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Effects of chickpea (*Cicer arietinum*) flour on quality of deep-fat fried chicken nuggets

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Abstract

In order to determine the potential values of chickpea flour (C) as coating material, the effects of chickpea flour on quality of deep-fat fried chicken nuggets were studied. Battering (chickpea flour:wheat flour; C:W) and breading (chickpea flour:corn flour; C:Co) applied to chicken meat as coatings. Increasing chickpea flour increased adhesion, yield, moisture content, penetration values and sensory properties in battering application. Moreover, it decreased frying loss and fat absorption significantly. The effects of chickpea flour in battering were higher than breading with the exception of sensory properties. The effects of chickpea flour in breading increased sensory scores much more than in battering. The results of studied parameters demonstrated that chickpea flour had the potential as a coating material.

Key words: Chickpea flour, edible coating, chicken nugget, wheat flour.

Introduction

Edible coatings are being known to protect perishable food products from mass transfer for a long time. The application of edible coatings on food such as chicken meat can provide an alternative method for reducing the quality changes. The different types of agricultural materials used to prepare edible coatings include polysaccharides, lipids and proteins [1-3].

The use of natural mixture from agricultural sources, to take advantage of each of these components in a ready system, appears as a new opportunity of material in the area of edible films. Chickpea is one of the important agricultural sources [4, 5]. Chickpea flour is valued for its nutritive seeds with high protein and starch content. On average chickpea seed contains about 20-28% protein and 52-57% carbohydrate. It has been well recognized as a valuable source of dietary proteins, minerals and vitamins in many parts of the world. Additionally, it has been eaten fresh as green vegetables, parched, fried, roasted, and boiled, as snack food, dessert and condiments. Chickpea (*Cicer arietinum*) is most widely grown food legume crop in South Asia, Anatolia and many parts of the world. It does not contain any specific major anti-nutritional or toxic factors and it can be easily dispersed and hence it may yield good properties of coating [4, 6, 7].

These characteristics of composition makes the chickpea flour an interesting source of raw material for the coating technology. The application of the optimized formulation coating from chickpea flour and other flours to chicken nuggets can show beneficial effects in the process. However, the effect of this flour on the food as battering or breading material has not been studied in detail. The aim of this work was to study the effect of different composite coatings from chickpea flour and other flours (wheat flour and corn flour) on the quality of chicken nuggets and to provide different alternatives to consumers.

Materials and Methods

Materials: Chicken breasts of same age were obtained from Adiyaman Banvit Co. in Turkey. Chickpea flour (C), wheat flour (W), corn flour (Co), salt, and baking powder were obtained from local grocery shops. Carboxymethylcellulose (CMC) was obtained from Smart Chemical Co. (Izmir, Turkey) Hydrogenated palmolein margarine was used as the frying medium (Frita, Unilever Co. Tekirdag, Turkey). Mini fryer (Tefal, FF1024, China) was used for carrying out frying operations. The capacity of fryer was 1 litre with thermostatic temperature control.

Methods: Chicken breast samples were frozen at -18^{o}C for 24 h. Then, they were thawed at 4±1^{o}C and cut into nuggets (2 cm x 2 cm x 3 cm). The nuggets were dipped in 100 ml of batters according to Table 1 and allowed to drain for 5 min. They were breaded with bread material mixtures (1:3, 1:1, 3:1 C:Co and 100% C). A total of 12 different coating combinations were applied. The samples that were not coated were used as control. After the coating process, the nuggets were fried at 180^{o}C. For every treatment, each 4 nuggets were fried in 1 litre of fat.

Table 1. Batter formulas (100 ml).

1:3 C:W mix;	23.9 g mix + 0.1 g CMC + 0.5 g salt + 0.5 g baking powder + distilled water
1:1 C:W mix;	23.9 g mix + 0.1 g CMC + 0.5 g salt + 0.5 g baking powder + distilled water
3:1 C:W mix;	23.9 g mix + 0.1 g CMC + 0.5 g salt + 0.5 g baking powder + distilled water

C:W: Chickpea flour: Wheat flour, CMC: Carboxymethylcellulose gum.

Determination of properties of coating materials: Water absorption capacity was determined according to Dogan and Unal [8]. The moisture content of coating materials was determined gravimetrically by oven-drying at 105°C for 4 h while the protein content of the coating materials was measured by using Kjeldahl analysis [9].

