A NOVEL APPROACH TO REDUCE FAT-UPTAKE IN FRIED CHICKEN USING EDIBLE COATING

Lovie Matthews[2], Daniel Ananey-Obiri[3], Seyed Vali Hosseini[4], Reza Tahergorabi[1]*

[1]Food and Nutritional Sciences Program, NC A&T State University, Greensboro, NC.
[2]Department of Industrial and Systems Engineering, NC A&T State University, Greensboro, NC.
[3]Computational Data Science and Engineering, NC A&T State University, Greensboro, NC.
[4]College of Natural Resources, University of Tehran, Karaj, Alborz, Iran

*Correspondence: rtahergo@ncat.edu; Tel.: +1-336-285-4865

Abstract

In this study, edible coatings of various concentrations (5, 10, and 15%) were prepared from chicken protein isolate using isoelectric solubilization/precipitation (ISP). A commercial batter (Louisiana Chicken Fry Batter Mix) and a cornstarch-based batter were used. Chicken breast samples coated, battered (with either commercial batter or cornstarch-based batter), breaded, and deep-fried in canola oil at 177 ◦C for 3-4 min. Uncoated samples were the control. Coated samples had significantly lower fat content and fat uptake. Also, they had lower L* and b* values in comparison to the control and commercial battered samples. The puncture force of the samples varied among treatments. Overall, the highest puncture force occurred in the sample with commercial battered samples. Increasing the protein content in Coating treatments positively affected the frying yield, increasing the yield from 57% in the sample with no breading and no coating to 84% in coated samples. The results of this study suggest that 15% chicken protein-based edible coating in combination with cornstarch in the batter will result in lower fat uptake and improve physicochemical quality attributes of the deep-fat fried chicken.

Keywords: Chicken; Edible coating; Deep-frying; Low-fat food

1. Introduction

For the past 30 years, obesity rates have been on the rise. Healthcare costs associated with obesity and chronic diseases have increased as well, attributing nearly $147 -$210 billion towards the national debt (Cawley & Meyerhoefer, 2009). French fries, deep-fried chicken, and chicken nuggets have become common staples in the American diet, as they are more accessible than home meal preparation due to socioeconomic status and convenience (Ananey-Obiri, Matthews, Azahrani, Ibrahim, Galanakis, & Tahergorabi, 2018; Ogden, Lamb, Carroll, & Flegal, 2010). A series of reactions occur during frying, but the oil's contact with the surface of the food product can yield variable oil absorption. Various studies have indicated a variety of methods that can reduce oil absorption in deep-fried foods (Brannan et al., 2014; Moreira, Sun, & Chen, 1997; Williams & Mittal, 1999). Coating and battering before frying create protective barriers that are influenced by the interaction with heat. The ingredients in the batter create a network structure that prevents moisture loss and reduces fat absorption (Adedeji, Liu, & Ngadi, 2010). Like battering, an edible coating can provide the same benefits. An edible coating is a protective layer made of edible materials, such as proteins. The effectiveness of the coating is determined by its mechanical

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and barrier properties, which depend on its composition and microstructure (Ananey-Obiri, et al., 2018). The edible coating made of myofibrillar proteins forms a gel-like structure due to denaturation. The main objective of this study was to examine the efficiency of the chicken-based protein coating in fat uptake reduction and the quality attributes of the deep-fat fried chicken breast. These quality attributes included color, texture, pH, frying yield, and sensory evaluation.

2. Materials and methods

2.3 Protein Isolation

Chicken protein was isolated using isoelectric solubilization and precipitation (ISP) according to Tahergorabi, Beamer, Matak, and Jaczynski (2012).

2.4 Edible Coating Preparation

After protein content was determined using the Bradford method, the isolate was weighed in a beaker and homogenized with 1:3 ddH_2O (w:v). Glycerol was added at 0.4% (w/w) of protein as a plasticizer. The mixture was gently stirred for 30 min as the pH was adjusted with 10 N NaOH to 11 and with 6 N hydrochloric acid to 7. The solution was filtered through two layers of cheesecloth to remove un-dissolved debris. The coating was refrigerated for up to 12 hours before use.

2.6 Batter and breading

Louisiana Chicken Fry Batter Mix (Baton Rouge, LA) as the control, and a corn-starch-based batter was used. The cornstarch-based batter consisted of 48.75% (w/w) wheat flour (King Arthur White Whole Wheat Flour, Norwich, VT), 48.75% corn starch (Argo Cornstarch, Memphis, TN), 1.0% HPMC (Methocel E15 Premium LV Hydroxypropyl Methylcellulose, Midland, MI), 1.0% salt (Morton Salt, Chicago, IL), 0.5% baking powder (Rumford Aluminum-Free Baking Powder, Terre Haute, IN) and 145 mL cold, deionized water. Plain breadcrumbs (Progresso, Minneapolis, MN) were used to bread the samples.

