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The Effects of Acorn Flour on Some Quality Characteristics of Chicken Patties

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A B S T R A C T

The study was carried out to develop chicken patties by incorporating acorn flour as a meat replacer at 3%, 6%, and 9% levels in the formulation. For this purpose, the chemical (moisture, protein, fat, ash), pH, thiobarbituric acid (TBA), and color analyses in the raw and cooked chicken patties were analyzed. In addition, the cooking properties (cooking yield, diameter reduction, thickness reduction), functional properties (moisture and fat retention) and sensory properties were examined on cooked chicken patties. There were significant changes in the chemical, cooking, functional, and color properties of chicken patties with acorn flour. The moisture and protein values decreased, in both raw and cooked samples incorporated with acorn flour but fat level increased only in raw acorn flour added samples. Lightness (L^*) and redness (a^*) values decreased significantly. The addition of acorn flour caused an increase in b* values of raw samples and a decrease in cooked samples. Acorn flour was not effective in preventing lipid oxidation. The addition of acorn flour contents in chicken patties improved functional and cooking properties, decreased cooking loss, and increased moisture and fat retention. The use of acorn flour improved the quality parameters of patties, but the addition of acorn flour resulted in a darker color in patties. The use of acorn flour in chicken meatballs did not negatively affect sensory properties except color. In conclusion, acorn flour can be used as a filler and binder in chicken patties.

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Introduction

With ever-increasing consumer demand for healthier food products, the meat industry has started producing functional and nutritional meat products with pleasant sensory characteristics.

One approach is to partially substitute meat with plant-based ingredients such as agricultural resources like fruit peel and seeds. These alternative sources are cost-effective and can improve the quality of meat products (Shokry, 2016; Echeverria et al., 2022).

Protein additives known as meat extenders are commonly derived from plant sources and are used to partially replace meat in various products. These additives are utilized to enhance the water-binding capabilities and improve the overall texture of meat products. This offers an opportunity for the reformulation of healthier and more sustainable meat products (Pintado and Delgado-Pando, 2020; Kyriakopoulou et al., 2021).

Acorn is an underutilized crop that has the potential to provide health benefits. In fact, food production systems need to be redesigned based on circular economy principles in order to use of resources efficiently and create new areas for using underutilized resources (Gustavsson et al., 2011). In this way, a market trend in which natural and dietary fiber-rich raw materials are sustainable can be developed and underused products can be reintroduced into the existing food chain (Martins et al., 2020).

The production of acorn flour involves steps such as peeling the fruits, straining/filtering, reducing particle size, drying or roasting, and milling. Acorns have a high tannin content and are characterized by a bitter taste due to these tannins. To remove this bitter taste, a leaching process is applied (Hoeche et al., 2014; Szablowska and Tanska, 2021).

Acorn is rich in unsaturated fatty acids, chlorophylls, carotenoids, phenolic compounds, fiber, proteins, vitamins and minerals. Its nutritional and functional characteristics make it beneficial for improving the nutritional profile of final products and reducing the risk of diseases like diabetes, cardiovascular disease, and inflammation (Silva et al., 2016; Vinha et al., 2016; Martins et al., 2020; Szabłowska and Tanska, 2021).

Another important feature of acorn flour is that it does not contain gluten. In this sense, acorn flour is recommended as a new alternative source in the production of gluten-free foods. Consequently, it becomes clear that acorns should be considered as functional foods or alternative sources of highly valuable and sustainable multipurpose food ingredients (Molavi et al., 2015; Coelho et al., 2018; Pasqualone et al., 2019; Masmoudi et al., 2020; Martins et al., 2022). Studies have shown that acorn flour is used in bakery products such as bread, cakes, biscuits, muffins and desserts due to its healthy and nutritious properties (Korus et al., 2017; Pasqualone et al., 2019).

In this study, acorn flour was used as a meat replacer in chicken patties to fortify them with highly valued and sustainable food ingredients. No study was performed on acorn flour as meat extenders in chicken patties. Therefore, the objective of this study was to analyze the effect of acorn flour on some quality characteristics of chicken patties.

Material and Methods

Materials

Fresh chicken breast and thigh meat, salt and spices (black pepper, cumin, garlic powder and onion powder) were obtained from a local market and acorn flour without tanen (6.21% protein, 10.9% fat %, 12.87% dietary fiber, 9.25% ash) were purchased from Artu-Kimya.

