1(4): 211-219 (2015) doi: 10.3153/JFHS15020

Journal of Food and Health Science

E-ISSN 2149-0473

ORIGINAL ARTICLE/ORİJİNAL ÇALIŞMA

FULL PAPER TAM MAKALE

EFFECTS OF FIBERS ON THE QUALITY OF FISH PATTIES STORED AT (0-4ºC)

Aslı CADUN[1], Şükran ÇAKLI[1], Duygu KIŞLA[2], Tolga Dinçer[1], Ömer Alper ERDEM[1]

[1] Ege University, Faculty of Fisheries, Department of Seafood Processing Technology, İzmir, Turkey

[2] Ege University, Faculty of Engineering, Department of Food Engineering, İzmir,Turkey

Received: 13.07.2015

Accepted: 09.09.2015

Published online: 14.09.2015

Corresponding author:

Aslı CADUN, Ege University, Faculty of Fisheries, Department of Seafood Processing Technology, 35100 Bornova, İzmir-Turkey

E-mail: asli.cadun@ege.edu.tr

Abstract:

The effect of different types (wheat fiber (WF) and apple fiber (AF)) of fibers and different sizes of wheat fibers (WF 200 and WF 400) on the quality of fish patties during storage was determined. Chemical quality (pH, TVB-N mg N/100g, TBA mg malonaldehyde/kg) instrumental (color, texture parameters and expressible moisture), sensory, and microbiological analysis (yeast and mold, total aerobic plate count) of fish patties were done to determine the effects of the fibers. Functional properties (WRC and FAC) of dietary fibers were also determined. Group control, WF 200 and WF 400 exceeded the consumption limits at day 3 while group AF 400 exceeded the consumption limits at day 5.

Keywords: Fiber, Fish patties, Chemical quality, Sensory, Expressible moisture, Microbiology

Introduction

The most widespread, extensively advertised, and consumed dietary fiber products are those derived from cereals (breakfast cereals, bakery products, biscuits, etc). However, over the past decade high dietary fiber materials from fruits (citrus, apple, and others) are being introduced in the market (Saura- Calixto 1998). Nymann et al (1987) wrote that in addition to wheat bran, the major source of dietary fibers, others sources such as fruits and vegetables have been found (Massiot and Renard 1997). Cho and Dreher (2001) wrote that the addition of fiber in the diet has been recommended strongly because it significantly reduces the risk of colon cancer, obesity and cardiovascular disease (Selgas et al 2005). Dietary fibers are not only desirable for their nutritional properties but also for their functional and technological properties (Aleson- Carbonell et al 2005). Different types of dietary fibers such as pea, apple, sugar beet, soy and citrus fibers as well as inulin and gums are now incorporated into foods for their nutritional properties or for their functional and technological properties (e.g. gelling or thickening properties) (Thebaudin et al 1997). Adding apple fiber as a source of dietary fiber into fish mince based products has not been studied. Apple fiber and apple pomace can be used in cakes, muffins (Chen et al 1988; Massodi et al 2002; Sudha et al 2007), and bread (Chen et al 1988; Masoodi and Chauhan 1998; Gomez et al 2003). The objective of the study was to determine the different size and types of dietary fiber on the quality of fish patties stored at between 0-4ºC.

Materials and Methods

Material

Frozen saithe (*Pollachius virens*) with a 2 months storage period was used as raw material. After being thawed at 4ºC during night, they were minced by using a Kitchen Aid KPM5 Professional meat grinder (St. Joseph, MI, USA). Ingredients (0.9% salt, 0.5% red pepper, 0.4% black pepper, 0.1% powdered onion and 0.1% garlic, 1.3% dried parsley, 0.5% cummin) were added. They were mixed and were divided into 4 groups. For this study Vitacel® (Orion Nişasta ve Kimya San. Tic. A.Ş., Izmir, Turkey) wheat fiber with different sizes and Vitacel® apple fiber were used. Groups were formulated as follows: Group 1: Control without fiber, Group 2 (WF 200): Addition of 3% of wheat fiber 200 with particles 250 µm long and 25 µm wide. Group 3 (WF 400): Addition of 3% of wheat fiber 400 with particles 500 µm long and 25 µm wide. Group 4 (AF 400): Addition of 3% of apple fiber 400 with particles 500 µm long and 25 µm wide After being homogenized with the ingredients, they were shaped manually and stored at between 0-4 ºC.

