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# THE EFFECT OF BUCKWHEAT FLOUR ON SOME QUALITY PROPERTIES OF CHICKEN MEATBALLS AS AN ALTERNATIVE TO WHEAT FLOUR

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**ABSTRACT**

Chicken meatballs were produced by using mixtures at different ratios of wheat flour and buckwheat flour. Fried meatballs were analysed about yield, diameter reduction, colour, moisture retention, fat absorption and sensory properties. Cold stored raw meatballs were evaluated for pH, Thiobarbutiric acid reactive substances and instrumental colour values. Addition of buckwheat flour in meatballs increased the yields and $L^*$ values after frying whereas decreased the diameter reductions, $a^*$ and $b^*$ values. Also, it increased the moisture retention and decreased fat absorption, had high scores at low levels of flour for colour and texture. pH, $L^*$, $a^*$ and $b^*$ values of raw samples were better at low ratios of buckwheat flour at the end of the storage whereas Thiobarbutiric acid reactive substances decreased with the increase of buckwheat flour. In view of all the results, it can be said that the use of 1:3 or 3:1 buckwheat flour: wheat flour mixes in the production of chicken meatballs would be more advantageous.

## 1. Introduction

The demand for ready-to-eat foods increases with the intensity of daily living conditions in societies. In particular, working people and young people demand more of this type of food. Therefore, food manufacturers try to develop products that meet this kind of food needs of consumers. They aim to win consumers' appreciation by producing food that is easy to prepare and even suitable for healthy nutrition (Dani and Pabalkar, 2013; Ivankovic et al., 2017; Özer and Seçen, 2018).

In order to meet the requirements mentioned in the prepared product, various food additives or natural sources which may contain these substances are used. Examples of these are structure modifiers such as starches, fibres, proteins, or preservatives such as organic acids or sensory quality enhancers such as colorants. Other examples are the use of flours of plants such as wheat, corn, chickpea or quinoa, which may contain some of the substances mentioned. The structural quality of the product can be preserved by using these flours and the shelf life can be increased. Different alternatives can be created for the healthy nutrition of consumers by increasing the fibre ratio in the product with the use of flours. Also, while the properties of foods such as colour and texture can be improved, the yield and moisture content after cooking can be increased due to the hydrophilic properties of the flour components, and the absorbed fat content can be reduced (Tarte, 2009; Petracci et al., 2013).

Poultry products are the most common groups where additives or flours are used. The quality of these products can be influenced by the using of mentioned materials. The delicate

structure of these meats can be supported by different vegetable flours, which can be advantageous in processing, preservation and consumption. Disintegration and oxidation problems in chicken meats can be reduced and colour can be improved (Dogan et al., 2005; Petracci et al., 2013; Santhi and Kalaikannan, 2014).

While the use of many plant-based flours in food preparation can be emphasized, another alternative is the buckwheat flour. Buckwheat is rich in vitamins, minerals and starches and is particularly advantageous in terms of protein and fibre content compared to wheat. It even has a protein structure with high biological value and does not contain gluten. Additionally, there are studies indicating that it is rich in antioxidant compounds such as polyphenols (Przybylski and Gruczynska, 2009; Wronkawska et al., 2010).

For these reasons, it is thought that it can provide various benefits in meatball production. However, it is understood that there is not much work done by adding buckwheat flour to chicken meatballs. Therefore, in this study, the effect of buckwheat flour mixed with wheat flour on some quality properties of chicken meatballs was investigated.

