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Meat yield and chemical composition of freshwater crab (*Potamon persicum* Pretzmann, 1962)

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Abstract: In this study, morphometric measurement, meat yield, moisture, pH, protein, fat, fatty acids and ash content were determined in a total of 102 (15 female and

87 male) freshwater crab (*Potamon persicum* Pretzmann,1962) caught from Aşağı and Yukarı Çay of Pertek, Tunceli. Meat yield in male and in female crabs were found to be as 12.75±0.38% and 10.93±0.32%, respectively. It has been observed that moisture and protein amounts were higher in female crabs than in male crabs. The amounts of fat were 0.96±0.31% in male crabs and 0.97±0.35% in female crabs. The amount of ash was 2.68±0.04% in male crabs and 2.66±0.03% in female crabs. It was determined that the content of monounsaturated fatty acids (female:male 33.56%:37.44%) in female and male crabs were higher than polyunsaturated (female:male 24.19%:21.62%) and saturated fatty acid (female:male 28.11%:32.85%) content. The highest fatty acid was found to be as omega-9, in terms of omega-3 (male crabs 8.54%, female crabs 14.85%), omega-6 (male crabs 10.04%, female crabs 5.46%) and omega-9 fatty acids (male crabs 23.65%, female crabs 19.14%) in freshwater crab (*Potamon persicum* Pretzmann, 1962) meat.

Keywords: Crab, fatty acids, meat yield, omega-9, protein.

Tatlı su yengeci Potamon persicum Pretzmann,1962'nin et verimi ve kimyasal bileşimi

Özet: Bu çalışmada, Tunceli ili Pertek ilçesi Aşağı ve Yukarı Çay'dan avlanan 15 dişi ve 87 erkek olmak üzere toplam 102 tatlı su yengecinin (*Potamon persicum* Pretzmann, 1962) morfometrik ölçümleri, et verimi, etin rutubet, pH, protein, yağ, yağ asitleri ve kül miktarları belirlenmiştir. Et verimi erkek yengeçlerde %12,75±0,38g, dişilerde ise %10,93±0,32g olarak saptanmıştır. Rutubet ve protein miktarlarının dişi yengeçlerde erkek yengeçlere göre daha fazla olduğu görülmüştür. Yağ miktarı erkek yengeçlerde %0,96±0,31, dişi yengeçlerde %0,97±0,35, kül miktarı ise erkeklerde

%2,68±0,04, dişilerde %2,66±0,03 olarak saptanmıştır. Dişi ve erkek yengeçlerde genel toplamda tekli doymamış yağ asitleri (dişi:erkek %33,56:%37,44) içeriğinin, çoklu doymamış (dişi:erkek %24,19:%21,62) ve doymuş yağ asitleri (dişi:erkek %28,11:%32,85) içeriğinden daha yüksek miktarda olduğu tespit edilmiştir. Tatlı su yengecinin (*Potamon persicum* Pretzmann, 1962) etinde omega-3 (erkek yengeç % 8,54, dişi yengeç %14,85), omega-6 (erkek yengeç % 10,04, dişi yengeç % 5,46) ve omega-9 (erkek yengeç % 26,65, dişi yengeç %19,14), yağ asitleri açısından en yüksek yağ asidi omega-9 (oleik asit) olarak bulunmuştur.

Anahtar sözcükler: Et verimi, protein, omega-9, yağ asitleri, yengeç.

Introduction

Aquatic creatures are one of the primary sources of animal protein. Aquatic foods, such as fish and shellfish, are deemed remarkable as they contain nine essential amino acids and have sufficient levels of Omega-3 and polyunsaturated fatty acids. In terms of such foods, crabs are counted as one of the cheapest shellfish products (26). It is also considered a healthy diet due to its high-quality protein and low-fat content (24).

Marine species of crabs are usually consumed in many countries (China, France, Indonesia, Japan, Philippines, Spain, and Thailand). In the world, 22 crab species are used directly as food and feed additives (16). In addition, crabs bear medical and pharmacological significance in the production of chitin and chitosan.

