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Utilization of stale bread in fried wheat chips: Response surface methodology study for the characterization of textural, morphologic, sensory, some physicochemical and chemical properties of wheat chips

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ABSTRACT

Wheat chips enriched with stale bread were produced and response surface methodology was used for the studying the simultaneous effects of stale bread level (0–50 g/100g), frying temperature (170 –190 °C) and frying time (40–60 s) on some physicochemical, chemical, textural, morphological and sensorial properties of chips. Additionally, product optimization was performed by using ridge analysis to detect the optimum levels of process variables. The dry matter, ash, Hunter Lab a and b values of samples increased with the increasing stale bread level. Higher frying temperature caused a decrease in the hardness and water activity values. Also, addition of stale bread in the formulation of chips decreased the oil uptake of samples significantly ($p < 0.01$). Sensory values of wheat chips increased with the increasing stale bread level. In general, panelists preferred wheat chips enriched with stale bread compared to control sample. The addition of stale bread made the structure of chips firm and electron microscopy analysis revealed that pores and fractures of chips decreased for the samples containing stale bread, which resulted in lower oil uptake during frying.

1. Introduction

Potato and corn chips are the most common salty snacks in the world and consumed by all age groups (Senthill, Ravi, Bhat & Seethalakshmi, 2002; Thakur & Saxena, 2000). One of the important driving forces of snack food industry is to develop new snacks by using alternative raw materials and ingredients. Although wheat flour has not been used as the main ingredient of fried chips in the industry, there are various studies in the literature concerning its possible utilization for the production of chips. (Cankurtaran, 2008; Kayacier, Yuksel, & Karaman, 2014a; Yuksel, Karaman, & Kayacier, 2014).

Bread is an inseparable part of a daily diet and it is probably the most commonly consumed food product in the world. Bread, a fermented food product, is generally produced with wheat flour, water, yeast and salt (Mondal & Datta, 2008; Yuksel, 2014). Staling occurs in the bread when it starts losing moisture after production and retrogradation of starch takes place (Ribotta, Cuffini, León, & Añón, 2004). For this reason, staling of bread causes the loss of some aromatic characteristics and textural properties of bread; therefore most people would not like to consume stale bread (Siljeström et al., 1988). Non-consumed stale bread is generally wasted to garbage causing the loss of economic and natural resources. Although there are many campaigns running in the world to curb the amount of stale bread waste; still millions of loaves of bread go to garbage every year. For example, in Turkey the amount of stale bread per day is about 5 million units in 2013 (TMO, 2013). On the other hand, stale bread can be used to be as a food ingredient in food industry. It is also known that the staling may provide some functional characteristics to bread. Stale bread contains more dietary fiber (due to resistant starch), has lower glycemic index and higher capacities of bile acids and water binding (Niba, 2002; Rabe & Sievert, 1992; Siljeström et al, 1988). These properties could be associated to lower oil uptake during frying for deep fried snacks.

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Hence the formulation of snack foods can be incorporated with stale bread flour to obtain chips with lowered oil content. Additionally, higher dietary fiber and lower glycemic index mean that the snacks prepared with stale bread addition could be healthier alternative to present snacks in the market. (Sajilata & Singhal, 2005; Sajilata, Singhal, & Kulkarni, 2006).

The objective of the present study is to enrich wheat chips with stale bread to produce a new snack food for consumers and snack industry. Response surface methodology was used to determine the optimum processing variables according to certain quality characteristics of wheat chips enriched with stale bread in order to obtain overall acceptability and low oil content.

2. Material and methods

2.1. Materials

Wheat flour was obtained from Hatap Flour Co. (Corum, Turkey). Initial analysis of flour revealed that it contained 11.8 g moisture, 10.92 g protein, 0.53 g ash in 100 g dry matter and its water activity was 0.54. Bread dough was produced in the laboratory using flour, yeast, salt and water. After fermentation the dough was baked at 220 °C for 20 min (fermentation conditions: 30 °C 45 min–30 °C 60 min respectively). Afterwards, bread was staled at room conditions for two days. The stale bread was ground using a food grinder (Kitchen Aid Professional 600, MI, USA) to obtain stale bread flour. It was determined that the stale bread contained 11.8 g moisture, 9.01 g protein, 1.93 g ash in 100 g dry matter and its a_w was measured to be 0.57. Corn oil (Bizim Brand, Istanbul, Turkey) used for the frying was purchased from local market in Kayseri (Turkey).

