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Fat Content and Fatty Acid Composition of Sheep Meat and Adipose Tissues at Retail Outlets in Khartoum State, Sudan

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Abstract

This study aimed to evaluate fat content and fatty acid (FA) composition of desert sheep meat and adipose tissues at retail outlets in Khartoum State, Sudan. A total of 25 carcasses of desert sheep were used in this study. Samples from *longissimus thoracic* muscle (LT), kidney fat (KF), and subcutaneous fat (SF) were obtained from each carcass for fat extraction using chloroform-methanol method, and FA analysis using CG/ MS technique. The fat contents were 80.76, 75.57, and 4.02% for KF, SF, and LT, respectively. The most abundant FAs were oleic, palmitic, and stearic, which comprised about 81 to 87% of the total FAs. The highest portion of oleic acid was found in LT (29.2%) followed by SF (27.22%), and the lowest portion (22.12%) was found in KF. The portion of palmitic acid was significantly higher in KF (30.17%) compared to that in LT (27.03%) or in SF (26.73%). Stearic acid was significantly higher in SF (33.32%) compared to KF (29.2%) and LT (26.74%). The proportions of linoleic acid were 9.35, 4.2, and 1.6% for LT, SF and KF, respectively. The proportion of α-linolenic was significantly higher in LT (0.7%) than in SF (0.5%).The LT muscle had the highest level desirable FAs (67.36%), followed by SF (65.74%), whereas the KF had the lowest level (55.83%) of desirable FAs.

Key words: Fat, fatty acids, sheep, Sudan

المستخلص

هدفت هذه الدراسة لتقييم محتوى الدهن و الأحماض الدهنية في اللحم و الإنسجة الدهنية للضان في منافذ بيع اللحوم بالتجزئة في ولاية الخرطوم. أخذت عينات من الجزء الصدري العضلة الطولية الظهرية و من النسيج الدهني تحت الجلد و حول الكلى من عدد 25 ذبيحة لتحديد محتوها الدهن و الاحماض الدهنية. أوضحت النتائج أن نسبة الدهن كانت 80.76% و 75.57% و 4.02% فى النسيج الدهني حول الكُلى و تحت الجلد و في العضلة الظهرية على التوالي. أكثر الاحماض الدهنية شيوعاً في الانسجة المختلفة كان الاوليك و البالمتيك و الاستيريك وشكلت مابين 81 الى 87% من الاحماض الدهنية الكلية. أعلى نسبة لحمض الاوليك (29.2%) كانت في العضلة الظهرية ثم فى الدهن تحت الجلد (27.22%) واقل نسبة كانت في الدهن حول الكلى (22.12%). نسبة حمض البالمتيك كانت أعلى فى الدهن حول الكُلى (30.17%) مما في العضلة الظهرية (27.03%) و الدهن تحت الجلد (26.37%)..نسبة حمض الإستيريك كانت أعلى معنوياً في الدهن تحت الجلد حول الكُلى (33.32%) مقارنة بدهون حول الكُلى (29.2%) و العضلة الظهرية (264. 7%). كانت نسبة حمض اللينوليك والفا-لينولينيك أعلى في العضلة الظهرية (9.35%) مقارنة بالدهن تحت الجلد (4.2%) و حول الكُلى 0.5 %. العضلة الطولية

الظهرية احتوت على النسبة أعلى من مجموع الاحماض الدهنية المرغوبة (67.36%) ومن ثم دهون تحت الجلد (65,74%) في حين أن الدهن حول الكلى إحتوي على اقل نسبة من الأحماض الدهنية المرغوبة (55.83%).

الكلمات المفتاحية: الدهون، الاحماض الدهنية، الضان، السودان

Introduction

Sudan has large sheep population of more than 40 million heads. Sheep in Sudan has been classified on the basis of morphology and distribution in to: Sudan Desert and Sudan Arid Upland. Desert sheep are further classified into tribal sub types, e.g. Hamari, Kabashi, in North and West Kordofan States, Shugor, Dubasi and Watish in the Central States More than 82% of sheep in Sudan are of the Sudan Desert type. More than 15 million heads of sheep are slaughtered annually for local consumption and export (MARF., 2017). These mentioned numbers reflect the importance of sheep meat in sudan.