While crabs can be fished in their natural habitat, crab cultivation is also widespread in various countries (Japan, Poland, Australia, Norway) (18). Various studies demonstrated that crab meat contains high protein, carbohydrate, and fiber, as well as low fat, and is a rich source of sodium, potassium, magnesium, calcium, and phosphorus (22,

24). Turkey's inland waters host 12 crab species belonging to the *genus Potamon*. According to the morphology of the freshwater crabs gonopods living in Turkey, those living in the Black Sea, Marmara and Aegean Regions are included in *Potamon ibericum tauricum* (Czerniavsky, 1884) subspecies, those living in the Mediterranean and South East Anatolia Regions are included in *Potamon potamios* (Oliver, 1804) subspecies, and those living in Lake Amik and its associated waters is included in the subspecies of *Potamon potamios setiger* (Bott, 1970) (17). The research subject, *Potamon persicum* Pretzmann, 1962, it is from the family of *Potamidae* and is commonly seen in Sivas, Kayseri, Malatya, Elazığ, Tunceli, Diyarbakir, Hakkari, Siirt, Van and Erzurum (17).

Since the review of the relevant literature revealed the shortage of studies on *P. persicum*, a freshwater crab, the present study aimed to research some properties and nutritional value of the mentioned crab and contribute to its consumption rates. For this purpose, the study investigated protein, moisture, fat, and ash contents, fatty acid composition, and pH of *P. persicum* fished in Aşağı and Yukarı Çay zone of Pertek district in Tunceli city, as well as its meat yield.

Materials and Methods

Materials: The research subject crabs (15 females, 87 males), were purchased from the fishers in the region (coordinates of the region: 38°59'20.7"N 39°18'22.7"E) and immediately brought to the laboratory in August-October 2011. After separating according to sex, the crabs were weighed, and their morphometric measurements (carapace width (CW), carapace length (CL), pincer length, and pincer width) were taken with a caliper. Then, crab meat was extracted, and the meat yield and the chemical

composition of meat (humidity, pH, protein, fat, fatty acids, and ash content) were determined.

Sample preparation: The crabs separated based on sex were given numbers, packed in polyethylene bags, and subjected to heat treatment for 5-6 min. in 95-100 ^{o}C water.

Proximate composition analysis: The meat was picked from the body, pincers, and legs of the crabs and weighed, and the results were indicated as %. Meat yield was determined according to the following formula.

Meat yield % = Meat weight (g) / Total weight (g) x 100

The moisture content of the samples was determined by TS 1743 ISO 1442 (33), pH-values were identified with pH meter (Metler Toledo, FE 20); and protein amounts were measured with the LECO FP 528 automatic nitrogen analyzer by the AOAC 955.04-1998 method (2). While TS 1744 method was used for the determination of fat in the samples (34), ash content was determined using TS 1746 ISO 936/2001 method (35).

Fatty Acid Analysis: Fatty acids were determined by the International Olive Council COI/T.20/Doc.no.28/2010 (19). For this purpose, a Flame Ionization Detector (FID) and Clarus 500 (Perkin Elmer, USA) gas chromatography device with autosampler containing DB-23 (50% -Cyanopropyl)-methylpolysiloxane (60 m x 0.25 mm x 0.25 μm) GC column were used. The sample was thoroughly mixed and homogenized, and approximately 60 mg of test sample was weighed into the test tube on a precision balance. 10 ml of n-heptane was added to the test tube and then 0.5 ml of methanolic KOH solution was added and the cap of the tube was closed. After shaking vigorously for 30 seconds and standing for one hour, the upper clear portion was removed. This part was put into 2 ml vials, made ready for injection and injected into the device. Mix standard was also injected into the device and the peaks were read. The content of methyl esters in the

sample is expressed as a percent by mass, relative to the ratio of the area of the corresponding peak to the sum of all peak areas. The temperatures of the injector and FID detector were set to 220 °C and 280 °C, respectively. The furnace temperature was set to 200 °C, starting at 100 °C for the first 5 minutes, then by increasing the temperature by 5 °C per minute until 180 °C and by 2 °C per minute until 200 °C. 1µL was extracted from the samples and injection was carried out at a split ratio of 1:25 (19).

Statistical analysis: All analyzes (carapace length, carapace width, live weight, pincer length, pincer width, meat yield, moisture content, pH-value, protein ratio, total fat and crude ash) in the study were carried out in triplicate. Statistical analysis of data was carried out applying the basic statistic tests using MiniTab 19. The t-test (independent t test) was used to compare male and female crab meats. The results are presented as mean ± standard deviation.