## 2. Materials and methods

Wheat flour (W), buckwheat flour (B), chicken meats and other ingredients were purchased from local sellers in Adiyaman and Istanbul (Turkey). Sunflower oil (Yudum, Balıkesir, Turkey) and mini fryer (Tefal, FF1024, China) were used for frying operations. The chicken breasts were freshly taken and kept at 4 ºC until the meatballs were produced, then they were minced in mincing machine for production. Five mixes were prepared as 100% W, 1: 3 B: W, 1: 1 B: W, 3: 1 B: W and 100% B. Then, samples were produced with 90.5% minced meat, 7% mix, 1.5% salt and 1% sunflower oil. Each of the samples was thoroughly kneaded and allowed to stand for 20 minutes at 4 ° C. Then, they were turned into round meatballs weighing 19 g and having a diameter range of 31-32 mm. Some of the meatballs were used in frying processes whereas the others were used for storage stability analyses. The first group was fried for 6 min at 180 ºC and their yield, diameter reduction, colour, moisture retention, oil absorption values and sensory quality characteristics were determined. The second group was stored at 4 ºC and changes in pH, TBARS and colour values were determined after 1, 5 and 10 days of storage.

### 2.1. Determination of some physical and chemical properties of flours

The colour values of flours were determined by a colorimeter (CR-400, Konica Minalto, Inc., Osaka, Japan). Water absorptions were determined according to Dogan and Unal (1990). The moisture contents of flours were founded gravimetrically by oven-drying (Nuve, FN500, Turkey) at 105 ºC for 4h, while the protein contents were detected by using Kjeldahl analiysis (Behr S2, Germany; AOAC, 2002). Total starch contents of flours were determined by using polarimeter (Autopol V Plus, USA), according to Elgün et al. (1998). From the nitrogen to protein conversion factor was applied as 5.7 for flours whereas the conversion factor of starch was used as 5.4734.

### 2.2 Determination of the yield, diameter reduction and colour values

The following equations (1) and (2) were used to calculate frying yields and diameter reductions. A precision balance was used for weight measurements, while a digital calliper (Mesem, Turkey) was used for diameter measurements (Kırpık and Kılınççeker, 2018).

$$\text{Frying yield} = \frac{\text{fried meatball weight}}{\text{raw meatball weihgt}} \text{ x } 100 \quad (1)$$

$$\text{Diameter reduction (\%)} = \frac{\text{raw meatball diameter} - \text{fried meatball diameter}}{\text{raw meatball diameter}} \text{x} 100 \quad (2)$$

The colour values of the fried samples and the raw samples in storage were determined by

a colorimeter (CR-400, Konica Minalto, Inc., Osaka, Japan) with illuminate D65, 2° observer, Diffuse/O mode, 8-mm aperture of instrument for illumination and 8 mm for measurement. The colorimeter was initially calibrated with a white references tile. After the measurements, color values were presented according to CIELAB system as $L^*$ (brightness), $a^*$ (redness) and $b^*$ (yellowness) values (Dogan, 2006). The colour of fried meatballs was measured in 4 min after the frying whereas it was measured in the end of each storage period for raw samples. Four meatballs were taken for each treatment and colour measurement was performed at three different points on surface.

### 2.3. Determination of moisture retention, fat absorption and sensory properties

Equations (3) and (4) were used to calculate moisture retention and oil absorption (Soltanizadeh and Ghiasi-Esfahani, 2015). An oven (Nuve, FN500, Turkey) at 105±2 °C temperature was used to find the moisture content of the raw and fried samples, while soxhlet extraction method with n-hexane was used to find the oil contents (Gerhardt, Germany; AOAC, 2002).

$$\text{Moisture retention (\%)} = \frac{\text{moisture in fried meatball (\%)}}{\text{moisture in raw meatball (\%)}} \text{ x frying yield} \quad (3)$$

$$\text{Fat absoption} = \text{fat in fried meatball (\%)} - \text{fat in raw meatball(\%)} \quad (4)$$

Ten students (five female and five male) from the food processing department of Adiyaman University were selected for sensory analysis of fried samples. The panellists evaluated on the hedonic scale for appearance, colour, smell, taste and texture. The method contained the scores in the range of 1 and 9 which depending on the degree of liking (1: dislike very much, 9: like very much), as described in Gokalp et al. (1999).

