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Full Length Research Paper

Effects of pan frying with different oils on some of the chemical components, quality parameters and cholesterol levels of rainbow trout (*Oncorhynchus mykiss*)

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The changes in chemical composition, cholesterol and fatty acids have been determined in raw and fried rainbow trout. Olive oil, sunflower oil, corn oil, margarine and butter were used in the frying process. Moisture content was decreased and protein, fat, ash and cholesterol contents were increased after frying. Differences in moisture, protein, fat, and ash content between the samples were significant ($P < 0.05$). pH, thiobarbituric acid (TBA), and total volatile basic nitrogen (TVB-N) values were within the limiting depletability values. In the fish fried with sunflower oil and corn oil, an important amount of decrease ($P < 0.05$) was determined for myristic, palmitic, palmitoleic, stearic, linolenic, arashidic, and docosahexaenoic acid (DHA). However, an important amount of increase ($P < 0.05$) was determined in heptadecanoic, oleic, and linoleic acid. DHA content was decreased in all oil groups. Cholesterol level was increased with the use of butter. The lowest level of cholesterol was observed in fish fried with margarine.

Key words: Rainbow trout, frying, fatty acid, cholesterol.

INTRODUCTION

Human beings need omega-3 fatty acids at every stage of life. It is known that more than 50% of dying reduces illnesses such as heart attack, embolism, high cholesterol and cancer. Therefore, nowadays people are very careful in their feeding patterns prefering healthy foods, especially in developed country. Among foods, seafood are rich in unsaturated fatty acids. Fat not only act as a source of energy but also, serve as a storage house for the fat soluble vitamins. With increase in the study on fish oil, it has been well understood that the fish fatty acids has positive effects on human health.

A regular consumption of fish is recommended in view of its high content of long chain omega-3 (n-3) polyunsaturated fatty acid (PUFA), especially eicosapentaenoic acid (EPA, $C_{20:5n-3}$) and docosahexaenoic acid (DHA, $C_{22:6n-3}$). No other food group is naturally as rich in n-3 PUFA as fish and other seafoods (Sioen et al. 2006). The nutritive value of fish can be affected by processing or cooking methods. Several studies were undertaken to determine the effects of different cooking methods on the fatty acids of fish species, in particular deep fat-frying, oven-baking, grilling, microwave cooking (Sebedio et al., 1993; Candela et al., 1997; Garcia-Arias et al., 2003; Gokoglu et al., 2004; Ersoy et al., 2006; Gladsyev et al., 2006; Sioen et al., 2006).

Rainbow trout (*Oncorhynchus mykiss*) is an extensively cultured species in Turkey. Total production of rainbow trout was 65.928 tons in 2008 (www.tuik.gov.tr). Recently, the consumption of this species has increased. In Turkey, rainbow trout is a widely consumed freshwater fish

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Abbreviations: PUFA, Polyunsaturated fatty acid; **EPA,** eicosapentaenoic acid; **DHA,** docosahexaenoic acid; **TBA,** thiobarbituric acid; **TVB-N,** total volatile basic nitrogen; **C,** fresh fish; **SFO,** sunflower oil; **OO,,** fish fried in olive oil; **CO,** fish fried in corn oil; **MO,** fish fried in margarine; **BO,** fish fried in butter.

Table 1. The temperature of oils and core fish meat.

Oil	Oil temperature	Core temperature of fish
Sun flower oil	180 ± 5°C	90.86 ± 1.96°C
Corn oil	190 ± 1°C	95.06 ± 1.22°C
Olive oil	180 ± 5°C	95.64 ± 0.92°C
Butter	175 ± 5°C	94.87 ± 1.37°C
Margarine	160 ± 5°C	96.00 ± 1.09°C

species. This species is usually treated by frying. In Turkish households, the use of saturated fats for pan-frying is being increasingly replaced by the use of more healthy unsaturated vegetable oils, especially olive oil. Some families are used to using butter oil for pan-frying.

The objective of the present study was to investigate the effect of pan-frying with five different culinary fats (olive oil, sun flower oil, margarine, butter and corn oil) on the chemical components, quality parameters and cholesterol levels of rainbow trout.

