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Production of deep-fried corn chips using stale bread powder: Effect of frying time, temperature and concentration

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ABSTRACT

In this study, utilization of stale bread powder was evaluated to produce low fat snack food formulation and for this purpose, corn chips were manufactured using stale bread at different concentrations. Response surface modeling technique was used to study the simultaneous effects of stale bread level (0–50%), frying time (40–60 s) and frying temperature (170–190 °C) on some physicochemical, textural and sensory properties of corn chips enriched with stale bread powder. Also, optimization of processing variables was performed for desired products. Results indicated that the addition of stale bread into the formulation decreased the oil content of the final product up to addition of 25% stale bread level. The hardness and yellowness of samples decreased with the increasing of stale bread level; while, the dry matter and ash contents as well as firmness value and sensory scores of samples increased with the increasing stale bread level. Generally, corn chips produced with the addition of stale bread were more preferred by the panel compared to control samples.

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1. Introduction

Bread, a commonly consumed cereal based product is a staple food consumed by the people in the world. Although bread can be produced traditionally using different types of flours from cereals including wheat, corn or oat, the most common bread is produced using the flour derived from the wheat. The basic formulation of bread, a fermented food product, includes wheat flour, water, yeast and salt (Mondal & Datta, 2008; Yuksel, 2014). Bread has many concurrent changes and they contribute to the overall modification toward a sensorial stale product. As is known, a partial crystallization occurs after gelatinization of starch, and it is called as retrogradation, when the gelatinized starch cooled down to ambient or sub ambient temperatures (Konuklar, Inglet, Cariere, & Felker, 2004; Lisinska & Golubowska, 2005; Mirzaei & Movahed, 2013). With this transition, hardening of the starch gel occurs, and the firmness of the stale bread crumb increases (Pedreschi, 2012). After the production of bread, staling process starts along with the moisture loss initiating the retrogradation of starch (Ribotta, Cuffini, León, & Añón, 2004). For this reason, staling of bread causes a loss in some aromatic characteristics and textural properties of bread change towards to the undesired direction, therefore the stale bread is not desired for consumption due to considerable loss in sensory acceptance (Siljeström et al., 1988). As a result, stale bread is generally wasted causing the loss of economic and natural resources. Although many campaigns are held worldwide to decrease the waste of stale bread; unfortunately, still millions of bread are wasted every year. On the other hand, previous studies indicate that stale bread can be utilized as a food ingredient in the food industry (Yuksel & Kayacier, 2016). In addition, bread can gain some functional characteristics as a result of staling. The studies investigating the functional characteristics of stale bread revealed that stale bread contains enzyme resistant starch with physiological effect similar to dietary fiber, lower glycemic index value and higher bile acids and water binding capacities (Siljeström et al., 1988; Rabe & Sievert, 1992; Niba, 2002). Because of these properties, it is thought that the stale bread may be used as a natural enrichment agent in the production of snack type foods. For that reason, it was aimed to use stale bread powder in the production of corn chips. To determine the simultaneous

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effect of frying temperature, frying time and stale bread level on certain quality characteristics of corn chips, response surface methodology study was applied.

2. Material and methods

2.1. Materials

Hatap Flour Company (Corum Turkey) provided wheat flour (11.8% moisture, 10.9% protein, 0.53% ash and 0.54 a_w) while corn flour (11.7% moisture, 5.33% protein, 0.73% ash and 0.49 a_w) (Kent, Kayseri, Turkey) and corn oil (Ulker, Istanbul, Turkey) were purchased from local markets in Kayseri (Turkey). Stale bread powder was prepared in the labaratory conditions. For this purpose, wheat flour, yeast, salt and water were used in bread formulation and the dough was produced. After resting and fermentation, the dough was baked at 220 °C for 20 min (fermentation conditions: 30 °C for 45 min-30 °C for 60 min, respectively). Afterwards, the breads were then staled at room conditions for two days. The staled bread was ground using a food grinder to obtain stale bread flour (11.8% moisture, 9.01% protein, 1.93% ash and 0.57 a_w).

2.2. Methods

2.2.1. Manufacturing process for the corn chips

Table 1 illustrates the formulation of corn chips containing different amount of stale bread flour. Wheat flour was added to the corn flour at 15% in each formulation to obtain the dough. Corn (35–60%)+wheat flour (15%) and stale bread (25–50%) were mixed in a dough mixer (Kitchen Aid Professional 600, MI, USA) for 5 min and water (55 ± 2 mL) was incorporated into the mix to make a dough which was then kneaded for 10 min. The dough was rested at room temperature for 30 min for proper hydration after covering it with a stretch film to avoid moisture loss. Afterwards, a sheet of dough with a thickness of 1 mm was obtained using a sheeter (Rondo, Doge, Model: SS0615, Switzerland). After that, deep frying of samples (6 × 2 cm) was conducted using a temperature controlled fryer (Mikrotest, Ankara, Turkey) according to the time-temperature combinations presented in Table 1. After deep frying, the samples were taken on the paper towel and cooled down to the ambient conditions.