Analytical Methods

Dietary Fiber Functional Properties

Water retention capacity (WRC) was measured following the method of Ang (1991). Samples (2 g) were mixed with distilled water (30 mL), centrifuged 2000g for 20 min and the excess supernatant was recovered. WRC was expressed as grams of water retained per gram of dry sample.Fat adsorption capacity (FAC). According to the method of Caprez et al (1986) FAC was measured as oil retention capacity (Sanchez- Alanso et al 2007b). Samples (0.5 g) were mixed with sun- flower oil (10 mL), left overnight at room temperature and centrifuged for 10 min at 3000g. The excess supernatant was decanted and FAC was expressed as grams of oil retained per gram of dry sample.

Physical and Chemical Quality Analysis of Fish Patties

Thiobarbituric acid, TBA, mg malonaldehyde/kg (Tarladgis et al 1960), total volatile base-nitrogen, TVB-N, mg N/100g (Vyncke 1996) and pH values of fillets were measured (ASU 1980). The pH value was recorded using a Hanna 211 model pH meter (Cluj-Napoca, Romania).

Instrumental Analysis

Color measurements were performed on saithe patties by using a Dr. Lange Spectro Pen ®. The color was measured on each 10 fish patties with repeating 3 times using different parts of the surface. In the CIE $L^*a^*b^*$ system, L^* denotes lightness on a scale from 0 to 100 from black to white; a^* denotes (+) red or (–) green; b^* denotes (+) yellow or (–) blue (Schubring et al, 2003).

The measurement of the texture properties (texture profile analysis or TPA) of fish patties was performed using a TA.XT Plus Texture Analyser (Stable Micro Systems, Godalming, UK) equipped with a flat cylindrical plunger (5 cm diameter). All TPA measurements were repeated 10 times (Schubring and Oehlenschlager 1997). Additionally, texture measurements on fish patties and the penetration force of homogenized patties were also determined using the TA.XTPlus fitted with a spiked aeration plunger equipped with 8

small cylinders, diameter 3 mm each, which are arranged in two different squares. Measurements were repeated three times (Schubring, 2001).

WHC was characterized by measuring EM, which means the quantity of liquid squeezed from fish patties up a compression (Jonsson et al 2001). EM was determined using a modification of the filter paper press method as described elsewhere (Schubring et al 2003). Samples were pressed between paired filter sheets (Schleicher & Schuell 2043 A, 7x7 cm) and parallel plates using a texture analyser TA.XTPlus (stable micro systems, Godalming, UK). WHC was determined as the expressible moisture, calculated as %=100 (initial weight-final weight)/initial weight.

Sensory Analysis

Sensory analysis of cooked fish patties were done by 5 trained panelists according to Yanar and Fencioglu (1999) and Vanitha et al (2013) with slight modifications. Fish patties were cooked in the oven at 135ºC just before serving to the panelists and panelists were asked to evaluate the fish patties according to appearance, texture, odor, flavor, juiciness, and overall quality with 10 point scale test. The observation was converted to equivalent numerical scores and a sensory score of 4 was taken as the borderline of overall acceptability.

Microbiological Analysis

For all microbial counts, 10 g of fish patties were weighed and transferred into 90 mL of 0.1% peptone water (Oxoid, Basingstoke, UK), and samples were homogenized in a Stomacher (IUL Instruments, Barcelona, Spain) for 1 min. From the prepared dilutions, total aerobic plate (AP) count and yeast-mold (YM) count were carried out. Plate Count Agar (PCA, Oxoid CM 325) was used for AP with incubation period of 30°C/24-48 while Potato Dextrose Agar (PDA, Oxoid CM 139) was used for YM count with incubation period of 30°C/3-5 days (Harrigan and McCance 1976).

Statistical Analysis

Data were subjected to one way analysis of variance (ANOVA) followed by Tukey and Duncan test to determine the significant differences (P<0.05) between mean values (SPSS 9.05).

