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Korrespondenzadresse:
ozgurgolge@hotmail.com

[1]) Alanya Alaaddin Keykubat University, ALTSO Tourism College, Alanya, Antalya 07450, Turkey; [2]) University of Adıyaman, Department of Food Processing, Technical Sciences Vocational School, TR-02040, Adıyaman, Turkey; [3]) Pamukkale University, Technology Faculty, Biomedical Engineering Dept. 20050, Denizli, Turkey

Effects of different fibers on the quality of chicken meatballs

Auswirkungen verschiedener Nahrungsfasern auf die Qualität von Hähnchenfleischbällchen

Ozgur Golge[1]), Osman Kılınççeker[2]), Ahmet Koluman[3])

Summary

The objective of this study was to determine the effects of pea fiber, orange fiber and inulin fiber on some quality properties of chicken meatballs. Samples were prepared with different formulations (3, 6 and 9 %) for each fiber. Analyzes of pH determination, thiobarbituric acid and color values of raw meatballs were evaluated during cold storage whereas color, yield, diameter reduction, moisture retention, fat absorption and sensory properties of fried meatballs were determined. As a results, it was observed that fibers had significant effect on quality of meatballs. Pea fiber increased pH, yield and moisture retention whereas decreased diameter reduction and fat absorption. Inulin fiber increased pH, diameter reduction and fat absorption. Additionally, orange fiber improved TBA, *a* and *b* values of samples, positively. In particular, it was found that 6, 9 and 9 % of pea fiber and 9 % of inulin fiber are more successful for chicken poultry production.

Keywords: chicken meatball, pea fiber, orange fiber, inulin fiber, product quality

Zusammenfassung

Ziel dieser Studie war es, die Auswirkungen von Erbsenfasern, Orangenfasern und Inulinfasern auf bestimmte Qualitätseigenschaften von Hühnerfleischbällchen zu bestimmen. Die Proben wurden mit unterschiedlichen Rezepturen (3, 6 und 9 %) je Faserart hergestellt. Während der Kaltlagerung der rohen Fleischbällchen wurden der pH-Wert und der Thiobarbitursäuregehalt ermittelt. Die Farbe, Ausbeute, Durchmesserreduzierung, Feuchtigkeitsretention, Fettabsorption und sensorische Eigenschaften wurden von den gebratenen Fleischbällchen bestimmt. Es wurde festgestellt, dass Fasern einen signifikanten Einfluss auf die Qualität von Geflügelfleischbällchen hatten. Erbsenfasern erhöhten den pH-Wert, die Ausbeute und die Feuchtigkeitsspeicherung, während der Durchmesserabbau und die Fettabsorption verringert wurden. Inulinfasern erhöhten den pH-Wert, den Durchmesserabbau und die Fettabsorption. Darüber hinaus verbesserten die Orangenfasern die TBA-, *a*- und *b*-Werte der Proben. Insbesondere wurde festgestellt, dass 6, 9 und 9 % Erbsenfasern und 9 % Inulinfasern sinnvoll für die Produktion von Geflügelfleischerzeugnisse sind.

Schlüsselwörter: Hühnerfleischbällchen, Erbsenfaser, Orangenfaser, Inulinfaser, Produktqualität

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Introduction

Changes in global trade, food production practices, industrialization, massive production demands and food consumption patterns which is triggered by changes demographic characteristics, lead a significant increase in vascular cholesterol binding related diseases and obesity. These major problems cause a demand on healthier food that triggers an effort to decrease these problems (Kilincceker, 2011; Tabarestani and Tehrani, 2014). Chicken meat, with an exception of speculations caused by bird flu that caused a decrease in consumption, is one of the major meat source in global culinary and kitchens. As the fat distribution of poultry meat is far more different than red meat, it is accepted as healthier than the red meat. The massive applications may cause changes in texture, shape, color of poultry meat and products. Also, storage may lead an oxidation, protolithic deterioration, changes in fatty acid, vitamin content and nutritional values. Consequently, sensory properties can to be unacceptable for consume. These problems usher rise of a double headed giant, economic burden and public health hazards. Therefore, the food manufacturers try to solve these problems and to improve the nutritional value of poultry products The applications for enrichment of taste, smell, texture, shape, color of poultry meat and products are important to trigger a demand. Additionally, nutritional values of enriched products are significantly higher. (Khalil, 2000; Ibrahim et al., 2011; Cava et al., 2012).

Meat products supplemented with non-meat ingredients are accepted as worthwhile due to additional values like antioxidant, antimicrobial and technological properties. Dietary fiber supplementation of poultry meat is widespread and initiated with low cost and easy access. Fibers may be profitable in low-fat chicken meatball production with many handy characteristics, like water holding capacity. Fibers are shown to increase frying yield and improve texture and sensory properties in meat and poultry products with an increased shelf life (Talukder and Sharma, 2010; Cava et al., 2012; Petracci et al., 2013).

