Pakistan J. Zool., vol. 48(2), pp. 383-388, 2016.

Fatty Acid Composition and Conjugated Linoleic Acid Content in Various Carcass Parts of Kivircik Lambs

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ABSTRACT

This investigation was conducted to determine the fatty acid composition of lamb meat. For this purpose, Kivircik lambs fattened intensively were slaughtered at the end of two-month fattening period. The fatty acid composition of the samples from leg, shoulder, rib, and breast parts of cold carcasses after slaughtering were analyzed for total saturated fatty acid (SFA), unsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), and conjugated linoleic acid (CLA). In the legs SFA, MUFA, PUFA and CLA were found to be 42.96, 40.80, 5.61, and 1.18%, respectively. In the shoulder these were 43.48, 43.21, 3.59, and 0.85%; in ribs 40.61, 45.36, 4.67, and 1.09% and in breast 37.88, 51.39, 3.89, and 1.20%, respectively. The results showed that the breast part of a carcass was the most advantageous part in terms of fatty acids.

Article Information

Received 22 June 2015
Revised 20 August 2015
Accepted 3 September 2015
Available online 1 March 2016

Authors' Contributions

AK and OGG designed the experiments, collected the data and wrote the article. IK performed statistical analysis. AK, IK and JY helped in preparation of manuscript.

Key words

Fatty acid, CLA, Lamb, Carcass parts.

INTRODUCTION

Mutton having a large amount of demand is priced in markets according to carcass regions. Meat of a carcass is marketed with its fat. Customer demand is a decisive factor on pricing and fattier regions are generally low-priced. Linking red meat and fats of animal origin on the scope of cardiovascular diseases (Wood *et al.*, 2008) can affect customer demands in a negative way. Therefore, customers think that less fatty meat is healthier. Fat deposition in a carcass changes depending on many factors (species, breed, nutrition, sex etc.). Tariq *et al.* (2013) the effect of slaughtering age on chemical composition in meat of Mengali sheep reared in Quetta, Pakistan. It is accepted that mutton carcasses are fattier than beef carcasses. There are different advantages and disadvantages of fats preferred commonly in human nutrition. The most significant factor determining this situation is the fatty acid composition. In addition, fatty acid composition varies depending upon carcass regions (Karabacak *et al.*, 2014). Some authors reported that the total ratio of saturated fat in mutton carcass was below 50% (Avila-Stagno *et al*., 2013; Karabacak *et al*., 2014). Apart from the saturated fat, PUFA ratio, the ratios of ω3, ω6, and CLA are essential for human health. In previous studies, it was stated that palmitoleic acid (C 16:1ω7) was positively associated with diabetes (Mozaffarian *et al.*, 2010). The major health benefits of CLA include anticancerogenic, antiatherogenic, antidiabetic, and anti-adipogenic effects, and it also has an important effect on immune system development (Ip *et al.*, 1995; Belury *et al.*, 1996; Pariza *et al.*, 1996; Kritchevsky, 2003). Antioxidant features of CLA were also discovered in some studies (Ha *et al*., 1990; Du *et al*., 2000; Joo *et al*., 2002; Hur *et al*., 2004). Ruminant fats, which are preferred significantly in human diet, involve more CLA than other nutritional fat sources (Chin *et al*., 1992). Mutton has the highest ratio of CLA compared to CLA ratio of other ruminants. Although there have been many studies conducted on factors affecting fatty acid composition in mutton carcass, number of published reports about comparing fatty acid composition in mutton carcass is still insufficient. In the light of such information, the current investigation was conducted to determine fatty acid composition in different carcass regions of lambs fattened intensively.

MATERIALS AND METHODS

This research was carried out in a commercial

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0030-9923/2016/0002-0383 $ 8.00/0

farm, which is located 22 km from the Konya province 38° 02' North latitude, 32° 30' East longitude and 1175 m altitude. In the current study, ten Kivircik (a native breed of Turkey) male lambs that were about 2 ½ months of age and had a average live-weight of 20 kg were used. After one week adaptation period, Kivircik lambs were fed *ad libitum* concentrated feed and 150g alfalfa a fattening period of 68 days. Daily live weight gain, feed conversion ratio, total feed consumption, slaughter weight and cold carcass weight were as 211g, 5.33, 79.9kg, 34.09 and 15.35kg, respectively. The chemical composition of the concentrate feed used in fattening period is presented in Table I.