### 2.4. Determination of pH and TBARS

These analyses were performed on raw samples to obtain information about storage stability in the end of each storage period. For pH analysis, 10 g of minced sample was homogenized in 100 ml of deionized water for 3 minutes and was measured by a pH meter (Orion 3-Star, Thermo Fisher Scientific, Waltham, M.A), as described by Ockerman (1985). TBARS analysis were determined according to the Tarladgis et al. (1960). For this analysis, 10 g of minced sample was mixed with 50 ml of distilled water. After the mixture, the homogenized sample was transferred to an 800-ml kjeldahl flask and 47.5 ml of distilled water and 2.5 ml of 4 N HCL were added on it. Then 50 ml of distillate were obtained from this mixture in the distillation unit. 5 ml of distillate was transferred to the tube and 5 ml of TBA reagent was added. It was heated for 35 minutes in boiling water and the absorbance at 538 nm was read using the spectrophotometer (UV-160 A, UV-Visible Recording Spectrophotometer, Shimadzu, Tokyo, Japan). TBARS numbers were multiplied by a predetermined coefficient (7.8) and expressed as mg malonaldehyde/ kg sample.

### 2.5. Statistical analysis

The study was conducted in two replications and three parallels. The data were subjected to analysis of variance (ANOVA). When there was difference between the samples, Duncan multiple comparison test at level of $p<0.05$ was applied to compare of mean (SPSS 16.0, CHICAGO, IL, USA). The results were presented as mean±standart deviation.

## 3. Results and discussions

### 3.1. Some properties of flours

Some physical properties of flours such as colour and water absorption and chemical properties such as moisture, protein and starch have a significant effect on product quality when they are added to foods such as meatballs. In this study, it was thought that these properties of the wheat and buckwheat flours will be helpful in the discussion of the results. According to the

results shown in Table 1, while *L** and *b** values for B were lower than W, the *a** value and water absorption were higher. In addition, it was determined that the moisture and starch contents of the B were lower than W, the protein content was higher.

**Table 1.** Some properties of wheat flour and buckwheat flour

| | *L** | *a** | *b** | Water absorption ration (%) | Moisture (%) | Protein (%) | Starch (%) |
|---|---|---|---|---|---|---|---|
| Wheat flour | 96.65 | -1.47 | 8.78 | 65.07 | 8.22 | 10.48 | 72.18 |
| Buckwheat flour | 90.91 | 0.1 | 6.86 | 114.21 | 7.42 | 11.46 | 68.15 |

### 3.2. The yield, diameter reduction and colour values of fried meatballs

The decrease in yield and diameter after cooking are generally a result of protein denaturation by heat treatment. These are important factors for product quality and can be influenced by the materials in the flour composition. Colour change is also affected by heat treatment, while the type and amount of natural colour pigment of the materials used are important criteria (Cava *et al*., 2012). In table 2; the yield, reductions in diameters and colour values of samples are shown after frying. According to the results, it was found that the addition of buckwheat flour increased the yield and caused an increase in the diameters as can be seen from the (-) signs in the results ($p<0.05$). Especially, the yield and diameter values of the samples containing 3:1 B:W and 100% B mixtures were found to be higher than the others. It is thought that the increase in the yield and diameter of the meatballs is due to the low moisture content of the buckwheat flour and the high protein and fibre ratio in its structure. Proteins and fibres having hydrophilic character caused an increase in weight by keeping water in the structure during frying. They even increased the efficiency by preventing the rupture of the pieces, and the diameters by swelling with heat treatment. Similarly, Ikhlas et al. (2011) observed that the yields increased after cooking when adding different flours to quail meat. Also, Santhi and Kalaikannan (2014) determined that addition of oat flour in chicken nuggets increased cooking yields whereas Kurt and Kılınççeker (2012) found increase of yields in meat patties prepared with different flours. Kırpık and Kılınççeker (2018) found that although there was no statistical difference in the fried chicken meatballs made by adding quinoa flour, the reductions of diameter decreased with increasing amount of flour. Serdaroglu (2006) determined that diameter reductions of cooked meat patties produced with oat flour decreased with the increase of flour. Also, Soltanizadeh and Ghiasi-Esfahani (2015) observed that diameter reductions of cooked beef burger significantly decreased with increasing of aleo vera powder in formula.