Results

Meat yield in male and in female crabs were found to be as 12.75 ±0.38% g, 10.93 ±0.32% g respectively (Table 1). The amounts of fat were 0.96±0.31% in male crabs and 0.97±0.35% in female crabs (Table 1). The ash contents were found to be as 2.68±0.04% and 2.66±0.03% in male and female crabs, respectively (Table 1). While male crabs have higher meat yield values than females, the situation is the opposite in terms of moisture content of the meat. Statistical difference was observed for both ($P<0.05$). Differences in other parameters were found to be insignificant. It was determined that the content of monounsaturated fatty acids in female and male crabs (33.56%:37.44%) were higher than the content of polyunsaturated (24.19%:21.62%) and saturated fatty acid (28.11%: 32.85%) content (Table 2). The highest fatty acid was found to be as omega-9, in terms

of omega-3 (8.54%, 14.85%), omega-6 (10.04%, 5.46%) and omega-9 fatty acids (23.65%, 19.14%) in male and female freshwater crab meat (*Potamon persicum* Pretzmann,1962), respectively (Table 2). Chromatograms of fatty acids of male and female crab meat are given in Figure 1-2, respectively.

Discussion and Conclusion

Since the relevant literature lacks studies on freshwater crab *P. persicum*, the acquired data were discussed considering the research on other crab species. In their study, Gökoğlu and Yerlikaya (15) measured the mean carapace width and length of *C. sapidus* individuals as 9.62 cm and 4.85 cm, and of *P. pelagicus* individuals as 13.25 cm and 6.15 cm, respectively. Therefore, it is thought that the variability with the results in our study is likely to be due to species differences. Türeli et al. (37) determined the total meat yield as 28.23% for female blue crabs and 41.99% for male blue crabs. The meat yield varies by species, sex, age, breeding season, feeding, and stomach content when fished (13). Eggs constitute 30-40% of a female crab's body weight at the time of spawning, which may reduce the meat yield. The low meat yield in the crabs investigated in the study can be attributed to their being in the spawning season (12). In a study by Ünlüsayın (38), meat proportions of *P. potamios* and *Ocypode cursor L.* were found to be 12.61±4.60% and 6.51±1.03%, respectively. Besides, Sachindra et al. (31) found the meat yield of the large sea crab *Charybdis cruciata* to be 29.7%.

In our study, the mean moisture content of crabs was found to be 81.22±1.12% for females and 80.23±2.26% for males (Table 1). Bilgin (6) found the highest moisture content of *Potamon potamios* (Olivier, 1804) in spring with a value of 81.03 ± 0.160%. In his study investigating how muscle tissue/water level would be affected by seasons,

Ayas (4) recorded the lowest moisture content in spring and the highest value in autumn and uttered an inverse ratio between protein/lipid level and water. Ünlüsayın (38) determined the moisture content of *P. potamios* as 74.20% for females and 77.64% for males. Naczk et al. (28) also found 79.10%-82.30% moisture content in the European green crabs, and such values are relatively close to our findings. Gökoğlu (14) delivered an increase in the water amount in lean fish due to the depletion of nutrients and energy reserves during spawning. Hence, it was deemed quite normal to measure high moisture content in the study crabs since they were in the spawning period and about to change their shells in autumn when they were fished.

The mean pH-values of the study crabs was determined as 8.21±0.03 for females and 8.16±0.12 for males (Table 1). Dima et al. (9), determined the pH of crab (*Ovalipes trimaculatus*) pincer meat to be 7.3. On the other hand, Degnan et al. (8) the pH value in blue crab meat found as 8.1 (*Callinectes sapidus*). Ultimately, it is considered that such pH differences may be caused by the feeding patterns, habitats, and physiologies of the animals.

In our study, the protein amounts were found higher in females than males, and the mean values were 13.26 ± 0.08% and 12.99 ± 0.20%, respectively (Table 1). In their study on blue crabs fished in Iskenderun Bay, Türeli et al. (37) determined the mean protein amounts of breast and pincer meat as 15.51% and 16.81% for males, while they were 16.67% and 14.26% for females. However, such values are higher than our findings. Similarly, Ayas and Özoğul (3) and Kuley et al. (21), measured the mean protein amounts for female crabs as 22.45% (breast meat), 26.51% (pincer meat) and for male crabs as 21.40% (breast meat) and 30.31% (pincer meat), respectively. These values are also

191 higher than the findings we obtained from *P. Persicum*. The variability in the findings is
192 thought to be due to the species differences and the body parts analyzed in the studies.

