Journal of the Hellenic Veterinary Medical Society

Vol 73, No 4 (2022)

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doi: [10.12681/jhvms.29784](https://doi.org/10.12681/jhvms.29784)

J HELLENIC VET MED SOC 2022, 73 (4): 5031-5038
ΠΕΚΕ 2022, 73 (4): 5031-5038

Research article
Ερευνητικό άρθρο

The possibilities of using quinoa flour in the production of chicken meat patties

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ABSTRACT: In this study, the mixtures obtained by mixing quinoa flour with wheat flour in different proportions were added to chicken meat patties and their effects on some quality characteristics were investigated. As a result of this study, the yields of the meatballs prepared with the mixes containing 50% and 100% quinoa flour were higher than those of other meatballs (69.59% and 69.71%, respectively). The moisture retention of the fried meatballs prepared with mixtures containing 50%, 70%, and 100% quinoa flour was found to be 45.80%, 45.97%, and 51.09%, respectively. The results indicated that the moisture retention of these meatballs was higher than those of meatballs containing 30 and 0% quinoa flour. In contrast, oil absorption rates in the fried samples were in the range of 4.46-5.65% for all quinoa-containing samples and were lower compared to the control sample. Firmness decreased in meat patties prepared with mixtures containing high quinoa rates. It was observed that quinoa flour did not have a negative effect on quality factors. It was concluded that especially the mixtures containing 30% and 50% quinoa flour can be recommended.

***Keywords*:** *Chicken meat patties;frying; quinoa flour; storage stability; wheat flour*

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Date of initial submission: 01-03-2022
Date of acceptance: 25-09-2022

INTRODUCTION

The development of healthy nutrition awareness around the world has increased people's demands for poultry meat and its products. In addition to its consumption as fresh meat, many processed products also stand out on the market shelves. For this reason, producers try to offer healthier and more attractive products to people by using various additives in this group of meats. They are trying to increase the quality, especially by using natural plant-derived components in their formulas (Kilincceker and Hepsag, 2011; Rubel et al., 2021).

However, studies related to moisture loss, fat absorption, textural changes, and deterioration, which are important problems in such products, which are mostly consumed by frying or cooking at high temperatures, are also increasing. On the other hand, in some studies; it has been stated that most of these mentioned problems occurring during the cooking process are reduced and quality properties are improved in similar products prepared with various plant-based flours.In these studies, it was emphasized that especially the protein and starch contents of seed flours were effective on the quality parameters.They stated that during the cooking process, these components increase the moisture content that can be retained in the product structure due to their properties such as denaturation or gelatination. Thus, the components contribute to improving the texture, reducing the absorbed fat ratio. In addition to the positive effects on product quality, it is emphasized that these flours reduced the rate of absorbed fat effectively in digestion and also reduced the calorie intake due to their high fibre content (Ilter et al., 2008; Petracci et al., 2013; Kılınççeker et al., 2015; Tamba-Berehoiu et al., 2019).

In many studies carried out to date, mostly wheat flour is used as an ingredient, while the studies related to the use of quinoa flour are limited. Whereas, quinoa is a seed having a very high protein and dietary fibre ratio. It is an annual plant, and its seed has important nutritional components.While the seed contains approximately 60% carbohydrates, 5% fat, and more than 4% fibre, the protein rate with high biological value can reach up to 20% depending on the variety. Because it does not contain gluten as a protein, it is an important resource for celiac patients. It also contains many vitamins, and it is very rich in essential amino acids.In addition, substances with antioxidant and antimicrobial properties such as some polyphenols, flavonoids, and phenolic acids are also found in quinoa (Ayaşan, 2020; Alsuhaibani et al., 2022).

For these reasons, it is understood that quinoa seed can be an important source in-human nutrition, and it can be used the product development due to its high protein and fibre content which have functional properties.In addition, it was thought that oxidation and microbiological problems which not only cause undesirable taste and odour but also reveal harmful substances for human health in chicken meat could be reduced and colour changes during storage could be decreased with quinoa (Vilcacundo and Hernandez-Ledesma, 2017; Baioumy et al., 2021).