For example, Cave et al. (2012) determined that cooked chicken products with tomato fiber, beetroot fiber and inulin had more good properties than control. Sanchez-Zapata et al. (2010) observed that tiger nut fiber decreased diameter reduction and increase yield of pork burger after cooking. Also, Mansour and Khalil (1997) found that addition of various types of wheat fiber improved the sensory properties of beef burger.

However, the functional properties of fibers change related with the its sources and affect the food production processes. It is important to use suitable fiber for less impact on final product quality (Sanchez-Zapata et al., 2010; Petracci et al., 2013). As fibers are accepted as additional value in food the numbers of studies are increasing. On the contrary, there are still less reports that are about chicken meatballs supplemented with fibers. This study aims to determine the effects of pea, orange and inulin fibers on some frying and storage stability properties of chicken meatballs.

Materials and methods

Materials

Pea fiber (moisture 6 %, total fiber 56.5 %, particle size <250 µm), inulin fiber (moisture 5 %, total fiber 90 %, particle size <250 µm) purchased from Kimbiotek Co. (Istanbul) and orange fiber (moisture 7 %, total fiber 68.2 %, <250 µm) bought from GMT Food Co. (Istanbul). Chicken breast fillets and other materials were obtained from a local market and stored under 4 °C until the experimental procedures. Fillets were produced in an integrated slaughterhouse and air chilled before packaging. All fillets were chopped to smaller proportions and were minced using no:3 coded plate attached meat grinder (Tefal, Le Hachoir 1500, France). Minced meat was mixed by using sterile spatulas for homogenization.

Ingredients and formulation for meatball designed to include: 9700 g minced meat, 150 g table salt (NaCl), 50 g black pepper (Irradiated) and 100 g sunflower oil (Yudum, Turkey). The mixture was molded for homogenization and set for 20 min under 4 °C.

The mixture was separated in to ten groups. The groups were designed as to supplement with 3, 6, 9 % of pea fiber, orange fiber and inulin fiber and no treatment control group. Each group divided into equally two parts and meatballs (approx. 20 g and 30 mm diameter) were made from each group. The first groups of meatballs were placed on plastic plates and covered with stretch film, stored at 4 °C. pH, TBA and color values of these samples were determined during storage. Second groups were used to determine some technological and sensorial properties of fried meatballs at 175 °C for 5 min in mini fryer (Tefal, Moulinex Minuto AF100316, France).

Methods

Determination of pH, TBA (thiobarbituric acid) values and color measurement

pH values, thiobarbituric acid (TBA) and, color analyzes were performed on 1st, 5th and 10th days post production. The pH values were measured with a pH meter (Orion 3-Star, Thermo fisher Scientific, Waltham, MA) after homogenization of 10 g sample with 100 ml deionized water for 1 min following the instructions outlined by Ockerman (1985).

Determination of the extent of oxidative rancidity of the samples on 1st, 5th, and 10th days of storage which was described by Tarladgis, Watts and Younathan (1960) was used. For this purpose, the samples were blended in a commercial blender (Waring Commercial Blendor), then 10 g of the blended samples was mixed with 50 mL distilled water at 50 ºC. The homogenate was transferred to an 800-mL Kjeldahl flask. Then, it was added 48 mL of distilled water (50 °C) and 2 mL of 18 % HCl. The resulted mixture was heated, and the first 50 mL of distillate was collected. Five milliliters of the distillate was added to 5 mL on TBA reagent, and was heated in a boiling water bath for 35 min. The absorbance was read at 538 nm (UV-160 A, UV-Visible Recording Spectrophotometer, Shimadzu, Tokyo, Japan) against a reagent blank. The TBA results were expressed as mg of malonaldehyde/kg samples (Tarladgis et al., 1960).

Color values were measured by using a portable colorimeter using Minolta Chroma Meter CR-400 (Konica Minolta, Inc., Osaka, Japan) with illuminant D 65, 2° observer, Diffuse/O mode, 8 mm aperture of the instrument for illumination and 8 mm for measurement. The instrument was calibrated with a white reference tile (L = 97.10, a = –4.88 and b = 7.04) before the measurements. Color was described according to CIELAB system as L (lightness), a (redness), and b (yellowness) values (Dogan, 2006).

Technological properties and sensory evaluation

Chicken meatballs were evaluated for technological properties and sensory characteristics. For this purpose, meatballs were measured for weight, diameter, moisture and fat values in before and after frying in mini fryer. Additionally, color and sensory evaluation were made after frying. Ten meatballs were used for each treatment.

