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Optimization of Cooking Time, Toasting Temperature and Tempering Time to Improve Physical Qualities of Corn Flake from Maize

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Abstract

In this study processing conditions of corn flake were determined to produce optimum corn flake characteristics such as untoasted flake thickness, low bulk density, high water absorption index and acceptable sensory qualities for maize variety of BH-540. It was also found that the effect of cooking time, toasting temperature, and tempering time most importantly influence physicochemical properties of processed corn flakes. The optimal processing conditions of corn flake form maize variety of BH-540 was found as cooking time (46 min), tempering time (71 min) and toasting temperature of 181^{o}C. Physicochemical properties such as untoasted flake thickness, toasted flake thickness, bulk density and water absorption capacity of optimally processed corn flakes were1.76 mm, 2.41mm, 1.08g/mL and 1.56mL/g respectively.

Keywords: Bulk density, Flake thickness, sensory quality, water adsorption

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Introduction

In many countries, cereal crops are the mainstay of life and the largest components of food in their daily diet. Ready to eat cereals are processed grain formulations suitable for human consumption without requiring further processing (Chinnaswamy and Bhattacharya, 1983). Ready to eat cereal breakfast foods can be conveniently classified in to two general types which are those made from whole grains and milled products. Both of these food types are available for the customer in the market in the form of flaked, shredded, granular, puffed and toasted breakfast foods. But corn flakes are the most common form of breakfast cereals (Fast, 1990). Toasting and tempering are the most important processing steps for the production of breakfast cereals. These two processing parameters influences the quality attributes of ready to eat corn flakes (Tribelhorn, 1991). Corn flakes are often toasted by placing them suspend in hot stream of air rather than laying them out on flaking

surface. The production of flaked cereals involves pre-processing, mixing, cooking, depluming, drying, cooling and tempering, flaking, toasting, and packaging (Chen and Yeh, 2001).The process of toasting induces many changes in corn flakes. Though toasting operation is conducted at low moisture content (usually below 10%), the use of high temperature for a short duration suddenly releases steam leaving behind an expanded non-collapsing structure. The development of crisp texture and characteristic flavor are an integral part of toasting process (Jones *et al.*, 2000).Physical and chemical changes to proteins occurring during processing of corn flakes affect texture of corn based ready to eat breakfast cereals. Processing conditions also influence the rheology and molecular fragmentation of starch that occurs during milling of conventional processed corn flakes (Bhattacharya and Prakash, 1994). Corn grits are tempered and milled at different processing conditions such as low and high moistures percentages, different tempering temperatures and time. All processing conditions directly influence physicochemical properties of processed corn flake (Baattacharya and Sumithra, 2008). Therefore, in this study optimization of basic processing conditions such as tempering time, cooking time and toasting temperature were investigated for the production of quality corn flake from maize BH-540 variety.

Materials and Methods

Sample collection and preparation

Maize (BH-540) sample was collected from Adet agriculture research center, Amhara regional sate, Ethiopia in 2016. BH-540 maize Variety was selected since it is highly produced maize in Ethiopia. The sample was cleaned to remove stones, under size and pest attacked corn grains. The cleaned maize was then soaked in water for 90 min at ambient temperature of 25^{o}C. The soaked maize was de-hulled and de-germinated using de-huller (model-SN11, bought from China) and de-germinator (mode-DTP 50, purchased from China) respectively. Then the grit was soaked in water for 24 hours at ambient temperature of 25^{o}C.

Experimental design and statistical analysis

Experiments were conducted using the central composite design for three factors as described by (Mariotti *et al.*, 2008) using design expert 8.0.7.1 software. The only difference from (Mariotti *et al.*, 2008) was, they employed this design for five factors. To visualize the combined effects

of three factors on the response, 3D response surface and contour plot were generated. The three independent variables namely tempering time, toasting temperature and cooking time each at five levels. The experiment was carried out at Bahir Dar food science and postharvest handling research center laboratory, Amhara regional state, Bahir Dar, Ethiopia. Significance was judged by determining the probability level less than 5% or simply ($p < 0.05$).