Preparation of Chicken Patties

The patties were prepared by using chicken breast and thighs. For patties production, medium-fat minced meat is obtained from the breasts and thighs of the whole broiler. The chicken breast (42%) and thigh meat (42%) were mixed through a 3 mm grinding along with the skin (11%) and the other ingredients (salt 1.5%, onion powder 1.8%, garlic powder 1.70%, black pepper 0.5%, cumin 0.5%) were added to the dough then the specified amount of degranulated acorn flour was added to the dough until the mixture was completely homogenized. Meat in the formulation was replaced with 3, 6, and 9% of acorn flour (Table 1). Four different treatments were prepared: Control sample (without acorn flour), AC3 samples (3% acorn flour added), AC6 samples (6% acorn flour added), AC9 samples (9% acorn flour added). The dough was shaped with stainless steel molds (Ø: 7 cm, thickness: 1 cm, weight: 30 g) and then all patties were cooked in a preheated oven (1300Termikel-Statik-Statik, Turkiye at 180°C for 10 min on both sides until the internal temperature reached to 72°C. After cooking, patties were cooled to room temperature and filled into polypropylene containers and kept in the refrigerator until the time of analysis.

Proximate composition, pH, cooking characteristics (cooking yield, diameter reduction, thickness reduction), functional properties (moisture retention, fat retention), lipid oxidation, sensory properties and color were evaluated in raw and cooked chicken patties. The experiment was performed twice. All measurements were carried out in triplicate.

Proximate Composition

Moisture, protein and ash content of patties were measured by using AOAC, 2002 methodologies. The fat content was measured according to Flynn and Bramblett, 1975.

pH Value

1 g of samples was homogenized in 9 ml of distilled water and pH value of chicken patties was measured using pH meter (WTW, Germany) (Abiala et al., 2022).

Color Measurement

The color values (L^*, a^*, b^*) were measured on the surface of five chicken patties using a colorimeter (Hunterlab Miniscan XE Plus, USA) (Kramer and Twigg, 1984).

Cooking Properties of Chicken Patties

Cooking yield (CY)

The cooking yield of chicken patties was calculated according to Murphy et al., 1975.

$$\text{CY (\%)} = \frac{\text{Weight of cooked sample}}{\text{Weight of raw sample}} \text{x100}$$

Diameter reduction(DR)

Changes in diameters were determined as reported by Modi et al., 2004 as follows:

$$DR(\%) = \frac{\text{DRCP} - \text{DCCP}}{DRCP} \times 100$$

Where;
DRCP: Diameter of raw chicken patties
DCCP: Diameter of cooked chicken patties

Thickness reduction(TR)

Thickness reduction was calculated according to Bunmee et al., 2022.

$$TR(\%) = \frac{\text{RPT} - \text{CPT}}{RPT} \times 100$$

Where;
RPT: Raw patty thickness
CPT: cooked patty thickness

Table 1. Chicken patties prepared with different ratios of acorn flour

Ingredients	Treatments			
	Control	AC3	AC6	AC9
Chicken meat	94	91	88	85
Acorn flour	0	3	6	9
Salt	1.5	1.5	1.5	1.5
Spice mix	4.5	4.5	4.5	4.5

Table 2. The proximate composition of chicken patties added different amounts of acorn flour

Properties		Treatments			
		Control	AC3	AC6	AC9
Uncooked	Moisture	67.10±1.54[a]	65.21±0.79[b]	63.86±0.91[b]	61.22±1.22[c]
	Protein	21.09±0.30[a]	20.48±0.25[ab]	20.00±0.10[ab]	19.22±1.09[b]
	Fat	5.95±0.08[b]	7.72±0.04[a]	7.65±0.54[a]	7.16±0.09[a]
	Ash	2.73±0.04[a]	2.68±0.02[a]	2.68±0.01[a]	2.72±1.05[a]
Cooked	Moisture	58.93±5.79[a]	54.33±8.36[c]	56.85±4.28[b]	55.86±2.46[bc]
	Protein	30.92±1.44[a]	29.72±0.03[a]	21.93±1.92[b]	21.60±0.29[b]
	Fat	11.50±0.01[a]	10.48±0.63[b]	9.39±0.70[c]	8.56±0.32[c]
	Ash	3.15±0.06[a]	3.04±0.03[a]	3.40±0.10[a]	3.18±0.04[a]

[a-c]Means within a row with different letters are significantly different (P<0.05)

Functional properties of chicken patties

Moisture retention (MR)