Results and Discussion

Dietary Fiber Functional Properties

While the long dietary fiber had a more open structure, the structure of the short one was more dense and absorbed less water than the long one (Sanchez- Alonso et al 2007b). Thebaudin et al (1997) reported that particle size effects fat absorption capacity and wheat bran fibers have a high FAC, especially at larger particle size which is same with our results. Functional properties of apple fiber AF 400, WF 200 and WF 400 was given in table 1. WF 400 have significantly higher FAC values than group with WF 200. Similar results have been reported by Sanchez Alanso, et al (2006) and Sanchez- Alonso et al (2007b).

Table 1. Functional properties of wheat and apple fiber

Groups	WRC (g/g)	FAC(g/g)
WF 400	10.24±1.32[a]	8.13±0.10[a]
WF 200	6.17±0.00[b]	4.69±0.12[b]
AF 400	3.40±0.02[c]	1.47±0.05[c]

* means in the same column with the same letter do not differ significantly at the level of 0.05 significance.

Physical and Chemical Quality Analysis

Physical and chemical quality changes of fish patties during storage were given in table 2. pH values of the control group and AF 400 decreased significantly at the end of the storage period ($p<0.05$), while pH values of group with WF 200 and WF 400 increased significantly at the end of the storage period ($p<0.05$).

TVB-N is used for determination of the spoilage level of fish during the storage period

(Oehlenschlager 1997). The level of 35 mg/100 g has been considered the upper limit, any level above 35mg/100g in fishery products are considered spoiled (Ludorff and Meyer 1973, Schormüller, 1968). TVB-N values of all groups increased significantly during the storage period. And group control, WF 200 and WF 400 exceeded the consumption limits according to TVB-N at day 5. While AF 400 was determined as still consumable at day 5. Yerlikaya et al (2005) reported that initial TVB-N value of fish patties produced from anchovy increased during the 6 days of refrigerated storage but did not exceed the throughout the storage. Gökoğlu (19994) reported that TVB-N values

of fish patties made from mackerel increased during the storage and exceeded the acceptable limits at day 10. Quantification of the amount of MDA by thiobarbituric acid (TBA) has been widely used as a parameter for the extent of oxidative deterioration of meat products (Kebede et al 2007). According to TBA results, no significant differences were determined between the groups and even at the end of the storage period, they were still found as in perfect quality (Schormüller 1968, 1969). Our present TBA results are similar with those of Sanchez Alanso et al (2006). They reported that no significant variation in the determination of the TBA index throughout frozen storage in the different lots for both types of muscles with and without fiber. Yanar and Fenercioğlu (1999) reported that TBA values of fish balls prepared from carp flesh did not exceed the acceptable limits during frozen storage.

Table 2. Chemical quality changes during storage period of fish patties

Groups	Storage (days)	pH	TVB-N (mg/100g)	TBA (mg malonaldehyde/kg)
Raw		6.45±0.01	18.03±0.51	2.89±3.44
Control	0	6.51±0.01^{a1}	19.21±1.35^{a1}	0.54±0.08^{a1}
	3	6.46±0.02^{b1}	24.24±0.51^{b1}	0.67±0.20^{a1}
	5	6.35±0.01^{c1}	40.20±2.71^{c1}	0.81±0.18^{a1}
AF 400	0	6.42±0.01^{a2}	19.51±0.89^{a1}	0.57±0.04^{a1}
	3	6.34±0.02^{b2}	22.46±0.51^{b2}	0.66±0.13^{a1}
	5	6.21±0.01^{c2}	30.15±0.89^{c2}	1.05±0.37^{a1}
WF200	0	6.56±0.01^{a1}	18.32±0.51^{a1}	0.34±0.06^{a2}
	3	6.51±0.01^{b3}	30.44±0.51^{b3}	0.47±0.01^{ab1}
	5	7.06±0.01^{c3}	68.27±41.23^{c3}	0.58±0.11^{b1}
WF400	0	6.50±0.05^{a1}	18.03±0.51^{a1}	0.44±0.06^{a12}
	3	6.46±0.02^{a1}	31.33±0.51^{b3}	0.73±0.39^{a1}
	5	7.12±0.01^{b4}	65.91±2.23^{c3}	0.74±0.13^{a1}