Experimental work

Cooking of grit was conducted at cooking temperature of 121^{o}Cas described by (Baattacharya and Sumithra, 2008) but at different cooking time levels (20, 30, 45, 60 and 70 min). After cooking, the grit was de-lumped using de-lumping machine and dried for five minutes at ambient environment (temperature 24.5^{o}C and Relative humidity of 45.6%).The aim of this experiment was to determine the optimum cooking time of corn processing. Tempering of the grit was conducted at different tempering time levels (10, 20, 80,140 and 180 min).The ultimate goal of this experiment was to optimize the tempering time of cornflake production. Tempered grits were flaked by using drum drier (model-HT-SQJ1, bought from china) at rotating speed of 80 rpm according to (Mariotti *et al.*, 2008).

After flaking operation, it was cooled for ten minutes at ambient environment (temperature 24.5^{o}C and Relative humidity of 45.6%).The flake was then dipped in to honey solution (1:3 ratio) as it was done by (Holtz *et al.*, 2001) to enhance the flavor of corn flake. Toasting was done at different temperature levels (132,150,175,200 and 217^{o}C) for 20min. Finally the produced cornflake was evaluated for its physicochemical quality characteristics such as flake thickness, bulk density, water absorption capacity and sensory quality attributes.

Physicochemical characterization of corn flake

Size characteristics (Flake thickness): Linear dimensions of flake were measured with digital calipers having 0.01 mm accuracy following a procedure by (AACC, 1976).

Bulk density: Volume of 100 g flakes was measured using a graduated measuring cylinder by a method (AACC, 1976).

Water absorption capacity: Water absorption capacity was measured by a method (Fleming *et al.*, 1974).

Sensory analysis: Sensory evaluation was carried out using 15 trained panelists (10 women and 5 men) to assess texture, colour, and flavor and over all

acceptability of the corn flake. The panelists were selected randomly from the staff of Bahir Dar food science and postharvest handling research directorate. They were allowed to evaluate in a separate section to reduce biased from each other .The panelists were instructed to rate the corn flake sensory qualities attributes based on 7-point hedonic scale ranging from 1= dislike extremely to 7= like extremely. The evaluation process was performed following the procedure by (Dimple and Rohanie, 2014).

Results and Discussion

Untoasted flake thickness

Flake thickness of untoasted corn flake was between 0.94 mm and 2.1 mm. High flake thickness of corn flake was found at cooking time (20 min) and tempering time (80 min). The results found in this study coincide with the result obtained and reported by (Baattacharya and Sumithra, 2008). Cooking and tempering time highly influences the corn flake thickness and flaking property. However toasting temperature had no significant effect at ($p>0.05$) on flake thickness. However different result was found and reported by (Jones *et al.*, 2000) where toasting temperature had a significant effect on flake thickness at ($p<0.05$).

Toasted flake thickness

The flake thickness of toasted corn flake was between 1.46 mm and 2.7 mm. During the experiment very thick toasted corn flake was obtained at cooking time (20 min), tempering time (80 min) and toasting temperature of 175ºC. So production of corn flake at these processing parameters would result undesirable quality of the product. The result found in this study was similar with the finding and reported by (Baattacharya and Sumithra, 2008).

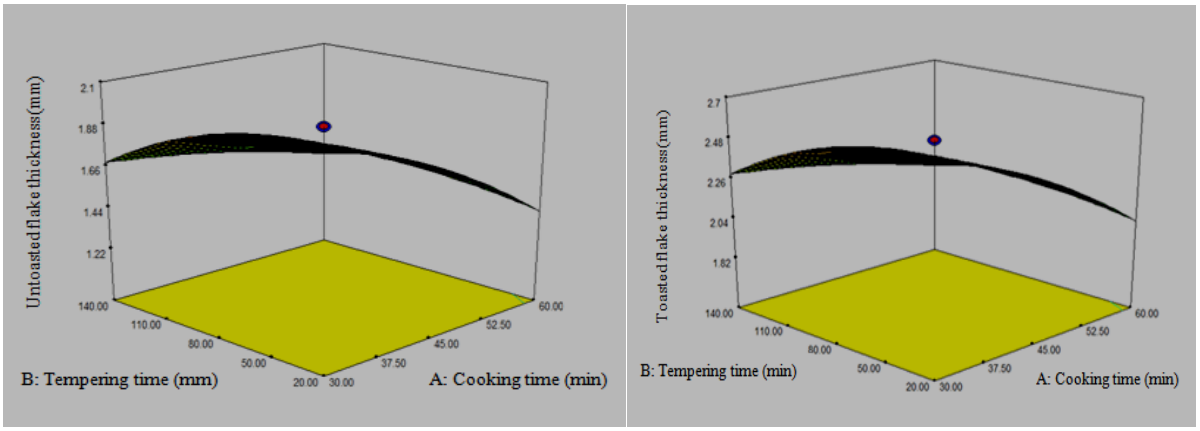

Figure 1. Response surface plots for flake thickness as function of tempering and cooking time