The use of 100% buckwheat flour caused an increase in *L** values ($p<0.05$) whereas *a** and *b** values decreased with the addition of this flour ($p<0.01$). The highest *L** value was in sample with 100% B. The best results for *a* value were found in the control and samples containing 1:3 B:W, while for *b** was found in the control group (Table 2). The natural colour components of the buckwheat flour were effective on the colour of fried meatballs. Although this flour is redder in colour, *a** and *b** values decreased due to the loss of phenolic compounds, which are highly present in buckwheat flour, and which have the ability to colour, during frying. Therefore, the excessive loss of phenolic compounds increased with the addition of this flour caused the brightness of the colour to increase. Lee et al. (2018) observed the increasing of *L** values of cooked sausage produced with buckwheat powder whereas decreasing of *a** value. Park et al. (2016) determined that *b** values of cooked pork patties decreased with buckwheat. Serdaroglu (2006)

was found that *L** values increased and *a** values decreased in beef patties with oat flour. In another study, it was emphasized that the colour values of the meatballs produced by adding different flours to the quail meat were different and the colour pigments in the flours played an important role in this (Ikhlas et al., 2011). In our study, it is understood that colour values are affected by heat treatment as well as pigments.

**Table 2.** Effects of buckwheat flour on yield, diameter reduction, and colour values of fried chicken meatballs

| Flour Mixes | Yield (%) | Diameter reduction (%) | *L** | *a** | *b** |
|---|---|---|---|---|---|
| Control | 79.91±0.39$^{c}$ | 0.51±0.66$^{a}$ | 54.35±1.26$^{b}$ | 15.73±0.53$^{a}$ | 39.08±0.18$^{a}$ |
| 1:3 B:W | 82.39±0.82$^{bc}$ | -0.61±0.83$^{ab}$ | 55.07±2.24$^{b}$ | 15.76±1.02$^{a}$ | 38.25±0.47$^{b}$ |
| 1:1 B:W | 82.31±1.31$^{bc}$ | -1.01±0.01$^{abc}$ | 55.68±0.11$^{b}$ | 13.31±0.40$^{b}$ | 37.39±0.27$^{c}$ |
| 3:1 B:W | 83.99±2.25$^{ab}$ | -1.71±0.23$^{bc}$ | 56.86±1.33$^{b}$ | 12.07±0.52$^{b}$ | 37.11±0.05$^{c}$ |
| 100% B | 85.74±0.17$^{a}$ | -2.60±1.18$^{c}$ | 61.45±0.31$^{a}$ | 8.07±0.03$^{c}$ | 35.07±0.26$^{d}$ |

W: wheat flour, B: buckwheat flour, $^{a-d}$ Within each column, different superscript letters show differences between the flour mixes ($P< 0.05$).