Determination of the viscosity of batter: Viscosities of batters were measured in 25°C and in 100 rpm using a viscometer (RVDV-E, Brookfield, USA).

Moisture and fat analysis of coated nuggets: The moisture in the samples was determined at 102°C for 6-8 h, and the fat content was determined using Soxhlet extraction method [10].

Performance analysis of coating nuggets: Performance parameters were determined by measuring the weight of the raw chicken nuggets (*X*), the weight of the coated chicken nuggets prior to frying (*Y*) and the weight of the coated chicken nuggets after frying (*Z*). Calculations of the performance parameters were as follows:

$$Adhesion\ \mathrm{degree} = \left(\frac{Y-X}{Y}\right)*100$$

$$Cooking\ \mathrm{loss} = \left(\frac{Y-Z}{Y}\right)*100$$

$$Yield = \left(\frac{Z}{X}\right)*100$$

Standard penetrometer (Yuksel Kaya Machine, Istanbul, Turkey) equipped with a total of 100 g lead weight was used to evaluate hardness in fried nuggets. Four nuggets were used for each replication. The depth was determined to 1/10 mm for each nugget sample.

Sensory analysis: Ten semi-trained judges assessed the sensory properties using a hedonic scale for the appearance, colour, odour, taste-flavour and texture for acceptability. Different values in the scale indicated the following reactions: 1 extreme dislike, 2 very much dislike, 3 moderate dislike, 4 slight dislike, 5 neutral, 6 like slightly, 7 like moderately, 8 like very much, 9 like extremely [11].

Experimental design and statistical analysis: The experimental design was completely a randomized factorial model (3 x 4), containing three levels of battering materials and four types of breading materials with two replications for each treatment. The data were subjected to analysis of variance (ANOVA), and the results were expressed as mean ± standard deviation (SD). When there were differences among the samples, the differences were compared by Duncan's multiple-range test at the levels of $P<0.01$ and $P<0.05$ using Statistical Analysis System Program (SPSS, Chicago, IL, USA).

Results and Discussion

Properties of coating materials: Water holding capacity, moisture and protein contents of coating materials are shown in Table 2. The highest water holding capacity was in wheat flour and the lowest absorption capacity was in chickpea flour. The highest moisture rate was in corn flour, whereas the lowest rate was in chickpea flour. The highest protein rate was in chickpea flour and the lowest rate was in corn flour (Table 2). The viscosity of 1:3 C:W, 1:1 C:W and 3:1 C:W in the batter were 72.2 cps, 69.8 cps and 73.2 cps, respectively.

Table 2. Physical and chemical properties of the coating materials.

Raw Materials	WHC (%)	Moisture (%)	Protein (%)
Chickpea Flour	67.65	5.75	24.63
Wheat Flour	82.80	11.45	10.36
Corn Flour	74.70	11.81	10.20

WHC Water holding capacity.

The performance of coating materials on nuggets: The effects of C:W mixtures on yield, frying loss and adhesion were found to be significant ($P<0.01$). As shown in Table 3, the mixture of 3:1 C:W had the highest adhesion degree value. However, 1:1 C:W had the lowest frying loss values. The effects of C:Co mixtures on yield, frying loss and adhesion were significant ($P<0.01$, Table 3). Although C:Co mixtures significantly ($P<0.01$) increased yield and decreased frying loss, significant ($P>0.05$) differences were not found between the effects of these mixtures. Adhesion degree values of C:Co mixtures were higher than 100% C.

Table 3. The effects of coating materials on mean values of yield, frying loss and adhesion degree in coated nuggets.

