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SOME QUALITY CHARACTERISTICS of FISH MEATBALLS MANUFACTURED with DIFFERENT VEGETABLE-BASED FLOURS

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Abstract

In this study, effects of different plant-based flours and frozen storage on some properties of fish meatballs were evaluated. Some physical, chemical, and sensorial properties of raw and fried meatballs were determined. The lowest pH value was in raw sample with pepper seed flour, and the thiobarbituric acid values were low in sample with control, wheat, barley, oat, and pepper seed flours. Oat decreased moisture, whereas wheat, barley, and rye decreased more the oil content of fried meatballs. Wheat, rye, and seed flours increased *a* values of fried samples. Control, wheat, oat, and seed flours had high levels of *b* values. Thiobarbutiric acid and total volatile basic nitrogen values increased, whereas yield and moisture, appearance and odour scores of samples decreased during storage. However, they had acceptable levels. As the results, it was seen that wheat and pepper seed flours could be used in comparison with the other seed flours to enhance the quality of fish meatballs.

Keywords: Fish meatball, vegetable-based flour, frozen storage, deep frying, quality

BİTKİ KÖKENLİ FARKLI UNLARLA ÜRETİLEN BALIK KÖFTELERİN BAZI KALİTE ÖZELLİKLERİ

Özet

Bu çalışmada, farklı bitkisel unların ve dondurarak depolamanın balık köftelerde bazı kalite özellikleri üzerine etkileri araştırılmıştır. Ham ve kızartılmış köftelerde çeşitli fiziksel, kimyasal ve duyusal nitelikler belirlenmiştir. Ham örneklerde en düşük pH, biber tohumu unu ile hazırlananlarda saptanmıştır. Tiyobarbütirik asit sayısı, kontrol, buğday, arpa, yulaf ve biber tohumu unlarını içerenlerde daha düşük bulunmuştur. Kızartılmış köftelerde, yulaf unu nem içeriğini, buğday, arpa ve çavdar unları ise yağ içeriğini önemli düzeyde azaltmışlardır. Buğday, çavdar ve biber tohumu unları kızartılmış örneklerin *a* değerlerini, kontrol, buğday, yulaf ve biber tohumu unları ise *b* değerlerini en çok artıran unlar olmuşlardır. Depolama süresince ham örneklerde tiyobarbütirik asit ve uçucu azotlu madde değerleri artarken, kızartma ile verim, nem, görünüş ve koku değerlerinin azaldığı, ancak genel olarak kabul edilebilir seviyelerde oldukları gözlenmiştir. Sonuç olarak, buğday unu ve biber tohumu unlarının balık köftelerin kalitesini artırmada daha avantajlı olabileceği belirlenmiştir.

Anahtar kelimeler: Balık köfte, bitkisel un, donmuş depolama, derin yağda kızartma, kalite

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INTRODUCTION

The addition of different vegetable-based flours in food products is on the increase nowadays due to their components and benefits to human health (1, 2). The flours are incorporated in the products especially for their functional and technological properties. The use of flours or their components such as protein and polysaccharide blends presents some advantages to food manufacturers (1-4).

Various types of flours have been used in meat and fish products to increase the physical, chemical, and sensorial properties due to their colour and water-binding and barrier against fat absorption properties. Flours are used to reduce the moisture loss and oil absorption of meatballs during frying (1-5). Protein denaturation and starch gelatinization also play an important role in the structure of fried meatballs. They affect the cooking yield and texture of meatballs (1, 4, 5, 7). Some studies emphasized that the different flours were found to be increase in cooking yield, enhanced the colour, taste and texture properties of finally products (1-8).

Plant-based flours can increase the shelf life of fish products because of their high protein, starch, and fibre contents. They can also increase the freeze-thaw stability of meatballs if added in appropriate levels (6). Oxidation and hydrolysis of lipids and proteins in fish meat increase and promote some chemical changes, rancidity, and microbiological load during storage. They affect the sensorial properties of products negatively (6, 9-11). Functional properties of flour components can affect the structure of products, and they can decrease lipid oxidation and activity of enzymes of products due to their water-binding ability. In addition, flours do not contain any anti-nutritional or toxic factors. Thus, they contribute to meatball quality during storage, processing, and consumption (6, 12, 13).