In this regard, in the current study, the flour mixtures prepared by using the different proportions of wheat flour and quinoa flour were used in chicken meat patties. The effects of mixtures containing quinoa flour and wheat flour on some quality factors after frying the chicken meat patties and during storage without frying were determined. Thus, different alternatives were presented to consumers and producers.

MATERIALS AND METHODS

Material

Wheat flour (W), quinoa flour (Q), chicken meats and other materials were purchased from local sellers in Van and Istanbul (Turkey). The chicken breasts were freshly purchased and kept at 4 °C until the meat patties were produced, then they were minced. Five mixes were prepared as 100% W, 30:70Q:W, 50: 50Q:W, 70:30Q:W, and 100% Q. Then, samples were produced with 90% minced chicken meat, 7.5% mix, 1.5% salt,and 1% sunflower oil. Each of the samples was kneaded and allowed to stand for 20 minutes at 4° C. Then, they were shaped with silicone moulds weighing 32 g and having a diameter range of 62 mm. were divided into two groups: the first group was used in frying processes. They were fried for 8 min at 180°C and their yield, colour, texture, moisture retention, oil absorption values, and sensory quality characteristics were determined. The second group was packed in polyethylene bags and stored at 4°C and changes in pH, TBARS (Thiobarbituric acid reactive substances), and TVC (total viable count) were determined after 1, 3, 7, and 10 days of storage.

Determination of the yield and colour values

Equation (1) shown below was used to calculate frying yields (Sayas-Barberá, et al., 2021).

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

The colour indices of the fried samples were determined by a colourimeter (CR-400, Konica Minalto-Osaka, Japan). While the colour of the fried meat patty was measured 4 minutes after frying, measurements were made at the end of each storage period in raw samples.

Determination of moisture retention, fat absorption, texture parameters and sensory properties

Equations (2) and (3) were used to calculate moisture retention and oil absorption (Soltanizadeh and Ghiasi-Esfahani, 2014). An oven was used to find the moisture content of the raw and fried samples, while the soxhlet extraction method was used to find the fat contents (AOAC, 2002).

$$\text{Moisture retention } (\%) = \frac{\text{moisture in fried sample } (\%)}{\text{moisture in raw sample } (\%)} x \text{ frying yield} \quad (2)$$

$$\text{Fat absorbtion } (\%) = \text{fat in fried sample } (\%) - \text{fat in raw sample } (\%) \quad (3)$$

The texture profile analysis was measured by using a TA.XT Plus Texture analyser (Stable Micro Systems, Ltd., Surrey, UK), equipped with a specific cylindrical probe (P/25). Samples were compressed under the following conditions, a pre-test speed of 2.0 mm $s^{-1,}$ a test speed of 1.0 mm s^{-1}, a post-test speed of 2.0 mm s^{-1}, a compression of 25%, and a trigger force of 5 g (Yu et al., 2017).

Ten students from the Food EngineeringDepartment of Yuzuncu Yil University were selected for sensory analysis. Panelists rated the samples on the hedonic scale for appearance, colour, odour, taste, and texture. This method included scores from 1 to 9, depending on the degree of liking (1: dislike very much, 9: like very much).

Determination of pH, TBARS andTVC

These analyses were performed on raw samples. 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.TBARS analysis was determined according to Tarladgis et al., (1960).Results wereexpressed as mg malonaldehyde (MDA)/kg sample. The TVC of the samples was determined by counting the colonies formed as a result of incubation at 30°C after inoculation in plate count agar(P-CA) (Merck, Darmstadt, Germany). Results were expressed as log cfu/g (Gokalp et al., 1999).

Statistical analysis

The data were subjected to analysis of variance (ANOVA). Duncan multiple comparison tests at the level of P<0.05 were applied when there were differences between the mixtures after frying or in the stored raw samples (SPSS 16.0, CHICAGO, IL, USA). The results were expressed as mean±standart deviation.