The moisture retention value was determined as reported by El-Magoli et al., 1996 as follows:

$$MR(\%) = \frac{CV \times MCP}{RW \times MRP} \times 100$$

Where;

CW : Cooked weight (g)

MCP: Moisture in cooked chicken patties

RW : Raw weight (g)

MRP: Moisture in raw chicken patties

Fat retention value(FRV)

The fat retention value was calculated according to Murphy et al., 1975 as follows:

$$FRV(\%) = \frac{CV \times FC}{UV \times FU} \times 100$$

Where;

CW : Cooked weight (g)

FC : Fat in cooked (%)

UW : Uncooked weight (g)

FU : Fat in uncooked (%)

TBAR Analysis

The lipid oxidation of chicken patties was determined according to Witte et al., 1970 and expressed as mg malonaldehyde (MDA)/kg sample.

Sensory Analysis

Sensory evaluation was carried out with 10 semi-trained panelists. Chicken patties were cooked in a preheated oven at 180°C for 10 min and the sample groups were coded with three-digit numbers and served randomly to the panelists. Samples were evaluated by scoring test in terms of color (1= very dark, 5= very light), flavor (1= very bad, 5= very good), juiciness (1= extremely dry, 5= extremely watery), texture (1= very hard, 5= very soft) and ova (1= not at all, 5= very good) (Ozunlu et al., 2018).

Statistical Analyses

A one-way analysis of variance (ANOVA) and Duncan's Multiple Range Tests at the level of P < 0.05 were performed in order to evaluate the effects on the treatments and the storage periods by SPSS software version 20 (SPSS, 2011).

Results and Discussion

Proximate Composition of Chicken Patties

According to Table 2, the proximate composition of patties was significantly different (P<0.05). In raw chicken patties, AC9 had the lowest moisture content -of 61.22%, while the control sample had the highest moisture content of 67.10%. Increasing the amount of acorn flour in uncooked patties resulted in a reduction of moisture content due to the increase in the amount of dry matter.

The lowering of moisture content in cooked chicken patties might be due to the denaturation of chicken meat proteins during cooking (Kashyap et al., 2012).

The high percentage of protein, fat and ash content in cooked chicken patties due to the decrease in the moisture content of the cooked samples. The protein content ranged from 21.09% to 19.22% for uncooked chicken patties and from 30.92% to 21.60% for cooked chicken patties. While the control samples had the highest protein value, 9% acorn flour-added samples had lower protein values. This was attributed to the low protein content of acorn flour and the higher meat content of control samples. Meat protein is superior to plant protein and biological value, essential micronutrient content, and net protein utility were higher than plant protein (Sathishkumar, 2019; Lim et al., 2021). In uncooked samples containing acorn flour had higher fat contents than controls (P<0.05). There were no significant differences in the ash contents of raw and cooked chicken patties (P>0.05).

pH and Color Values of Chicken Patties

The pH and color values of chicken patties formulated with various amounts of acorn flour AC (3%, 6%, and 9%) are shown in Table 3. The pH of the uncooked patties ranged between 6.04 and 6.30, while the pH of the cooked patties ranged between 5.92 and 6.00. The pH value of raw chicken patties with acorn flour was lower than that of control, but the reduction in pH was not significant (P > 0.05). Comparatively low pH in acorn flour added samples may be attributed to the various biologically active compounds of acorn flour that have antioxidant activity (Rakic et al., 2007).

The same result was found by Chatterjee et al. 2019, Chappalwar et al. 2021 and Qiu and Chin 2022. Chatterjee et al., 2019 reported that the pH of raw chicken patties with tapioca flour was consistently lower than that of the controls. Chappalwar et al., 2021 reported that control chicken patties had significantly (P<0.05) higher pH values than lemon albedo, mango peel and banana peel powder added patties.

Table 3. pH value and *L**, *a**, *b** values of raw and cooked chicken patties formulated with different amounts of acorn flour

Properties		Treatments			
		Control	AC3	AC6	AC9
Uncooked	pH	6.30±0,27[a]	6.25±0.32[a]	6.10±0.36[a]	6.04±0.39[a]
	*L**	43.63±0,79[a]	42.86±0.70[ab]	42.46±1.39[ab]	41.86±1.06[b]
	*a**	2.07±0,21[c]	3.62±0.41[b]	4.29±0.72[ab]	4.79±0.48[a]
	*b**	9.01±0,45[c]	9.75±0.41[b]	9.96±0.35[ab]	10.42±0.36[a]
Cooked	pH	6.07±0.10[a]	6.03±0.05[a]	5.97±0.07[a]	5.92±0,07[a]
	*L**	50.20±0.98[a]	46.06±1.00[b]	46.26±0.49[b]	45.97±0.70[b]
	*a**	2.63±0,94[b]	3.38±0.68[a]	3.41±0.73[a]	3.39±0.94[a]
	*b**	8.83±2.90[a]	6.28±2.04[b]	6.66±2.99[b]	7.02±3.18[b]