### 3.3. The moisture retention, fat absorption and sensory properties of fried meatballs

While moisture and fat contents in foods affect sensory properties such as texture, they also have an importance on calorie value. These are also important features in fried meatballs and affect consumers' preferences. In general, the moisture content of such products decreases, the oil content increases, thus manufacturers turn to various production techniques or additives to solve this problem (Pinero et al., 2008.) In our study, it was determined that adding buckwheat flour increased moisture retention, decreased oil absorption during frying (Figure 1). While the highest moisture retention ratios were determined in meatballs prepared with 3:1 B:W and 100% B mixes as 87.2% and 87.78% ($p<0.05$), the lowest oil absorptions were also observed in these two samples as 0.94% and 0.93% ($p<0.01$). In particular, it is believed that buckwheat flour's water absorption ability, protein and fibre content were effective on these results. These components increased the water absorption ability in the meatballs whereas reduced the water loss and the oil penetration. Ikhlas et al. (2011) found that the addition of different flours in meatballs prepared from quail meat increased ratios of moisture retention during cooking. Serdaroglu (2006) determined that oat flour increased the moisture retention in cooked patties. In addition, in another study, it determined that the increase in amount of flour in chicken meatballs prepared by adding quinoa flour increased moisture retention and decreased fat absorption during frying (Kırpık and Kılınççeker, 2018). Similarly, Soltanizadeh and Ghiasi-Esfahani (2015) found that addition of aloe vera powder to meat burgers in the range of 1-5% increased the moisture retention and decreased the fat absorption during frying. They also observed that the increase in the amount of aloe vera supported the results. In these studies, it was said that components such as protein, starch and fibre in the structure of plants are effective on the results. Especially, in studies with flours, it was emphasized that strong structures which were formed by coagulation of proteins and gelatinization of starch were effective against substance transfer. Our results were similar to these works.

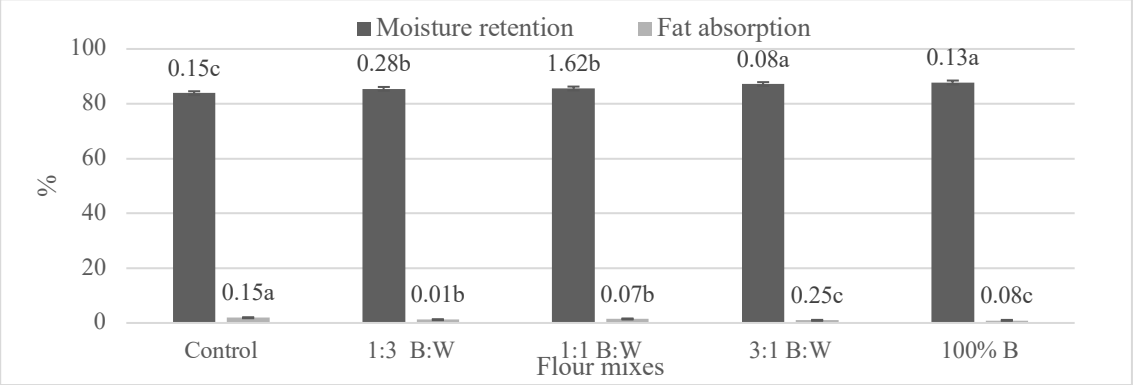


**Figure 1.** Effects of buckwheat flour on moisture retention and fat absorption rations of fried chicken meatballs

Sensory characteristics are the most important criteria on consumer choice. These properties can be influenced by the type and amount of ingredients used in foods. They should be identified for newly developed products (Soltanizadeh and Ghiasi-Esfahani 2015; Kırpık and Kılınççeker, 2018). In our study, colour and texture properties were affected from buckwheat flour ($p<0.05$). While 100% buckwheat flour decreased these properties as 5.75 and 5.95 ($p<0.05$), it was found that the other mixtures were not different statistically and scored high (Table 3). The decrease in colour scores can be attributed to the decrease in red and yellow colour ratios, as can be seen from the measurements with the colorimeter. Because, these colours are the criteria's that support the desired golden-red (or golden-yellow) colour formation in fried products. The decrease in texture scores is thought to be due to the hard structure caused by excessive amounts of buckwheat flour. This firmness also emphasized by the panellists. Similar to the results, Kılınççeker and Karahan (2019) determined that the colour and texture scores in chicken meatballs prepared with adding of carob flour and breadcrumbs were high such as in control but decreased when 100% carob flour was used. In addition, Kırpık and Kılınççeker (2018) found that when the mixtures prepared with quinoa flour and breadcrumbs were added in chicken meatballs, the colour scores of other mixes were not different, but scores of samples with 100% carob flour also decreased, statistically. In addition, the texture scores were found to be at acceptable level and statistically not different in this study. Finally, Santhi and Kalaikannan (2014) observed that when the addition of oat flour in chicken nuggets, many quality characteristics were improved, however some of sensory scores decreased.