RESULTS

Quality characteristics of fried chicken meat patties

The yield and colour after frying are important factors for influencing consumer acceptance. In the meantime, the shrinkage may increase. Also, the colour change occurs depending on both the product composition and the heat treatment. Therefore, many studies aim to increase the yield, to ensure the formation of a bright reddish (golden-yellow) colour in the product (Kilincceker and Yilmaz, 2019). In this sense, in the present study, the effects of quinoa flour on some physical properties of fried chicken meat patties were examined (Table 1). As can be seen from the table, the yield increased with the increasing level of quinoa (p<0.01). The yields of the meatballs prepared with the mixes containing 50% and 100% quinoa flour were higher than those of other meatballs (69.59% and 69.71%, respectively). On fried meatballs, $L*$indexes increased with increasing level of quinoa flour and $a*$ index decreased (p<0.01). However, there were no significant differences in $b*$ values (P>0.05). The best results, for $L*$ indexes, were found in the samples containing 50%, 70%, and 100% quinoa flour (47.51, 44.57, and 47.02, respectively). The $a*$ indexes were better than those of others as 19.83, 18.09 and 16.07 in the samples prepared with control, 30% quinoa and 70% quinoa.However, the $b*$ colour indexes of the fried samples varied between 22.06 and 28.78.

Table 1. Effects of quinoa flour on some physical properties of fried chicken meat patties

Mixture	Frying yield (%)	*L**	*a**	*b**
Control	62.41±0.64[b]	33.40±0.60[c]	19.83±3.68[a]	24.26±3.94[a]
30% Q	62.44±3.06[b]	39.90±2.29[b]	18.09±2.91[a]	22.06±3.55[a]
50% Q	69.59±0.95[a]	47.51±1.24[a]	13.35±0.59[b]	26.20±0.37[a]
70% Q	62.31±1.72[b]	44.57±1.48[a]	16.07±0.53[ab]	28.78±4.18[a]
100% Q	69.71±1.32[a]	47.02±3.28[a]	8.41±1.37[c]	26.98±0.58[a]

[a-c] Different letters in the same column indicate significant differences among the mixtures (P<0.05).*L**:brightness, *a**:red(+)-green(-), *b**: yellow(+)-blue(-).

Table 2. Effects of quinoa flour on texture parameters of fried chicken meat patties

Mixture	Hardness (N)	Springiness	Cohesiveness	Chewiness (N)	Gumminess (N)
Control	65.56±0.00[a]	0.42±0.00[b]	0.75±0.00[a]	20.83±0.00[a]	49.82±0.00[a]
30%Q	46.41±10.70[b]	0.84±0.08[a]	0.63±0.18[a]	23.87±3.83[a]	28.25±1.79[b]
50% Q	17.07±0.94[c]	0.45±0.05[b]	0.85±0.16[a]	33.60±37.51[a]	14.49±3.57[d]
70% Q	20.82±2.84[c]	0.38±0.01[b]	0.86±0.06[a]	6.76±1.14[a]	18.09±3.78[cd]
100% Q	26.92±1.40[c]	0.46±0.003[b]	0.89±0.09[a]	11.08±1.64[a]	24.02±3.91[bc]

[a-c] Different letters in the same column indicate significant differences among the mixtures (P<0.05).

