Buletin Peternakan 46 (3):184-192, August 2022

ISSTAP
Indonesian Society for Sustainable Tropical Animal Production

Bulletin of Animal Science

ISSN-0126-4400/E-ISSN-2407-876X Accredited: 36a/E/KPT/2016
http://buletinpeternakan.fapet.ugm.ac.id/

Doi: 10.21059/buletinpeternak.v46i3.74048

The Carcass and Nutritional Meat Characteristics of Sapudi and Cross Merino Sheep

Himmatul Khasanah[1]*, Gayuh Syaikhullah[2], and M. Adhyatma[2]

[1]Program Study of Animal Husbandry, Faculty of Agriculture, University of Jember, Jember, 68121, Indonesia
[2]Animal Science Department, Politeknik Negeri Jember, Jember, 68101, Indonesia

Article history
Submitted: 11 April 2022
Accepted: 15 July 2022

* Corresponding author:
Telp. +62 852 5909 2227
E-mail: himma@unej.ac.id

ABSTRACT

Sheep meat plays an important role in accomplishing balanced and healthy nutrition as a source of protein, fat, and essential micronutrients such as zinc, iron, and vitamin B12. The amino and fatty acid composition of meat in different breeds need to be assessed to characterize and determine the development prospects of sheep that produce healthy and good quality meat. Therefore, this study aimed to investigate the phenotypic characteristics of the Sapudi and Cross Merino meat sheep including the carcass performance and meat qualities. We reared four Sapudi and four Cross Merino ewes in the same feed and environmental management for two months then slaughtered and analysed the carcass, non-carcasses and chemical meat properties. We used *Bicep femoris* muscle to perform proximate, amino acid, and fatty acid contents. An independent t-test was conducted to compared obtained data. Heart weight and protein content were higher in Sapudi sheep. Of the 51 fatty acids observed, we found 11 and 10 types of fatty acid in the Sapudi and Cross Merino meat, respectively. The fatty acid percentage of Sapudi meat tended to have higher value compared to Cross Merino. We also found that the two breeds have the same amino and fatty acid compositions. The levels of glycine, arginine, serine, tyrosine, phenylalanine, lysine and threonine were statistically higher in Cross Merino than Sapudi. In conclusion, the non-carcass, crude protein, amino acid and fatty acid level were significantly different between Sapudi and Cross Merino.

Keywords: Amino acid, *Bicep femoris*, Fatty acid, Meat protein, Proximate

Introduction

Sheep is an animal protein source that is in great demand by the public. East Java is the second producer of sheep after West Java, with a total production of 7,800 tons in 2020, increasing 2.5% from 2019 (Directorate General of Livestock and Animal Health, 2020). In East Java, many types of sheep are raised intensively in smallholder farms and medium-scale businesses. The sheep farming business in East Java is generally aimed at producing male sheep targeted for sale during the Eid al-Adha Feast of Sacrifice (Komariah *et al.,* 2015), *aqiqah*, and fulfilling the demands of daily traders (satay and other processed lamb and sheep meat) (Widianingrum and Khasanah, 2021). Farmers in East Java Province raise fat-tailed sheep and crossbreed because they consider it has good productivity, adaptability, prolificacy, and good performance in fattening and crossbreeding. Sapudi sheep is one of the indigenous sheep classified as fat-tail sheep commonly raised in Madura Island and East Java. Moreover, the characteristics of fat-tailed sheep are also quite promising and profitable in terms of the carcass percentage (Sodiq and Tawfik, 2004).

Meat is an essential source of nutrients for people, mainly oligo-elements, essential amino acids, and fatty acids. The lamb meat has its attractiveness, some consumers like a lamb meat because of its distinctive odor (off-flavor), and others avoid consuming that meat because they do not like the odor. Other factors influencing sheep meat preference were its tenderness with good consistency, the price according to quality, and the distinctive and fresh odor (Suryadi *et al.*, 2016). In some developing countries, lamb meat is also an essential factor in preventing malnutrition and increasing food security (Mlambo and Mapiye, 2015). Awareness of healthy consumption patterns makes consumers more aware of and choose nourishing food, especially red meat products. A previous study reported that lamb meat plays an essential role in fulfilling balanced and healthy nutrition as the primary source of protein, fat, and essential micronutrients such as zinc, iron, and vitamin B12 (Ekmekcioglu *et al.*, 2018). It was identified that there were sixteen fatty acid compositions in Fat and Thin-tailed sheep meat in Indonesia, including total Saturated Fatty Acid (SFA), Monounsaturated Fatty Acid (MUFA), Polyunsaturated Fatty Aacid (PUFA) were detected in each of the samples. There were 7 types of SFA: (12:0); (14:0); (15:0); (16:0); (17:0); (18:0); (20:0), 4 types of MUFA: (14:1); (16:1); (18:1); (18:1n9c), and 5 types of PUFA: (18:2n6c); (20:2); (20:4n6); (20:5n3); (22:6n3) (Gunawan *et al.*, 2019).