**Table 3.** Effects of buckwheat flour on sensory properties of fried chicken meatballs

| Flour Mixes | Appearance | Colour | Odour | Taste | Texture |
|---|---|---|---|---|---|
| Control | 6.90±0.28$^{a}$ | 6.65±0.21$^{ab}$ | 6.15±0.21$^{a}$ | 6.95±0.49$^{a}$ | 7.25±0.07$^{a}$ |
| 1:3 B:W | 6.65±0.49$^{a}$ | 7.05±0.07$^{a}$ | 6.80±0.14$^{a}$ | 7.05±0.21$^{a}$ | 7.15±0.07$^{a}$ |
| 1:1 B:W | 6.95±0.64$^{a}$ | 7.35±0.21$^{a}$ | 6.20±0.28$^{a}$ | 6.85±0.92$^{a}$ | 6.75±0.64$^{ab}$ |
| 3:1 B:W | 6.75±0.49$^{a}$ | 6.80±0.42$^{a}$ | 6.40±0.85$^{a}$ | 7.20±0.56$^{a}$ | 7.00±0.28$^{a}$ |
| 100% B | 6.10±0.71$^{a}$ | 5.75±0.64$^{b}$ | 5.70±0.99$^{a}$ | 5.85±0.78$^{a}$ | 5.95±0.07$^{b}$ |

W: wheat flour, B: buckwheat flour, $^{a-b}$ Within each column, different superscript letters show differences between the flour mixes ($P< 0.05$).

### 3.4. The pH, TBARS and colour values of raw meatballs

Protolithic and oxidative degradation in sensitive foods such as meatballs are the most important factors affecting product quality. Storage time has effects on these. During storage, substances that occur such as ammonia increase the pH value, while products such as aldehyde formed as a result of oxidation of fatty acids increase the level of TBARS. Thus, smell deteriorates, and taste may be bitter. Therefore, both pH and TBARS can be used as indicators of raw meatball quality. Even colour values may be affected by them. The materials in formulas can affect the pH, TBARS and colour of the raw meatballs. Thus, it is recommended to measure these values periodically (Gokalp et al., 1999). In general, buckwheat flour and storage times had an effect on pH and TBARS values (Table 4). On the first day, the lowest pH was determined as 5.85 in the control, while it was determined in the range of 5.90-5.95 in the other samples ($<0.05$). The pH values of some samples decreased after 10 days of storage. At the end of the 10$^{th}$ day, the lowest pH values were measured as 5.73, 5.77 and 5.77 in control and in samples with 1:3 B:W and 1:1 B:W mixes ($p<0.01$). The lowest TBARS value in first day was in control as 0.10 mg/kg. Although this value decreased in some samples on the 5$^{th}$ storage day, it was found that there was generally an increase at the end of 10 days storage. At the end of the 10$^{th}$ day, TBARS values of samples prepared with 3:1 B:W and 100% B mixtures were found to be lower than the others as 0.16 mg/kg and 0.17 mg/kg ($p<0.05$). *L** values decreased with increasing amount of B in meatball content in each storage period. While this value was not generally affected by the increase in storage time, a fluctuating decrease was observed in samples containing only 3:1 B:W. While the highest *L** value was determined as 68.83 in the control sample on the first day, the values of control and samples with 1:3 B:W mix on the 10$^{th}$ day were higher than the others as 68.12 and 67.02 ($p<0.01$). The *a** values of the samples decreased only with the increase of B on the 5$^{th}$ day ($p<0.01$), while these values decreased with the increase of storage time, generally. At the end of 5 days storage the best results were 3.98, 3.81 and 3.83 in the control sample and in the samples prepared with 1:3 and 1:1 ($p<0.01$). The *b** values decreased with increasing B in the end of the 5$^{th}$ and 10$^{th}$ days, while storage time decreased this value of some samples. The *b** values on the first day were in the range of 17.38-19.38. At the end of 10 days of storage, the *b** values of the control sample and samples containing 1:3 B:W and 1:1 B:W mixes were found to be better than others (as 19.19, 18.37 and 17.90).