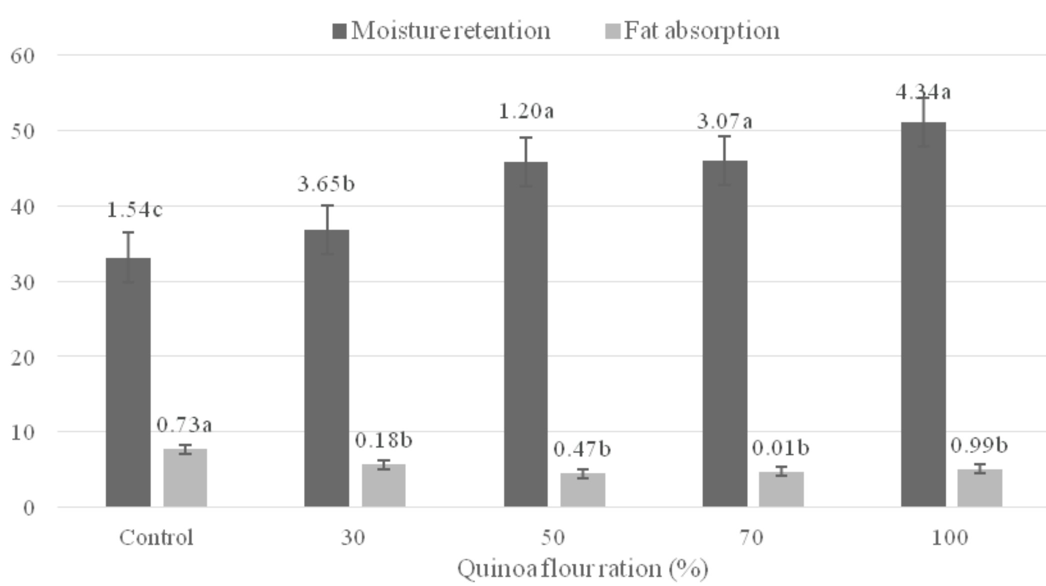

Fig. 1. Effects of quinoa flour on moisture retentions and fat absorptions of fried chicken meat patties (%)

Moisture and fat content are important characteristics that can change the sensory quality of cooked products. They affect properties such as texture and taste. In addition, reducing the calorie value of fried samples is an important issue for producers, as it also affects the preference of consumers who are conscious of healthy nutrition. For this reason, manufacturers prefer materials and production techniques that reduce moisture loss and oil absorption in fried products (Kilincceker and Yilmaz, 2019). According to our results shown in Figure 1, the addition of quinoa flour in the meatball composition increased the amount of moisture retained in the product (p<0.01)whereas decreased fat absorption (p<0.05) during frying. The moisture retention of the fried meatballs prepared with mixtures containing 50%, 70% and 100% quinoa flour was found to be 45.80%, 45.97% and 51.09%, respectively. The results indicated that the moisture retention of these meatballs was higher than those of meatballs containing 30 and 0% quinoa flour. In contrast, oil absorption rates in the fried samples were in the range of 4.46-5.65% for all quinoa-containing samples and were lower compared to the control sample.

Table 3. Effects of quinoa flour on sensory properties of fried chicken meat patties

Mixture	Appearance	Colour	Odour	Taste	Texture
Control	8.90±0.31[a]	8.50±0.84[a]	9.00±0.00[a]	8.50±0.85[a]	6.70±0.94[b]
30% Q	8.70±0.67[a]	8.90±0.31[a]	8.90±0.32[a]	9.00±0.00[a]	7.10±0.87[b]
50% Q	7.20±0.63[b]	7.40±0.51[b]	7.90±1.20[b]	7.60±0.52[b]	7.05±0.95[b]
70% Q	6.10±0.74[c]	7.00±0.47[bc]	6.40±1.07[c]	6.60±0.70[c]	7.30±1.06[b]
100% Q	6.70±0.48[b]	6.70±0.82[c]	6.10±0.56[c]	6.40±0.70[c]	8.30±1.06[a]

[a-c] Different letters in the same column indicate significant differences among the mixtures (P<0.05).

The texture of food refers to a group of physical properties that occur depending on its structural components. Change of texture properties causes a great impact on consumer liking.Therefore, it is important to provide desired texture values that will attract the consumer to products such as chicken meatballs(Verma et al., 2016).The texture profile analyses of our study are presented in Table 2. When the amount of quinoa flour in the meatball increased, the hardness and gumminess generally decreased. The lowest hardness results were measured as 17.07 N, 20.82 N, and 26.92 N in meatballs prepared with 50%, 70% and 100% quinoa flour, respectively. The springiness value gave a high value at the lowest quinoa level (P<0.01). While other treatments varied between 0.38-0.46, the highest springiness was found to be 0.84 in meatballs containing 30% quinoa flour. Cohesiveness and chewiness results were not affected by quinoa flour levels (P>0.05).The cohesiveness values were in the range of 0.63-0.89, and the chewiness values were in the range of 6.76-33.60 N.The gumminess values were 14.49 N, 18.09 N and 24.02 N for samples prepared with 50%, 70% and 100% quinoa flour, respectively. The values were lower compared to samples containing 30 and 0% quinoa flour.

Sensory characteristics are another important factorthat can affect consumer preference. For this reason, it is beneficial to detect sensory properties in product development studies (Kırpık and Kılınççeker, 2018). In this sense, sensory properties are determined and the results are given in Table 3. It was determined, that sensory scores decreased as the level of quinoa flour increased in the meatball composition, while only the texture scores increased in samples containing 100% quinoa flour. The increased quinoa levels decreased the sensory scores, however, the scores were still above 6, meaning that sensory properties were in the acceptable range.