There are many researches in the literature showing the effects of various flours on quality of meats and chicken meats. However, little research has been done to increase quality and shelf life by using flours in fish products. Fish meats have a soft structure, and they deteriorate quickly. Thus, decreasing these problems with the use of various flours that have different rates of functional components is important for food manufacturers. Physiochemical characteristics of protein, starch, and dietary fibre and colour pigments can improve storage stability and frying characteristics after the frying of fish meatballs. This study was designed to investigate the effects of wheat flour, barley flour, oat flour, rye flour, and pepper seed flours on quality characteristics of fish meatballs during storage.

MATERIALS and METHODS

Materials

In this study, barley flour (B), oat flour (O), and rye flour (R) were purchased from Smart Chemical Co. (Izmir, Turkey). The red pepper seeds were obtained from a paprika manufacturer, they were milled into flour (P). Carp (*Cyprinus carpio*), wheat flour (W), bread crumb and other ingredients were obtained from local markets in Adıyaman. Corn oil was used as frying medium (Yudum, Yudum Co., Balıkesir, Turkey). A mini fryer (Arzum, AR 246) that has a thermostatic heat control was used for carrying out deep frying operations.

Methods

Fresh fish were eviscerated, beheaded and washed with chilled water by hand. They were boiled for 1 min in water and cooled to ambient temperature. Their skins and bones were removed and the remainder part was minced using mincing machine. The mince was used for preparing the meatball batter in accordance with the following equation that ensuring the rates of materials in fish meatball batter with pre-trials by panellists.

Fish meat batter was consisted of 88.5% fish mince, 9% flour, 1.5% salt, and 1% onion powder. Then, each 20 g of batter was shaped roundly. Finally, samples were packaged in polyethylene plates with stretch films and stored -18 °C for 90 days. Frozen samples were thawed at +4 °C, and analysed for storage stability of raw samples and colour and sensory values of fried samples (6 min at 170 °C). A fish meatball formulation with bread crumb addition was used for the control (C).

Storage Stability Analyses of Raw Fish Meatballs

Stability analyses were done at the end of the 0^{th}, 30^{th}, 60^{th}, and 90^{th} days. pH, thiobarbituric acid (TBA), and total volatile basic nitrogen (TVB-N) values of raw fish meatballs were evaluated. pH values were determined by using a pH meter (Orion 3-Star, Thermo fisher Scientific, Waltham, MA) as obtained by Ockerman (14). TBA values (mg of malondialdehyde/kg) were attained according to the distillation method as described by Tarladgis et al. (15). TVB-N values were determined according to Schormüller (16).

Cooking Yield, Moisture and Fat Analyses of Fried Fish Meatballs

These analyses were performed during storage. Cooking yield was obtained as follows:

$$\textit{Cooking yield}\,(\%) = \frac{w_1 \times 100}{w_0}$$

where w_0 is the weight of fish meatball before frying and w_1 is the weight after frying. Moisture contents of fried samples were determined by oven air method at 105±2 °C and fat contents were determined by using soxhlet extraction method (17).

Instrumental Colour Analysis

The colour values of fish meatballs were measured by using a portable colorimeter (Minolta CR-400, Osaka, Japan) after frying processes at the end of the 0^{th} and 90^{th} storage day. The instrument was standardised against a white standardisation plate before each measurement. The colour was maintained according to CIELAB systems as *L* (lightness), *a* (redness) and *b* (yellowness) values, as described by Dogan (18). Four meatballs were used for the analysis of each treatment. Four measurements were taken for each sample.

Sensory Analysis

Sensory analyses were conducted in the same periods as the colour analyzes. The fried fish meatballs were coded after 5 min and served in a random order. Ten semi-trained judges assessed the sensory properties using a hedonic scale for the appearance, colour, odour, flavour, and texture scores. Different values in the scale indicated the following reactions: 1: extreme dislike, 2: very much dislike, 3: moderate dislike, 4: slight dislike, 5: neutral, 6: like slightly, 7: like moderately, 8: like very much, 9: like extremely (19).

Statistical Analysis

The experimental design was completely a randomized factorial model (5x4), containing five levels of flours and four levels of storage days with two replications for each treatment. The data were applied to analysis of variance (ANOVA), and the results were indicated as mean ± standard deviation (SD). Duncan's multiple-range test was applied on the data to determine differences and interactions using Statistical Analysis System Program, whereas the indipendent T-test was applied to evaluate effects of times on colour values and sensory scores (SPSS, CHICAGO, IL, USA).