Table I.- Chemical composition of the concentrate fed to lambs[1]

Chemical composition	Percentage (%)
Dry matter	88.00
Organic matter[2]	78.09
Crude protein	14.52
Crude fiber	9.89
Crude ash[2]	9.91
Crude fat	1.59
Calcium	0.60
Phosphorus	0.40
Calculated metabolizable energy (kcal/kg)	2562

[1]Analysed value as feed, [2] Analysed value dry matter

After slaughtering, the carcasses were immediately transferred to cooler at 4°C. After 24 h conservation period, carcasses were separated into various parts on the basis of standard carcass discerned method reported by Colomer-Rocher *et al.* (1987). Afterwards, 20 g leg, shoulder, rib, and breast fat samples were taken from each carcass. Samples were packaged by vacuum and stored at -27°C until analysis. At the beginning of each analysis, the samples were allowed to equilibrate to room temperature, ground and extracted with chloroform/methanol (2:1 v/v) according to the method of (Folch *et al.*, 1957). Methyl esters were prepared by transmethylation, using KOH 2 mol/L in methanol and n-heptane, according to method 5509 of the ISO (1978).

The fatty acid methyl esters were analyzed via a HP (Hewlett Packard) Agilent 6890N model gas chromatograph (GC), equipped with a flame ionization detector (FID) and fitted with a HP-88 capillary column (100 m, 0.25 mm i.d. and 0.2 μm). Chromatographic conditions were performed according to the modified method (Ledoux *et al*., 2005) as follows: injector and detector temperatures were 250 and 280ºC, respectively. The oven was programmed at 60ºC initial temperature and 1 min initial time. Thereafter the temperature increased at 20ºC/min to 190ºC held for 60 min then increased at 1ºC/min to 220ºC and held for 10 min at 220ºC. Total run time was 107.5 min. it was used the helium as the carrier gas (1 ml/min). Identification of fatty acids and trans isomers were carried out by comparing sample FAME peak relative retention times with those obtained for Alltech, Nu-Check Prep. Inc. USA and Accu standards. Linoleic acid conjugated methyl ester (mixture of *cis*- and *trans*-9,11- and -10,12-octadecadienoic acid methyl esters, catalog number O5632) was purchased from Sigma-Aldrich (St Louis, MO, USA). The obtained results were expressed as FID response area in relative percentages. Each result reported here is the average value of three GC analyses. The descriptive statistics of each trait investigated in the current study were expressed as mean±SE. The obtained results were evaluated by One-way ANOVA, with a significance level of 0.05, using the Minitab packet program (Minitab, 1995). Mean separation for determining significant differences was performed using the Duncan test.

RESULTS

Leg, shoulder, rib, and breast fatty acid composition of the samples taken from the Kivircik lambs under intensive fattening condition are given in Table II. Differences in total SFA between the carcass parts were found statistically significant ($P<0.05$). The highest percentage of total SFA was observed in the shoulder, and was the lowest in the breast. Of the fatty acids forming SFA, the predominant one was palmitic acid (C 16:0). The differences in total MUFA between the carcass parts were statistically significant ($P<0.05$). The highest percentage of MUFA was found in the breast. Whereas, the lowest percentage was observed in the leg. Oleic acid (C 18:1ω9) was the major fatty acid composing MUFA. Statistically significant differences in PUFA between the carcass parts were noted ($P<0.05$). The highest percentage of PUFA was observed for the leg, but the lowest percentage was recorded in the shoulder. Among PUFAs, linoleic acid (C18:2ω6) had the highest percentage in the all carcass parts. Compared with other carcass parts, the breast had the lowest percentage of total trans fatty acids (TFA). The difference between the average levels of TFAs was observed in the breast and the average levels observed in other carcass parts was statistically significant ($P<0.05$). Trans vaccenic acid (C 18:1*t*11) was the major TFA fatty acid existing in all of the carcass parts. It was observed in the current investigation that the level of total CLA in the