Quality characteristics of raw chicken meat patties after storage

The deterioration that occurs during storage in easily perishable foods such as chicken meat is important in terms of quality and economy.In this regard, proteolytic, oxidative, and microbial activities are effective on the shelf life of the product. Substances such as ammonia formed during storage increase the pH value, while aldehyde-like substances formed due to oxidation of fatty acids increase the TBARS value. Similarly, the increase in the activity of microorganisms can damage the sensory quality of the product and can be dangerous for consumer health.Therefore, it is useful to determine these values during storage in product development studies(Gokalp et al., 1999; Dave and Ghaly, 2011; Puvača et al., 2015). The results of the present study during the storage period are presented in Table 4.

The effect of the mixtures on pH was significant in all storage periods, while the effect on TBARS values became important 1st and 10th day (P<0.01).In addition, on the 1st and 3rd storage periods, the mixtures had a significant effect on the TVC (P<0.01). As can be seen from Table 4, it has been understood that the pH values fluctuated over time. On the 1st day, the lowest pH was found in meat patties prepared with 100% quinoa flour as 5.77, whereas the lowest values on the 10th day were determined to be 5.81 and 5.78 in those prepared with 50% and 100% quinoa flour. TBARS values generally increased with storage time.On the first day of storage, the lowest TBARS results were determined in the control group and samples with 50% and 70% quinoa flour to be 0.06 mg/kg, 0.09 mg/kg, and 0.09 mg/kg respectively, while on the 10thday of storage, the lowest values were determined in the control and samples with 70% quinoa flour as 0.18 mg/kg and 0.44 mg/kg.While the total number of mesophilic aerobic microorganisms generally increased with time, it had the lowest value of 3.03logcfu/g in the sample containing 30% quinoa flour on the 1st day. On the 10th day, it was found to be 6.87 log cfu/g and 6.66 log cfu/g, for control and the samples prepared with 50% quinoa flour, respectively (Table 4).

Table 4. Effects of quinoa flour on some physicochemical and microbiological properties of raw chicken meat patties at cold storage

Storage day	Mixture	pH	TBARS mg/kg samples	TVC Log cfu/g
1st	Control	5.87±0.01^{bw}	0.06±0.004^{dw}	3.42±0.11^{bz}
	30% Q	5.89±0.04^{bx}	0.17±0.004^{aw}	3.03±0.06^{cy}
	50% Q	5.89±0.03^{bw}	0.09±0.01^{cz}	3.42±0.10^{by}
	70% Q	5.95±0.01^{aw}	0.09±0.01^{cw}	3.37±0.08^{bz}
	100% Q	5.77±0.005^{cw}	0.15±0.01^{bz}	4.01±0.14^{az}
3rd	Control	5.82±0.03^{bx}	0.11±0.17^{aw}	4.63±0.11^{aby}
	30% Q	5.90±0.03^{ax}	0.31±0.40^{aw}	4.04±0.03^{cy}
	50% Q	5.84±0.01^{bx}	0.17±0.04^{ay}	4.40±0.09^{bx}
	70% Q	5.94±0.02^{aw}	0.20±0.04^{aw}	4.13±0.22^{cy}
	100% Q	5.72±0.01^{cx}	0.20±0.01^{ay}	4.80±0.13^{ay}
7th	Control	5.88±0.01^{bw}	0.10±0.009^{aw}	6.43±0.07^{ax}
	30% Q	5.99±0.01^{aw}	0.22±0.113^{aw}	6.38±0.38^{ax}
	50% Q	5.81±0.01^{cxy}	0.25±0.004^{ax}	6.69±0.19^{aw}
	70% Q	5.87±0.01^{bx}	0.64±0.86^{aw}	6.83±0.22^{ax}
	100% Q	5.73±0.01^{dx}	0.42±0.004^{ax}	6.71±0.25^{ax}
10th	Control	5.85±0.01^{bw}	0.18±0.004^{ew}	6.87±0.34^{aw}
	30% Q	5.86±0.04^{bx}	0.51±0.008^{cw}	7.96±1.25^{aw}
	50% Q	5.81±0.006^{cy}	0.60±0.004^{bw}	6.66±0.57^{aw}
	70% Q	5.95±0.01^{aw}	0.44±0.008^{dw}	7.55±0.31^{aw}
	100% Q	5.78±0.01^{cw}	1.05±0.004^{aw}	7.72±0.08^{aw}