*__a,b,c:__ different letters in the same column for an attribute of a group show a significant difference ($p<0.05$).
__1,2,3:__ different numbers in the same column for the same storage day show a significant difference($p<0.05$).
__n:__ 3 (arithmetic mean ±SD)

Instrumental Analysis

Changes in color parameters during storage period were given in table 3. L*(lightness) and b* (yellowness) values of WF 200 and WF 400 were significantly higher than the values of group control and AF 400 during the storage period ($p<0.05$). Sanchez Alanso et al. (2007b) reported that the addition of wheat fiber increased the b* value significantly. a*(redness) values of group with apple fiber were slightly higher than the other groups during the storage period ($p>0.05$). The color of dietary fibers influenced the color of fish patties. The differences in color may affect the consumer preference.

Changes in expressible moisture was given in table 4. When comparing expressible moisture of the groups at the end of the storage period, group control has the lowest expressible moisture (means highest water holding capacity) ($p<0.05$). These results are comparable to that reported by Sanchez Alanso et al (2006) and Sanchez Alanso et al (2007b). They reported that water binding capacity was lower in samples containing wheat dietary fiber as an ingredient than in control sample. The proportion of bound water did not change significantly when different particle size of wheat dietary fiber was used which was the same as the result of the present study.

Changes in texture parameters during storage period were given in table 5. Hardness value of WF 200 increased while AF 400 decreased significantly at the end of the storage period ($p<0.05$). WF 400 and control were harder than the other groups. When comparing adhesiveness and springiness values, no significant differences were determined during shelf life of each group. According to resilience values, trends were not consistent when comparing groups.

Table 3. Changes in color parameters during storage period of fish patties.

Color parameters	Storage Period (day)s		
	0	3	5
Control L*	38.32±1.20^{a1}	34.02±1.73^{b1}	36.28±1.45^{c1}
a*	05.70±1.28^{a1}	04.56±0.83^{b1}	04.66±0.64^{ab1}
b*	18.24±1.93^{a1}	16.73±1.60^{ab1}	16.39±1.65^{b1}
AF400 L*	38.35±1.50^{a1}	34.88±2.93^{b1}	36.62±1.36^{ab1}
a*	07.64±1.04^{a2}	06.13±1.24^{b2}	06.19±0.99^{b2}
b*	19.73±1.40^{a1}	18.70±1.26^{ab12}	17.66±1.66^{b1}
WF 200 L*	44.28±1.79^{a2}	40.96±1.50^{b2}	44.41±1.85^{a2}
a*	05.97±0.60^{ab12}	05.19±0.66^{a12}	06.00±0.87^{b2}
b*	22.02±0.96^{a2}	20.05±1.17^{b2}	20.5±1.59^{b2}
WF 400 L*	46.26±3.05^{a2}	40.75±2.55^{b2}	43.38±1.44^{b2}
a*	06.62±0.77^{a2}	5.25±0.96^{b12}	05.73±1.35^{b12}
b*	22.03±2.26^{a2}	19.51±2.36^{b2}	21.58±1.85^{ab2}

**: Means in the same column with the same number in the same day in the same attribute do not differ significantly at the level of 0.05 significance.
Means in the same row with the same letter in the same attribute do not differ significantly at the level of 0.05 significance. **n:** 3 (arithmetic mean ±SD)

Table 4. Expressible moisture values of fish patties

Groups	1.Day	5.Day
Control	3.10±0.34^{a3}	0.89±0.29^{b1}
AF400	4.11±0.59^{a23}	2.60 ±0.51^{b2}
WF200	6.69±1.40^{a1}	3.04±0.67^{b2}
WF400	5.97±0.64^{a12}	2.91±0.78^{b2}

* means in the same row with the same letter do not differ significantly at the level of 0.05 significance.
means in the same column with the same lnumber do not differ significantly at the level of 0.05 significance.