Table II.- Fatty acid composition of different carcass parts of Kıvırcık Lambs (g/100 g total fatty acids)[1]

Fatty acid	Leg	Shoulder	Rib	Breast	S.E.M.	*P*-Value
C 10:0	0.19	0.18	0.19	0.18	0.01	0.926
C 11:0*	0.03^{ab}	0.03^{b}	0.05^{a}	0.02^{b}	0.00	0.005**
C 12:0	0.24	0.22	0.30	0.26	0.02	0.287
C 13:0	0.06 ^{b}	0.06^{b}	0.09^{a}	0.04^{b}	0.01	0.003**
C 14:0	3.40^{ab}	3.10^{b}	2.45^{c}	3.82^{a}	0.11	0.001**
C 15:0	1.18^{ab}	1.24^{ab}	1.53^{a}	0.91^{b}	0.06	0.001**
C 16:0	21.83	22.39	20.79	21.12	0.31	0.269
C 17:0	3.25^{b}	3.72^{ab}	4.26^{a}	2.26^{c}	0.15	0.001**
C 18:0	12.45^{a}	12.26^{a}	10.68^{ab}	8.83^{b}	0.44	0.006**
C 19:0	0.22^{b}	0.20^{b}	0.17^{b}	0.32^{a}	0.01	0.001**
C 20:0	0.05^{a}	0.03^{b}	0.04^{a}	0.05^{a}	0.00	0.001**
C 21:0	0.05	0.04	0.05	0.05	0.00	0.873
C 22:0	0.01	0.01	0.01	0.02	0.00	0.085
Σ SFA	42.96^{a}	43.48^{a}	40.61^{ab}	37.88^{b}	0.63	0.002**
C 14:1ω5	0.29	0.27	0.29	0.35	0.02	0.292
C 15:1ω5	0.34^{a}	0.34^{a}	0.45^{a}	0.21^{b}	0.02	0.001**
C 16:1ω7	2.88^{b}	2.96^{b}	3.23^{b}	4.34^{a}	0.14	0.001**
C 17:1ω8	1.76^{b}	2.09^{ab}	2.92^{a}	2.49^{ab}	0.12	0.003**
C 18:1ω9	33.89^{b}	35.94^{b}	36.63^{b}	42.26^{a}	0.75	0.001**
C 18:1ω7	1.53	1.54	1.71	1.64	0.03	0.136
C 20:1ω9	0.10	0.06	0.12	0.09	0.01	0.065
C 22:1ω9	0.01	0.01	0.01	0.01	0.00	0.353
Σ MUFA	40.80^{b}	43.21^{b}	45.36^{b}	51.39^{a}	0.96	0.001**
C 18:2ω6	4.62^{a}	2.91^{b}	3.80^{ab}	3.08^{b}	0.16	0.001**
C 18:3ω6	0.08	0.09	0.07	0.07	0.00	0.150
C 18:3ω3	0.36^{a}	0.19^{b}	0.29^{a}	0.32^{a}	0.02	0.001**
C 20:2ω6	0.10	0.09	0.11	0.07	0.01	0.157
C 20:3ω6	0.05^{a}	0.03^{b}	0.05^{ab}	0.03^{b}	0.00	0.001**
C 20:3ω3	0.02	0.01	0.02	0.01	0.00	0.536
C 20:4ω6	0.16^{a}	0.06^{b}	0.12^{a}	0.13^{a}	0.01	0.001**
C 20:5ω3	0.02	0.02	0.02	0.01	0.00	0.634
C 22:2ω6	0.02	0.02	0.02	0.02	0.00	0.766
C 22:3ω3	0.03	0.03	0.04	0.02	0.00	0.180
C 22:4ω6	0.05	0.05	0.05	0.03	0.00	0.078
C 22:5ω6	0.02	0.03	0.01	0.02	0.00	0.195
C 22:5ω3	0.06^{a}	0.04^{b}	0.05^{ab}	0.06^{a}	0.00	0.013*
C 22:6ω3	0.02	0.02	0.02	0.02	0.00	0.767
Σ PUFA	5.61^{a}	3.59^{b}	4.67^{ab}	3.89^{b}	0.19	0.001**
C 14:1*t*9	0.08^{b}	0.08^{b}	0.13^{ab}	0.16^{a}	0.01	0.007**
C 16:1*t*9	0.52^{a}	0.45^{ab}	0.40^{b}	0.41^{b}	0.01	0.001**
C 18:1*t*9	0.08^{b}	0.10^{ab}	0.17^{a}	0.06^{b}	0.01	0.001**
C 18:1*t*11	8.50^{a}	8.03^{a}	7.32^{ab}	4.80^{b}	0.43	0.005**
C 18:2*t*9,*t*12	0.15^{a}	0.10^{b}	0.13^{ab}	0.11^{ab}	0.01	0.009**
C 18:2*t*9,*c*12	0.12	0.11	0.12	0.10	0.01	0.575
Σ TFA	9.45^{a}	8.87^{a}	8.27^{ab}	5.64^{b}	0.43	0.005**
C 18:2 *c*9,*t*11	1.15	0.83	1.07	1.18	0.06	0.092
C 18:2 *t*10,*c*12	0.01	0.01	0.01	0.01	0.00	0.902
C 18:2 *c*11,*t*13	0.02	0.01	0.01	0.01	0.00	0.200
Σ CLA	1.18	0.85	1.09	1.20	0.06	0.088
Σ ω3	0.51^{a}	0.31^{b}	0.44^{a}	0.44^{a}	0.02	0.001**
Σ ω6	5.10^{a}	3.28^{b}	4.23^{ab}	3.45^{b}	0.17	0.001**
ω3/ω6	0.10^{b}	0.09^{b}	0.10^{b}	0.13^{a}	0.00	0.001**