Determination of cooking yield parameters

Weights and diameters of meatballs in before and after frying were used to calculate frying yield and diameter reduction parameters according to the equations 1 and 2.

$$\text{Frying yield (\%)} = \frac{\text{cooked meatball weight}}{\text{raw meatball weight}} \times 100 \quad (1)$$

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

Moisture contents of raw and cooked samples were determined by oven air method at 105 ± 2 °C whereas fat contents were evaluated by using soxhlet extraction method with n-hexane (AOAC, 2002). Then, "moisture retention" and "fat absorption" parameters were calculated according to the equations 3 and 4 (Soltanizadeh and Ghiasi-Esfahani, 2015):

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

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

Sensory analysis

Chicken meatballs were served warm (35 ºC) in random order to ten membered trained panel (graduate students of Adıyaman University, Department of Food Processing). In preliminary sessions, trainings were made for evaluation of the meatball treatments to the panelists. The panelists assessed the sensory properties by using a hedonic scale in terms of appearance, color, odor, flavor, and texture. Values in the scale indicated the following ratings: 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 (Gokalp et al., 1999).

Statistical analysis

The experimental procedure was designed in two replications and three parallel. As a factorial design, three different levels (3, 6, and 9 %) of three different factors (pea, orange and inulin fibers) were studied. Results were evaluated by using variance analyzes and importance re-evaluated by using Duncan Test ($P<0.05$; SPSS, CHICAGO, IL, USA). It is summarized in figure 1.

Results

Protolithic and oxidative deteriorations are important factor for meat products. They form an undesirable secondary product and reduce quality. Ammonia that occurs during the storage leads to increase of pH values. TBA indicates the oxidation level and occurs by oxidation of fatty acids of meat products. TBA and pH levels are accepted as indicators of quality. Color of the uncooked meatballs is the major criteria of consumers which affects choice. It can be affected by additives or long storage period. Due to this, it is suggested to measure color changes, periodically (Gokalp et al., 1999; Kilincceker, 2017). Determination of pH, TBA, and color values of raw samples in different storage times were summarized in table 1. It can be seen in table 1 that pH values of orange fiber enriched meatballs at 1th and 5th days are lower than pea and inulin enriched meatballs. However, orange fiber and inulin fiber decreased the pH values by 10th day of storage. The lowest pH value was recorded in sample with 9 % orange fiber as 5.98. According to TBA results; 6 % and 9 % levels of inulin fiber were more advantageous for TBA than other treatments in first storage period whereas it understood 3 % pea fiber is advantageous against other in last period. In general, it was observed that addition of fiber caused high TBA value. Also, extension of storage time increased the TBA values of samples. The hard and cracked