2.1 Chicken Sample Preparation

Fresh boneless, skinless chicken breasts were purchased from a local grocery store, and 10 ± 1g were cut as uniformly as possible. Each sample was pre-dusted with all-purpose flour (Great Value, Bentonville, AR), followed by the edible coating and/or batter. The final step was breading, with the sample layered on top of the breadcrumbs and more breadcrumbs sprinkled on top of the sample. The samples were tapped to adhere the breading to the batter. The chicken breast samples were fried at 177 °C in canola oil (Wesson Pure, Conagra, Chicago, IL) using the Presto® Dual ProFry/1800W (National Presto Industries Inc., WI., U.S.) for 3 min. A summary of the various treatments is presented in Table 1.

2.5 Fat and moisture contents, fat uptake, color, and texture measurements

Fat, moisture, contents of the fried samples were determined according to AOAC, (2010). The frying yield was measured as well (Maskat, Yip, & Mahali, 2005). Color measurements were taken using a Minolta Chroma Meter CR-400 colorimeter (Minolta Camera Co. Ltd., Japan). The textural properties were measured utilizing a puncture probe with the texture analyzer (Model TA-XT2, Texture Technologies Corp., Scarsdale, NY).

2.13 Sensory evaluation

A sensory evaluation was conducted after IRB (Institutional Review Board) approval was obtained for the survey. The participants evaluated the appearance, texture, odor, and color on a 9-point hedonic scale based on the degree of preference. Choices ranged from 1-dislike extremely to 9-like extremely.

2.14 Statistical Analysis

In this study, a one-way analysis of variance was used to compare sample results. All experiments were completed in triplicate. For every experiment, the mean and variance were obtained using SAS Statistical Package (Version 16.0, SAS Institute, Cary, North Carolina, USA). Tukey's test was used to determine the difference in the mean values among all treatments.

3. Results and Discussion

3.1 Fat content, fat uptake, pH, and texture

Fat content and fat uptake of deep-fried chicken breast samples are shown in Table 2. The coated samples had the lowest fat uptake compared to the control($P \leq 0.05$). This is because the protein coating formed from myofibrillar proteins creates a gel-like structure due to heat. This allows enough strength to create a protective barrier (Ananey-Obiri et al., 2018). However, there was no significant difference between the coated samples ($P \geq 0.05$). Similarly, Ananey-Obiri et al., (2020) reported that chicken drumsticks' protein-based edible coating at 5%, 10%, and 15% reduced fat-uptake to more than 35, 50, and 60%, compared to control samples, respectively, and no significant difference among the coated samples was found. Even though no significant difference in moisture content was observed among the various treatments ($P \geq 0.05$), on average, the highest moisture was retained in edible coated samples. That is, using an edible coating retains moisture in deep-fat fried foods. Fig. 1 depicts the pH changes of the deep-fried samples. The coated samples with 10 and 15% protein had the highest pH values among all treatments **(**$P \leq 0.05$).

Table 3 shows the texture results for the samples. The texture was analyzed by the puncture force test, which indicates the tooth action in food mastication at 15% force in Newtons (N). The force of mastication decreased among the treatments ($P \leq 0.05$), indicating a change in the thickness of the batter, breading, and coating. A higher peak force can indicate an increased moisture loss (Lima & Singh, 2000). The highest puncture force among all treatments was observed for the commercial battered sample (105 N) followed by coated samples with 5% protein and battered with corn starch. The amount of force decreased among the coated samples, indicating a decreased moisture loss. Similar to a study by Rayner, Ciolfi, Maves, Stedman, and Mittal (2000), deep-fried samples coated with 10% soy protein were softer than uncoated fried samples.

3.4 Color Determination

Table 4 depicts the color values of the fried samples. The coated samples were less light than the uncoated samples. However, the L* values of the coated samples were not significantly different. This could be due to the presence of myoglobin in the isolated protein used for coating. When myoglobin is exposed to heat the color becomes darker. Although the ISP method has been shown to remove the pigments from the raw materials, the presence of remaining myoglobin might have influenced the color. In general, the a* and b* values of the coated samples were not significantly different from each other while the b* values for coated samples were lower than the control samples.