:** P<0.05, *:** P<0.01, SFA, saturated fatty acid; MUFA: unsaturated fatty acid; PUFA, polyunsaturated fatty acid; TFA, trans fatty acids; CLA, conjugated linoleic acid; ω3, omega-3; ω6, omega-6; [1]n=10.

breast was higher than in other carcass parts The percentage of rumenic acid (C 18:2 *c*9 *t*11), which is of great importance for human health, was higher in the breast than in the other carcass parts. Among carcass parts, the highest percentage of total ω3 and those of total ω6 were determined to be in the leg. The ω3/ω6 ratio in the carcass parts was higher in the breast ($P<0.05$).

DISCUSSION

Sanudo *et al.* (2000) reported intramuscular fatty acid values in Spanish Merino, Rasa Aragonesa, and Welsh Mountain breeds. Present values of palmitoleic acid fatty acid in all regions were higher compared with those reported values (2.69, 2.66, and 2.12, respectively). The SFA value for Spanish Merino (43.22) was similar to the shoulder and leg values recorded in the current study. On the other hand, the SFA values for Welsh Mountain and Rasa Aragonesa (49.97 and 47.35) were found higher than the corresponding values for all regions examined under the study. Present PUFA values were less than the values (14.61, 15.84, and 6.99) reported for the three former breeds. Mir *et al.* (2000) reported some values for fatty acids in leg and rib of Suffolk x Dorset crossbred lambs in the control group with palmitic acid (leg: 27.5, and rib: 30.0), stearic acid (C18:0) (leg: 14.7, and rib: 17.4), oleic acid (leg: 47.9, and rib: 45.5), linoleic acid (leg: 8.6, and rib: 5.7), and linolenic acid (C18:3ω6) (leg: 1.1, and rib: 1.3). Present findings were lower than those values reported by Mir *et al*. (2000). Diaz *et al.* (2002) reported the SFA, MUFA, and PUFA values in subcutaneous fat of lambs fed indoors as 57.16, 37.63, and 5.21, respectively, in the loin, and 56.80, 35.22, and 5.12, respectively, in the leg. SFA values obtained in the study were determined to be lower than the previously reported values; on the other hand, MUFA values were found higher. The values of PUFA recorded for the leg showed similar results with the earlier related reports. Caneque *et al.* (2005) reported that SFA, MUFA, PUFA, palmiteloic and oleic acid values of subcutaneous fat in the leg region of Manchego-breed lambs were measured as 57.15, 39.18, 3.67, 3.48, and 35.4, respectively. In the current study, SFA, palmitoleic and oleic acid values in the leg region were considered to be lower than those values reported previously, but present PUFA values were considered to be higher than the previously reported values, and MUFA value illustrated similarity. The palmitic acid value (20.4) reported by Demirel *et al.* (2006) for *longissimus thoracis* of Kivircik lambs confirmed the current results. The authors reported that the palmitic acid (1.97) value is but higher in the stearic acid (20.2) value in comparison to the present study. Additionally, oleic acid value (36.4) reported by Demirel *et al*. (2006) was found similar to the present values obtained in the shoulder and rib regions. Castro *et al.