193 Musaiger and Al-Rumaidh (27) determined the mean protein values (*P. pelagicus*)
194 as 19.80% for females and 19.80% for males in raw meat. In Atlantic blue crabs
195 (*Callinectes sapidus* Rathbun, 1896), Ağbaş (1) found the highest crude protein value in
196 male pincer meat with 16.10% and the lowest in female breast meat with 12%. Skonberg
197 and Perkins (32) found the mean protein value of green crabs to be 17.1%. Cherif et al.
198 (7) found the protein value in pincer meat of *Carcinus mediterraneus* between 17.80-
199 18.20%, while Gökoğlu and Yerlikaya (14) determined the mean protein values of *C.*
200 *sapidus* and *P. pelagicus* as 15.00% and 21.54%, respectively. Moreover, the crude
201 protein values of the crabs determined in the study of Moronkola et al. (25) are higher
202 (19.2-28.3 g/100g) than those determined in this research.

203 Low protein levels in this study might have stemmed from many factors such as
204 sex, season, species, size, differences in sexual maturation, fishing area, feeding
205 characteristics, and carapace change time (4, 26). Crabs change carapace once a year
206 thanks to the growth. They hold water in their muscles before the change, which increases
207 the water ratio in muscles, leading to a reduction in the protein ratio (3). As a matter of
208 fact, in his study, where the effects of sex and season on crab meat were investigated,
209 Ayas (4) found the highest protein value in spring and the lowest value in autumn and
210 associated the result with carapace change.

211 Pati et al. (30) found the protein content as 30-59%, the fat content as 7-11%, the
212 ash content as 38-39% (dry weight), and moisture content as 71-79% in their study, in
213 which they examined the effects of spawning period and season on female crab meat.
214 When compared with the values in the study of Pati et al. (30), except for moisture

content, the results of our study were determined to be higher depending on the season and spawning period.

Ayas and Özoğul (3) determined the fat amounts as 0.96% for female blue crabs and 1.11% for male blue crabs, and such findings are relatively close to the results obtained in our study. Ayas (4) found the lipid level of crabs higher in winter than in other seasons. He attributed this to the reproductive and spawning periods lasting in spring, summer and autumn and also argued that carapace change in autumn might influence the higher levels of lipids in crabs. In Atlantic blue crabs, Ağbaş (1) determined the highest fat content with 2.97% in male breast meat and the lowest with 1.01% in male pincer meat. Türeli et al. (36) stated that the fat rates were 1.16% for male blue crabs and 2.26% for female blue crabs, while they were 1.45% for male sand crabs and 1.16% for female sand crabs. In addition, Kuley et al. (21) determined the fat proportions as 1.62% for female crabs and 1.64% for male crabs. In contrast to our study, Ünlüsayın (38) reported higher fat proportions in crabs fished from Lake Eğirdir as 4.63% for males and 2.66% for females. These differences are thought to be due to many factors such as species, size, sex, feeding, habitat, spawning period, carapace change, and season (5).

On the other hand, the mean ash amounts were found to be $2.66 \pm 0.03\%$ for females and $2.68 \pm 0.04\%$ for males. In Atlantic blue crabs, Ağbaş (1) determined the highest ash content with 2.37% in female pincer meat and the lowest with 1.79% in male pincer meat. These values are slightly lower than our findings. In blue crabs caught in Iskenderun Bay in winter, Türeli et al. (37) determined ash level as 3.28% in female breast meat. Ünlüsayın (38) determined ash amounts as 1.95% for females and 2.67% for males, while Kuley et al. (18) determined it to be lower than our findings as 1.16% for females and 1.10% for males.

Despite high numbers of crabs in seas and inland waters, crab meat consumption is not common due to cuisine traditions and lack of information. As a result of the relevant examinations, it was concluded that the species could be a good dietary food item, especially because it contains high-quality protein, has a balanced fatty acid profile, is a sufficient source of minerals, and contains low fat. Therefore, it is thought that increasing crab meat consumption at the national and international level will be of great importance.