3.5 Frying yield

The frying yield of the fried samples is indicated in Table 5. Frying yield has an inverse relationship with cooking loss. The frying yield among all the coated and corn starch battered samples was higher than the control which means it experienced more cooking loss than the coated samples. Ananey-Obiri et al., (2020) also reported an average of 84% frying yield in coated fried samples.

3.6 Sensory evaluation

The sensory score of the deep-fried samples were shown in Fig. 2. There was no significant difference among all the samples. That is the coating or the batter containing corn starch did not alter the sensory properties of the deep-fried chicken samples.

Conclusions

In conclusion, fat uptake reduction in the samples occurred due to the use of an edible coating. Application of the edible coating on deep-fat fried foods had no deleterious effect on the pH, color, and textural properties of the product. Findings from this study provide deep frying industries the opportunity to provide a healthier food product by reducing oil uptake during deep-fat frying while maintaining the desirable qualities of the fried products.

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Table 1. *Treatments used to Prepare the Deep-Fried Chicken Samples*

Treatments	Commercial Batter	Corn Starch Batter	Chicken Protein Based Edible Coating	Breading
CN	No	No	No	No
CB	Yes	No	No	Yes
CS	No	Yes	No	Yes
CS 5%	No	Yes	5%	Yes
CS 10%	No	Yes	10%	Yes
CS 15%	No	Yes	15%	Yes

CN- control with no battering, no coating, and no breading; CB-commercial batter with no coating; CS-corn starch batter with no coating; CS 5%-corn starch batter with battering, 5% coating, and breading; CS 10%-corn starch batter with battering, 10% coating, and breading; CS 15%- corn starch batter with battering, 15% coating, and breading

Table 2. *Fat and Moisture Contents of Fried Chicken Samples with Edible Coating and Two Batters*

Treatments	Fat content	Fat-uptake	Moisture content
CN	8.83 ± 0.99^a	5.08 ± 0.99^a	47.35 ± 3.31^a
CB	7.51 ± 0.44^a	3.76 ± 0.44^a	50.02 ± 1.78^a
CS	8.77 ± 0.13^a	5.01 ± 0.13^a	48.34 ± 3.50^a
CS 5%	4.95 ± 0.99^b	1.15 ± 0.99^b	51.81 ± 1.14^a
CS 10%	4.70 ± 0.10^b	0.90 ± 0.10^b	52.51 ± 2.46^a
CS 15%	4.39 ± 0.68^b	0.59 ± 0.68^b	52.18 ± 2.66^a

The data are presented as mean values ± standard deviation. Different letters within the same row indicate significant differences (Tukey's Test, $p<0.05$) between mean values.

Table 3. *Texture Analysis of Fried Chicken Samples with Edible Coating and Two Batters*

(N)	Treatments					
	CN	CB	CS	CS 5%	CS 10%	CS 15%
Puncture Force	12.61 ± 3.52^c	105.40 ± 9.95^a	70.33 ± 9.31^b	75.91 ± 9.72^b	9.14 ± 2.56^c	5.44 ± 1.35^c

The data are presented as mean values ± standard deviation. Different letters within the same row indicate significant differences (Tukey's Test, $p<0.05$) between mean values.

Table 4. *Color Properties of Fried Chicken Samples with Edible Coating and Two Batters*

Treatments	L*	a*	b*
CN	56.32 ± 2.33^{a}	5.52 ± 0.59^{c}	18.78 ± 1.47^{b}
CB	57.94 ± 1.05^{a}	9.51 ± 0.43^{ba}	24.91 ± 0.54^{a}
CS	50.46 ± 0.71^{b}	11.41 ± 0.13^{a}	13.7 ± 0.22^{c}
CS 5%	50.59 ± 2.35^{b}	8.1 ± 1.64^{bc}	10.86 ± 1.96^{dc}
CS 10%	48.00 ± 0.80^{b}	10.59 ± 0.35^{ba}	12.96 ± 1.07^{dc}
CS 15%	49.19 ± 1.74^{b}	9.13 ± 1.61^{ba}	9.28 ± 2.66^{d}

The data are presented as mean values ± standard deviation. Different letters within the same row indicate significant differences (Tukey's Test, p<0.05) between mean values.

Table 5. *Frying Yield of Fried Chicken Samples with Edible Coating and Two Batters*

(%)	Treatments					
	CN	CB	CS	CS 5%	CS 10%	CS 15%
Frying Yield	57.73 ± 0.66^{b}	82.18 ± 0.19^{a}	84.45 ± 0.42^{a}	84.12 ± 0.22^{a}	81.30 ± 0.71^{a}	84.46 ± 0.45^{a}

The data are presented as mean values ± standard deviation. Different letters within the same row indicate significant differences (Tukey's Test, p<0.05) between mean values.