The fat of meat is commonly believed to be a causal factor in the incidence of obesity, cardiovascular disease (CVD), and inflammatory diseases (McAfee *et al.*, 2010). However, the effect of fat depends much upon its fatty acid (FA) composition rather than quantity. Saturated and *trans*FAs are a risk factor for CVD, and promote inflammation (Garg and Wood, 2013). In contrast, polyunsaturated fatty acids (PUFA) have been related with physiological and health benefits, such as decrease the occurrence of CVD, atherosclerosis, hypertension (Adkins and Kelley, 2010), some cancers, inflammatory diseases (Laviano *et al., 2013*); in addition to improve eye and brain development (Hooper *et al., 2006*).

Fat is an important constituent of animal tissues, and has significant effects on nutritional value and quality of meat. The amount of fat and degree of solidification are varied among animal tissues. Type of FAs (saturated, monounsaturated or polyunsaturated) determines the physical characteristics and nutritional value of fat. Various factors affect the FA composition of animal tissues, such as: genetic variability (Werdi Pratiwi *et al., 2006*), sex (Mahgoub *et al., 2002*), and anatomical locations of tissues (Abuelfatah *et al., 2014*). However, diet is generally considered to be the most important factor affecting the FA composition of animal tissues (Banskalieva *et al., 2000*; Raes *et al., 2004*; Woods and Fearon, 2009). Spite of the importance of sheep meat in Sudan, there is no available information about FA composition. Therefore, the objective of this study was to evaluate fat content and FA composition of sheep meat at retail outlet at Khartoum state.

Materials and Methods

Samples Collection

A total of 25 carcasses of Sudan desert sheep, obtained from Khartoum state markets during October and November 2016, were used in this study. Samples were taken from *longissimus thoracic* muscle (LT*)* (from 10^{th} to 12^{th} rib), kidney fat (KF) and subcutaneous fat (SF) (from the back between the 10^{th} and the 12^{th} ribs) were taken from each carcass. Then all the samples were packaged and kept at -18 °C until fat and FAs analysis.

Lipid extraction and fatty acids analysis

The total FAs were extracted from the samples based on the method of Folch *et al., (*1957) using chloroform–methanol 2:1 (v/v). About 1 g of fresh muscle or fat of sample was used. The FAs were transmethylated to their FA methyl esters (FAME) using 0.66 N KOH in 14% methanol and methanolic boron trifluoride

(BF3) according to the methods of AOAC (2007).

The qualitative of the FAs was carried out using GC/MS technique model (GC/MS-QP2010-Ultra),Simadzu Company, Japan, with capillary column (Rtx-5ms-30 m × 0.25mm × 0. 25 µm). The sample was injected using split mode, helium as the carrier gas passed with flow rate 1.61 ml/min, the temperature program was started from 60°C with rate 10°C /min to 300 ° C as final temperature degree, the injection port temperature was 300 °C and the interface temperature was 250 °C. The sample was analyzed by using scan mode in the range of m/z 40- 550 charges to ratio, and the total run time was 24minutes. A reference standard (mix C4–C24 methylesters; Sigma–Aldrin, Inc., St. Louis, Mo, USA) was used for determining individual FA.

Statistical Analysis

Data were analyzed using SPSS program (version 13). One-way ANOVA was used to compare the differences between fat content and FA composition of sheep tissues. Duncan's multiple range test was employed to detect the significance between means. Differences between the least squared means were considered to be significant at $P < 0.05$.

Results

The result of fat content is illustrated in Figure **1.** The highest percentage of fat content was found in KF (80.76%), followed by SF (75.57%), and the lowest (4.02%) was represented by LT.