2.2.2. Proximate composition of corn chips samples

The official procedures (AOAC, 2000) were followed for the determination of dry matter, oil, ash content and water activity of the samples. Chips samples were dried at 105 °C for 4 h in an oven (Nüve FN 120, Ankara, Turkey) to calculate the water and dry matter content. Ash content was determined by incinerating the samples at 550 °C in ash oven (Protherm, Ankara Turkey) for 4 h. The color values of chips samples were measured by a colorimeter (Konica Minolta, model CM-5, Mississauga, ON, Canada) and recorded as L, a and b. The oil content of the samples was determined using Soxhlet extraction system. The water activity of samples was measured using an automatic a_w meter at 25 °C (Decagon, USA).

2.2.3. Textural analysis

Texture Analyzer (TA.XT Plus, Stable Micro System Ltd., Surrey, England) was used to determine the textural characteristics of corn chips. The analysis was conducted using an attachment called as Kramer shear (HDP/KS-5) with 30 kg of load cell. Chips which placed as perpendicular to ensure maximum number of blades touching the samples (6 × 2 cm) during analysis were broken on the blades. The blades lifted down on the sample at a vertical speed of 5 mm/s. The force (kg) which breaks the sample was calculated using a time-deformation curve obtained after analysis. The measurements were replicated 5 times.

2.2.4. Sensory analysis

The sensory analysis of corn chips incorporated with stale bread was evaluated by fifteen members which are the members of a trained panel from the Food Engineering Department at Erciyes University. A seven-point hedonic scale was used by the panel members to evaluate the specific sensory characteristics. For the evaluated sensory parameters like taste/odor, color, crispness and overall acceptability, panel members used the scale between 1 and 7 which shows 1 is very low or undesired and 7 shows very high or desired property.

2.2.5. Statistical analysis and modeling

Stale bread, frying temperature and frying time were selected to be processing variables for modeling. Box Behnken experimental design having 3-factors-3 levels (Box & Behnken, 1960) with three replicates at the center point was used and predictive regression models were constructed for the all analysis parameters. Table 1 illustrates coded and uncoded values of the 3 processing variables (factors), levels and experimental design. For each response variable a second-order polynomial equation of function X_i was fitted as shown below:

$$Y = b_0 + \sum_{i=1}^{3} b_i X_i + \sum_{i=1}^{3} b_{ii} X_{ii}^2 + \sum_{\substack{i=1 \\ i<j}}^{3} \sum_{j=1}^{3} b_{ij} X_i X_j \quad (1)$$

where Y denotes the estimated response and X_i and X_j denote processing variables (stale bread, frying temperature and frying time) while b_0, b_i, b_{ii}, b_{ij} are constants. Analysis was performed by using the uncoded values in Table 1. The number of runs was restricted as 15 in the Box-Behnken design. Experimental variances were predicted from the center runs of the model after the experimental combinations were implemented in triplicate (6^{th},12^{th} and 14^{th} in Table 1). JMP statistical package software (Version 5.0.1.a SAS Institute. Inc. Cary, NC, USA) was used for conducting the response surface analysis and calculation of maximum and minimum response for increment radii from the center of the original design for estimated ridges. On the other hand, computational work including 3D surface plots was accomplished by using Statistica (Version 8.0 Statsoft Inc. OK, USA) for estimated ridges. Significance level was 0.05 for the determination of significant parameters of the models.

3. Results and discussion

3.1. Effect of stale bread on some physicochemical properties of corn chips

Table 2 shows the physicochemical parameters of corn chips enriched with stale bread powder. Increasing stale bread concentration resulted an increase in the dry matter levels of samples significantly ($p < 0.05$, Table 3). But, the linear effect of frying temperature and time for the dry matter content of samples was determined to be insignificant ($p > 0.05$, Table 3). The highest dry matter content was 99.84% in the corn chips containing 50% stale bread and fried at 180 °C for 40 s while the lowest to be 98.42% in the sample containing 0% stale bread and fried at 170 °C for 50 s (Table 2). Regression model (Table 4) constructed for the prediction of dry matter content of the corn chips enriched with stale bread with notably high coefficient of determination ($R^2 = 0.85$). Rababah et al. (2012) investigated the effect of flavor compounds on corn

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