Table 5. Changes in texture parameters during storage period

Groups	Storage (days)	Hardness (N)	Adhesiveness	Springiness	Cohesiveness	Chewiness	Resilience
Control	**0**	92.38±3.40^{a1}	-0.04±0.08^{a1}	0.73±0.07^{a1}	0.55±0.04^{a1}	36.08±4.27^{a12}	0.17±0.01^{a12}
	3	108.32±5.12^{b1}	-0.63±0.57^{a1}	0.73±0.13^{a1}	0.54±0.08^{a1}	41.80±4.66^{a1}	0.18±0.06^{a12}
	5	100.18±7.71^{a1}	-1.28±1.47^{a1}	0.72±0.11^{a1}	0.54±0.04^{a1}	40.86±5.69^{a1}	0.18±0.02^{a1}
AF400	**0**	77.42±4.15^{a2}	-0.03±0.02^{a2}	0.74±0.06^{a1}	0.54±0.02^{a1}	30.54±2.96^{a1}	0.14±0.01^{a1}
	3	86.26±4.41^{b2}	-0.01±0.01^{a1}	0.72±0.02^{a1}	0.54±0.08^{a1}	34.15±2.55^{b2}	0.15±0.01^{a1}
	5	62.39±4.03^{c2}	-0.63±0.57^{b12}	0.79±0.04^{b1}	0.71±0.03^{b2}	35.47±2.82^{b1}	0.26±0.03^{b2}
WF 200	**0**	82.37±5.72^{a2}	-0.01±0.01^{a1}	0.70±0.14^{a1}	0.65±0.08^{ab2}	36.66±3.43^{a23}	0.23±0.07^{a2}
	3	81.80±4.03^{a2}	0.00±0.00^{a1}	0.74±0.20^{a1}	0.69±0.07^{a2}	44.26±3.63^{b1}	0.25±0.10^{a23}
	5	91.95±2.33^{b1}	-1.28±1.47^{a2}	0.78±0.01^{a1}	0.58±0.04^{b1}	39.14±4.83^{ab1}	0.30±0.04^{a1}
WF 400	**0**	98.05±6.7^{a1}	-0.01±0.00^{a1}	0.70±0.17^{a1}	0.64±0.09^{a2}	45.02±4.87^{a3}	0.20±0.09^{a12}
	3	93.57±7.52^{b1}	-0.01±0.01^{a1}	0.81±0.02^{a1}	0.73±0.03^{b2}	46.19±3.28^{b1}	0.30±0.04^{b3}
	5	96.11±4.92^{a1}	-0.24±0.34^{a12}	0.72±0.10^{a1}	0.61±0.06^{a1}	40.82±3.76^{a1}	0.21±0.05^{a1}

*: Means in the same column with the same number in the same day in the same attribute do not differ significantly at the level of 0.05 significance.
Means in the same column with the same letter in the same group do not differ significantly at the level of 0.05 significance. **n:** 3 (arithmetic mean±SD)

Sensory Analysis

Changes in sensory parameters during storage was given in table 6. Sensory scores were only recorded for fish patties that had not exceeded the microbiological limit value of 6 log cfu/g (Kılınç, 2007; Kaba et al. 2012) According to sensory parameters and overall quality scores, group with apple fiber were slightly higher than the other groups. Panelists also mentioned that no fruity taste in fish patties with AF 400 was determined. It seems that it lost its fruity odor in the fish patties. It might be because of adding other ingredients (salt, red pepper, black pepper, onion, garlic, parsley, and cumin) and/or the amount of those ingredients.

Microbiological Analysis

Changes in AP counts of fish patties were given in Table 7. AP count is generally used as an acceptability index for fish and fish products because of the bacterial effects in spoilage (Jeon et al., 2002; Çoban and Özpolat, 2013). The inital AP count of fish patties was 5.22–5.94 log CFU/g. Significant differences ($P < 0.05$) were determined between the groups (Table 7). The lowest AP counts were observed in the fish patties with AF 400 as compared to other groups during whole storage period at 0-4°C. At the time of spoilage, AP count was determined as 10^6–10^7 cfu/g in fish products (Ulrike et al. 2000; Sehgal et al. 2011). In the present study, fish patties with WF 400, WF 200 and control samples spoiled at 3 days while fish patties with AF 400 spoiled at 5 days of storage. TVB-N is one of the most widely used indices of fish and fish product quality. Although TVB-N values of fish patties increased with the growth of microorganisms by the storage period, all groups except one with AF 400 exceeded the consumption limits according to TVB-N results at day 5. Changes in YM counts of fish patties were given Table 8. The inital YM count of fish patties was 2.08–2.98 log CFU/g. Similar to the AP counts, the lowest YM counts were observed in the fish patties with AF 400 during whole storage period at 0-4°C Kilinc (2009) did not detect any yeasts and molds in anchovy patties during refrigerated storage period. However, Guran et al (2015) determined YM counts in fish patties during the storage at 4°C as 2.48 (0. day), 2.89 (2. day) and 3.20 (4. day). In that study, results of sensory evaluation showed that the shelf life of fish patties was 4 days. Our results were almost similar to the findings of that study. It must be noted that a good correlation was noted between microbiological (AP) and chemical parameters (TVB-N) of all groups.

