Use of linseed and coconut flours in chicken patties as gluten free extenders

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Abstract. Patties were extended with gluten free flours (linseed flour: LF, coconut flour: CF and their combination: LC) at a level of 5%. Control sample (B) was formulated with the same level of breadcrumbs. Using gluten free extenders did not change the water holding capacity (WHC); however, improved cooking yield resulted (P<0.05). Similarly, LF, CF and LC patties had lower diameter reduction and thickness change compared to the control sample (P<0.05). Due to color differences between breadcrumbs and gluten-free flours, color values of patties were affected significantly by the extender type (P<0.05). LF patties had the lowest L* and b*, the highest a* values within all patty groups. Different trends were observed in TBARS values of patties during storage, but in any case, all patties had TBARS values lower than 2.0 mg MA/kg throughout the storage. No significant differences were observed in patties’ sensory properties.

1. Introduction

Celiac disease is a major immune-mediated public health problem which is characterized by intestinal inflammation from gluten ingestion [1]. The prevalence of celiac disease is estimated at 0.7–1.4% of the population [2]. When consumed by a person with celiac disease, gluten triggers an autoimmune response that results in damage to intestinal villi, nutritional deficiencies, cancer and other autoimmune diseases [3]. The main precaution for a person with celiac disease is adhering strictly to a gluten-free diet, which means not only scratching gluten-containing raw materials from the diet but also all products that contain them [4].

Nowadays, chicken patties show great economic and industrial importance and are widely consumed. This type of product contains different binder and extenders to improve stability, water holding capacity (WHC) and sensory properties, to entrap lipids and reduce the cost [5]. Moistened or dried breadcrumbs are usually used as binders and extenders in patties [6]. However, use of breadcrumbs obtained from gluten-containing products in patties is a limiting ingredient for people with celiac disease. For this reason, gluten-free alternatives could be better options for patty formulations.

Linseed (Linum usitatissimum L.) has become an emerging functional ingredient in recent years because of its fatty acid composition, phytochemicals, fiber content, and potential health benefits [7]. Previous studies have been carried out on the use of linseed oil and flour in different meat products [8]–[11]. Coconut (Cocos nucifera) is another emerging functional food due to its high fiber content, low
glycemic index, low amount of digestible carbohydrates, other nutrients, and it has no gluten [12]. Thus, coconut flour has become a good alternative for a healthy, gluten-free diet.

Even though different meat products containing coconut flour or linseed flour exist, no study was performed on these flours as breadcrumb replacers in chicken patties. Therefore, the main aim of this study was to investigate technological and oxidative effects of using coconut and/or linseed flours individually or their mixture as breadcrumb replacers in chicken patties.

2. Materials and Methods

Four different patty formulations were prepared as shown in Table 1. Chicken breast and skin were purchased from a local butcher, and breadcrumbs (Bağdat Baharat, Turkey), coconut flour (8.52 fat, 19% protein, 39% dietary fiber), linseed flour (4.13% moisture, 34.48% protein, 5.35% fat, 12.31% dietary fiber) were obtained from a local market. Chicken breast and chicken skin as a fat source were separately ground through a 3 mm plate with kitchen type grinder (Arnica, Turkey). Ground meat and skin, extenders (depends on formulation), salt and other ingredients were mixed for 1 min. Chicken patties were formed with stainless steel molds (d: 9 cm, h: 1.5 cm). After forming, the patties were cooked on an electric grill (Premier, Turkey) for 3.5 min each side at 180°C until the core temperature reached 72°C.

Moisture and ash contents of raw and cooked patties were determined according to AOAC procedures [13]. Protein content was determined using an automatic nitrogen analyzer (FP 528 LECO, USA) based on the Dumas method. Fat content was evaluated according to Flynn and Bramblet [14]. pH was measured in triplicate using a pH-meter (WTW pH 3110 set 2, Germany), equipped with a penetration probe. Cooking yield (CY) was determined by calculating weight differences for patties before and after cooking. To measure the diameter and thickness at the same locations before and after a cooking, three points on per patty were marked. The diameter and thickness of raw and cooked patties were recorded using Vernier calipers and calculated according to Serdaroglu & Demircioglu [15]. WHC was determined according to Hughes et al. [16]. Energy value (kcal/100 g) was calculated based on the European Parliament regulations [17]. Thiobarbituric Acid Reactive Substances (TBARS) value was measured according to Witte et al. [18]. A portable colorimeter (CR400, Konica-Minolta, Japan) was used to determine the surface color of the patties according to the Commission International d’Eclairage (CIE) standards. Patties were randomly assigned for sensory evaluation, were served warm to a ten-membered panel (graduate students of Ege University Food Engineering Department), and were subjected to sensory evaluation for appearance, color, texture, fattiness, juiciness, flavor and general acceptability. The experiment was performed twice, all analyses were carried out in triplicate, and the data was evaluated by one way and two-way analysis of variance (ANOVA) using SPSS software version 23.0. Differences among the means were compared using Duncan’s Multiple Range Test.

