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Analysis of Fatty Acids Composition of Longdong Black Goat Muscle Tissue by Gas Chromatography-Mass Spectrometer

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Abstract

The current study determines the composition of Fatty Acid (FA) of Longdong black goat muscle tissues (Chinese breed) with analysis in sex of representative, Longdong black goat muscle tissues (30 from females and 30 from males) were determined using Mass spectrometer. The results approved that female's goats muscle tissues had a lower amount of Saturated Fatty Acid (SFA) with 27.87%, than males with 28.06%. Oleic acid C18:1 is 18.15% in females to 27.15% in males. Higher proportion of Poly Unsaturated Fatty Acids (PUFA) Linoleic acid (C18:2), arachidonic acid (C20:4n3c) with 15.45%, 11.14% respectively in cut male's muscle tissue. Eicosatetraenic acid (C20:5n3c) was found 17.76% in female's muscle. Omega-3 Polyunsaturated Fatty Acids (PUFA) Linolenic acid (C18:3n3) and docosahexaenoic (C22:6n3) with 2.4% and 2.58% were observed in both sex goat muscles tissue. SFA were found in low values between 12% to 1.08% in both sex muscle tissues. PUFA ratio was higher than SFA ratio in males with 31.90% and in females 27.87%. Monounsaturated fatty acid (MUFA) levels also were observed higher with about 29.21% than the values of saturated fatty acids (SFA) values 27.87% in females. All muscle tissues in both females and males have the same type of fatty acid composition with different in proportions, there is a little effect in sex proportions.

Keywords: Fatty acids; Longdong goats; Sex; Gas chromatography; Mass spectrometer

Introduction

Goats are one of the most widely domesticated animals, as evidenced by their wide distribution and utilization due to their high adaptability to a broad range of environments. They are also able to utilize marginal land to produce high-quality protein products. Goat meat is the primary source of protein in many parts of the world, especially Asia and Africa. The importance of goats is associated with the increasing number of goats globally [1]. FAO, annual report stated that the worlds goat population was around 720 million in 2000, with annual meat production of around 4.2 million metric tons [2].

Goat meat has been extensively compared to lamb and mutton, and difference in flavor and aroma have been noted [3]. China has the largest goat populations in the world. Goats are found throughout China, with approximately 476×10^6 kg of goat meat. This production comes from all regions of the country, but the major amount comes from Southern China [4]. The Chinese indigenous goat breeds are also the natural gene pool for goat breeding. Some breeds possess specific gene resources endowed by nature. It is commonly accepted that the breed diversity is the genetic ability of a breed or a population adapting to human demand variation. The diversity of Chinese goat breeds just leads to the extensive adaptability [5]. Goats tend to be leaner (intra-muscular and back fat), have a lower dressing percentage, and higher muscle shear force values than sheep [6]. Conjugated linoleic acid (CLA) and polyunsaturated FA (PUFA), especially those of the n-3 series, are beneficial to human health; whereas myristic and palmitic acids are considered to negatively impact health, healthful FA benefit the cardiovascular system and lipid metabolism and may help to prevent cancer [7]. The study was to determine Longdong black goat muscle tissues (Chinese breed) With analyses of fatty composition and the effect of sex.

Materials and Methods

Materials

Source of meat samples: Sixty of Longdong black goat, Chinese breeds (female, n=30, male, n=30) which had an initial live weight of 11~16 kg, were obtained from a commercial herd of Huan county located on east of Gansu province northwest of China, December 2016, average temperature is 8.6°C-9.9°C. Samples was carried out with guidelines of Gansu Agricultural University Animal Care Committee.

Sample collection: Samples from the meat of five parts from muscle tissue were collected (2016) at Huan county in Gansu, China, left side without stomachs, intestine. Muscles tissues of Sirloin, Shoulder, Shank, Flank, and Hindleg were collected. The total separated muscle tissue was minced, until obtaining a homogeneous sample and stored frozen; in a freezer to prevent oxidation and structural changes in the fatty acids, samples were store at −65°C.

Methods

Extraction of fatty acids: Approximately 50 g of muscle tissue was thawed, minced and homogenized in a FJ200-Shomogenizer (Shanghai Suoying Instruments, Shanghai, China) and 5 g sample was transferred to a 50 mL round flask. Then 8 mL BF3-methanol (14%) was added to the sample. The sample was removed to a 50 mL screw-cap tube.