Table 6. Changes in sensory parameters during storage period of fish patties

Groups	Storage (days)	Appearance	Odour	Texture	Juiciness	Flavour	Overall Quality
Control	0	8.75±0.50^{a1}	7.75±0.96^{a1}	7.50±0.58^{a1}	7.00±1.41^{a1}	7.25±0.50^{a1}	7.75±0.96^{a1}
	3	7.75±1.26^{a1}	7.25±0.50^{a1}	7.00±0.82^{a1}	6.25±0.50^{a1}	6.75±0.50^{a1}	7.00±0.82^{a1}
	5	**	**	**	**	**	**
AF 400	0	8.75±1.26^{a1}	9.25±0.50^{a1}	7.75±0.96^{a1}	7.50±1.00^{a1}	8.25±1.71^{a1}	8.25±1.50^{a1}
	3	7.75±1.26^{a1}	8.00±0.82^{a1}	7.75±1.26^{a1}	7.00±0.82^{a1}	7.25±1.26^{a1}	7.25±1.26^{a1}
	5	**	**	**	**	**	**
WF 200	0	7.50±1.00^{a}	8.00±0.82^{a}	7.75±1.26^{a}	7.50±1.29^{a}	8.00±0.82^{a}	8.00±0.82^{a}
	3	**	**	**	**	**	**
	5	**	**	**	**	**	**
WF 400	0	7.25±0.96^{a}	8.25±1.50^{a}	7.25±0.96^{a}	7.25±1.50^{a}	7.50±0.58^{a}	7.75±0.96^{a}
	3	**	**	**	**	**	**
	5	**	**	**	**	**	**

*: Means in the same column with the same number in the same day in the same attribute do not differ significantly at the level of 0.05 significance.
Means in the same column with the same letter in the same attribute do not differ significantly at the level of 0.05 significance. **n:** 3 (arithmetic mean±SD)

**: According to microbiological results, they passed the consumption limits.

Table 7. Changes in total aerobic plate (AP) counts of fish patties stored at (0-4ºC)

	Storage Period (day)		
	1	3	5
Control	5.23±0.03[a]	6.31±0.12[b]	6.68±0.09[b]
AF 400	5.28±0.08[a]	5.44±0.02[a]	6.02±0.02[a]
WF 200	5.22±0.05[a]	6.71±0.08[c]	7.93±0.10[c]
WF 400	5.94±0.03[b]	7.73±0.12[d]	8.93±0.04[d]

* means in the same column with the same letter do not differ significantly at the level of 0.05 significance.

Table 8. Changes in yeast mold counts of fish patties stored at (0-4 ºC)

	Storage Period (day)		
	1	3	5
Control	2.98±0.03[b]	3.32±0.07[c]	3.59±0.08[c]
AF 400	2.08±0.03[a]	2.69±0.01[a]	2.86±0.04[a]
WF 200	2.20±0.26[a]	3.45±0.04[d]	3.71±0.03[d]
WF 400	2.23±0.20[a]	3.07±0.06[b]	3.38±0.03[b]

* means in the same column with the same letter do not differ significantly at the level of 0.05 significance.

Conclusion

Apple fibers have been incorporated into bakery products. According to the results of the present study, it can be also incorporated into fishery products which are not common. According to the present study adding apple fiber to fish patties prolong shelf life at 0-4ºC.

References

Aleson-Carbonell, L., Fernández-López, J., Pérez-Alvarez, J.A. Kuri, V. (2005): Functional and Sensory Effects of Fibre-rich Ingredients on Breakfast Fresh Sausages Manufacture. *Food Science and Technology International,* 11: 89-97.

