baked flat bread (Sangak) was investigated. Part-baked Sangak bread was packaged in 100% CO_2, 50% CO_2:50% N_2, 25% CO_2:75% N_2 and air as a control and stored at 25 °C for 21 days. Color, firmness, moisture, density and microbiological analyses of the package breads were carried out at 3-day intervals during storage. No significant effect of MAP was found on moisture, color and texture during the storage of part-baked bread, while the total aerobic plate count (APC) and the mold and yeast count (M + Y) were dependent on the concentration of CO_2 in the package headspace. With increasing concentration of CO_2, microbial counts were decreased. Density of part-baked bread was also somewhat influenced by the MAP. The observed reduction in the density of control samples during storage was less than those in MAP. The results of the present study demonstrated that it is possible to prolong the shelf-life of Sangak bread from a few days to about 21 days by using bake-off technology (BOT) and MAP under high CO_2 concentration.

1. Introduction

Bread is one of the main foods around the world due to its superior nutritional, sensorial and textural characteristics. However, bread is a food with rapidly degrading quality characteristics and its shelf-life is only a few days at room temperature. Microbial spoilage and staling are the main factors limiting shelf-life of the bakery products. This reveals the importance of studying formulation, processing, packaging, and storage conditions of these products (Galic et al., 2009; Karaoglu et al., 2005; Kotsianis et al., 2002).

Bake-off technology (BOT) is an efficient method to delay the staling process of the baked goods and reduce economic losses in the bakery industry. BOT is a two-stage baking process; in the first stage, the fermented dough is baked under the defined oven conditions into part-baked product with proper crumb texture, minimum crust coloration and maximum moisture. After a storage time, the second baking process is done at the time of serve. The final re-baking creates the appropriate flavor and crust color. In addition, starch retrogradation can be reversed, thus, breadcrumb becomes soft and fresh bread is provided for the consumers (Karaoglu et al., 2005; Leuschner et al., 1999; Mandala et al., 2009). However, high moisture content of part-baked bread can accelerate the microbial spoilage, especially if stored at ambient temperature. The most common solution for this problem is the freezing process. But, this method has disadvantages, including reduced quality of part-baked bread due to ice crystal growth and high energy consumption during the production, storage and distribution chain of the frozen product (Barcenas and Rosell, 2006).

Another method used to increase the shelf-life of part-baked bread is modified atmosphere packaging (MAP). MAP is defined as the packaging of a perishable product in an atmosphere which has been modified so that its composition is something other than that of air (Rodriguez-Aguilera and Oliveira, 2009). The most used gases in MAP of bakery products are carbon dioxide and nitrogen. Antibacterial and antifungal effect of CO_2 has been proved completely, but its high solubility in water and lipids can result in pack collapse due the reduction of headspace volume. Nitrogen is a relatively inert gas with no odor, taste, or color. N_2 has no antimicrobial activity but it inhibits the growth aerobic spoilage by providing an anaerobic condition. Also, the low solubility of N_2 in foods can be used to prevent pack collapse by using CO_2/N_2 gas

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mixtures (Ooraikul, 2003; Sivertsvik et al., 2002). Despite the known effect of MAP to prevent the microbial spoilage of bread, conflicting results have been reported on the effect of atmosphere inside a package on staling and physio-chemical quality changes occurring during bread storage (Rasmussen and Hansen, 2001). The results in a study by Knorr and Tomlins (1985) suggest reducing crumb firmness of white and whole meal bread during storage in CO_2. Similar results were obtained by Cencic et al. (1996), who found a relevant decrease of bread firmness packed in 100% CO_2. On the other hand, Black et al. (1993) and Rasmussen and Hansen (2001) showed that bread firming is not affected by atmosphere. Contrary to these findings, Hematian Sourki et al. (2010) found a negative correlation coefficient between headspace CO_2 concentration and hardness of flat bread.

Sangak bread is one of the most widely used kinds of flat bread in Iran and is made of whole-wheat flour. The characteristics of Sangak bread are good flavor, high nutritional value and ease of digestion due to large amounts of fiber. This research is part of a study on the par-baked Sangak bread to provide a better understanding of the phenomena involved in the process. Few studies on preservation of part-baked bread in MAP are available in the literature (Leuschner et al., 1999; Smith et al., 1983). However, to our knowledge, no previous researches have studied the MAP of part-baked Sangak bread.

The objectives of the present study were to (1) investigate the effect of part-baking on the staling of Sangak bread and (2) evaluate the quality and microbial characteristics of part-baked Sangak bread packaged in different atmospheres during storage at room temperature.