Saturated NaCl tube was vortexed 2810 × 5 Fatty Acids methyl ester (FAME), 500 mg Na_2SO_4 to 5 mL original and vortexes again, at 35°C in a RE3000A rotary evaporator (Shanghai Yarong Instruments, Shanghai, China), reconstituted in 1 mL of HPLC grade hexane, and directly submitted to analysis.

Fatty acid by GC/MS: Fatty Acids were analyzed with (Agilent 6890 N) gas chromatograph (GC) coupled to a mass detector MS (Agilent 5973 N) (Agilent Technologies Inc, Palo Alto, CA), a fused silica capillary column DB-23 (30 m × 0.25 mm i.d, J and W Scientific, was used for the separation of fatty acids. Helium as the carrier gas (flow rate=1.0 mL min^{-1}). Temperature injector was 260°C. The oven temperature program was as follows: 140°C for 4 min and 4°C min^{-1} to 230°C, held for 15 min. The ion source and the Quadro pole temperature were 150°C and 230°C, respectively, MS transfer line was 230°C. MS scan range was set from 40 to 550 amu. Fatty acids were identified by comparison of retention times with reference compounds purchased from Supelco, USA. Fatty acid contents had been expressed as percentage of total FAMEs analyzed based on the internal standard technique, using tricosanic acid C23:0 as standard.

Data analysis: Effects of slaughter and their interactions, means were computed and tested for differences using package one-way ANOVA (General Linear Models) and excel 10 for other data (mean, standard error and the ratio).

Results and Discussion

Fatty acids of muscles

Identified by MS library (Table 1; Figure 1), the most abundant fatty acid are arachidonic, C20:4n3, linoleic, C18:2, stearic, C18:0, oleic, C18:1, Palmitic, C16:0, Eicosatetraenoic, C20:5n3 and docosahexaenoic C22:6n3 acids, The proportion of (PUFA) 0.46% to 17.76% in females, and 0.53% to 15.45% in males (Table 2). Linoleic C18:2n3c, eicosatetraenoic C20:5n3 were found in the highest amounts, 15.45%, 17.76% in both female and male respectively. This also illustrated by Wood et al. reported that in muscle, the high proportion of 18:2n6 in phospholipid compared with neutral lipid in all species means that muscle from lean animals has high proportions of this major PUFA [8]. The main MUFA component were palmitoleic C16:1, hexadecenoic (C16:1n9-C16:1n11) acids (Figure 2). Oleic C18:1, higher of C:18 oleic acid 18.15% in females and 27.15% in males, low amounts of palmitoleic acids C16:13.1% in females to 2.06% in males. Total of (SFA) contents were lauric C12:0, butyric C4:0, and myristic C14:0 acids in low amounts between 0.12% to 1.08% in both sex muscle tissues, compared to high amounts of palmitic acid C16:0, margaric acid C17:0 and stearic acid C18:0 8.81%to 16.20% in female and male muscles tissues. The level of PUFA and PUFA:SFA ratio were greater in Longdong male animals compared with females. The concentration of PUFA in females was parallel to Banskalieva et al. From both female and male FA composition of muscles tissues observed that the mean of MUFA, PUFA were lower 21.25%, 21.93% respectively than the mean amounts of SFA 27.87% in female, with higher amounts in male 29.21%, 31.90% and SFA 28.06% [9] (Table 2). Also observed that the SFA:MUFA ratio of females was 1.32 and PUFA:SFA was 1.14 in males and this result going with Kris Etherton, mentioned PUFA:SFA ratio one of the main criteria's currently used to evaluate the nutritional quality of the lipid fraction of foods, nutritional guidelines suggested PUFA:SFA ratio above 0.4, although several researchers stated that this ratio must be considered together with n-6:n-3 ratio due to the benefits of linoleic acid (n-6) on health, that is produced only when PUFA/SFA ratio is no greater than 1.5 also according to nutritional guidelines, means also that Longdong goat meat is suitable meat, healthy and more safety for human consumption (Table 2) [10]. However, the result demonstrates current dietary guidelines [11].