[a-c]Means within a row with different letters are significantly different (P<0.05)

Table 4. Cooking properties and functional properties of chicken patties

Parameters	Control	AC3	AC6	AC9
Cooking properties (%)				
Cooking yield	72.12±0.08[b]	75.61±0.89[a]	74.05±0.55[a]	75.53±0.69[a]
Diameter reduction	9.37±7.03[a]	7.82±0.71[b]	6.71±3.76[c]	4.71±4.00[d]
Thickness reduction	23.64±0.90[a]	20.14±0.67[b]	19.14±0.80[b]	14.26±0.08[c]
Functional properties				
Moisture retention	63.42±0.82[a]	64.22±0.06[a]	66.54±0.16[b]	69.09±0.62[c]
Fat retention	87.78±0.50[b]	86.87±1.27[b]	85.98±0.08[b]	89.62±0.56[a]

[a-d]Means within a row with different letters are significantly different (P<0.05)

Qiu and Chin, 2022 who reported that the addition of lotus rhizome root powder did not affect the pH values of raw and cooked pork patties. The pH values of the raw samples were higher than those of the cooked chicken patties.

The highest lightness values were observed in control samples of raw and cooked chicken patties and reducing the amount of chicken meat led to a decrease in the *L** values of cooked chicken patties. The addition of acorn flour to raw chicken patty formulation (AC3, AC6, and AC9) caused a slight reduction in *L** values and an increase in *a** and *b** values when compared with the control sample. This is possibly due to the darker brown color of acorn flour. As the level of acorn flour increased, the chicken patties became less light. The original brown color of the acorn flour made the color of the chicken meatballs more intense. Similar to our observation, Sharefiabadi et al., 2021 found that the addition of linseed flour to chicken patties resulted in a darker color.

While control samples of uncooked samples showed the lowest *a** and *b** values, AC9 samples showed the highest value. In cooked patties, lightness and yellowness decreased while redness increased. Control samples had the highest *L** value and *b** values than those of acorn flour added samples (P<0.05). The difference in color properties of chicken nuggets may be attributed to the oxidization of heme pigment during cooking and the conversion of myoglobin to metmyoglobin, which is brown in color (Lukman et al., 2009). Similarly, Serdaroglu et al., 2021 reported a decreased *L** value in chicken meat emulsion due to the color of pomegranate seed powder, which is light brown. Chappalwar et al., 2021 reported that lemon albedo powder increased *L** values of chicken patties due to the whitish-yellow color of lemon albedo powder.

Cooking Properties and Functional Properties of Chicken Nuggets

The cooking properties and functional properties of the chicken patties are given in Table 4. Cooking yield values increased significantly (P<0.05) in acorn flour added chicken patties. Cooking yield varied between 72.12-75.61%. Chicken patties with acorn flour had higher cooking yields than control samples (P<0.05). AC3 samples showed similar moisture and fat retention values as controls. The incorporation of 9% acorn flour into chicken patties demonstrated a positive effect on their water binding and fat binding capabilities. This observed effect can be attributed to the presence of dietary fiber in acorn flour which possesses the ability to bind both water and oil. The highest moisture retention values were recorded in AC9 samples due to the higher fiber content of AC9. A similar result was reported by Ali et al., 2022 who reported that the cooking yields of chicken patties added cantaloupe peel and seeds powder were higher than the control samples at zero time. Chappalwar et al., 2021 also observed an increase in moisture and fat retention values of chicken patties with the addition of lemon albedo.

The diameter reduction was significantly decreased with an increasing ratio of acorn flour. AC9 samples showed the lowest diameter reduction (P<0.05). The highest diameter reduction was observed in the control sample, probably due to the shrinking of meat, denaturation of proteins, and water and fat loss. These results are in agreement with those of Ali et al., 2022 who reported that the lower shrinkage value was observed in the cantaloupe peel and seeds powder added patties.

The highest reduction of thickness was recorded in control samples. The thickness reduction was decreased by increasing the ratio of acorn flour in chicken patties. The significant reduction in the diameter of AC9 samples exhibited results similar to the reduction in thickness (P<0.05).