**Table 4.** Effects of buckwheat flour on pH, TBARS (mg malonaldehyde/kg sample) and colour values of raw chicken meatballs at cold storage periods

| Storage days | Flour mixes | pH | TBARS | *L** | *a** | *b** |
|---|---|---|---|---|---|---|
| 1$^{st}$ | Control | 5.85±0.00$^{bx}$ | 0.10±0.01$^{by}$ | 68.83±1.63$^{ax}$ | 4.11±0.39$^{ax}$ | 19.38±0.22$^{ax}$ |
| | 1:3 B:W | 5.90±0.03$^{abx}$ | 0.16±0.00$^{ax}$ | 66.89±1.89$^{abx}$ | 3.99±0.71$^{ax}$ | 18.52±1.75$^{ax}$ |
| | 1:1 B:W | 5.91±0.01$^{aby}$ | 0.19±0.04$^{ax}$ | 66.49±1.67$^{abx}$ | 3.87±0.27$^{ax}$ | 18.71±0.85$^{ax}$ |
| | 3:1 B:W | 5.92±0.03$^{abx}$ | 0.16±0.00$^{ax}$ | 66.39±0.40$^{abx}$ | 4.21±0.13$^{ax}$ | 18.13±0.06$^{ax}$ |
| | 100% B | 5.95±0.01$^{ax}$ | 0.18±0.00$^{ax}$ | 63.77±1.90$^{bx}$ | 4.31±0.20$^{ax}$ | 17.38±0.42$^{ax}$ |
| 5$^{th}$ | Control | 5.91±0.05$^{ax}$ | 0.11±0.00$^{ay}$ | 67.45±0.53$^{ax}$ | 3.98±0.15$^{ax}$ | 19.73±0.27$^{ax}$ |
| | 1:3 B:W | 5.90±0.01$^{ax}$ | 0.11±0.00$^{ay}$ | 67.35±0.11$^{ax}$ | 3.81±0.04$^{ax}$ | 19.85±0.53$^{ax}$ |
| | 1:1 B:W | 5.94±0.01$^{ax}$ | 0.09±0.00$^{by}$ | 66.35±1.70$^{abx}$ | 3.83±0.37$^{ax}$ | 19.08±0.25$^{ax}$ |
| | 3:1 B:W | 5.92±0.04$^{ax}$ | 0.09±0.00$^{by}$ | 64.65±0.02$^{bcy}$ | 2.93±0.20$^{by}$ | 17.86±0.06$^{by}$ |
| | 100% B | 5.95±0.03$^{ax}$ | 0.09±0.00$^{by}$ | 62.92±0.81$^{cx}$ | 2.95±0.07$^{by}$ | 16.38±0.51$^{bx}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10th | Control | 5.73±0.00$^{cy}$ | 0.22±0.00$^{ax}$ | 68.12±0.85$^{ax}$ | 2.40±0.56$^{ay}$ | 19.19±0.59$^{ax}$ |
| | 1:3 B:W | 5.77±0.02$^{bcy}$ | 0.19±0.02$^{abx}$ | 67.02±0.37$^{abx}$ | 2.17±0.10$^{ay}$ | 18.37±0.79$^{abx}$ |
| | 1:1 B:W | 5.77±0.01$^{bcz}$ | 0.19±0.01$^{abx}$ | 65.06±0.84$^{cdx}$ | 2.11±0.03$^{ay}$ | 17.90±0.79$^{abx}$ |
| | 3:1 B:W | 5.83±0.05$^{bx}$ | 0.16±0.01$^{bx}$ | 65.53±0.30$^{bcxy}$ | 2.09±0.21$^{az}$ | 17.49±0.07$^{bz}$ |
| | 100% B | 5.92±0.01$^{ax}$ | 0.17±0.01$^{bx}$ | 63.65±0.76$^{dx}$ | 2.72±0.10$^{ay}$ | 17.21±0.50$^{bx}$ |