Peak	R.T.*	Area (Abund.min)	Fatty acid	Structure
1	5.274	19130	Butyric acid	C4:0
2	5.628	28236	Lauric acid	C12:0
3	7.989	53113	Myristic acid	C14:0
4	10.98	18506	Palmitic acid	C16:0
5	13.37	22399	Hexadecenoic acid	C16: 1n9
6	14.13	63578	Palmitoleic acid	C16:1
7	14.73	81776	Hexadecenoic acid	C16:1n11
8	14.93	11360	Margaric acid	C17:0
9	15.65	14943	Stearic acid	C18:0
10	16.16	39045	Oleic acid	C18:1
11	17.9	19055	Linoleic acid	C18:2 n3c
12	19.4	40477	Linolenic acid	C18:3n3
13	19.93	13596	Arachidonic acid	C20:4
14	20.55	47653	Eicosatetraenoic acid	C20:5n3
15	21.96	82754	Docosahexaenoic acid	C22:6 n3

Table 1: MS identification of fatty acid compounds names. *RT: Retention of time.

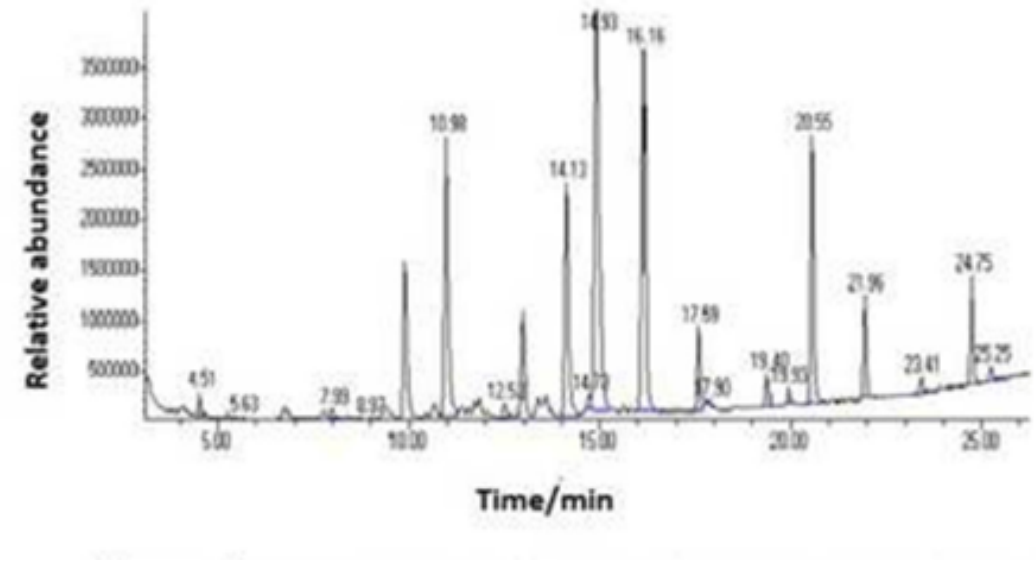

Figure 1: GC-MS Analysis of fatty acid of Muscle tissue of Longdong black goat.

Sex and Weight

Sex has some influence on carcass Fatty Acid (FA) composition and meat properties of Longdong black goats (Table 2). The abundant fatty acids in female and male goat muscle tissues were margaric C17:0, oleic C18:1, palmitic C16:0, stearic C18:0, linoleic, palmitoleic C16:1, C18:2, archidonic C20:4, and eicosatetraenoic C20:5 acids. Oleic C18:1 acid was found in low proportion in the muscle tissues of female goats were (18.15%) (Table 1) in all muscle tissue cuts (sirloion, shoulder, shank, flank, and hind leg), male goats had higher amounts (27.15%) (Table 2). The flank compromised lowest proportion of C16:1, C18:2, 0.37% to 0.47% respectively of the muscle tissues of female goats, whereas the shoulder and hind leg cuts had the highest composition of stearic C18:0, 11.45%, oleic C18:1 30.32% of muscle tissues. Palmitic C16:0, were observed in low proportion (1.75%), in all muscle cut of Females, but had a higher proportion (16.20%) in males. Females goat showed a higher percentage of stearic C18:0 ranging from 14.90% to 8.81% in males (Tables 1 and 2). Female had higher levels of C4:0, C16:0, C17:0, C18:1, C16:1n9, and C20:5 but lower levels of C18:2, C18:3, C20:4 0.46%, 0.70%, 0.97% respectively (Table 2). Compare to the high amount of linoleic C18:2 acids, archidonic C20:4 acid and linolenic acid C18:3, in males 15.45%, 11.14% and 1.70%. The values for the Longding black goats were also like those reported by Karaca et al., that these variances in proportion may be due to several factors, among them and the age of the animals, which could influence the amount of fat deposition when the animals are supplemented with concentrate or fed in a pasture system (Table 2) [12]. Mahgoub et al. reported that weight at slaughter influenced composition, with others having more total carcass and total body fat than intact males or females at an 11 kg slaughter weight, whereas female does have more total body weight carcass, but the study demonstrate that male have the total body weight carcass [13]. Overall, myristic C14:0 acid ranging from 0.26% to 0.32% of total FA and linolenic C18:3, acid was found in a low amount ranging from 0.69% to 1.70% of total FA of both female and male respectively. Concentrations of palmitoleic C16:1, hexadecenoic acids (C16:1n9-C16:1n11) and other FA composition, butyric C4:0, lauric C12:0 acids were observed in low concentrate ranging from 0.17% to 0.75% in females compare to 0.12% to 0.57% in males which probably contributed to the low amounts of saturated fatty acids composition in the muscle tissues of Longdong black goat. Mahgoub et al. reported that weight at slaughter affect composition, whether having more total body and total carcass fat than intact males or females at 11 kg slaughter weight, whereas female does have more total body and carcass fat than male, which had more fat than intact males, at 18 and 28 kg slaughter weights for males and females respectively. The result was similar to this study, which is ranging from 10 kg to 15 kg for Longdong black goat [13,14]. As detected in the study, differences in the muscle tissues composition between different primal cuts was reported [15]. However, the main difference FA content in female may be due to the balance between the energy of the diet and nutritional needs of the goats (Tables 3 and 4).