Amtliche, Sammlung von Untersuchungsverfahren (ASU) nach § 35 LMBG 1980. Messung des pH- Wertes in Fleisch und Fleischerzeugnissen. Untersuchung von Lebensmitteln, L06.00/2.

Ang, J.F. (1991): Water retention capacity and viscosity effect of powdered cellulose. *Journal of Food Science*, 56(6): 1681-1684.

Caprez, A., Arrigoni, E., Amodo, R., Neukom, H. (1986): Influence of different type of thermal treatment on the chemical composition and physical properties of wheat bran. *Journal of Cereal Science*, 233–239.

Chen, H., Rubenthaler, G.L., Leung, H.K. Baranowski, J.O. (1988): Chemical, physical and baking properties of apple fiber compared with wheat and oat bran. *Cereal Chemistry*, 65(3): 224-247.

Cho, S.S., Dreher, M.L. (2001). Handbook of dietary fiber. New York: Marcel Dekker Inc.

Çoban, Ö.E., Özpolat, E. (2013): the effects of different concentrations of rosemary (*Rosmarinus officinalis*) extract on the shelf life of hot-smoked and vacuum-packed *luciobarbus esocinus* fillets. Journal of *Food Processing and Preservation,* 37: 269-274

Gomez, M., Ronda, F., Blanco, A., Caballero, P.A., Apesteguia, A. (2003): Effect of dietary fiber on dough rheology and bread quality. *European Food Research and Technology*, 216: 51-56.

Gökoğlu, N. (1994): Balık köftesinin Soğukta Depolanması, *Gıda Dergisi*, 19(3): 217-220.

Guran, H.S., Oksuztepe, G., Coban, Ö.E., İncili, G.K (2015): Influence of Different Essential Oils on Refrigerated Fish Patties Produced from Bonito Fish (*Sarda sarda* Bloch, 1793). *Czech Journal of Food Science*, 33 (1): 37–44.

Harrigan, W.F. McCance, M.E. (1976): Laboratory methods in food and dairy microbiology. London: Academic Press Inc.

Jeon, J., Kamil, J.Y.V.A., Shahidi, F. (2002). Chitosan as an edible invisible film for quality preservation of herring and Atlantic cod. *Journal of Agricultural and Food Chemistry*, 50: 5167–5178

Kilinc, B. (2009): Microbiological, sensory and color changes of anchovy (*Engraulis encrasicholus*) patties during refrigerated storage. *Journal of Muscle Foods*, 20: 129–137

Sehgal, H.S., Shahi, M., Sehgal, G.K., Thind, S.S. (2011): Nutritional, microbial and organoleptic qualities of fish patties prepared from carp (*Cyprinus carpio* Linn.) of three weight groups. *Journal of Food Science and Technology*. 48: 242-245

Jonsson, A., Sigurgisladottir, S., Hafsteinsson, H., Kristbergsson, K. (2001) **:** Textural properties of raw Atlantic salmon (*Salmo salar*) fillets measured by different methods in comparison to expressible moisture. *Aquaculture Nutrition*, 7: 81-89.

Kaba, N., Yücel, Ş, Çorapçı, B. Özer, Ö., Eryasar, K. (2012) : Shelf life of anchovy patties stored at 4°C. *Akademik Gıda*, 10(4): 19-23.

Kebede, E., Mannheim, C.H., Miltz, J. (2007): The TBA method as an index of oxidation of thermally preserved turkey meat in plastic trays and cans. *Journal of Food Processing and Preservation*. 22(2): 139-153.

Ludorff, W., Meyer, V. (1973): Fische und Fischerzeugnisse. Hamburg-Berlin: Paul Parey Verlag.

Massiot, P., Renard, CMGC. (1997): Composition, Physico-chemical Properties and Enzymatic Degradation of Fibres Prepared from Different Tissues of Apple. *Lebensmittel-Wissenschaft & Technologie*, 30: 800–806.

Masoodi, F.A., Chauhan, G.S. (1998): Use of apple pomace as a source of dietary fiber in wheat bread. *Journal of Food Processing and Preservation,* 22: 255-263.