W: Wheat flour, B: Buckwheat flour. $^{a-d}$ Within each column, different superscript letters show differences between the flour mixes within each storage period ($P< 0.05$). $^{x-z}$ Within each column, different superscript letters show differences between the storage periods with respect to same flour mix ($P< 0.05$)

Similarly, Tamsen et al. (2018) studied the effect of using amaranth flour instead of wheat flour in chicken nugget. They mixed the amaranth flour into the wheat flour in 0%, 50% and 100% ratios and added to chicken nugget. They observed that the pH values of the nuggets increased with increasing of amaranth flour but decreased during storage. Additionally, they determined that the TBARS increased during the storage and it was lower in meatballs prepared with amaranth than the control. They emphasized that these results are due to phenolic substances in antioxidant properties in amaranth flour. In another study, 1, 3 and 5% aloe vera powder were added to beef burgers and stored in cold storage for seven days. At the end of storage, it was determined that the lowest pH value was found in samples containing 5% aleo vera and this result was attributed to the acidic character of this plant. The researchers found that pH values decreased during storage and were below 5 in all samples. In addition, they were stated that the amount of TBARS in these meatballs which was initially in the range of 0.52-0.55 mg/kg increased during storage. Nevertheless, the results in samples containing 3% and 5% aleo vera powder were lower than other. They indicated that the low values in these samples were due to phenolic substances in the Aleo vera (Soltanizadeh and Ghiasi-Esfahani, 2015). Park et al. (2016) produced the pork patties with 1% and 3% of buckwheat powder and fermented buckwheat powder and stored at 4 °C for 14 days. Although TBARS values increased during storage, they found that the results in samples containing buckwheat and fermented buckwheat were lower than others. They stated that the lowest value was in the group containing fermented buckwheat as 0.283 mg/kg and the decrease was due to phenolic substances and flavonoids formed in fermentation. In general, our results were similar to these studies and also did not exceed consumption limits reported as pH=6.5 and TBARS=0.7-1 mg malonaldehyde/kg samples by Gökalp et al. (1999). Park et al. (2016) determined that the brightness ($L^*$) and yellowness ($b^*$) values of uncooked pork patties decreased with buckwheat flour increasing. They attributed that the decrease in results to the colour substances in buckwheat structure. Park et al. (2017) determined that when salami prepared with buckwheat flour, $L^*$ values increased and $b^*$ values shown fluctuation whereas $a$ values did not change. In addition, they found that $L^*$ values reduced during cold storage and this decline is due to oxidation. In another study, Kilincceker and Yilmaz (2019) found that colours of raw chicken meatballs with different fibre may change according to fibre type and amount. Also, they said that some colour criteria may decreased owing to oxidation in cold storage. The colour results in our study were similar to those mentioned.

## 4. Conclusions

In this study, the addition of buckwheat flour can affect the quality of chicken meatballs is determined. As the amount of this flour in meatball composition increased, yield and $L^*$ values of fried samples increased whereas diameter reductions, $a^*$ and $b^*$ values decreased. Furthermore, moisture retention ratios during frying increased while oil absorption ratios decreased. The pH and colour characteristics of the stored raw samples showed

decrease in some treatments at the end of the storage, while the amount of TBARS increased. However, pHs increased in samples containing high levels of buckwheat flour on the last storage day, whereas TBARS decreased in the same period and the same samples. It was also determined that the pH and TBARS numbers did not exceed the consumption limit during storage. Consequently, it was understood that buckwheat flour could be mixed with wheat flour and used in the production of chicken meatballs, and the best treatments were 1:3 B:W and 3:1 B:W.

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