Bulk density

The bulk density of corn flake was found as 1.08 g/mL to 1.35 g/mL. The highest bulk density was recorded with processing parameters of cooking time (60 min), tempering time (140 min) and toasting temperature of 200^{o}C. The results in the study were very similar with report by (Baattacharya and Sumithra, 2008). Cooking and tempering had a significant effect on bulk density of toasted corn flake ($p<0.05$). Different result was reported by (Mariotti *et al.*, 2006) as a decrease in bulk densities of corn flake occurs at relatively higher tempering time and toasting temperature.

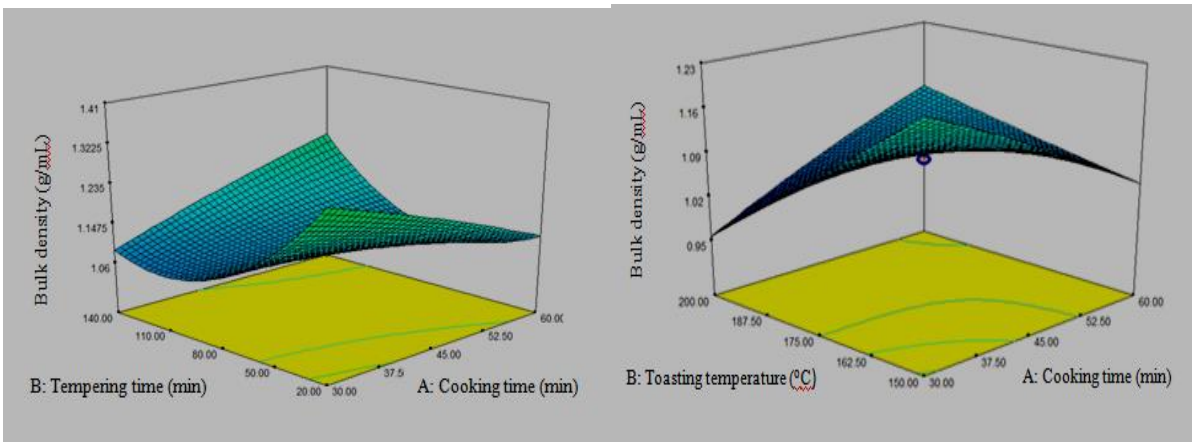

Figure 2. Response surface plots for flake bulk density as function of toasting temperature, tempering and cooking time

Water absorbtion capacity

Waterabsorption capacity of corn flake was ranging from 0.83 g/mL to 2g/mL as shown in figure 3 below. The lowest water absorption capacity was scored at processing condition of cooking time (20 min), tempering time (80 min) and toasting temperature(175^{o}C) while the highest water absorption capacity was at cooking time(70 min),tempering time(80 min)and toasting temperature(175^{o}C) which was very different from finding and reported by (Baattacharya and Sumithra, 2008). Cooking time, tempering time and toasting temperature had significant effect at ($p<0.05$) on water absorption capacity of corn flake. The degree of effect of cooking time, tempering time and toasting temperature on water absorption capacity of corn flake was also completely different than the findings and reports by (Tran and Smith, 2011). (Mariotti *et al.*, 2006) also reported different result and justify it as puffing leads to the new organization of the outer layers and high porosity of matrix have been indicated to be

responsible for the rapid hydration of the puffed materials and predominance of capillary water absorption. Different researchers found different result and reached to conclusion based on scientific merits. But the main reason for those different results probably due to variety and agronomic practice differences of cereal crops.