MATERIALS AND METHODS

Sample preparation

The fish, rainbow trout (*O. mykiss* Walbaum, 1792) were obtained from trout farm in Isparta, Turkey. The fish were harvested from ponds by dip net, kept in cold iced boxes and transferred to the laboratory within 2 h. A total of 42 fish was provided. The mean length and weight of fish were 28.28 ± 0.95 cm and 256.47 ± 22.96 g, respectively. On arrival at the laboratory, the fish were washed with tap water to remove adhering blood and slime. Then, fresh fish were prepared using a handling process, namely eviscerating, beheading and washing, and then cooked by frying.

Cooking procedures

The first group (C) was uncooked. Sun flower oil, corn oil, olive oil, butter, and margarine were used for pan-frying. For all the frying experiments, frying pan □Ø = 30 cm) was used on the heating unit. After each frying process, the pan was cleaned in the same way. During frying, the core temperature of fish and oil was recorded (Thermometer model Testo 105). The temperature of oils and core fish meat were measured (Table 1).

The amount of culinary fat used for pan-frying was equal approximately. Oils were used once with the food/oil ratio being 500 g/l. The rainbow trout samples (n = 7) were pan-fried for 10 min. After pan-frying, each fried sample was deboned and skinned and then minced. Minced fish samples were frozen at -18°C prior to all analyses. All minced samples were vacuum packaged for protection against atmospheric oxygen.

Analytical procedures

Moisture content was measured with automatic moisture analyzer (AND MX-50). Protein contents were determined (Velp UDK 142) according to Kjeldahl methods (Nx6,25) (AOAC, 2000). Crude fat, and crude ash contents were determined according to standard procedures (Lovell, 1975; Lovell, 1981). pH was measured in the dorsal muscle with a digital electronic pH meter with a glass electrode (WTW Mark 320). Thiobarbituric acid (TBA) was determined as described by Erkan and Özden (2008) reported from Weilmeier and Regenstein (2004) and Khan et al. (2006). Total volatile basic nitrogen (TVB-N) values were estimated using the method described by Malle and Tao (1986) and Malle and Poumeyrol (1989).

The method of Bligh and Dyer (Hanson and Olley, 1963) was carried out for the lipid extraction. Fatty acid profile was determined by gas chromatography after methylation with sodium metoxide according to methods of Izquierdo et al. (2002) and Tokuşoğlu et al. (2007). The samples were injected into a gas chromatography (QP 5050 GC/MS) fitted with a capillary column Cp WAX 52 (CB50 m x 0.32 mm x 1.2 µm). The temperatures of the injection port and detector were 240 and 250°C respectively. The oven temperature was 175°C for 27 min running time, followed by an increase to 215°C at a rate of 4°C/min and 5 min at 215°C and followed by an increase to 240°C at a rate of 4°C/min and 15 min at 240°C. The carrier gas was helium (10 psi). The identification of peaks was performed by comparison of their retention times with those of pure standard Supelco 37 component FAME mix, 18919-1 amp. (Cat no: 18919).

The determination of cholesterol was carried out by gas chromatography according to the method described by Psomas et al. (2003) and Fletouris et al. (1998) Perkin Elmer Autosystem XL GC equipped with Zebron ZB-1 column (15 m x 0.32 mm i.d.). The oven temperature was 285°C. The temperatures of the injection port and FID detector were both 300°C. The sample (1 µl) cholesterol was identified by comparing its relative and absolute retention times.

Statistical analysis

Every parameter was measured in triplicate for each sample. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) v.9.0 for Windows. Analysis of variance (ANOVA) was used and statistical significance was set at $P < 0.05$.

RESULTS AND DISCUSSION

Table 2 shows the chemical composition of fresh and fried samples. According to these analyses, water content was decreased but protein, fat and ash contents were increased in fried rainbow trout samples. pH, TBA, and TVB-N values of all samples are given in Table 3. The pH value was found as 6.787 ± 0.054 in raw fish materials and decreased after frying. The TBA value of raw rainbow trout was 0.420 ± 0.015 µgMDA /kg. This value increased in the fried samples. In addition, TVB-N value was increased in fried samples except for the fish

Table 2. Some chemical components of fresh and fried samples (% ± SE).