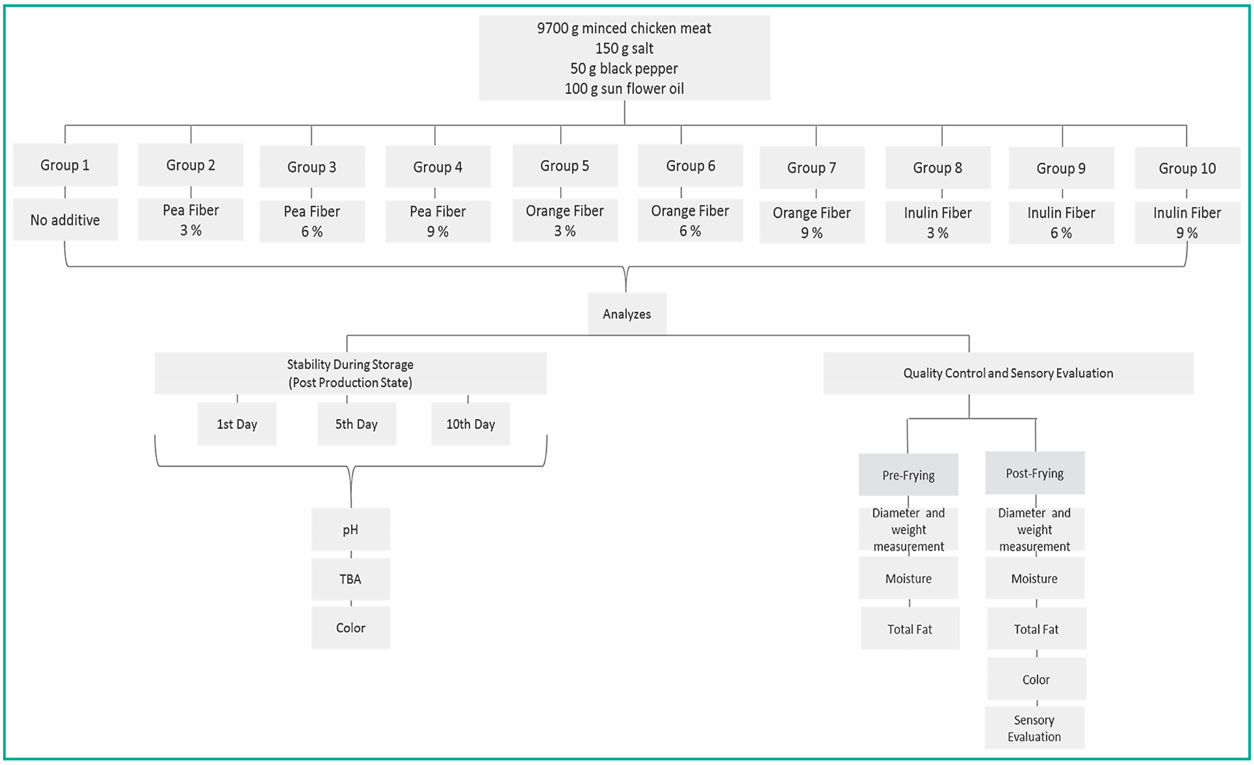

FIGURE 1: *The experimental procedure.*

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structure formed by fiber addition increased the penetration of oxygen while the increase in storage time trigged the oxidation of unsaturated fatty acids and leaded to an increase in TBA values. Nevertheless lowest TBA value was recorded in 3 % pea fiber enriched samples as 0.20 mg/kg on the 10th day (table 1).

In table 1; *L* value is indicator of lightness and is higher on surface of sample with orange fiber than other samples at levels of 3 % on 1^{th} day. However, pea fiber was more advantageous than orange fiber and inulin fiber at level of 9 % on 10^{th} day. Addition of fiber increased *L* values on 1^{st} and 5^{th} days whereas storage period caused various changes on *L,* generally. This value had higher results in 6 % and 9 % pea fiber enriched samples on 10^{th} day as 48.79 and 50.35. Natural color of fibers was found effective on a values, which indicates red-green, was higher in pea and inulin fibers enriched meatball samples. Addition of pea fiber increased a values whereas orange fiber decreased on 1st and 5th days, generally. Storage also increased a values of meatballs. On the 10^{th} day of storage, 3 % pea, 9 % pea and 9 % inulin fibers enriched samples had higher a value than other as 4.60, 4.28 and 4.32. In table 1; *b* value seems to be higher in orange fiber enriched samples. Especially, amounts of pea fiber and orange fiber have a direct effect on the increasing of *b* values. At the end of the storage period, *b* value was higher in 6 % and 9 % of orange fiber enriched samples with values of 13.50 and 13.19, respectively.

Like uncooked samples, color is an important feature for cooked meatballs. Consumers demand bright goldish color (Kilincceker, 2017). Color values of cooked meatballs are given in table 2. It can be seen that, all fiber enriched samples represent lower *L* values with most decrease in orange and inulin fibers. Also, addition of fiber decreased this value on surface of samples with orange fiber and inulin fiber. Highest *L* value was recorded in 6 % pea fiber enriched meatball samples as 59.36. Generally, orange and inulin fibers caused significant rise in *a* values and high fiber concentrations increased this value. Highest *a* value was recorded in 9 % orange fiber enriched meatball samples as 12.18. Fiber enrichment increased *b* values in cooked samples. Orange fiber and inulin fiber were more advantageous than pea fiber at levels of 3 % and 6 %. Conversely, pea fiber had high value at level of 9 %. Addition of fiber increased b values of sample with pea fiber whereas caused irregular changes on this results of sample with orange fiber. Highest *b* measured on enriched meatballs with 9 % pea fiber as 23.88 (table 2).

Structural deteriorations are occurred by protein denaturation in meat and meat products which are fried at high temperatures, caused lower water holding capacity. They increase oil absorption and cause shrinkage and hardening of fried product. Fiber enrichment helps to decrease these problems. Addition of fiber not only helps to avoid structural deterioration but also helps to reduce calories (Cava et al., 2012; Soltanizadeh and Ghiasi-Esfahani, 2015). Some structural properties obtained from this study are summarized in table 3. According to table; it was understood that pea fiber was more advantageous than other for yields. In fact, fiber addition show fluctuational change with pea fiber whereas orange and inulin fibers decreased the yields. Highest frying yield was obtained from 6 % pea fiber enriched samples (93.30 %). Fiber types were generally found no effect on diameter reducing. Only, orange fiber decreased the diameter reduction at level of 9 %. However, addition of fiber caused

TABLE 2: *Effect of fiber type and concentration on color properties of fried meatballs.*

	Fiber type	Fiber concentration Control (0 %)	3 %	6 %	9 %
L	Pea	60.74^{aA}	57.03^{aA}	59.36^{aA}	55.69^{aA}
	Orange	60.74^{aA}	57.74^{aA}	48.24^{bB}	37.17^{bC}
	Inulin	60.74^{aA}	52.89^{bB}	46.28^{bC}	45.96^{abC}
a	Pea	0.22^{aB}	0.57^{bB}	0.75^{bB}	3.85^{cA}
	Orange	0.22^{aD}	1.39^{bC}	5.04^{aB}	12.18^{aA}
	Inulin	0.22^{aC}	4.65^{aB}	7.68^{aA}	8.52^{bA}
b	Pea	15.49^{aC}	16.54^{bBC}	17.51^{bB}	23.88^{aA}
	Orange	15.49^{aC}	18.32^{abAB}	19.38^{aA}	16.83^{cBC}
	Inulin	15.49^{aB}	19.82^{aA}	19.53^{aA}	20.28^{bA}

$^{a–c}$: Within each column, different superscript lowercase letters show differences between the fiber types within each concentration ($p < 0.05$). $^{A–D}$: Within each row, different superscript uppercase letters show differences between the concentrations within each fiber ($p < 0.05$).