2. Materials and methods

2.1. Materials

Whole wheat flour appropriate for production of Sangak bread with 92% extraction rate, 11.037% protein, 1.32% ash, 14% water and 1.55% lipid was purchased from Baharestan Milling Factory, Iran (AACC, 2000). Dried active yeast was obtained from Kelarmaye Co., Iran. The mixed gases used contained 100% CO_2, 30% CO_2:70% N_2 and 20% CO_2:80% N_2. They had a purity of 99.9% and were obtained from Sepahan Acetylene, Iran. Polyamide/polyethylene bags (20 × 25 cm and 100 μm thickness) with permeability for CO_2, O_2, N_2 and H_2O at 25 °C of 9.333×10^{-21}, 1.309×10^{-20}, 7.536×10^{-21} and 6.047×10^{-19} kmol/m s Pa, respectively, were procured from Nadi Plastic Arya, Iran. All chemicals and microbiological culture media used in this study were purchased from Merck Company (Germany) and were of analytical grade.

2.2. Bread making and packaging

Sangak bread was produced using the following formula: 100 g whole-wheat flour, 100 g water (25 °C), 1 g salt and 1 g dried active yeast. The ingredients were mixed for 15 min at 50 rpm (HOBART mixer, model C-100, USA), and then dough was fermented for 60 min at 30 °C and 75–85% relative humidity in a proofing cabinet. The dough was divided into portions of 120 g and sheeted to 5 mm thickness. Part-baking was done in a forced convection oven (BOSCH, HBA73B550, Germany) at 250 °C for 6 min. The loaves were left to cool at room temperature and cut with dimensions of 15 × 15 × 0.8 cm. Each loaf had an average weight of 109.46 g and volume of 221.94 cm^3. The loaves were packed by using a vacuum packaging machine (HENKOVAC, E–153, Netherlands) in a modified atmosphere that contained 100% CO_2, 30% CO_2:70% N_2, 20% CO_2:80% N_2 and atmospheric air as control. Thus, 84 packages were prepared and experiments were carried out in duplicate. The samples were stored for 21 days at 25 °C in an incubator (Wisecube, WIG-105, Korea), and were analyzed at 3-day intervals. Before testing, half of each loaf was full-baked at 250 °C for 4 min.

2.3. Quality analyses

2.3.1. Determination of moisture content, apparent density and storage weight loss

Moisture contents of whole part-baked and full-baked Sangak breads were evaluated during storage with an air-oven (Memmert, UNB400, Germany) at 105 °C (AACC, 2000; method 44-15A).

To determine the apparent density of the part-baked Sangak bread, after weighing the sample, its volume was measured using the rapeseed displacement (AACC, 2000; method 10-5).

To determine the weight loss of the part-baked Sangak bread during storage, the weights of the loaves were determined before packaging and after opening the package for testing.

2.3.2. Crust color

The color of part-baked Sangak bread crust was evaluated by means of a colorimeter in RGB system (RGB-1002, Lutron, Taiwan). The measured values were converted into Hunter Lab system using the EasyRGB-PC Software (version 1.2). The parameters determined were L ($L = 0$ is equivalent to black and $L = 100$ is equivalent to white), a ($-a$ = greenness and $+a$ = redness) and b ($-$b = blueness and $+b$ = yellowness).

2.3.3. Bread firmness

To evaluate the changes in the texture of Sangak bread due to staling, crust and crumb firmness was measured using the penetration test. A universal testing machine with a 1.27-cm diameter aluminum plunger at a rate of 100 mm/min and a 500 g to 5 kg load cell was used (model 1140, Instron Ltd., High Wycombe, U.K.), then the firmness curves (force vs. distance) were plotted (AACC, 2000; method 74-09). The force readings at the center of sample thickness were taken as a measure of crumb firmness and the maximum force required to penetrate a sample was considered as a measure of crust firmness. The experiment was performed at six different points from each loaf of the part-baked and full-baked Sangak breads.

2.4. Microbiological analyses

For microbiological analyses, different parts of part-baked Sangak bread were sampled and 10 g of sample (obtained from different parts of the part-baked bread) was homogenized with 90 mL of sterile 0.85% peptone solution for 2 min. Thus, dilution 10^{-1} was prepared. The other dilutions were obtained from this solution to the dilution of 10^{-6}. A 0.1 ml aliquot from each dilution was spread in triplicate on about 15 ml of plate count agar (PCA) and potato dextrose agar (PDA) for the total aerobic plate count (APC) and the mold and yeast count (M + Y), respectively. Inoculated petri plates were incubated at 37 °C for 2 days and 25 °C for 3 days to determine the total aerobic plate count and the mold and yeast count, respectively. After incubation, the results of the counts were expressed as colony forming units (CFU) per gram of part-baked Sangak bread.

2.5. Statistical analyses

The experiments were performed in a completely randomized block design with three replications. Some of the samples were not evaluated because of package leak and stickiness of crumb due to ropiness. Therefore, the obtained data were not balanced and subjected to statistical analysis using the generalized linear model