Masoodi, F.A., Sharma, B., Chauhan G.S. (2002): Use of apple pomace as a source of dieatary fiber in cakes. *Plant Foods for Human Nutrition,* 57: 121-128.

Nyman, M., Palsson, K.E., Asp, N-G. (1987): Effects of processing on dietary fibre in vegetables. *Lebensmittel Wiss Technology,* 20: 29-36.

Oehlenschlager, J. (1997): Volatile amines as freshness/spoilage indicators, a literature review, In J. B. Luten, T. Borresen, J. Oehlenschlager (Eds.). Seafood from producer to consumer, integrated approach to quality: 25th WEFTA International Seafood Conference. Amsterdam, The Netherlands: Elsevier Science B.V. 38: 571–586.

Sanchez- Alanso, I., Haji- Maleki R., Borderias, A.J. (2006): Effect of wheat fibre in frozen stored fish muscular gels. *European Food Research Technology*, 223: 571-576.

Sanchez- Alanso, I., Haji- Maleki, R., Borderias, A.J. (2007a): Wheat fiber as a functional ingredient in restructured fish products. *Food Chemistry*, 100: 1037-1043.

Sanchez- Alonso, I., Solas M.T., Borderias, A.J. (2007b): Technological implications of addition of wheat dietary fibre to giant squid (*Dosidicus gigas*) surimi gels. *Journal of Food Engineering*, 81: 404-411.

Saura-Calixto, F. (1998): Antioxidant Dietary Fiber Product: A New Concept and a Potential Food Ingredient. *Journal of Agricultural and Food Chemistry*, 46: 4303-4306.

Selgas, M.D., Caceres, E., Garcia, M.L. (2005): Long-chain Soluble Dietary Fibre as Functional Ingredient in Cooked Meat Sausages. *Food Science and Technology International,* 11: 41-47

Schormüller, J. (1968): Handbuch der lebensmittekhemie (Band HI/2). Berlin: Springer.

Schormüller, J. (1969): Handbuch der lebensmittelchemie (Band IV). Berlin: Springer.

Schubring, R., Oehlenschlager, J. (1997): Comparison of the ripening process in salted Baltic and North Sea herring as measured by instrumental and sensory methods. *Zeitschrift für Le0bensmittel-Untersuchung und –Forschung,* 205: 89-92.

Schubring, R. (2001): Double freezing of saithe fillets. Influence on sensory and physical attributes. *Nahrung/Food*, 45: 280-285

Schubring, R., Meyer, C., Schlüter, C., Boguslawski, S., Knorr, D. **(**2003): Impact of high pressure assisted thawing on the quality of fillets from various fish species. *Innovative Food Science and Emerging Technologies,* 4:257-267.

Sudha, M.L., Baskaran, V., Leelavathi, K. (2007): Apple pomace as a source of dietary fiber and polyphenols and its effect on the rheological characteristics and cake making. *Food Chemistry*, 104: 686-692.

Tarladgis, B.G., Watts, B.M., Younathan, M.S., Dugan, L.Jr. (1960): A distillation method for the quantitative determination of malonaldehyde in rancid foods. *Journal of American Oil Chemists Society*, 37: 44-48.

Thebaudin, J.Y., Lefebvre, A.C., Harrington, M., Bourgeois, C.M. (1997): Dietary fibers: Nutritional and Tecnological Interest. *Trends in Food Science & Technology,* 8: 41-47.

Ulrike, L, Janne, L., Maria, F.A., Eija, H.T, Kai, E., Haana, K. (2000): Microbiological qualityand shelf-life of vacuum-packaged gravid rainbow trout stored at 3 and 8°C. *International Journal of Food Microbiology*, 70: 221-230.

Vyncke, W. (1996): Comparison of the official EC method for determination of total volatile bases in fish with routine methods. *Archiv für Lebensmittelhygiene* 47:110-112.

Yanar, Y. Fenercioglu, H. (1999): The utilization of carp flesh as fish ball. *Turkish Journal of Veterinary and Animal Science*. 23: 361-365.

Yerlikaya, P., Gökoğlu, N., Uran, H. (2005): Quality changes of fish patties produced from anchovy during refrigerated storage, *European Food Research and Technology*, 220: 287-291.