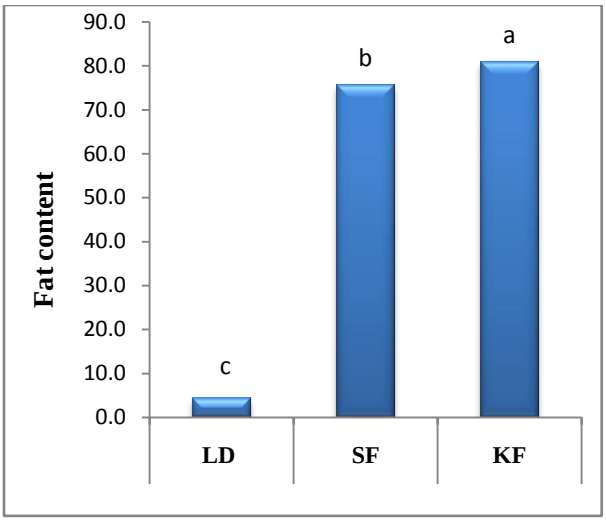

Figure 1: Fat content of *Longissimus thoracic* muscle (TD), subcutaneous (SF) and kidney fat (KF) of sheep at retail outlet.

Bars with different alphabet notation differ significantly ($P < 0.05$).

The result of FA composition of LT, SF and KF of sheep is shown in Table 1. Palmitic (C16:0), stearic (C18:0) and oleic (C18:1) were comprised the largest proportions of FAs in sheep tissues with significant differences in their proportions among the tissues. Oleic acid represented the most abundant FA in LT (29.2%), whereas palmitic was the most abundant FA (30.17%) in KF, while stearic being the most abundant FA in SF (33.32%). The sheep tissues contained 9.35%, 4.2% and 1.6% of linoleic acid in LT, SF and KF, respectively. The proportion of α-linolenic was significantly higher in LT (0.7%) compared to SF (0.5); however, this essential FA was not detected in KF.

The total SFA and UFA content significantly differed among sheep tissues. The highest level of UFA (40.62%) was exhibited by LT, while the lowest level of UFA (26.85%) was observed in KF. In SF, the level of UFA was 32.42%. For the total MUFA and PUFA, they varied significantly among the sheep tissues. The highest levels of MUFA and PUFA were found in LT

followed by SF, and the lowest levels were scored by KF.

The total percentage of desirable FAs was significantly higher in LT (67.36%), than in SF (65.74%), and the lowest percentage (55.83%) was found in KF.

The UFA: SFA ratio was significantly different among sheep tissues. The highest ratio (0.68) was found in LT, and the lowest ratio (0.37) was found in KF, whereas in SF laid in between (0.48).

The PUFA: SFA ratio showed significant difference among tissues of sheep tissues, with values of 0.17, 0.07, and 0.02 for LT, SF, and KF respectively.

Table 1 Fatty acid composition of *Longissimus thoracic* muscl*e* (LT), subcutaneous fat (SF) and kidney fat (KF) of sheep at retail outlet

	Tissue[1]		
	LT	**SF**	**KF**
Fatty acid (%) of total fatty acids			
C10:0 carpic	0.39^{b}	-	1.06^{a}
C12:0, lauric	0.44^{b}	1.0^{a}	1.11^{a}
C14:0, myristic	3.18^{c}	4.51^{b}	9.48^{a}
C15:0, pentadecanoic	0.60^{c}	1.0^{b}	1.34^{a}
C15:1, pentadecanoic	-	-	-
C16:0, palmitic	27.03^{b}	26.73^{b}	30.17^{a}
C16:1, palmitoleic	1.37^{a}	0.5^{b}	1.48^{a}
C17:0, heptadecanoic	1.00^{b}	1.02^{b}	2.07^{c}
C17.1, heptadecenoic	-	-	0.59
C18:0, stearic	26.74^{b}	33.32^{a}	28.98^{b}
C18:1 n-9, oleic	29.20^{a}	27.22^{b}	22.12^{c}
C18:2 n-6, linoleic	9.35^{a}	4.2^{b}	1.60^{c}
C18:3 n-3, linolenic	0.70^{a}	0.50^{b}	-
C20:0, arachidonic	-	-	0.73
SFA[2]	59.38^{c}	67.58^{b}	73.1 5^{a}
UFA[3]	40.62^{a}	32.42^{b}	26.85^{c}
MUFA[4]	30.57^{a}	27.72^{b}	24.19^{c}
PUFA[5]	10.05^{a}	4.70^{b}	1.60^{c}
Desirable FA[6]	67.36^{a}	65.74^{b}	55.83^{c}
UFA/SFA	0.68^{a}	0.48^{b}	0.37^{c}
PUFA/SFA	0.17^{a}	0.07^{b}	0.02^{c}

[1] LT= *longissimus dorsi* muscle, SF= subcutaneous fat, KF= kidney fat

[2] SFA (saturated fatty acids) = C10+C12:0 +C14:0+C15:0+C16:0+C17:0+ C18:0+C20.