RESULTS and DISCUSSIONS

In this study, the effects of flours on the pH ($P<0.01$) and TBA ($P<0.01$) values were found to be significant, whereas the effects on TVB-N values were not found to be significant ($P>0.05$, Table 1).

The lowest pH value was detected with P, whereas the TBA values with C, W, B, O, and P were lower than those with R. These differences might be due to the antioxidant materials and protein present in P. P has a high level of antioxidant and antimicrobial components as phenolic contents, flavonoids, and fibres (20-22). Thus, pH value of samples with P might be decreased compared to others. R has higher unsaturated fatty acid content than others (23). High TBA values in samples with R might be connected with the oxidation of fatty acids (Table 1).

Table 1. The effects of different flours on the pH, TBA, and TVB-N values of raw fish meatballs

Flour	n	pH	TBA (mg/kg)	TVB-N (mg/100g)
C	8	6.38±0.08^a	0.59±0.36^b	23.65±6.68
W	8	6.41±0.05^a	1.05±0.77^b	20.38±3.72
B	8	6.44±0.07^a	2.16±2.56^b	22.80±5.60
O	8	6.41±0.06^a	0.45±0.15^b	22.16±4.92
R	8	6.44±0.05^a	4.66±3.78^a	21.78±3.92
P	8	6.26±0.06^b	0.94±0.64^b	23.15±4.17

C: control, W: wheat flour, B: barley flour, O: oat flour, R: rye flour, P: pepper seed flour

The storage periods of fish meatballs significantly affected the pH, TBA, and TVB-N values of raw samples ($P<0.01$). Generally, pH showed fluctuating exchange during storage. Yet TBA and TVB-N values increased during storage (Figure 1).

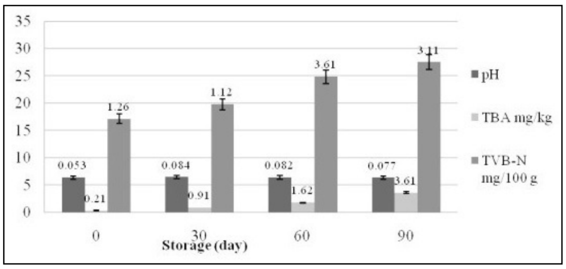

Figure 1. The effects of storage on the pH, TBA, and TVB-N values of raw fish meatballs

An interaction between flours and storage times was observed for pH, TBA, and TVB-N values ($P<0.01$). The lowest pH was measured as 6.19 in sample prepared with pepper seed flour at the 90th day. Increasing pH values might be the outcome from the results of proteolytic effects. Proteolytic enzymes cause degradation of nitrogenous compounds, leading to basic components. The fluctuating exchange of pH may be related to the reactions of these basic materials, causing the accumulation of oxidation products, such as aldehydes and ketones (6, 24). However, the mean pH of all fish meatballs is not higher than the limit of 6.5 recommended by Varlik et al. (19) and Gulyavuz and Unlusayin (25). pH was lower than the values reported by Otles and Berkay (26) for siquid pane, haddock pane, Alaska pollock croquet, and fish burger products, and those minimum pH levels are 7.07, 6.82, 6.7, and 6.45, respectively (Figure 1).

TBA values represent the content of secondary lipid oxidation products. The lowest TBA value was determined as 0.18 mg/kg in sample prepared with wheat flour at 0th day. However it increased in all of sample during storage. Some authors report that the malondialdehyde content can increase during storage period because of lipid oxidation. Lipid oxidation in foods affects the quality of products during frozen storage (6, 19, 27). The TBA values of fish meatballs after storage, at the level of consumption, provided by Gogus and Kolsarici (28) and Varlik et al. (19) range from 7 to 8 mg/kg. Moreover, in the final storage period, the TBA values were generally in the range of 3–5 mg/kg and the products were grouped in the good quality category (Figure 1; 19).