Coating materials	n	Adhesion degree (%)	Frying loss (%)	Yield (%)
Battering				
Control	2	_	37.78±0.12 ^{a}	62.20±0.12 ^{b}
1:3 C:W	8	12.64±0.58 ^{ab}	23.90±1.76 ^{b}	87.41±1.72 ^{a}
1:1 C:W	8	11.81±0.23 ^{b}	21.10±2.06 ^{c}	88.97±2.74 ^{a}
3:1 C:W	8	13.67±0.52 ^{a}	23.27±2.11 ^{bc}	88.5±2.81 ^{a}
Breading				
Control	2	_	37.78±0.12 ^{a}	62.20±0.12 ^{b}
1:3 C:Co	6	13.29±0.67 ^{a}	22.45±3.04 ^{b}	89.41±3.32 ^{a}
1:1 C:Co	6	13.61±0.34 ^{a}	23.49±2.09 ^{b}	87.94±1.89 ^{a}
3:1 C:Co	6	12.80±0.54 ^{a}	22.42±2.83 ^{b}	87.88±2.85 ^{a}
100 % C	6	11.13±0.33 ^{b}	22.68±0.96 ^{b}	87.94±1.77 ^{a}

n: total samples. The alphabets a, b and c in superscripts are the statistical differences among samples.
- The samples that were not coated were used as control.

It was obvious that chickpea flour was an adhesive material as the other flours. Moreover, its effect was higher in battering than the wheat flour. In breading, its effect is as well as the corn flour. This is because its protein level is higher whereas its moisture content is lower than the corn flour. It adheres on the nugget surface and is degraded during the frying process and provides a barrier of film that inhibits the mass loss from the food substrate. Battering materials were viscous solutions. They consisted of polysaccharides (starch) that have a fine particle size and made an adhesive surface on food for the bread crumbs. These materials become gelatinous because of gums and starches in the flour and therefore provide a coating on the surface of the food. They provide an excellent barrier against mass transfer from food matrix. They increase the adhesion degree and yield values, whereas they decrease the frying loss values. However, the decrease in yield and the increase in frying loss are because of the decomposition of the cells of coating materials and meat. In this way, the outward mass transfer in nuggets increase nuggets during deep frying. Prevention of this can be achieved by the use of coating components as proteins, hydrocolloids or different flours [12-15]. According to our results, this can be achieved by the use of chickpea flour as a coating component.

Moisture, fat and penetrometer values: In the ANOVAs of moisture and fat content and penetrometer values, it was determined that the effects of battering mixtures were significant on the results (*P*<0.01). The increasing chickpea flour in the C:W mixtures increased moisture values and decreased fat values (Table 4). Moreover, the C:W mixtures increased penetrometer values.

The effects of breading materials on moisture and fat values was not significant (*P*>0.05, Table 4). However, C:Co mixtures and 100% C increased significantly (*P*<0.01) penetrometer values. Statistical differences for penetrometer values were only found between control and C:Co groups (Table 4).

Table 4. The effects of coating materials on moisture, fat and penetrometer values in coated nuggets after frying.

Coating materials	n	Moisture (%)	Fat (%)	Penetrometer (mm)
Battering				
Control	2	54.61±1.05 [a]	7.35±0.15 [c]	7.64±0.33 [b]
1:3 C:W	8	52.01±1.35 [b]	9.74±0.66 [a]	13.78±0.98 [a]
1:1 C:W	8	53.64±1.94 [ab]	9.04±0.85 [ab]	13.51±1.37 [a]
3:1 C:W	8	55.07±1.23 [a]	8.53±0.57 [b]	13.01±1.68 [a]
Breading				
Control	2	54.61±1.05 [a]	7.35±0.15 [a]	7.64±0.33 [b]
1:3 C:Co	6	53.13±2.37 [a]	9.11±0.95 [a]	13.51±1.38 [a]
1:1 C:Co	6	53.71±1.52 [a]	8.64±0.59 [a]	13.17±1.22 [a]
3:1 C:Co	6	53.44±2.13 [a]	9.28±0.99 [a]	12.56±2.16 [a]
100 % C	6	54.03±2.12 [a]	9.37±0.80 [a]	13.15±1.50 [a]

n: total samples. The alphabets a, b and c in superscripts are the statistical differences among samples.

The decrease in moisture content and the increase in fat content might be due to the destruction of coating materials and meat structure during frying. In particular, denaturation in meat protein structure during frying increases the moisture loss and leads to a harder texture. During frying process, migration rate of moisture was related to barrier formation of coating materials [16-18].

In all the battering materials, coated samples that contained a high rate of chickpea flour had the highest moisture and the lowest fat content values. The reason for these effects might be due to the highest adhesion effects of chickpea in the battering group, because it has a lower moisture and higher protein rate. It strenghthened the coating structure and prevented moisture migration from nuggets. Thus, it provided more juicy nuggets and high penetrometer values together with other flours.