[3] UFA (unsaturated fatty acids) C15:1+ C16:1 + C17:1 + C18:1n-9 + C18:2 n-6 + C18:3 n-3.

[4] MUFA (monounsaturated fatty acids) = C15:1+C16:1+C17:1+C18:1 n-9

[5]PUFA = C18:3 n-3 + C18:2 n-6.

[6]Desirable FA= C18:0+MUFA+PUFA.

Discussion

This study aimed to assess fat content, and FA composition in LT muscle and adipose tissue of sheep carcasses obtained from retail outlets, with an emphasis on the nutritional value. Fat content and FA composition, whether in muscle or adipose tissues, contribute significantly to various aspects of quality and the nutritional value of meat. In this study, the values of fat content for LT was lower than that reported in a similar study by conducted by Enser *et al.,* (1998) in English lamb at retail outlet. In General, the amount of intramuscular fat is associated to overall carcass fatness; however, it also affected by genotype (Fisher *et al., 2000*). The fat content of adipose tissues SF and KF in this study in agreement with Wood *et al., (*2004) who reported that adipose tissue contains 60–90% lipid.

The FAs in meat have 12–22 carbon atoms. However, minor quantities of shorter chain length FA (C8–C10) were found in lamb fat (Wood and Enser, 2017). The detected FAs in the current study were within this range. Nevertheless, for shorter FAs (8-10 carbons), only carpic acid (C10:0) was detected in LT muscle.

The high level of total SFA in the all studied tissues is in consistent with the fact that meat appears to be the greatest sources of SFA. The SFA in ruminant meat can originate from the feed, and formed in the rumen from UFA dietary, or synthesized from acetate and glucose in the liver or adipose tissue (Wood, 2007). The variation in levels of SFA among LT muscle, which had the least proportion of SFA, and adipose tissues was reported previously in numerous studies, i.e. (Wood *et al.,* 2008; Noci *et al.,* 2011). Palmitic (C16:0) and stearic (C18:0) comprised the major SFAs in sheep tissues. Palmitic acid (C16:0) in meat is of special nutritional concern in human population due to its role in increasing plasma low density lipoprotein (LDL) cholesterol, a main risk factor for CVD in human , while stearic acid does not exhibit such an effect (Denke and Grundy, 1992; Tholstrup *et al.,* 1994). Therefore, the consumption of sheep KF, which was found to have the highest level of palmitic acid in this study, must be avoided.

UFA in meat generally accounts for around 40–50%, and contribute the largest share of UFA in a human diet after oils (Woods and Fearon, 2009). In agreement with many studies, i.e. (Noci *et al., 2011*) oleic acid (C18:1) represented the most abundant fatty acid in muscle and subcutaneous fat in sheep.

Only α-linolenic and linoleic PUFA are known to be essential for animals as animal lack of enzyme fatty acyl-CoA desaturase (Δ12 and Δ15) (Whitney *et al.,* 2010). The sheep LT muscle contained high proportion of these essential FAs, where KF had low proportion or lacked to these beneficial FAs. The internal fat (omental fat, mesenteric fat and kidney fat) contains high levels of SFA, while the muscle fat has the highest PUFA content as a component of cellular membranes (Warriss, 2000).

The UFA: SFA, PUFA: SFA ratios are usually used as an indicator to judge the nutritional value of fat. The recommended ratio of PUFA: SFA in human diets according to the British Department of Health, (1994) is >0.45. Although LT scored the highest ratio PUFA: SFA (0.17) among the studied tissues; however, it still below the recommended ratio (0.45). Nevertheless, the ratio of PUFA: SFA in red meat is found to be around 0.1 (Enser *et al.,* 1998).

It can be concluded that sheep meat contains considerable percentage of beneficial fatty acids. Subcutaneous fat contains more desirable fatty acids than that of kidney fat.

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