TVB-N value was lowest in sample prepared with oat flour at the 0th day (15.50 mg/100g). This value increased with prolonged storage periods. Volatile and non-volatile basic compounds can arise primarily from protein degradation (29). Some studies reported that TVB-N values increase with the extension of storage periods and affect the acceptability of fish meat products (6, 19). However, in our study the mean TVB-N values were similar to those in the literature that reported as 25–30 mg/100g for a good-quality product at the end of the storage (19, 25). The results were also similar to the report of Arslan et al. (30), who studied carp flesh during a 11-month storage period and found 19.68–24.4 mg/100g TVB-N content (Figure 1).

As shown in table 2, the effects of different flours on cooking yield were not found to be significant ($P>0.05$). However, the effects of flour on the moisture and fat contents were significant at the level of $P<0.05$ and $P<0.01$, respectively. Moisture contents of sample with C, W, R, and P were higher than those with B and O after frying. Fat values in sample with W, B, and R were lower than others. These results might be due to its high protein, starch, and dietary fibre contents. In addition, O has high level natural fat. Thus, it can be decrease moisture of samples while it increases fat contents after frying. W, B, and R have higher starch compared to others (21, 31). Gelatinization of starch during frying might decrease fat absorption and moisture loss in fish meatballs (Table 2). Moreover, in some study it is said that the protein and starch content of cereals and legumes may affect the moisture and fat retention of cooked food. During the cooking processes, protein–protein interactions cause a stronger protein matrix and starches form a gelatinize matrix, which can retain mass transfer inside food (3, 32-35).

Storage periods have a significant effect on cooking yield and moisture values of fried fish meatballs ($P<0.01$). Fat values of samples were not affected by storage ($P>0.05$). Significant interactions were found between the flours and storage for moisture and fat values ($P<0.01$), whereas significant interactions were not found for yield ($P>0.05$). The highest moisture

Table 2. The effects of different flours on the cooking yield, moisture, and fat values of fried fish meatballs

Flour	n	Cooking yield (%)	Moisture (%)	Fat (%)
C	8	75.89±1.14	50.04±1.72^{a}	9.18±1.21^{b}
W	8	72.47±2.59	50.39±3.53^{a}	4.75±0.87^{d}
B	8	73.19±4.22	48.76±2.55^{ab}	5.88±1.05^{cd}
O	8	73.71±4.21	46.70±1.50^{b}	11.36±1.96^{a}
R	8	72.34±2.75	49.82±1.91^{a}	6.77±0.74^{c}
P	8	74.32±3.57	49.43±2.48^{a}	9.82±1.94^{b}

C: control, W: wheat flour, B: barley flour, O: oat flour, R: rye flour, P: pepper seed flour

was found as 53.40% in sample prepared with wheat flour at the 0th day. Fat value was lowest in sample prepared with wheat and barley flours at the 30th and 60th days as 4.33% and 4.32%, respectively. Cooking yield and moisture value decreased during storage (Figure 2). Generally, cooking yield shows similar change with moisture of products. Initially, formation of a hard structure retained the water inside the meatballs. Thus, cooking yields were high in these periods (3, 5, 10). The decreases of yield and moisture might cause decay of structure of flours that provide strong meatball structure during storage. Thus, the structure of meatballs can also decay during storage and cause more matter loss during frying and the cooking yield and moisture values can decrease after frying (Figure 2). Similar decreasing effect of storage period was also reported by Kilincceker et al. (6) and Kilincceker et al. (13) for coated-fried fish fillets and coated-fried chicken meatballs.

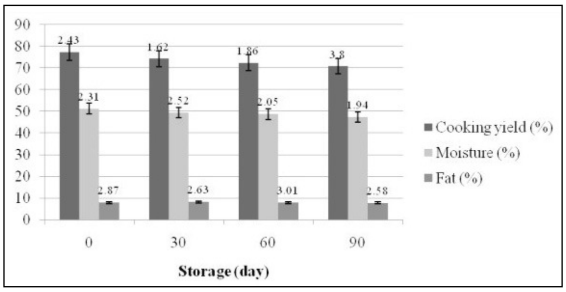

Figure 2. The effects of storage on the cooking yield, moisture, and fat values of fried fish meatballs