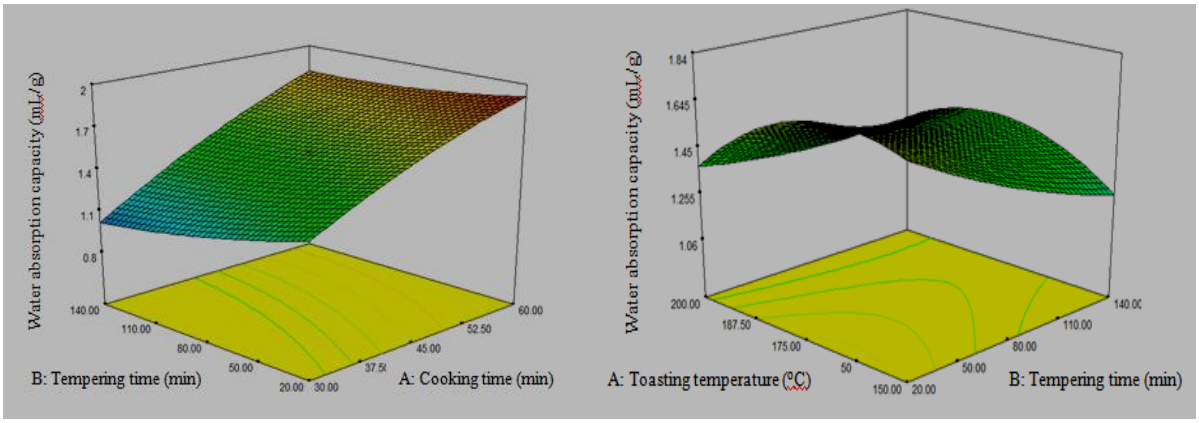

Figure 3. Response surface plots for corn flake water absorption capacity as a function of toasting temperature, tempering and cooking time

Sensory quality

Cooking time, tempering time and toasting temperature had significant effect on sensory quality of corn flake at (P<0.05).Cooking time and toasting temperature had positive effect while tempering time impact was negative on sensory quality attributes of processed corn flake. The interaction effect of cooking and tempering time had more effect than interaction of tempering time and toasting temperature on sensory qualities of corn flake. The result obtained was very different than the finding and report by (Fast, 1990). The result of overall acceptability of optimally processed corn flake coincides with the result reported by (Camill *et al*., 2013). As observed in figure 4 below over all acceptability of corn flake was found as six which show high consumer preference of the corn flake.

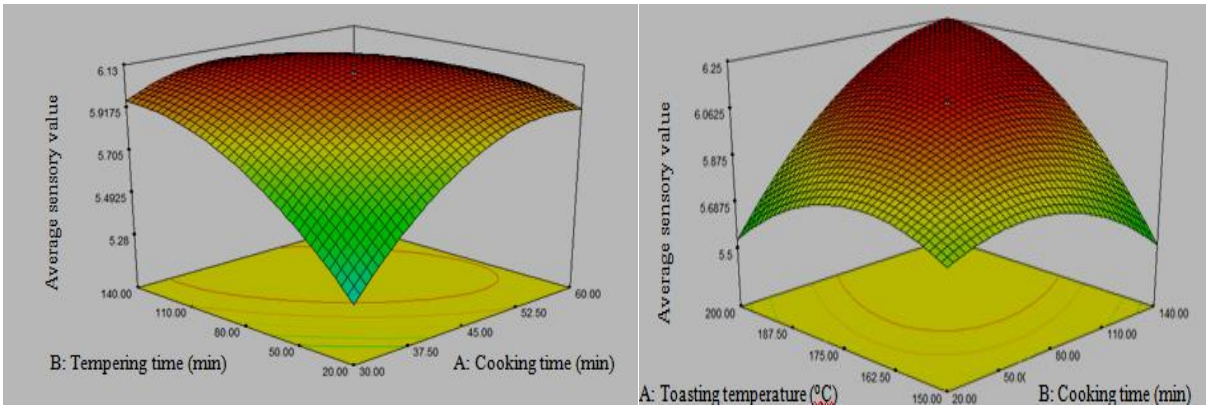

Figure 4. Response surface plots for corn flake average over all acceptability as a function of toasting temperature, tempering and cooking time

Conclusion

Optimization of processing conditions of corn flake is an important factor to enhance its physicochemical characteristics. Cooking time, tempering time and toasting temperature had significant effect at ($p<0.05$) on physicochemical qualities of corn flake. Physical characteristics influence sensory and functional properties and thus finally the overall acceptability of corn flakes. The optimal processing conditions of corn flake fromBH-540 maize variety were found as cooking time (46.62 min), tempering time (71.12 min) and toasting temperature of 181.14ºC. Optimally processed corn flakes had best physicochemical properties which in turn increase market values due to high consumer preference. At optimal processing condition corn flake physicochemical characteristics were flake thickness (1.76mm), puffed thickness (2.41mm), bulk density (1.08g/mL), water absorption capacity (1.56 mL/g) and very good overall acceptability of sensory values.

Acknowledment

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Conflict of interest

The authors declare that there is no conflict of interest.

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