Table 5. TBA values of chicken patties incorporated with acorn flour

TBA (mg malonaldehyde/kg sample)	Control	AC3	AC6	AC9
Uncooked	0.01±0.02[a]	0.02±0.02[a]	0.06±0.07[b]	0.07±0.08[b]
Cooked	0.03±0.07[a]	0.02±0.03[a]	0.25±0.06[b]	0.27±0.04[b]

[a-d]Means within a row with different letters are significantly different (P<0.05)

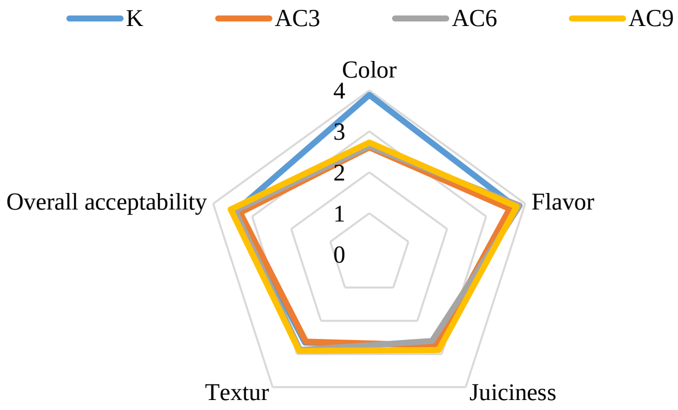

Figure 1. Sensory properties of chicken patties
[a-b]Means within a row with different letters are significantly different (P<0.05)

The reduction of the shrinkage of the patties may be due to the ability of fiber in acorn flour. The fiber in acorn flour prevented the transfer of water to the surface by creating a network (Hartman et al., 2020).

TBA Values

The TBA values of uncooked and cooked chicken patties incorporated with acorn flour are shown in Table 5. The TBA values of uncooked chicken patties ranged from 0.01 mg malonaldehyde/ kg sample to 0.07 mg malonaldehyde/kg of sample. The TBA values were high for uncooked (raw) chicken patties in 6% and 9% acorn flour added groups. TBA values of cooked chicken patties ranged from 0.02 mg malonaldehyde/kg sample to 0.27 mg malonaldehyde/kg of sample. It was observed that the TBAR levels of cooked samples increased in comparison to raw samples. After cooking, TBA values increased gradually in these patties. The meat and skin in chicken patty composition (ingredients), grinding, and cooking process accelerate the autooxidation in muscle foods. The process like mincing damages the muscle structure and increases the exposure of the fatty acids to catalyzing factors (Warriss, 2000). The lipid oxidation of the cooked patties was also closely related to the unsaturated fatty acids concentration and the presence of different iron species (Shimizu and Iwamoto, 2022). Acorns are rich in monounsaturated fatty acids, mostly oleic acid, linoleic and linolenic acids. The increase in malonaldehyde concentration showed that acorn flour added chicken patties are highly susceptible to oxidative changes (Lyon et al., 1988). However, the TBA values of all samples were below the acceptable limit value of 0.5 to 1 mg malonaldehyde/kg sample (Tarladgis et al., 1960).

Sensory Analysis

The sensory evaluation of chicken patties is shown in Figure 1. It was determined that the color values of chicken patties with different amounts of acorn flour added were lower than the control group, and they were darker than the control samples. One of the reasons for this is that acorn flour has a light brown color. While the color of the chicken meatball groups containing acorn flour showed a statistically significant difference compared to the control group (P<0.05), there was no significant difference (P>0.05) among them.

No significant difference (P>0.05) was found between the chicken patties groups in terms of taste, juiciness and general acceptance values.

Conclusion

This study was carried out to improve the quality and cooking properties of chicken patties by the addition of acorn flour which was considered as a good source of extender and dietary fibers. The incorporation of acorn flour improved the functional and cooking properties of chicken patties in terms of higher moisture and fat retention values and a significant decrease in cooking loss. However, the addition of acorn flour resulted in a darker color in cooked chicken patties and also especially 6% and 9% acorn flour addition was not effective in preventing lipid oxidation of chicken patties. The use of acorn flour in chicken meatballs did not negatively affect sensory properties except color. In conclusion, acorn flour can be used as a filler and binder in chicken patties and will bring a new perspective to processed chicken meat products. However, further research is needed to evaluate the effect of acorn flour on the quality properties of chicken meat products during cold or frozen storage periods.

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