* (2005) averagely reported myristic acid (C14:0 (4.73)), palmitic acid (24.64), margaric acid (C17:0 (2.51)), stearic acid (10.36), palmitoleic acid (2.09), oleic acid (42.32), linoleic acid (4.36), SFA (42.75), MUFA (45.98), and PUFA (4.83) for subcutaneous fat in a control group consisting of Ojalada lambs. Güler *et al.* (2011) reported for the SFA, MUFA, PUFA, CLA, and palmitoleic acid; 41.79, 41.99, 4.96, 0.61, and 2.42, values in subcutaneous adipose tissue of Akkaraman lambs, which were concentrate feed. In the current study, MUFA values in leg, PUFA values in rib, CLA values in shoulder, and palmitoleic acid values in leg and shoulder showed similarity to corresponding values reported by Güler *et al.* (2011). Karabacak *et a*l. (2013) reported that SFA, MUFA, PUFA, CLA, trans and palmitoleic acid values from the breast region of Malya lambs were 39.52, 51.40, 4.45, 0.96, 3.67, and 3.81, respectively. The previous values were found similar to the values reported in the current study. In other previous study, Karabacak *et al.* (2014) remarked SFA, MUFA, PUFA, CLA, and palmitoleic acid ratios as 46.22, 40.38, 4.79, 1.49, and 3.22 in leg; 42.69, 44.17, 4.29, 1.69, and 3.75 in shoulder; 42.56, 46.17, 3.80, 1.53, and 4.14 in rib; and 40.27, 49.50, 3.72, 1.59, and 4.63 in breast, respectively. The findings of the current study on MUFA, PUFA, CLA and Palmitoleic acid values in leg; on SFA, MUFA and PUFA values in shoulder; on MUFA values in rib; and on PUFA, CLA and palmitoleic acid values in breast were in agreement with the values reported by Karabacak *et al.* (2014). Various advantages and disadvantages of fats used in human nutrition can be mentioned.

Customer demand determines prices of carcass parts. Since customers think that less fatty meat is healthier in sense that linking fats of animal origin and red meat to cardiovascular diseases, fattier regions are generally low-priced by affecting customer demand in a negative way. Considering the results, it is evident that breast region is more advantages than other carcass parts in terms of healthy fatty acid content, on the contrary widely accepted by consumers.

CONCLUSIONS

Taking into account the results of the current study, it could be seen that the breast was the carcass region where TFA ratio and total SFA had the lowest ratio and total MUFA had the highest ratio. The highest

ratio of total PUFA is registered in the leg. The highest values of total CLA ratio were recorded for the leg and breast. Additionally, the breast region had the highest ratio of palmitoleic acid. Considering the results, it is clearly evident that the breast region was more advantageous than other carcass parts in terms of fatty acid content.

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