Group	Water	Protein	Fat	Ash
C	73.780 ± 0.255^{a}	19.629 ± 0.229^{d}	4.224 ± 0.060^{d}	1.430 ± 0.058^{d}
OO	59.467± 0.298^{d}	28.035 ± 0.672^{a}	7.667 ± 0.161^{ab}	1.925 ± 0.012^{a}
SFO	59.723 ± 1.067^{d}	26.410 ± 0.358^{bc}	7.903 ± 0.874^{a}	1.866 ± 0.047^{a}
CO	60.913 ± 0.266^{d}	27.504 ± 0.177^{ab}	6.523 ± 0.519^{bc}	1.829 ± 0.006^{ab}
MO	63.267 ± 0.390^{c}	26.979 ±0.089^{abc}	5.540 ± 0.060^{cd}	1.725 ± 0.035^{bc}
BO	65.013 ± 0.175^{b}	26.133 ± 0.164^{c}	5.292 ± 0.123^{cd}	1.636 ± 0.026^{c}

*Different letters in the same column show significant differences among samples ($P < 0.05$). C: Control; OO: fried with olive oil; SFO: fried with sun flower oil; CO: fried with corn oil; MO: fried with margarine; BO: fried with butter.

Table 3. The pH, TBA, TVB-N and cholesterol values of fresh and fried samples (± SE).

Group	pH	TBA (µgMDA/kg)	TVB-N (mg/100g)	Cholestrol (µg/g)
C	6.787 ± 0.054^{a}	0.420 ± 0.015^{e}	22.960 ± 2.019^{c}	14.260 ± 0.217^{e}
OO	6.353 ± 0.012^{c}	2.113 ± 0.061^{a}	26.933 ± 0.488^{ab}	56.037 ± 1.306^{b}
SFO	6.350 ± 0.006^{c}	1.763 ± 0.038^{b}	23.800 ± 0.244^{bc}	33.363 ± 0.979^{c}
CO	6.477 ± 0.012^{b}	1.560 ± 0.044^{c}	28.260 ± 0.447^{a}	56.810 ± 0.586^{b}
MO	6.433 ± 0.012^{b}	0.757 ± 0.041^{d}	22.680 ± 0.194^{c}	19.043 ± 0.794^{d}
BO	6.410 ± 0.010^{bc}	1.493 ± 0.022^{c}	24.984 ± 1.239^{bc}	69.000 ± 1.183^{a}

*Different letters in the same column show significant differences among samples ($P < 0.05$). C: Control; OO: Fried with olive oil; SFO: Fried with sun flower oil; CO: Fried with corn oil; MO: Fried with margarine; BO: Fried with butter

Table 4. The changes in the fatty acid contents of fresh and fried rainbow trout samples (% ± SE).

Fatty acid	C	OO	SFO	CO	MO	BO
$C_{4:0}$	-	-	-	-	-	0.663±0.068^{a}
$C_{6:0}$	-	-	-	-	-	0.673±0.064^{a}
$C_{8:0}$	-	-	-	-	0.337±0.037^{b}	0.523±0.038^{a}
$C_{10:0}$	-	-	-	-	0.347±0.092^{b}	1.297±0.072^{a}
$C_{12:0}$	-	-	-	-	3.307±0.162^{a}	1.457±0.080^{b}
$C_{14:0}$	2.290±0.079^{b}	1.067±0.028^{c}	1.080±0.044^{c}	0.800±0.090^{d}	2.390±0.040^{b}	7.087±0.222^{a}
$C_{16:0}$	19.097±0.044^{b}	16.110±0.078^{c}	14.313±0.312^{d}	15.627±0.364^{c}	26.873±0.402^{a}	27.013±0.302^{a}
$C_{16:1}$	2.863±0.108^{a}	1.693±0.106^{c}	1.413±0.052^{cd}	1.173±0.043^{d}	1.403±0.223^{cd}	2.153±0.022^{b}
$C_{17:0}$	0.317±0.022^{c}	0.330±0.049^{c}	0.503±0.015^{a}	0.397±0.029^{bc}	0.487±0.028^{ab}	0.360±0.026^{c}
$C_{18:0}$	6.180±0.241^{c}	4.617±0.069^{e}	5.497±0.107^{d}	4.487±0.168^{d}	7.783±0.338^{b}	9.913±0.166^{a}
$C_{18:1}$	25.747±0.289^{d}	50.907±0.304^{a}	29.770±0.520^{b}	28.477±0.260^{c}	27.577±0.343^{c}	25.423±0.403^{d}
$C_{18:2\ \omega\text{-}6}$	27.417±0.829^{b}	18.040±0.370^{d}	39.983±0.205^{a}	40.687±0.467^{a}	20.303±0.098^{c}	14.957±0.435^{e}
$C_{18:3\ \omega\text{-}6}$	20.303±0.098^{c}	14.957±0.435^{e}	1.523±0.047^{b}	1.713±0.015^{b}	1.507±0.234^{b}	1.600±0.010^{b}
$C_{20:0}$	0.373±0.046^{bc}	0.407±0.035^{ab}	0.257±0.015^{d}	0.287±0.041^{cd}	0.307±0.030^{bcd}	0.490±0.021^{a}
$C_{22:6\ \omega\text{-}3}$	8.623±0.306^{a}	3.673±0.540^{c}	4.630±0.195^{bc}	4.650±0.808^{bc}	5.333±0.207^{b}	5.213±0.199^{b}