TABLE 1: *Effect of fiber type and concentration on pH, TBA and color values of raw meatballs at different storage periods.*

		1st day Fiber concentration				5th day Fiber concentration				10th day Fiber concentration			
	Fiber type	Control (0 %)	3 %	6 %	9 %	Control (0 %)	3 %	6 %	9 %	Control (0 %)	3 %	6 %	9 %
pH	Pea	5.88^{aAZ}	5.90^{aAZ}	5.88^{aAZ}	5.86^{bAZ}	6.30^{aAY}	6.12^{aBCY}	6.16^{aBY}	6.09^{bCY}	7.22^{aAX}	7.26^{aAX}	7.27^{aAX}	7.06^{aBX}
	Orange	5.88^{aAZ}	5.69^{bBZ}	5.50^{bCY}	5.41^{cDY}	6.30^{aAY}	5.95^{bBY}	5.57^{bCY}	5.18^{cDZ}	7.22^{aAX}	6.87^{bBX}	6.65^{bCX}	5.98^{cDX}
	Inulin	5.88^{aBZ}	5.93^{aBZ}	5.92^{aBZ}	5.93^{aAZ}	6.30^{aAY}	6.15^{aBY}	6.29^{aAY}	6.18^{aBY}	7.22^{aAX}	6.75^{bBX}	6.66^{bBX}	6.52^{bBX}
TBA mg/kg	Pea	0.10^{aAY}	0.04^{aAY}	0.09^{aAZ}	0.11^{aAZ}	0.20^{aBX}	0.20^{aBX}	0.24^{aABY}	0.28^{aAY}	0.22^{aBX}	0.20^{bBX}	0.37^{aABX}	0.62^{aAX}
	Orange	0.10^{aAY}	0.04^{aCZ}	0.05^{bBCZ}	0.10^{aABZ}	0.20^{aBX}	0.21^{aBY}	0.23^{aABY}	0.25^{aAY}	0.22^{aCX}	0.37^{aBX}	0.42^{aBX}	0.57^{aAX}
	Inulin	0.10^{aAY}	0.03^{aBZ}	0.04^{bBY}	0.01^{bBZ}	0.20^{aAX}	0.20^{aAY}	0.21^{aAY}	0.23^{aAY}	0.22^{aBX}	0.47^{aABX}	0.67^{aAX}	0.75^{aAX}
L	Pea	42.85^{aCXY}	46.29^{bBXY}	48.47^{aABX}	51.06^{aAX}	40.85^{aDY}	44.89^{aCY}	47.10^{aBX}	49.21^{aAX}	47.36^{aAX}	48.17^{aAX}	48.79^{aAX}	50.35^{aAX}
	Orange	42.85^{aCXY}	48.94^{aBX}	50.84^{aBX}	52.94^{aAX}	40.85^{aCY}	47.62^{aBX}	48.77^{aBXY}	50.56^{aAX}	47.36^{aAX}	48.21^{aAX}	48.60^{aAY}	46.44^{bAY}
	Inulin	42.85^{aBXY}	46.53^{bABX}	51.04^{aAX}	51.19^{aAX}	40.85^{aBY}	46.76^{aAX}	49.21^{aAX}	49.21^{aAX}	47.36^{aAX}	47.59^{aAX}	47.90^{aAX}	48.18^{abAX}
a	Pea	1.60^{aBY}	2.58^{aAY}	2.58^{aAY}	2.42^{aAY}	1.66^{aCY}	2.53^{aBY}	2.57^{aBY}	2.87^{aAY}	3.66^{aAX}	4.60^{aAX}	3.92^{aAX}	4.28^{aAX}
	Orange	1.60^{aBY}	2.00^{bAY}	1.75^{bABY}	1.88^{aABX}	1.66^{aBY}	2.11^{abAY}	1.31^{bCY}	1.02^{cDY}	3.66^{aAX}	3.58^{aAX}	3.77^{aAX}	2.84^{bAX}
	Inulin	1.60^{aAY}	1.70^{bAY}	2.22^{aAY}	2.08^{aAY}	1.66^{aBY}	1.96^{bABY}	2.45^{aAY}	2.07^{bABY}	3.66^{aAX}	3.29^{aAX}	3.96^{aAX}	4.32^{aAX}
b	Pea	9.39^{aDX}	11.26^{bCX}	11.95^{bBX}	12.91^{abAX}	9.25^{aDX}	10.81^{cCX}	11.77^{bBX}	12.62^{bAX}	10.75^{aBX}	11.29^{abABX}	11.50^{bABX}	12.70^{aAX}
	Orange	9.39^{aDX}	12.60^{aCX}	14.08^{aBX}	15.09^{aAX}	9.25^{aDX}	12.73^{aCX}	13.57^{aBX}	14.19^{aAY}	10.75^{aBX}	12.29^{aABX}	13.50^{aAX}	13.19^{aAZ}
	Inulin	9.39^{aBX}	10.65^{bABY}	12.58^{bAX}	12.15^{bAX}	9.25^{aBX}	11.55^{bAX}	12.10^{bAX}	11.75^{bAX}	10.75^{aAX}	10.57^{bAY}	11.38^{bAX}	12.07^{aAX}