As in this study, a previous study [19] determined a decrease of moisture loss in chicken drumsticks coated with different flours during deep frying. Another study [4] has shown that blending of chickpea flour with equal proportion of gelatinized starch was very effective in reducing the oil content of the fried product. Gennadios *et al.* [16] reported that Balasubramaniam detected 16.4% decreasing moisture loss in coated chicken meat during the frying process. Similarly, Serdaroglu *et al.* [17] determined that meatballs with blackeye bean flour and chickpea flour had higher water holding capacity than other treatment groups.

Different studies have indicated that oil uptake during deep fat frying is localized at crust [19, 20].Thus, in our research, the results of oil rate from nuggets that minced with their coatings were higher than the control due to the scanty moisture content of coatings.

Sensorial properties: The C:W mixtures increased significantly (*P*<0.01) the scores of appearance, colour, odour, taste and texture (Table 5). Moreover, the effects of C:Co mixtures on sensory parameters were found to be significant (*P*<0.01). The increasing chickpea flour in the breading mixtures increased the scores of sensory parameters. Breading mixtures contained only chickpea flour had the highest scores for sensory parameters (Table 5).

The increasing of sensorial values in battering group compared to control was related to the golden-yellow colour and nice fried odour, taste and texture provided by the flours of chickpea and wheat. Chickpea flour had more absorption and protein rate in comparison with the corn flour. It caused a blister and no crack surfaces, golden-red colour, soft chickpea odour, which was indicated as very nice by the judges, high chewing quality, and juicy and crispy texture. All sensorial properties in the coated nuggets were at high acceptable levels (5.9 and above, Table 5).

The results of sensorial analyses were similar to the results in the literature related to coating materials based on protein and polysaccharides based materials such as gums, flour or their mixture [16, 18, 21].

Table 5. The effects of coating materials on sensorial parameters in coated nuggets after frying.

Coating materials	n	Appearance	Colour	Odour	Taste	Texture
Battering						
Control	2	5.3±0.28 [b]	4.6±0.14 [b]	5.3±0.70 [b]	4.9±0.56 [b]	5±0.42 [b]
1:3 C:W	8	6.4±0.80 [a]	6.6±0.31 [a]	6.5±0.43 [a]	6.5±0.49 [a]	6.14±0.39 [a]
1:1 C:W	8	6.5±0.64 [a]	6.6±0.61 [a]	6.4±0.42 [a]	6.3±0.45 [a]	6.44±0.50 [a]
3:1 C:W	8	6.4±0.65 [a]	6.6±0.56 [a]	6.6±0.2 [a]	6.7±0.33 [a]	6.5±0.30 [a]
Breading						
Control	2	5.3±0.28 [c]	4.6±0.14 [c]	5.3±0.70 [b]	4.9±0.56 [c]	5±0.42 [c]
1:3 C:Co	6	5.9±0.61 [bc]	6.3±0.45 [b]	6.2±0.48 [a]	6.1±0.38 [b]	5.9±0.35 [b]
1:1 C:Co	6	6.2±0.86 [ab]	6.5±0.59 [ab]	6.7±0.31 [a]	6.6±0.24 [ab]	6.2±0.37 [ab]
3:1 C:Co	6	6.8±0.20 [a]	6.8±0.38 [ab]	6.5±0.22 [a]	6.4±0.53 [ab]	6.5±0.29 [a]
100 % C	6	6.9±0.35 [a]	6.9±0.26 [a]	6.7±0.22 [a]	6.8±0.35 [a]	6.7±0.29 [a]

n: total samples. The alphabets a, b and c in superscripts are the statistical differences among samples.

Conclusions

The chickpea flour had a much better performance as a coating on chicken nuggets compared to the wheat flour and corn flour. Although chickpea flour was much more effective on nuggets, it can also be used with wheat flour or corn flour in battering and breading formulations. In consideration of fat content of nuggets, chickpea flour should be preferred for use in breading. Effective reductions in fat uptake can be achieved by modification of the chickpea flour. Increasing chickpea flour in coating formulations increased sensory values. The scores of sensory properties were higher than 5.8, which indicated that chickpea flour at its applied levels were acceptable. Usage of these materials in the edible-coating process can be more advantageous than other flours in terms of the quality criteria investigated.

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