*Different letters in the same line show significant differences among samples ($P < 0.05$). - : Not detected C: control; OO: fried with olive oil; SFO: fried with sun flower oil; CO: fried with corn oil; MO: fried with margarine; BO: fried with butter.

fried in margarine (MO). The frying process increased the cholesterol content of rainbow trout (Table 3). Fatty acid contents of rainbow trout before and after pan frying in olive oil, sun flower oil, corn oil, margarine and butter are shown in Table 4.

According to results of chemical composition analyses, it has been determined that raw rainbow trout includes 73.78 ± 0.255 % water, 19.629 ± 0.229% protein 4.224 ±0.060% fat, and 1.430 ± 0.058% ash. The composition of raw fish is similar to the findings of Gokoglu et al. (2004). Moisture value was decreased while protein, fat and ash contents were increased in all oil groups (Table

2). Generally, differences in moisture, protein, fat, and ash content between the samples were significant ($P < 0.05$). The effects of different cooking methods on proximate composition and mineral contents of rainbow trout were determined in the study of Gokoglu et al. (2004). Changes in dry matter, protein and ash contents were found to be significant ($P < 0.05$). The finding of Gokoglu et al. (2004) is similar to our results. Fried fish had a higher level of fat than raw fish, mainly due to the absorption of fat by the fish. The absorption of fat through frying also caused an increase of dry matter. Garcia-Arias et al. (2003) and Gokoglu et al. (2004) have also reported similar findings. Türkkan et al. (2008) found a decrease in moisture, an increase in ash and fat after frying in Seabass as in our study. Results of proximate composition analysis are similar to the findings of Erkan et al. (2010) related fried samples.

In another study at which the chemical compositions of some fish that were cooked as fresh and through different ways were determined, it was determined that there existed an important amount of decrease in the content of water, and increase in the content of protein, fat, and ash (Puwastien et al., 1999). Garcia-Arias et al. (2003) in their studies at which they examined the contents of chemical components and fatty acid in the pilchard loins applied through cooking-freezing-reheating, determined that there existed a decrease in the content of water in the fish fried with olive oil, and an increase in the content of protein-fat-ash. These knowledge also support our results.

The analysis of pH, TBA and TVB-N which are the quality parameters of fish were carried out on the fried fish in this study. It has been determined that the values of pH, TBA and TVB-N which were obtained at the end of analysis were within the limiting values of depletability (Table 3). In the researches, there was no relation between the effect of nutrient component and the cooking methods of fish and the possibility of comparing them is not possible because there were no data on these parameters. While this value was found as 14.260 ± 0.217 µg/g in the fresh fish (C) base on the result of cholesterol analysis, it was determined as 33.363 ± 0.979 µg/g in the fish fried in sunflower oil (SFO), 56.037 ± 1.306 µg/g in the fish fried in olive oil (OO), 56.810 ± 0.586 µg/g in the fish fried in corn oil (CO), 19.043 ± 0.794 µg/g in the fish fried in margarine (MO), 69.000 ±1.183 µg/g in the fish fried in butter (BO), (Table 3). As it has been understood, the highest content of cholesterol was determined in the samples with butter, and it has been observed that this value increased more after cooking. The reason for it is that the butter which is rich in saturated fat was used for frying. The lowest value was determined in the samples of fish fried with margarine. In the studies carried out by Candela et al. (1997) on the effect of frying and heating procedure to the content of cholesterol and fatty acid in some fish, there was a decrease in the content of cholesterol after frying, and it was supposed that it occurred due to the increase in the dry material and the absorption while frying. In their study in which they investigated the changes of cholesterol oxidation while being stored as frozen and grilled, Saldanha and Bragagnolo (2007) reported that there existed an important increase in the amount of choles-terol oxidation. These methods damaged the content of PUFA and cholesterol, and ketocholesterol was formed through products of cholesterol. In the findings, the increase in the content of cholesterol can be due to the derivatives of ketocholesterol which changes depending on the conditions of frying.