$^{a–c}$: Within each column, different superscript lowercase letters show differences between the fiber types within each concentration ($p < 0.05$). $^{A–D}$: Within each row, different superscript uppercase letters show differences between the fiber concentrations within each storage period ($p < 0.05$). $^{X–Z}$: Within each row, different superscript uppercase letters show differences between the storage periods with respect to same fiber type and concentration ($p < 0.05$).

TABLE 3: *Effect of fiber type and concentration on technological properties of fried meatballs.*

Technological properties	Fiber type	Fiber concentration Control (0 %)	3 %	6 %	9 %
Frying yield (%)	Pea	88.99^{aC}	91.37^{aB}	93.30^{aA}	88.63^{aC}
	Orange	88.99^{aA}	89.74^{aA}	85.22^{bB}	81.65^{bC}
	Inulin	88.99^{aA}	84.63^{bB}	77.41^{cC}	76.08^{cC}
Diameter reduction (%)	Pea	3.55^{aA}	-2.08^{aA}	0.11^{aA}	-0.09^{abA}
	Orange	3.55^{aAB}	3.53^{aAB}	4.43^{aA}	-1.41^{bB}
	Inulin	3.55^{aB}	3.07^{aB}	1.95^{aB}	7.69^{aA}
Moisture retention value (%)	Pea	83.16^{aB}	86.11^{aA}	87.18^{aA}	81.19^{aB}
	Orange	83.16^{aA}	83.53^{aA}	73.31^{bB}	67.46^{bC}
	Inulin	83.16^{aA}	75.37^{bB}	65.57^{cC}	62.66^{cD}
Fat absorption value (%)	Pea	3.48^{aA}	2.51^{bB}	2.62^{bB}	2.47^{bB}
	Orange	3.48^{aA}	2.56^{bB}	3.38^{abA}	2.89^{bAB}
	Inulin	3.48^{aC}	3.67^{aC}	4.49^{aB}	5.48^{aA}

$^{a–c}$: Within each column, different superscript lowercase letters show differences between the fiber types within each concentration ($p < 0.05$). $^{A–C}$: Within each row, different superscript uppercase letters show differences between the concentrations within each fiber ($p < 0.05$).

the irregular results in diameters for orange fiber whereas increased the results for inulin fiber. The lowest diameter reductions were measured 3 % pea fiber and 9 % orange fiber enriched samples as –2.08 % and –1.41 % after frying. That is, diameters increased in these samples (table 3).

Fiber enrichment between 6–9 % was found to be important for moisture retentions of meatballs. It can be said that frying process causes a decrease in moisture rations. Using of fiber can affect moisture loss in products. Generally, moisture retentions were higher in sample with pea fiber than other (table 3). However, addition of fiber decreased moisture retentions of samples. After frying process, highest moisture retention was recorded in 3 % and 6 % pea fiber enriched groups as 86.11 % and 87.18 %. Fat absorption was found to be lower in higher fiber enriched group with an exception of pea fiber and orange fiber. These fibers were more advantageous to decrease of fat absorption compared to inulin fiber. Also, addition of fiber was increased fat absorption in sample with inulin. Lowest fat absorption was 2.47 % in 9 % pea fiber enriched meatballs on the contrary highest fat absorption was recorded 5.48 % in 9 % inulin enriched samples. Especially, pea fiber helped to form a soft smooth surface because of the low total fiber content which help to reduce cracks and decreased moisture loss and fat absorption (table 3).