Fatty acid Composition	Female (10-12 kg)		Male (10-15 kg)		Effect of sex
	Mean	SEM*	Mean	SEM	
C4:0	1.08	0.05	0.12	0.02	*
C12:0	0.17	0	0.14	0.01	
C14:0	0.32	0	0.26	0.06	
C16:0	1.75	0.06	16.2	0.51	*
C17:0	9.63	0.57	2.53	0.18	
C18:0	14.93	1.35	8.81	0.95	
C16:1	0.36	0	0.95	0.09	

C16:1n9	1.99	0.06	0.57	0.12	*
C16:1n11	0.75	0.02	0.54	0.05	
C18:1	18.15	0.91	27.15	1.35	
C18:2	0.46	0	15.45	0.89	
C18:3	0.7	0.01	1.7	0.11	
C20:4	0.96	0.01	11.14	0.6	
C20:5	17.76	0.18	3.07	0.267	*
C22:6	2.054	0.04	0.53	0.08	
SFAa	27.87	1.43	28.06	0.99	
MUFAb	21.25	0.88	29.21	1.41	
PUFAc	21.93	0.21	31.9	1.54	
PUFA: SFA	0.8	0.05	1.14	0.08	
SFA:MUFA	1.32	0.1	0.97	0.06	

Table 2: Fatty acid composition of muscle tissue of different sex and weight. SEM: Standard Error Mean.

			Female				
Fatty acid Composition	**Sirloin**	**Shoulder**	**Shank**	**Flank**	**Hind Leg**	**Mean**	**SEMa**
C4:0	1.2	1.21	1.03	0.93	1.04	1.08	0.05
C12:0	0.16	0.15	0.17	0.17	0.18	0.17	0
C14:0	0.33	0.31	0.32	0.31	0.32	0.32	0
C16:0	1.65	1.69	1.75	1.99	1.67	1.75	0.06
C17:0	8.71	9.71	10.75	8.02	10.94	9.63	0.57
C18:0	19.45	11.45	15.69	13.03	15.04	14.93	1.35
C16:1	0.38	0.34	0.35	0.37	0.37	0.36	0
C16:1n9	2.02	2.02	2.1	1.77	2.03	1.99	0.06
C16:1n11	0.7	0.78	0.78	0.71	0.76	0.75	0.02
C18:1	20.36	19.2	15.49	19.19	16.53	18.15	0.91
C18:2	0.47	0.46	0.46	0.47	0.44	0.46	0
C18:3	0.68	0.68	0.67	0.73	0.72	0.7	0.01
C20:4	0.99	0.98	0.96	0.94	0.92	0.96	0.01
C20:5	17.2	18.16	17.68	18.15	17.6	17.76	0.18
C22:6	1.94	2.02	2.02	2.19	2.1	2.054	0.04
SFAb	31.5	24.52	29.71	24.45	29.19	27.87	1.43
MUFAc	23.46	22.34	18.72	22.04	19.69	21.25	0.88
PUFAd	21.28	22.3	21.79	22.48	21.78	21.93	0.21
PUFA: SFA	0.67	0.91	0.73	0.92	0.74	0.8	0.05
SFA:MUFA	1.34	1.1	1.59	1.11	1.48	1.32	0.1

Table 3: Fatty acid compositions and Standard error mean (SEM) of muscles tissues Longdong female black goats breed. a: Standard error of mean, b: Saturated fatty acids, c: Monosaturated fatty acids, d: Polyunsaturated fatty acids.