Table 1. Formulation of chicken patty samples

| Sample | Chicken meat (%) | Chicken skin (%) | Breadcrumbs (%) | Linseed flour (%) | Coconut flour (%) |
|--------|-----------------|-----------------|----------------|------------------|------------------|
| B      | 81.5            | 10              | 5              | -                | -                |
| LF     | 81.5            | 10              | -              | 5                | -                |
| CF     | 81.5            | 10              | -              | -                | 5                |
| LC     | 81.5            | 10              | -              | 2.5              | 2.5              |

* Sample denomination: B (chicken patties formulated with breadcrumbs), LF (chicken patties formulated with linseed flour), CF (chicken patties formulated with coconut flour), LC (chicken patties formulated with coconut and linseed flour).

** 1.5% salt, 1% onion powder, 0.5% garlic powder, and 0.5% black pepper powder added to all of chicken patties.
3. Results and Discussion
Chemical composition of raw and cooked patties in terms of moisture, protein, lipid and ash contents, total energy and pH values are shown in Table 2. Total moisture, protein, fat and ash in raw samples ranged between 67.15-67.89%, 5.49-6.43%, 16.90-17.40%, 2.41-2.86%, respectively. No significant differences were observed in moisture and protein contents of patties. The highest fat content was found in LC patties, which could be related to the oil content of coconut and linseed flours. The lowest ash content was found in B sample (P<0.05). The pH of the patties was between 6.16-6.26, and addition of linseed flour and coconut flour increased the pH of the patties.

Total moisture, protein, fat and ash in cooked patties were between 63.47-64.83%, 6.47-6.93%, 19.32-21.75%, 2.77-3.21%, respectively. Higher moisture content was recorded for CF samples compared to B after cooking, even though WHCs of these groups were similar (P<0.05). This behavior might be the result of better water absorption ability of coconut flour. Similar findings were recorded by Afoakwah et al. [12]. No differences were recorded among the fat contents (P>0.05). The lowest protein content was found in CF while LC had the highest protein content (P<0.05). Similar to raw patties, in cooked patties, the lowest ash content was found in B while higher ash contents were observed in LF, CF and LC samples (P<0.05). The energy contents of patties ranged between 161.26-167.87 kcal/100 g, and the lowest energy content was found in CF (P<0.05). In a previous study, blending coconut flour with wheat flour resulted in lower energy values compared to 100% wheat flour [19]. The pH of cooked patties ranged between 6.46-6.50, and the highest pH value was observed in CF treatment (P<0.05), while the rest of the patties had similar (lower) pHs (P>0.05).

Table 2. Chemical composition of raw and cooked chicken patties

| Sample | Moisture (%) | Fat (%) | Protein (%) | Ash (%) | Energy (kcal/100 g) | pH |
|--------|--------------|---------|-------------|---------|---------------------|----|
| B      | 67.80±0.47   | 5.49±0.01| 17.25±0.52  | 2.41±0.02| 146.22±1.86         | 6.16±0.01|
| LF     | 67.58±0.19   | 6.16±0.10| 16.90±0.73  | 2.86±0.07| 149.01±1.41         | 6.25±0.01|
| CF     | 67.68±0.58   | 6.24±0.11| 17.10±0.23  | 2.58±0.09| 150.14±2.40         | 6.26±0.01|
| LC     | 67.15±0.24   | 6.43±0.07| 17.40±0.61  | 2.83±0.04| 152.21±0.74         | 6.18±0.01|

| Sample | Moisture (%) | Fat (%) | Protein (%) | Ash (%) | Energy (kcal/100 g) | pH |
|--------|--------------|---------|-------------|---------|---------------------|----|
| B      | 64.07±0.19   | 6.93±0.55| 20.12±0.05  | 2.77±0.02| 167.31±3.01         | 6.48±0.01|
| LF     | 64.48±0.40   | 6.80±0.30| 21.06±0.87  | 2.85±0.03| 164.70±3.24         | 6.46±0.01|
| CF     | 64.83±0.04   | 6.47±0.51| 19.32±0.32  | 2.95±0.07| 161.28±2.11         | 6.50±0.01|
| LC     | 63.47±0.19   | 6.91±0.30| 21.75±0.40  | 3.21±0.02| 167.87±1.96         | 6.47±0.01|

All values are means ± SD of three replicates.
Means within the same column with different superscripts (a-d) are different.

Technological characteristics and color parameters of patties are summarized in Table 3. WHC of patties was between 93.81-94.90%, and no significant differences were found (P>0.05). This might be the result of similar moisture and protein contents in the patties, since moisture/protein ratio is an important parameter for WHC of meat products [20]. Use of gluten-free extenders in chicken patty formulations increased the cooking yield significantly even though the WHC of the patties was similar (P<0.05). Therefore, it could be said that linseed and coconut flours might help to retain fat within the matrix of during the cooking process [21, 22]. Significant differences in diameter and thickness changes among the extenders were identified (P<0.05), patties extended with breadcrumbs had highest values, and no difference was shown among the patties formulated with other extenders. Similar results were observed by Cocaro et al. [23] in chicken burger patties where linseed flour was used.