Sensory properties like color, odor, taste, texture should be determined for affectivity of the applications in food processing. They are important criteria to determine of consumer preference (Gokalp et al., 1999; Can, 2012). Sensory properties of meatballs enriched with different fibers were shown in table 4. Generally, it can be said that 6 % levels of orange fiber and inulin fiber were more advantageous for appearance and color. However, pea and inulin fibers at level of 9 % had better results than orange fiber for taste, addition of fiber in meatballs increased the appearance scores for inulin fiber whereas it caused the irregular increase for pea fiber and orange fiber. Similarly, pea fiber increased the color scores at the levels of 3 % and 9 % whereas it decreased at level of 6 %. Fiber concentrations were not found effective on other sensory properties. Samples with 9 % pea fiber and 9 % inulin fiber had better appearance (6.20 and 6.50) and color (6.20 and 6.55) values than other. The best odor scores were in samples with 6 % and 9 % inulin fiber as 6.30 and 6.45. The highest taste score was in samples with 9 % inulin fiber (7.20) whereas texture scores were higher for 6 % and 9 % inulin fiber as 7.30 and 7.20, respectively. Especially, total fiber content of inulin affected taste and texture scores (table 4). It created a tight and brittle structure at high fiber rations and showed a higher demand by the panelists.

Discussion

It is thought that the content of nitrogen in the pea fiber is high and it more increased the pH value because of nitrogen deterioration of during storage. Addition of fiber affected the pH values. Especially, addition of orange fiber that has acid character decreased pH values of meatballs. Fibers that are acidic character, may lead a decrease in pH values. Generally, pH values increased during storage because of protolithic deteriorations. Similarly, Kilincceker (2017) showed that storage time has a parallel relationship with increase in pH values of chicken meatballs (table 2). Sanchez-Zapata et al. (2010) determined that different levels of tiger nut fiber in pork burger were not caused changes. They observed that pH values of burgers changed in the range of 6.12–6.20. Soltanizadeh and Ghiasi-Esfehani (2015) reported that the pH values of beef burgers with different levels of *Aloe vera* reduced during the 7 days storage (4 °C). Yılmaz (2004) determined that the pH values of meatballs with 5, 10, 15, 20 % rye bran ranged 6.02 to 6.09. They were reported the highest pH values from 10 % and 20 % rye bran. We found higher pH values on the 10th storage day than these study due to using of different fibers and storage. In last storage day, some samples exceeded the consumption limit value that pointed by Gokalp et al. (1999) as 6.5 owing to microbial and enzymatic deteriorations. Our data shows similarity with Can (2012), who reported that the pH values in enriched chicken meatballs with thyme oil as 5.9–6.4 after the 12th day of cold storage.

In different studies; Kilincceker and Yılmaz (2016) used apple, lemon and pea fibers in chicken meatballs. They reported that 4 % lemon fiber represented TBA value as 0.76 mg/kg and 8 % lemon fiber as 0.65 mg/kg. On the opposite of our data, they reported low TBA values in fiber

TABLE 4: *Effect of fiber type and concentration on sensory properties of fried meatballs.*

Sensory properties	Fiber type	Fiber concentration Control (0 %)	3 %	6 %	9 %
Appearance	Pea	4.10^{aB}	5.65^{aA}	5.10^{bAB}	6.20^{aA}
	Orange	4.10^{aB}	5.55^{aAB}	5.95^{aA}	5.55^{aAB}
	Inulin	4.10^{aB}	5.35^{aAB}	5.55^{abAB}	6.50^{aA}
Color	Pea	4.85^{aB}	5.50^{aAB}	4.50^{bB}	6.20^{aA}
	Orange	4.85^{aA}	5.45^{aA}	6.05^{aA}	5.25^{aA}
	Inulin	4.85^{aA}	5.85^{aA}	5.30^{abA}	6.55^{aA}
Odor	Pea	5.95^{aA}	5.75^{aA}	5.60^{aA}	6.10^{aA}
	Orange	5.95^{aA}	5.85^{aA}	5.70^{aA}	5.05^{aA}
	Inulin	5.95^{aA}	6.20^{aA}	6.30^{aA}	6.45^{aA}
Taste	Pea	6.15^{aA}	5.80^{aA}	6.60^{aA}	5.80^{abA}
	Orange	6.15^{aA}	6.00^{aA}	6.15^{aA}	4.15^{bA}
	Inulin	6.15^{aA}	6.75^{aA}	6.75^{aA}	7.20^{aA}
Texture	Pea	6.15^{aA}	6.25^{aA}	6.30^{aA}	5.65^{aA}
	Orange	6.15^{aA}	6.20^{aA}	6.20^{aA}	4.70^{aA}
	Inulin	6.15^{aA}	6.45^{aA}	7.30^{aA}	7.20^{aA}

$^{a–c}$: Within each column, different superscript lowercase letters show differences between the fiber types within each concentration ($p < 0.05$). $^{A–C}$: Within each row, different superscript uppercase letters show differences between the concentrations within each fiber ($p < 0.05$).

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enriched meatballs and represented a data justifying the advantage of 4 % of apple and lemon fiber over pea fiber. Cava et al. (2012) reported that oxidation to be slower than control groups in tomatoes and beet fiber enriched chicken samples which were stored at 4 °C for 10 days and represented a change in TBA values between 2.03–3.82 mg/kg. They reported that fiber type and amount have a directly effect on TBA values. Generally, our results lower than these studies. However, TBA values of raw samples were at the acceptable levels of consumption reported by Gokalp et al. (1999) range from 0.7 to 1 mg/kg.