It is well-known that essential fatty acids are involved in maintaining certain physiological functions in the human body, providing energy, and helping maintain body temperature (11). Nevertheless, since such fatty acids cannot be synthesized within the body, they must be taken ready-made with food. Our research revealed that crab meat might be necessary for a balanced diet since crab meat contains essential fatty acids.

Our study found that the amounts of monounsaturated fatty acids (37.44%) were higher than those of saturated fatty acids (32.85%) and polyunsaturated fatty acids (21.62%) in the crabs (Table 2). Palmitic acid (C16:0) had the highest ratio as saturated fatty acid in both female and male crabs we examined. As evident in Table 2, it was determined that male crabs contained more saturated fatty acids than females. In terms of monounsaturated fatty acids, oleic acid (omega-9) was found to have the highest amount. In contrast, linolenic acid (omega-3) and linoleic acid (omega-6) were the highest amounts in terms of polyunsaturated fatty acids. While the amounts of monounsaturated fatty acids were higher in male crabs, the amounts of polyunsaturated fatty acids were higher in female crabs (Table 2). Moruf and Lawal-Are (26) analyzed the fatty acid profiles of *Callinectes amnicola* and *Portunus validus* crabs, and, similar to our results, palmitic and oleic acids were the highest amounts as saturated fatty acid and monounsaturated fatty acid, respectively. Reporting that palmitic acid was the highest-

amount saturated fatty acid in *Carcinus maneus* species, Naczk et al. (28) had obtained similar results with our research. Cherif et al. (7) revealed that palmitic and stearic acids, oleic acid and arachidonic acid had the highest-amount fats in *Carcinus mediterraneus* species. It is considered that the resulting differences may arise from the species difference. In their study with blue crabs and swimming crabs fished in Mersin Bay, Özoğul et al. (29) reported lower amounts of saturated fatty acids and monounsaturated fatty acids than our study but revealed higher polyunsaturated fatty acids than ours. Nevertheless, similar to our study, Keivandokht et al. (20) found higher amounts of palmitic acid from saturated fatty acids; oleic acid from monounsaturated fatty acids; and alpha-linoleic acid from polyunsaturated fatty acids.

Dvoretsky et al. (10), determined the amount of monounsatured, saturated and polyunsatured faty acids as 17.2%, 27.6% and 55.2% in Barents Sea red king crab meat (*Paralithodes camtschaticus*), respectively. The amount of monounsaturated faty acids and saturated faty acids found in Barents Sea red king crab meat by Dvoretsky et al. (10), is lower compared to our findings, while the amount of polyunsatured faty acids is higher. The amount of palmitic acid (C:16:0) detected in red king crab meat (16.2%) by Dvoretsky et al. (10), is close to the value we determined in male crab meat (15.82%). Lian et al. (23), determined the polyunsatured, monounsatured and saturated fatty acids in cooked leg meat of red king crab (*Paralithodes camtschaticus*) as 50.9%, 27.0% and 22.1%, respectively. The researchers determined the amount of palmitic acid (C16:0) as 15.4% and the amount of stearic acid (C18:0) as 4.1%. These findings are close to the values found in male crab meat in the current study (15.82% and 4.16%, respectively).

In our study, essential fatty acids were determined as palmitic, oleic, palmitoleic, linoleic, and linolenic acids. Compared with the other studies, different results in our

study can be related to many factors such as species, environmental factors, feeding, and spawning period. Ghazali et al. (13), stated in their study that the fatty acid profile was near related to feeding and ovarian maturity phases. Besides, it was found out that there were no statistically significant differences between freshwater female and male crabs by the chemical composition of their meat ($P > 0.05$). However, sex-based differences were suggested in terms of the fatty acid profile.

Overall, despite high numbers of crabs in seas and inland waters, crab meat consumption is not typical due to cuisine traditions and lack of information. It was concluded that crab meat could be a food item with high nutritional quality because this species contains high-quality protein, has a balanced fatty acid profile, is a sufficient source of minerals, and contains low fat. At the same time, benefiting from crabs abundant in the seas and inland waters will both contribute to the country's economy and create new employment opportunities with the establishment of crab meat processing factories. Finally, it is thought that the findings obtained in this study will contribute to the relevant literature on the morphological and chemical composition of *P. persicum*.

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Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Statement

This study does not present any ethical concerns.