			Male				
Fatty acid Compositio n	**Sirloin**	**Shoulder**	**Shank**	**Flank**	**Hind Leg**	**Mean**	**SEMa**
C4:0	0.07	0.12	0.21	0.11	0.11	0.12	0.02
C12:0	0.16	0.11	0.14	0.14	0.15	0.14	0.01
C14:0	0.47	0.24	0.07	0.26	0.28	0.26	0.06
C16:0	15.52	16.28	18.04	15.04	16.1	16.2	0.51
C17:0	2.42	2.81	1.87	2.87	2.66	2.53	0.18
C18:0	9.6	12.19	7.16	7.82	7.27	8.81	0.95
C16:1	0.65	1.11	1.14	0.87	0.98	0.95	0.09
C16:1n9	1.01	0.36	0.37	0.46	0.66	0.57	0.12
C16:1n11	0.43	0.47	0.72	0.5	0.56	0.54	0.05
C18:1	29.87	25.73	26.77	23.06	30.32	27.15	1.35
C18:2	15.21	14.05	17.15	17.75	13.1	15.45	0.89
C18:3	1.45	1.94	1.76	1.92	1.45	1.7	0.11
C20:4	10.56	10.54	10.09	13.48	11.01	11.14	0.6
C20:5	2.12	3.08	3.04	3.71	3.4	3.07	0.267
C22:6	0.55	0.52	0.41	0.81	0.38	0.53	0.08
SFAb	28.24	31.75	27.49	26.24	26.57	28.06	0.99
MUFAc	31.96	27.67	29	24.89	32.52	29.21	1.41
PUFAd	29.89	30.13	32.45	37.67	29.34	31.9	1.54
PUFA: SFA	1.06	0.95	1.18	1.43	1.1	1.14	0.08
SFA:MUFA	0.88	1.15	0.95	1.05	0.82	0.97	0.06

Table 4: Fatty acid compositions and Standard error of mean (SEM) of muscles tissues of Longdong male black goats breed. a: Standard error of mean, b: Saturated fatty acids, c: Monosaturated fatty acids, d: Polyunsaturated fatty acids.

Discussion

The study indicated that male's carcasses had higher contents of C18:0, C16:0, C18:1, C18:2 and C20:4 acids of FA in the muscle tissues compare to lower contents of C14:0, C4:0, C12:0, and C20:5 acids, than females. The goat cuts (Sirloin, Shoulder, Shank, Flank, and Hind leg presented higher proportions of SFA (31.5%) and lower proportions of PUFA (21.28%) in female than males 28.24%, to 29.89% respectively. Stearic acid C18:0, oleic acid C18:1 and linoleic acid C18:2 were the main SFA, MUFA, and PUFA in the muscle tissue. PUFA, MUFA proportions comprised the lower proportions 21.28%, 23.46%,

respectively in Longdong black female goat samples. A decrease in fatty acid proportion was observed in the male goat in C4:0, C16:1n9, C16:1n11, C17:0, C18:0 (Tables 2 and 3). According to FA composition, Longdong black goat males had the major constituents MUFA (31.96%), and PUFA (29.89%). Whereas SFA were the major constituents of females (31.5%). Hajji et al. mentioned all individual PUFAs were affected by the diet, with higher percentages for meat from pasture-fed animals [16]. Female goat (SFA) C4:0, C17:0, C18:0, in sirloin followed by the shoulder, shank, flank and hind leg had the highest proportion in Caracas, with lowest value of C12:0, C14:0, C16:0 acids 25.64%, 2.24% respectively. Male carcass had highest value proportion of C16:0 acids 16.20%. MUFA Oleic acid C18:1, had the highest proportion of females and male's carcass compared to low value of C16:1, c16:1n9 and c16:1n11 in both animals (Figure 2). Therefore, Longdong goats showed the highest proportion of polyunsaturated fatty acids (PUFA) C18:2, C20:4 26.59%. FA among all the types analyzed of male goats. Whereas female have less of total carcass FA of C18:2, C20:4 1.42%, also obtained C20:5 with high proportions in females at all types of carcass samples 17.76%. The very long chain n-3 PUFA (22:6n-3), were observed in FA muscle tissues of Longdong goat meat with a low proportion 2.05%, 0.53% in females and males. Eduardo et al. reported that the goats produced 16.7-16.4% of total fatty acids [17]. Todaro et al., Sanz Sampelayo et al. and Nudda et al. reported that n-3 FAs are measured as the most important dietary FA for human health [18-20]. Nowdays human health recommendations include a dietary n-6:n-3 FA optimum of 2.0-2.5, but most human food stuffs have a ratio nearer to 5.0-10.0 [7].