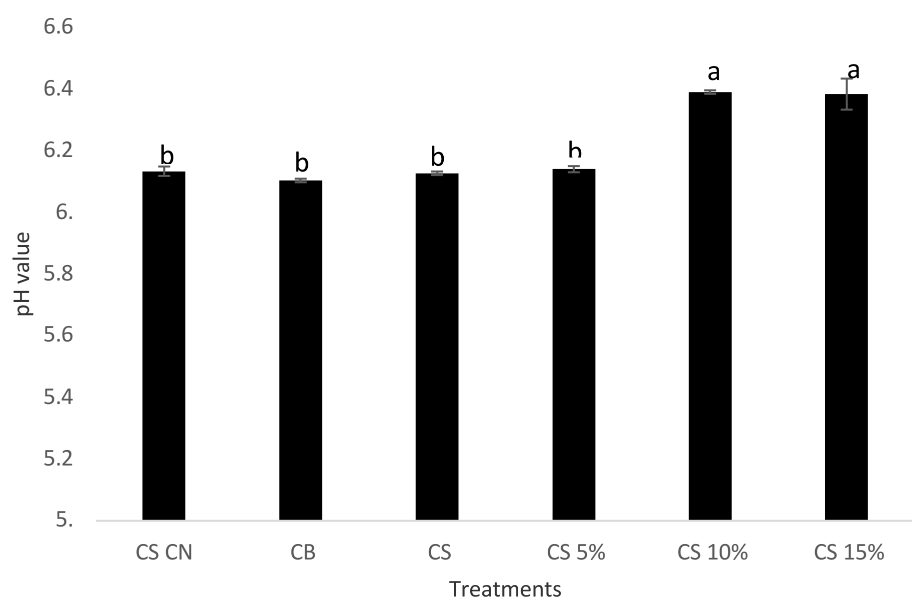

Figure 1. pH values of deep-fat fried chicken breast samples coated with different concertation of edible coating and corn starch batter and commercial batter. Data are given as mean values ± standard deviation. The letters on the top of the data bars indicate significant differences (Tukey's Test, p<0.05) between mean values.

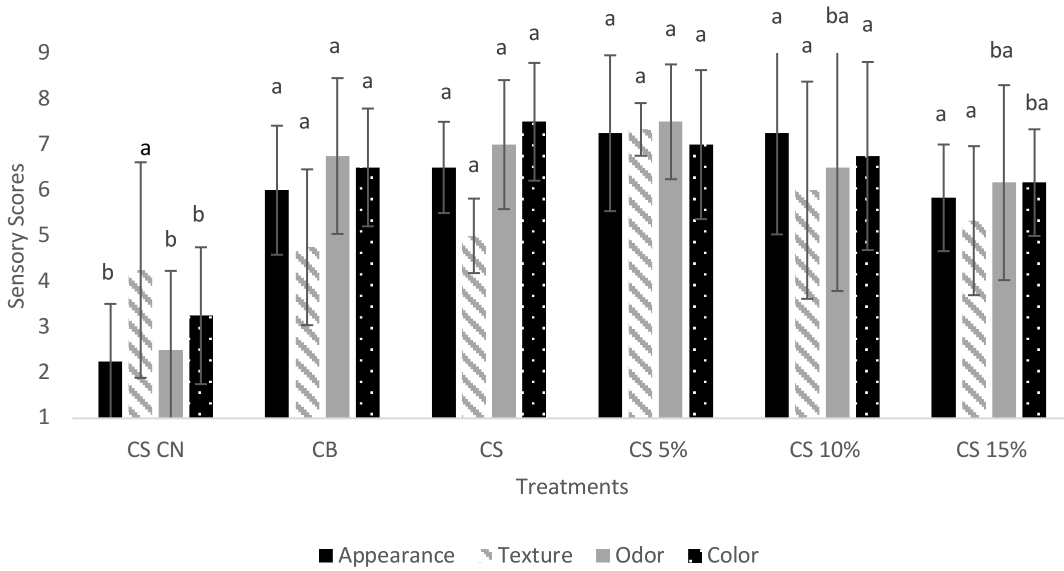

Figure 2. Sensory scores of deep-fat fried chicken breast samples coated with different concertation of edible coating and corn starch batter and commercial batter. Data are given as mean values. The letters on the top of the data bars indicate significant differences (Tukey's Test, $p<0.05$) between mean values.