Aleson-Carbonel et al. (2005), reported that beef meatballs enriched with lemon fibers show changes in color which shows a similarity with our results. Cava et al. (2012) showed that L value of tomatoes and beet root fiber enriched raw chicken product are lower than inulin enriched and control group. Additionally, tomatoes fiber caused to increase *a* value on the contrary beet root and inulin fibers decrease the value of samples. They measured color values of batters in the range of 47.7–67.8 for *L,* 0.6–-13.5 for *a,* and 5.7–37.7 for *b.* In our study, *L, a* and *b* values were generally lower than in this study. These differences were because of different fibers and levels. Kilincceker and Yılmaz (2016) determined that *L* values were higher in lemon and pea fiber enriched raw samples than other. Oxidation during storage periods also decrease the *L* value of some meatballs.

In similar studies; Kilincceker and Yılmaz (2016) reported rise in *L, a, b* values of pea fiber enriched cooked samples. Yılmaz (2004) determined that 20 % rye bran increased *L* values of meatballs. He said that addition of rye bran increased *b* values whereas decreased a values of cooked meatballs. Gadekar et al. (2016) studied to evaluate the effect of replacing different levels of added fat with inulin on the physicochemical, sensory and textural attributes of low-fat lamb nuggets. They determined that inulin fiber decreased the *L* value of lamb nuggets whereas it no changed *a, b* values.

Kilincceker and Yılmaz (2016) reported that increase in the amount of apple and lemon fibers leads cracks and decreases yield whereas pea fiber helps to avoid hardening and reduces cracks and increases yield. In a similar study, Cava et al. (2012) showed that tomato fibers help to reduce cooking loss. Talukder and Sharma (2010) determined that the cooking yield of chicken meat patties prepared with wheat bran and oat bran was affected by the bran content (0, 5, 10 and 15 %) increased. In another study; Sanchez-Zapata et al. (2010) determined that cooking yield in pork burger with tiger nut fiber was higher than control sample. Soltanizadeh and Ghisai-Efsehani (2015) indicated that *Aloe vera* contributed to decrease cooking loss and diameter reductions in beef burgers. *Aloe vera* acts as a hydrocolloid and improves the quality of beef burgers. Sanches-Zapata et al. (2010) observed that tiger nut fiber decreased the diameter reduction values of pork burger. Also, Mansour and Khalil (1997) said that wheat fiber reduced the diameter reduction values as compared to control. Our results are supported by these studies.

However, Serdaroglu (2006) determined that oat flour increased the moisture retention values in beef patties. Pinero et al. (2008) observed that addition of 13.45 % oat fiber in beef patties increased the moisture retention. Similar results obtained by Ulu (2006) and Kurt and Kılınççeker (2012) for moisture retention. Sanchez-Zapata et al. (2010) reported that tiger nut fiber affected the moisture retention of pork burgers. They said that 15 % fiber had higher moisture retention values than 5 % and 10 % levels. Yasarlar et al. (2007) determined that 20 % rye bran decreased the fat content compared to control. Mansour and Khalil (1997) evaluated that cooked beef burgers with wheat fibers had lower fat content than control. Also, Santhi and Kalaikannan (2014) indicated that addition of oat flour in cooked chicken nuggets caused a decrease in the fat content.

Sensory evaluation of fiber enriched samples were found better than control group. This is also similar with thyme enriched chicken meatballs (Can, 2012), apple, lemon and pea fiber enriched chicken meatballs (Kilincceker and Yılmaz, 2016) and inulin fiber enriched lamb nuggets (Gadekar et al., 2016). However, Mansour and Khalil (1997) observed that fiber types were significant in cooked beef burgers whereas wheat fiber levels were not significant. However, Oliveira et al. (2016) found that using of apple fiber as a fat replacer in chicken meatballs didn't affect all sensory properties. Our some results were supported by these studies, generally.

Conclusion

Fiber enrichment of chicken meatballs revealed satisfactory results with a guarantee of both chemical and sensory properties. Pea, orange and inulin fibers are thought to be applicable and acceptable at various amounts. Especially, it can be said that 3, 6 and 9 % levels of pea fiber and 9 % inulin fiber are more advantageous in this study than other treatments. These treatments can be useful for technological advantageous and dietary benefits. It is obvious that designing a product of this kind is a long run which needs further evaluations. Further studies should be done to determine to reflect the responses of the product to different storage methods.

Conflict of interest

Authors confirm that there is no conflict of interest.

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Address of corresponding author:
Dr. Ozgur Golge
Alanya Alaaddin Keykubat University
ALTSO Tourism College
Alanya, Antalya 07450
Turkey
ozgurgolge@hotmail.com