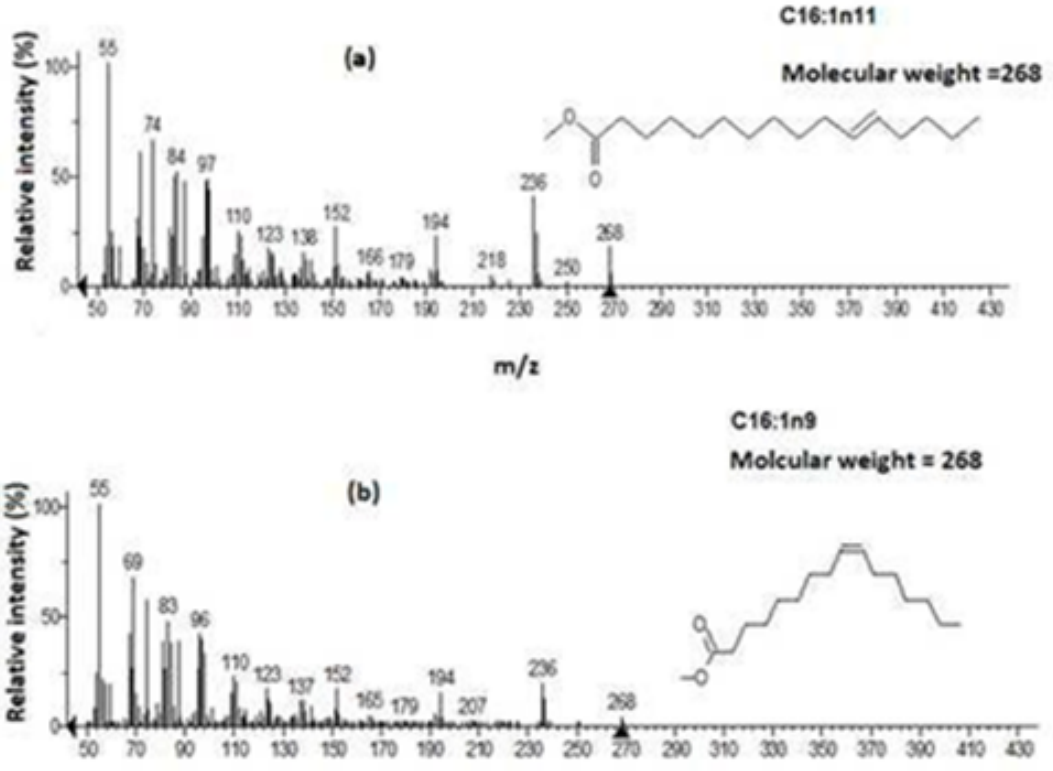

Figure 2: a)11-Hexadecenoic acid, methyl ester, b)9-Hexadecenoic acid, methyl ester.

Conclusion

The study demonstrates that the FA of Longdong black goat analysis showed high amounts of oleic acid C18:1, then Stearic acid C18:0 and palmitic C16:0. MUFA epitomized the major amounts of male goats were as SFA and PUFA were the major amounts of females. The FA composition of the sirloin, shoulder, shank, flank and hind leg muscle tissues from Londong black goats had some significant (P=0.05) effect in sex only in the differences in amount proportions of fatty acid compositions. Nutritional ratios PUFA/SFA agreed with international health organizations suggested. Within the desirable limits. Due to its low price it can replace lamb and mutton particularly among low-income groups. Can replace lamb and mutton particularly among low-income groups.

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