2.2. Methods

2.2.1. Preparation of chips

Chip samples were prepared with wheat flour and ground stale bread at different proportions as presented in Table 1 (100:0; 75:25; 50:50). To form dough, wheat flour and ground stale bread were mixed as a dry mixture using dough mixer (Kitchen Aid Professional 600, MI, USA) for 5 min and then 50 mL tap water was incorporated into the mix which was kneaded for 10 min. After kneading the dough was covered with a stretch film to prevent drying of dough and rested for 30 min at room conditions for proper hydration. Afterwards, the thickness of dough was adjusted to 1 mm using a lab-scale sheeter (Rondo, Doge, Model:SS0615, Switzerland). Finally, chip samples were deep fried using a temperature controlled fryer (Mikrotest, Ankara, Turkey). Different frying temperature (170, 180 and 190 °C) and frying duration (40, 50 and 60 s) were chosen as presented in Table 1 for the optimization of processing variables. Fried chip samples were cooled and rested on paper towel at ambient conditions.

2.2.2. Proximate composition of wheat chips

Dry matter, oil, ash contents and water activity of the samples were determined according to the official procedures (AOAC, 2000). Dry matter content of the samples was determined by drying samples at 105 °C for 4 h in a laboratory oven (Nuve FN 120, Ankara, Turkey). Ash content was measured by incinerating the samples at 550 °C for 4 h using an ashing furnace (Protherm, Ankara Turkey). Oil content of chip samples was analyzed using a soxhlet extraction system. The water activity of samples was measured using an automatic a_w meter (Decagon, USA).

2.2.3. Color analysis

The color values of chip samples determined using a colorimeter (Lovibond RT Series Reflectance Tintometer, England) were recorded as L (brightness), a (±red–green) and b (±yellow–blue) according to the Hunter scale. The chip samples were milled with mortar and the milled samples poured in a tube. Afterwards, the tube was placed to colorimeter and the color was measured.

2.2.4. Textural analysis

Textural characteristics of wheat chips were determined using a Texture Analyzer (TA.XT Plus, Stable Micro System Ltd., Surrey, England) equipped with a Kramer shear cell attachment (HDP/KS-5) using a 294.3 N of load cell for the analysis. The analyses were performed with six replicates at room temperature. Wheat chips (approximately 3 g) were placed in the Kramer shear cell and samples were placed to be perpendicular to the Kramer shear blades to ensure maximum number of blades contacting to the samples. The blades travelled at 5 cm/min during analysis. The fracture force (N) which is the maximum force required to break the sample was measured from the time–force curve.

2.2.5. Scanning electron microscopic analysis

SEM analysis of wheat chips enriched with stale bread were conducted according to the procedure described by Konuklar, Inglet, Cariere, & Felker, 2004. Two chips were fixed in 10 mL of 14 mL/L glutaraldehyde solution for 2 h. Afterwards, the samples

Table 1
Second order design matrix used for the evaluation of the effects of process variables (stale bread, frying temperature and frying time) on some physicochemical, chemical and sensory properties of wheat chips enriched with stale bread.

	Coded values			Uncoded values		
Runs	Stale bread (g/100g) X_1	Frying temp. (°C) X_2	Frying time (s) X_3	Stale bread (g/100g)	Frying temp. (°C)	Frying time (s)
1	0	−	−	25	170	40
2	+	0	−	50	180	40
3	+	0	+	50	180	60
4	−	−	0	0	170	50
5	−	0	+	0	180	60
6	0	0	0	25	180	50
7	−	+	0	0	190	50
8	+	+	0	50	190	50
9	0	+	+	25	190	60
10	+	−	0	50	170	50
11	0	−	+	25	170	60
12	0	0	0	25	180	50
13	−	0	−	0	180	40
14	0	0	0	25	180	50
15	0	+	−	25	190	40