The flours did not affect *L* values ($P>0.05$), but addition of different flours affected *a* ($P<0.05$) and *b* ($P<0.05$) values of fried fish meatballs (Table 3). The colour values of fried fishery products arise mainly from the pigmentation of fish meat and the additives that are used in formulation (36). In this study, the amount of fish meat was equal while the type of flour was different among formulations. Generally, W, R, and P increased *a* values, whereas C, W, O, and P increased *b* values of fried samples. Colour values can be affected by natural colour pigments of flours. Maillard reactions also could change the colour values of samples during frying (1). Especially, O and P have a higher red-yellow colour than others. These pigments might affect *a* and *b* values of fried fish meatballs. W might increase Maillard reactions due to its high protein and carbohydrate contents. It could increase *a* and *b* values of fried samples (Table 3). Other researchers also have obtained similar results in meat products. (5, 37-38).

The effects of frozen storage on the colour values were not found to be significant ($P>0.05$; the values are not shown in the manuscript). However, an interaction between flours and storage times was observed for *L*, *a*, and *b* values ($P<0.01$). The highest *L* and the lowest *b* values were measured as 37.03 and 8.83 in sample prepared with barley flour at the 0th and 90th days, respectively. The lowest *a* value was detected as 8.03 in control

Table 3. The effects of different flours on the colour values of fried fish meatballs

Flour	n	*L*	*a*	*b*
C	4	31.96±1.69	9.14±1.29^{c}	13.55±0.36^{ab}
W	4	32.26±1.55	11.36±1.24^{a}	13.99±0.78^{ab}
B	4	31.19±6.86	9.39±0.86^{bc}	12.27±4.04^{b}
O	4	35.91±1.37	9.43±1.81^{bc}	16.21±0.60^{a}
R	4	30.47±0.77	10.95±0.74^{ab}	12.56±0.66^{b}
P	4	33.48±1.59	10.27±0.97^{abc}	14.70±0.28^{ab}

C: control, W: wheat flour, B: barley flour, O: oat flour, R: rye flour, P: pepper seed flour sample at the 0th day. Aditionally, sensory scores were not affected by flours (P>0.05). All of the sensory scores were found to be at acceptable levels. The values were in the range of 5.52–7.52 (the values are not shown in the manuscript).

Appearance and odour, which are sensory properties, were affected by storage (P<0.01). These values decreased during storage (Figure 3). Significant interactions between the flours and the storage times were not found for sensory properties (P>0.05). The acceptability of fishery products that are stored frozen depends on the changes in their sensory properties. Generally, sensory properties are affected by the results of physical, chemical, and microbiological quality (19, 28). In this study, TBA and TVB-N values increased during storage. These factors could decrease the appearance and odour scores of fish meatballs. An increase in TBA could negatively affect colour and appearance, whereas an increase in TVB-N could cause bad odour (6, 19). Also, the decrease in moisture content during long storage periods can negatively affect the appearance and odour of meat balls. However, the surface of products in the end of the storage was more crooked and the intensities of odours were in a high level than the initial period. Fan et al. (9), Ojagh et al. (10), and Song et al. (11) also determined that sensory scores decreased by storage period. However, fish meatballs are still considered to be acceptable at the end of storage (Figure 3).

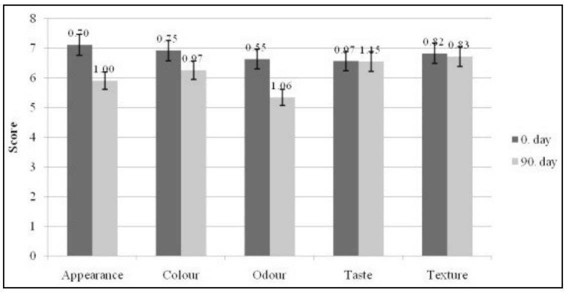

Figure 3. The effects of storage on the sensory scores of fried fish meatballs

CONCLUSION

The results showed that different plant-based flours can be used as an extender for some qualities of fish meatballs. Their different properties can have positive effects on the fish meatballs during frozen storage. Also, the nutritional values of meatballs can be improved by making use of flours. Especially, it was determined in this study that W and P should be used more than others. Finally, it is thought that this work can be a reference for manufacturers and consumers of and future scientific studies about fishery products.

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adreslerinden erişilebilir. Yazarlar, makale göndermeden önce yazım kurallarını tam olarak okumalı ve makalelerini burada verilen kurallara göre hazırlamalıdırlar.