$^{a\text{-}e}$ Different letters in the same column indicate significant differences among the mixtures in each storage time (P<0.05). $^{w\text{-}z}$ Different letters in the same column indicate significant differences for the same mixture in different storage times (P<0.05).

DISCUSSION

In a study conducted by Kırpık and Kılınççeker (2018) were determined that when breadcrumbs and quinoa flour mixtures were added to chicken meatballs, as the amount of quinoa flour increased, the yields of the fried samples increased. Similarly, Baioumy et al., (2021) determined that adding 1:1 quinoa flour: tiger nut flour to beef patties reduced losses in cooked samples. Sayes-Barbera et al. (2021) observed that quinoa derivatives generally decreased the cooking loss from meat patties during cooking. When 5%, 10%, and 15% quinoa flour were added to the meat burgers instead of soy flour, it was determined that the cooking yield increased (Shokry, 2016). Also, it was revealed that while $L*$ and $b*$ values increased, $a*$ values decreased. Al-Mamun et al. (2018) found that adding different amounts of corn flour to chicken meatballs was effective on cooking loss, and the lowest value was found in the samples containing 5% corn flour. Ikhlas et al. (2011) and Santhi and Kalaikannan (2014) also observed some plant-based flours increased the yields in poultry products. In these studies, it was emphasized that the hydrophilic properties of proteins, starches, and fibres found in the composition of flour, as well as the barrier structure formed as a result of coagulation of proteins and gelatinization of starches, increase the frying yields. Park et al. (2021) observed that the addition of buckwheat decreased the $b*$ values. Saikia et al. (2019) observed that as the black gram flour ratio increased in cooked duck meat patties, $L*$ values increased, while $a*$ and $b*$ values decreased. But they said that these changes were statistically insignificant. Especially, they attributed the increase in $L*$ value to the light colour of black gram flour. Ikhlas et al. (2011) found that the addition of different flour in quail meat patties changed the colour properties of cooked samples. In our study, colour indices of fried meatballs were also affected by the colour pigments of quinoa flour. The increase in $L*$ value and decrease in a value was attributed to the pigments in quinoa flour having a low effect on colour and a lighter reddish colour occurring during heat treatment.

Our findings were consistent with reported data Kırpık and Kılınççeker (2018) who revealed that an increased level of quinoa flour in fried chicken meatballs increased the moisture retentions and decreased fat absorption. Similarly, Baioumy et al. (2021) determined that the supplementation of 1:1 quinoa flour: tiger nut flour to beef patties increased moisture retention in cooked samples. Shokry (2016) observed the increase in moisture retention and decrease in oil absorption with the increasing level of quinoa flour (from 5% to 15%) in cooked meat burgers. These results might be due to retention with water-binding of the fibre and starch in the quinoa structure, also the protein matrix formed during the heat treatment. In addition, starch gelatinizes during heat treatment and supports the strong structure formed by proteins against moisture loss and oil absorption. The results of our study agree with the above-mentioned studies.

Özer and Seçen (2018) observed that the addition of quinoa flour in the cooked beef burgers decreased hardness, chewiness, and gumminess, whereas springiness values were not affected. Similarly, Shokry, (2016); Saikia et al. (2019), Chatterjee et al. (2019), and Öztürk-Kerimoğlu et al. (2020) observed that the addition of flour having a high fibre ratio in formulation decreased the hardness.