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419

420 **Table 1.** The mean morphometric values and chemical composition of crab meat (n: 102).

	Male	**Female**
Carapace length(cm)	3.65±0.73	3.67±0.60
Carapace width (cm)	4.68±1.62	4.70±0.90
Average live weight (g)	54.78±20.12	53.80±12.95
Pincer length (cm)	5.50±1.90	5.05±1.05
Pincer width (cm)	1.03±0.20	1.05±0.15
Meat yield (%)	12.75 ± 0.38^{a}	10.93 ± 0.32^{b}
Amount of moisture(%)	80.23 ± 2.26^{b}	81.22 ± 1.12^{a}
pH value	8.16±0.12	8.21±0.03
Protein ratio(%)	12.99±0.20	13.26±0.08
Total fat(%)	0.96±0.31	0.97±0.35
Crude ashes(%)	2.68±0.04	2.66±0.03

421 a,b: Indicates statistically significant difference between the groups ($P<0.05$).
422 The differences in results obtain from female and male crabs (t- test).
423

424 **Table 2.** The composition of fatty acids determined in crab meat.

Number	Composition of Fatty Acids	Fatty Acids of Male Crabs(%)	Fatty Acids of Female Crabs(%)
	Saturated Fatty Acids (ΣSFAs)	32.85	28.11
1	Lauric acid (C12:0)	1.18	0.66
2	Tridecanoic Acid (C13:0)	0.02	0.06
3	Myristic acid (C14:0)	2.30	1.73
4	Cis-10 Pentadecanoic acid (C15:0)	0.39	0.30
5	Palmitic acid (C16:0)	15.82	11.91
6	Heptadecanoic acid (Margaric) (C17:0)	0.37	0.36
7	Stearic acid (C18:0)	4.16	2.62
8	Arachidic acid (eicosanoic) (C20:0)	2.73	5.46
9	Behenic acid (C22:0)	0.12	0.11
10	Lignoceric acid (C24:0)	5.76	4.90
	Unsaturated Fatty Acids	59.06	57.75
	Monounsaturated Fatty Acids (ΣMUFAs)	37.44	33.56
11	Myristoleic acid (C14:1)	0.45	0.40
12	Pentadecanoic acid (C15:1)	0.68	2.29
13	Palmitoleic acid (C16:1)	10.51	9.30
14	Heptadecenoic acid (Margoleic acid) (C17:1)	0.95	0.90
15	Oleic acid (C18:1 n9)	23.65	19.14
16	Eicosenoic acid (Gadeloic) (C20:1)	0.80	1.08
17	Erucic acid (C22:1 n9)	0.40	0.45
	Polyunsaturated Fatty Acids (ΣPUFAs)	21.62	24.19
18	Linoleic acid (C18:2 n6)	10.04	5.46
19	Linolenic acid (18:3 n3)	8.54	14.85
20	11C,14C Eicosadienoic acid (C20:2)	0.57	0.78
21	8C,11C,14C Eicosatrienoic acid (C20:3 n6)	0.06	0.07
22	11C,14C,17C Eicosatrienoic acid (C20:3 6)	0.00	0.10
23	Arachidonic acid (C20:4 n6)	2.41	2.93
	Unidentified	8.09	14.14
	ratio of saturated fatty acids / ratio of unsaturated fatty acids	0.56	0.49
	Σω6	12.51	8.56
	Σω3	8.54	14.85
	ω3/ω6	0.68	1.73
	ω6/ω3	1.46	0.58