According to the results of fatty acid analysis, it was determined that there existed an important amount of decrease ($P < 0.05$) in myristic, palmitic, palmitoleic, stearic, linoleic, linolenic, and docosahexaenoic acid in the fish fried with olive oil, and an important amount of increase ($P < 0.05$) in oleic acid. In the fish fried with sunflower oil and corn oil, an important amount of decrease ($P < 0.05$) was determined in myristic, palmitic, palmitoleic, stearic, linolenic, arashidic, and docosahexaenoic acid. However, an important amount of increase ($P < 0.05$) was shown in heptadecanoic, oleic, and linoleic acid. Due to the olive used in the fish fried with margarine and butter, some of the fatty acids were determined which could not be determined in fresh fish. While caprilic, capric and lauric acid were determined in both the fish fried with margarine and the samples fried with butter, butyric acid and caproic acid were determined only in the samples including butter, while the amount of myristic acid indicated an increase in the samples fried with butter, palmitic and heptadecanoic acid. Stearic acid did not indicate any increase in the samples fried wit butter and margarine. Palmitoleic, linoleic, linolenic and docosahexaenoic acid indicated decrease in the samples of fish fried with both lubricant. While arashidic acid decreased in the samples fried with margarine, it increased in the fish fried with butter. Again, while it increased in the sample fried with margarine which was the content of oleic acid, the change in the samples fried with butter was deemed as unimportant ($P > 0.05$) (Table 4).

In the salmons (*Oncorhychus gorbuscha*) cooked through different methods, it was reported that the content of fatty acid was negatively effected only by the transaction of frying, there existed decrease in the amount of many unsaturated fatty acid, and that especially docosahexaenoic acid which was one of the essential fatty acids decreased (Gladshev et al., 2006). In their studies in which they investigated the effects of frying procedure with margarine and olive oil to the fatty acid content of cod and salmon, Sioen et al. (2006) expressed that for codfish, lauric, myristic, palmitic and stearic acid increased after the procedure of frying with margarine. On the other hand, a decrease occurred in unsaturated fatty acids. For salmon, lauric, palmitic and stearic acid increased, while myristic acid decreased. DHA which is one of the polyunsaturated fatty acids decreased. In the same study, it was determined that there existed a decrease in the saturated fatty acids for codfish, an increase in the monounsaturated fatty acids (MUFA), an important decrease in the polyunsaturated fatty acids

(PUFA) as a result of frying with olive oil; for salmon a little increase was determined in the saturated fatty acids and MUFA, but a decrease at the value of PUFA. Garcia-Arias et al. (2003) examined the contents of chemical component and fatty acid in the pilchard fillets applied through cooking-freezing-reheating. In the study, it was determined that DHA decreased while an increase occurred in oleic and linoleic acid. Olive oil was used for frying. In another study, linolenic, docosahexaenoic and palmitoleic acid decreased after frying with sun flower oil (Türkkan et al., 2008). Similar findings were found by Larsen et al. (2010) in fried King Salmon (*Oncorhychus tshawytscha*). All these results accord with the study's data.

Conclusion

While examining the changes of fatty acid of fried products, the content of the oil used should also be considered other than the weight and length of fish; and it must not be forgotten that these features will affect the fatty acid composition of the fish. Furthermore, it should be noted that the content of margarine is sometimes changed by the producers. In fish, saturated fats are slightly affected generally by heat treatment. Products of oxidation can occur at temperature above 150°C. Since unsaturated fats are affected by heat treatment, then frying is not a suitable method of cooking for fish. The process of frying has caused some fatty acids to increase in fish (like the increase of oleic acid in olive oil) while some to decrease (PUFA, especially DHA). The procedure of frying increased the content of cholesterol in trout especially with the use of butter. The lowest in cholesterol has been determined in fish fried with margarine. In the unsaturated fatty acids, the least change was found in the samples fried with margarine. However, fish fried with margarine is not recommended due to the presence of trans fatty acids.

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