Kırpık and Kılınççeker (2018) found that when it was added the mixtures prepared from breadcrumbs and quinoa flour to chicken meatballs, the appearance, smell, and colour scores did not differ, while the colour and taste scores decreased in some samples. They attributed the decrease in colour scores to the light colour occurring after frying and the decrease in taste scores to the specific taste of quinoa. Despite these results, they emphasized that all scores were above 5. Baioumy et al. (2021) revealed that quinoa-tiger nut flour had a positive effect on the sensory properties of beef patties. Shokry (2016) determined that the addition of different levels of quinoa to meat burgers improved texture, tenderness, and juiciness, also it was determined quinoa flour had no also negative effects on other sensory criteria. Park et al. (2021) stated that the taste, texture, and acceptability of the meatballs prepared with quinoa starch and washed quinoa seed increased, due to the functional properties of quinoa starch and other components. In addition, Santhi and Kalaikannan (2014) also stated that when they added oat fibre to chicken nuggets, some quality factors improved, while some sensory results decreased.

In addition, it was understood that some applications can limit the increase of pH, TBARS and TVC counts in raw meatballs stored in the cold. As in our study, Baiumy et al. (2021) found quinoa-tiger nut flour (1:1) slowed the increase of TBARS and microbial counts of beef patties during frozen storage. They attributed these results to antioxidant and antimicrobial compounds in the composition of quinoa flour and tiger nut flour. Al-Mamun et al. (2017) found that the pH value of raw chicken meatballs containing different proportions of corn flour was affected by freezing during storage, while the TBARS value was not. They found that while the pH value increased over time, the lowest value was on the 15th day and the results showed a change in the range of 5.98-6.02.In addition, they determined TBARS was in the range of 0.10-0.11 mg/kg during storage. Park et al. (2021) made a study by using corn, quinoa starches, and washed quinoa grain, it was observed that chicken meatballs made with the addition of quinoa starch-quinoa seed mixture reduced oxidation during frozen storage. They said that the functional properties of quinoa starch and the antioxidative substances in the seed structure are effective in the limitation of oxidation. In addition, they determined that all chicken meatballs had TBARS values below the maximum 3 mg MDA/kg which is the limit value for a good quality meat product at the end of storage. In another study, quinoa seed, quinoa flour and its' wet-milling coproducts were used in meat patties and stored in frozen storage. In the aforementioned study, it was determined that pH and TBARS values increased over time, whereas quinoa derivatives were generally ineffective on pH and they decreased TBARS values (Sayas-Barberá et al., 2021). In a study conducted by Saikia et al. (2019), patties prepared by adding black gram flour in different proportions were stored in the cold after pre-cooking. They determined that the total number of microorganisms increased during storage. They said that at the end of 10 days, the TVC was in the range of 4.64-4.81 log cfu/g and these values were at an acceptable level. Verma et al. (2016) found that pH, TBARS, and TVC increased in chicken meatballs prepared with green cabbage during cold storage. However, they said that the use of green cabbage was effective to limit the increased rates of these criteria, they attributed this to the antioxidant and antimicrobial substances in its structure, and that the use of green cabbage at a rate of 15% would be appropriate. In addition, some authors said that fluctuation of pH and TBARS values may be related to the reactions of basic materials and oxidation products such as aldehydes and ketones (Kılınççeker et al., 2015). Our results were similar to these studies, and it was understood that they did not also exceed the limits given by Gökalp et al. (1999) for pH (6.5) and TBARS (0.7-1 mg MDA/kg). In addition, it was also seen that even after 10 days of storage, the control sample and samples containing 50% quinoa flour did not exceed the limit values specified as 7 log cfu/g by ICMSF (1992).

CONCLUSION

According to the results of the study, quinoa flour increased the retained moisture content, while it reduced the amount of absorbed fat. Some treatments increased the *L** and *a**indices after frying. Due to the juicy structure, which was created by quinoa flour in the meat patties, the hardness value was reduced. Also, sensory scores of texture received high scores due to the juicy structure obtained by quinoa flour. According to the results of the storage stability analysis, pH and TBARS values of meatballs were found to be in the acceptable range even at the end of storage. When quinoa flour was used at a 50% level, the growth rate of bacteria was below 7 log cfu/g which is the acceptable level proposed for the TVC. According to all results, it was detected that quinoa flour can be an alternative to wheat flour in the production of chickenmeat patties. Also, while it can be recommended to use mixtures containing 30% and 50% quinoa for such products, it has been understood that more research should be done on this subject.

CONFLICT INTEREST

The authors declare that they have no conflict of interest.

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