Color parameters (L*, a*, b*) were affected by the extender type (P<0.05), and this finding may be attributed to the different colors of the extenders. L*, a*, and b* values of patties ranged between 45.86-61.78, 0.68-4.55, and 16.40-22.83, respectively. Use of LF resulted in darker colored chicken patties while CF and B patties were similar (P>0.05). This observation is supported by the work of Hautrive et al [24], who found that linseed flour in hamburgers resulted in darker and more reddish products.
Yellowness of LC patties was similar to that of B patties (P>0.05). CF patties had the lowest a* and the highest b* values within all treatments, due to the characteristic white color of coconut flour (P<0.05). Ayandipe et al. [20] reported that using coconut flour in chicken sausage as a filler resulted in higher L* and lower b* values.

| Sample | WHC (%) | CY (%) | DR (%) | LT (%) | L* | a* | b* |
|--------|---------|--------|--------|--------|----|----|----|
| B      | 93.81±0.67 | 86.25±1.41 | 13.75±1.41 | 4.18±0.46 | 60.59±0.82 | 1.54±0.21 | 19.04±0.61 |
| LF     | 94.90±0.38 | 91.61±0.41 | 8.38±0.41 | 1.81±0.50 | 45.86±0.44 | 4.55±0.16 | 16.40±1.01 |
| CF     | 94.20±0.87 | 92.09±0.45 | 7.90±0.45 | 1.40±0.26 | 61.78±0.53 | 0.68±0.16 | 22.83±0.32 |
| LC     | 94.13±0.42 | 90.08±1.08 | 9.38±0.55 | 1.34±0.03 | 52.66±0.79 | 3.40±0.07 | 18.15±0.30 |

All values are means ± SD of three replicates.
Means within the same column with different superscripts (a-d) are different
WHC: water holding capacity, CY: cooking yield, DR: diameter reduction, TC: thickness change

Lipid oxidation is one of the main chemical changes that results in physical, sensory and nutritional quality deterioration in meat products. TBARS values of the chicken patties are shown in Table 4. Initial TBARS values ranged between 1.09-1.86 mg MA/kg. As presented in Table 4, extender type and storage time had significant effects on TBARS values. Initial TBARS values of B and CF treatments were similar and lower than in LF and LC treatments (P<0.05). Similar to our results, Hautrive et al. [24] stated that using linseed flour as a pork backfat replacer in hamburgers can increase TBARS values, probably due to the high polyunsaturated fatty acid profile of linseed flour. Samples incorporated with breadcrumbs had similar TBARS values until day 4, but however, significant increment was observed on day 6 (P<0.05). In contrast, TBARS values of LF decreased throughout the storage and were significantly lower compared to day 0 (P<0.05). The highest TBARS values of CF and LC samples were found on day 4. After that, significant decrement was observed in these samples, probably the result of decomposition of secondary lipid oxidation products (P<0.05). At the end of storage, CF patties had the lowest TBARS value (P<0.05), while other samples had similar (higher) values (P>0.05). In any case, all patties had TBARS values lower than 2.0 mg MA/kg throughout the storage. Any changes in product formulation can affect flavor, mouthfeel, and texture of the meat products, and in some cases, can greatly alter the sensory characteristics.

Sensory properties of chicken patties are shown in Figure 1. Appearance, color, texture, fattiness, juiciness, taste, and general acceptability of the samples ranged between 6.88-7.47, 6.76-7.35, 6.80-7.40, 6.72-6.78, 6.20-6.80, 6.42-7.3, and 6.76-7.34, respectively. The sensory properties of patties were found similar to each other (P>0.05), in contrast to Cócaro et al. [23]. All patties had acceptable scores, and this finding is an indicator of the promising potential of using as extenders linseed and coconut flours in gluten-free chicken patties.

| Sample | Storage Time (Days) | 0 | 2 | 4 | 6 |
|--------|---------------------|---|---|---|---|
| B      |                     | 1.08±0.03 | 0.92±0.01 | 1.03±0.05 | 1.53±0.05 |
| LF     |                     | 1.86±0.03 | 1.79±0.05 | 1.63±0.22 | 1.48±0.05 |
| CF     |                     | 1.12±0.02 | 1.15±0.01 | 1.91±0.09 | 0.97±0.02 |
| LC     |                     | 1.85±0.01 | 1.56±0.01 | 1.85±0.05 | 1.58±0.07 |

All values are means ± SD of three replicates.
Means within the same column with different superscripts (a-d) are different
Means within the same row with different superscripts (X-Z) are different
4. Conclusion
The present study indicates that use of linseed flour, coconut flour or their combination as extenders in chicken patties presented favorable impacts on technological and sensory characteristics. The physical properties suggested that cooking yield was lower and changes in diameter and thickness were higher in patties formulated with breadcrumbs. Sensory analysis showed that extender type did not negatively affect the evaluated parameters. As a result, using linseed and coconut flours as breadcrumbs replacer in chicken patty formulation could have a great potential in gluten-free diets for people with celiac disease without the patties undergoing technological and sensorial deterioration.

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