425

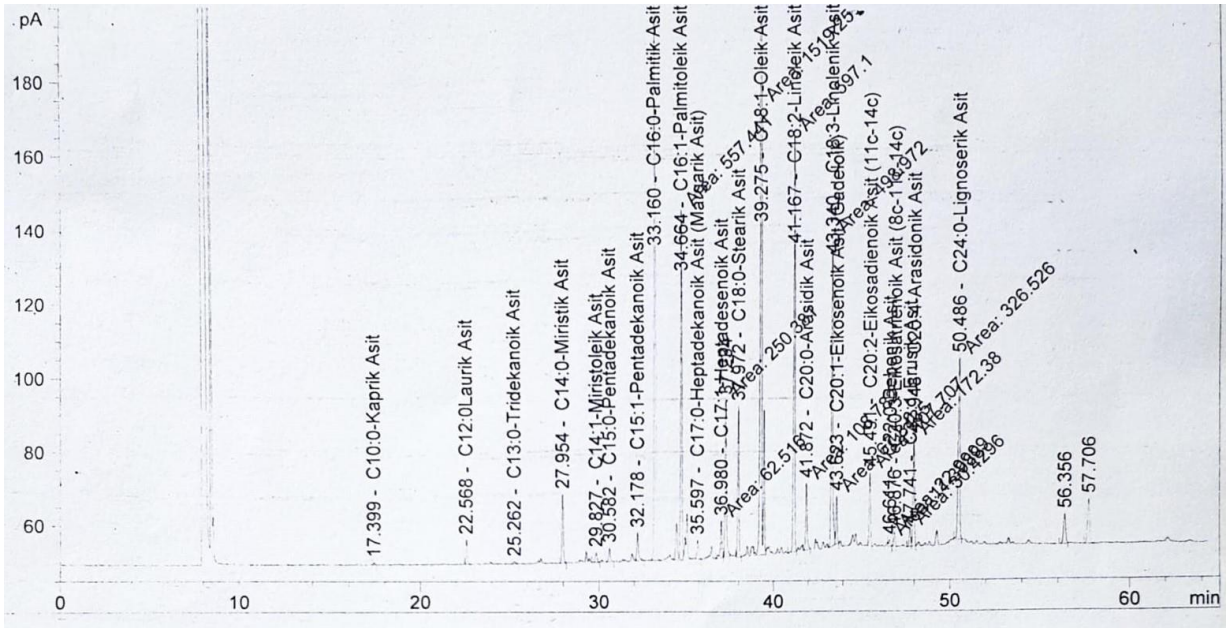

Figure 1. Fatty acid chromatogram of male crab meat.

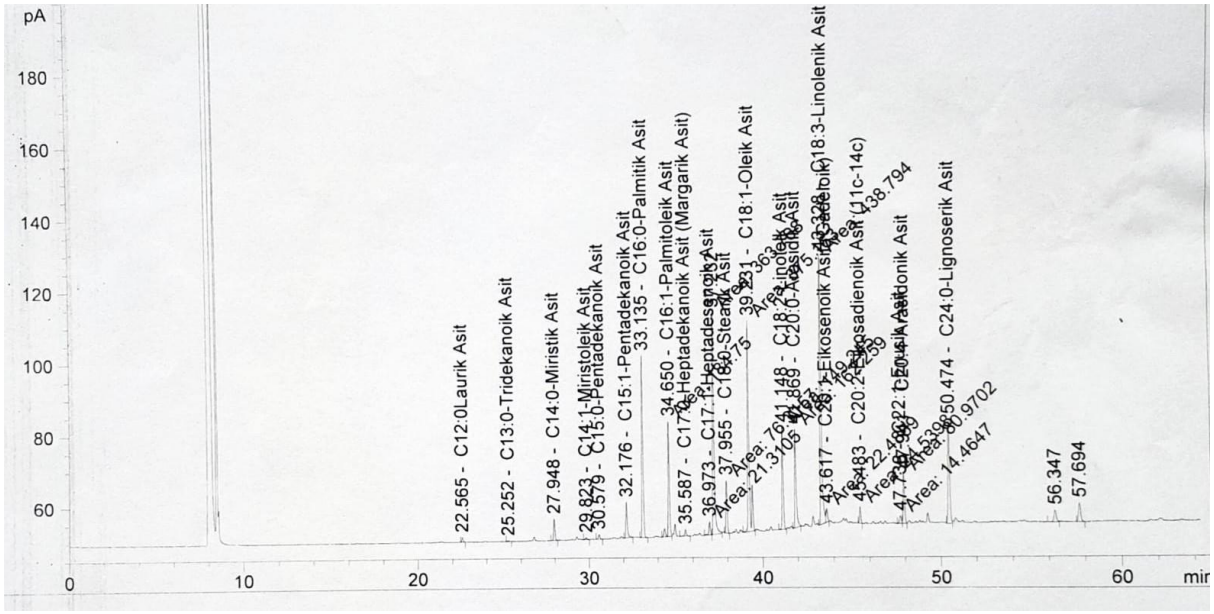

Figure 2. Fatty acid chromatogram of female crab meat.