The benefits of lamb meat reported by Calder (Calder, 2015) that it contains n−3 polyunsaturated (PUFA), branched fatty acids (BCFA), trans(t)11-18:2], rumenic acid [RA; cis(c)9, a natural isomer of conjugated fatty acid (CLA), which is a precursor to vaccenic acid that stimulate human health. The fatty acid components in meat also affect consumers' taste, aroma, texture, and acceptability (Ran-Ressler *et al.*, 2014; Chikwanha *et al.*, 2018). Amino acid content is also an essential consideration in determining meat quality. Amino acids in various parts of the meat and at different ages showed a significant variation where the *longissimus dorsi* meat had higher histidine, arginine, valine, and isoleucine content than the Brachial triceps part (Crăciun *et al.*, 2012).

The meat quality traits are influence by several factor such diet and genetics (Mwangi *et al.,* 2019). Modification of carcass, fatty acid and amino acid composition can be done by altered the diet and provide some additive (Galli *et al.*, 2020; Arif *et al.,* 2022). Furthermore, the breed or genotype is also influencing sheep's growth (Setiyono *et al.,* 2017; Pelmus *et al.,* 2020), carcass (Clinquart *et al.,* 2022) and meat quality, such as meat's physical characteristics, chemical composition, and cholesterol content (Şirin *et al.*, 2017; Aksoy *et al.*, 2019). Gene expression alters among individuals, groups, and populations is considered as a determinant of phenotype variation, including protein and fat level. The typical sets of proteins level are associated with the identical biological process covary among individuals, showing that these functions are highly controlled at the protein level (Wu *et al.,* 2013). Furthermore, breed variation of MUFA and SFA ratio and the longer chain C20 and C22 PUFA metabolism have been studied, deliberating potential genetical variation in fatty acid metabolism (De Smet *et al.,* 2004). Genetic correlations and heritability values for the balance of specific fatty acids and amino acid have been assessed in previous studies and coincide with the remarks at the phenotype level concerning the intramuscular fat status. Sheep meat fatty acid's heritability estimated ranging from 0.25 to 0.46 (Rovadoscki *et al.,* 2018), while total protein and amino acid of red meat varied among breed ranging from low to high in sheep and beef (Juárez *et al.,* 2021). Esteves *et al.* (2019) reported that the genetic group influenced muscle and fat weight as well as the eye muscle length. Therefore, the selection of sheep genotypes can also help producing healthy and preferred meat. Preceding data such as proximate contents, amino and fatty acid profiles of Sapudi and cross merino sheep is unexplored and required to determine as primary inventory information for upcoming breeding programs to develop nutritious food sources. This study aimed to compare carcass and non-carcass, proximate content, amino acid, and fatty acid profiles of intensively reared Sapudi and Cross Merino sheep.

Materials and Methods

Sheep rearing

This study was designed to determine the differences in the carcass and nutritional characteristics of Sapudi and Cross Merino sheep meat using simple independently comparative analysis. The animals used were four yearlings male Sapudi sheep and four local Cross Merino sheep from Jember. Sheep were reared in uniform conditions in an intensive individual cage and carried out for two months with complete concentrate feed. The composition of feed was Corn Distillers Dried Grains with Soluble - protein (DDGS), Corn Gluten Feed (CGF), copra meal, oil palm meal, pollard, bran, dried kangkong, and minerals. The nutrient quality of feed was presented in Table 1 followed minimum requirement of concentrate feed for sheep fattening SNI 8819:2019. Animals were fed as much as 3% of body weight and provided ad libitum water. Before slaughtering process, the animals were fasted for 20 hours to minimize the error variation because of feed including digested feed. The slaughtered process is conducted by a butcher applying for animal welfare according to the slaughtering procedure at Unit Pelaksana Teknis (UPT) Rumah Potong Hewan Jember by cutting the throat of the animal, severing the carotid arteries, jugular vein, and trachea. After that the skin was trim and the organs was separated with carcass.

Table 1. Nutritional value of concentrate feed

Variables	Value (%)
Moisture content	13
Ash content	8
Crude protein	13
Crude fat	7
Calcium	0,5
Phosphorus	0,2
Total digestible nutrient	65

Carcass and non-carcass characteristics

The carcass and non-carcass including *longissimus dorsi* (LD) depth, hearth, liver, lungs and kidney weight were measured. The LD depth was measured at the last rib and 2 cm lateral according to Grill *et al.* (2015).

Meat nutritional qualities analysis

The left leg was used for *Bicep femoris* muscle collection and then used for determining the proximate contents, fatty acid (FA), and amino acid (AA) profiles. Measurement of crude protein using Kjeldahl analysis, fat content using Soxhlet extraction procedure, ash content by ashing using furnace at 600°C, and carbohydrate contents by separation method (AOAC, 2005). Long chain fatty acid analysed using methyl ester preparation following AOCS Ce 2-66 (1993) then procedure of gas chromatography for fatty acid determination according to Ratnayake *et al.* (2006), while identification of methionine and cysteine was performed by HPLC (Dahl-Lassen, 2018), and other amino acids were determined by the UPLC method (Waters, 2012). In this study, the amino acid tested except for tryptophan. The collected data were analyzed statistically using an independent t-test using IBM SPSS 26, Chicago, USA.

Results and Discussion

Carcass and non-carcass percentage of Sapudi and Cross Merino sheep

The slaughter weights of Sapudi and Cross Merino sheep after reared for two months were 25.43 and 25.26 kg. The slaughter characteristics of the two observed breeds are not significantly different such as carcass weight amounted to 10.03 kg for Sapudi sheep and 10.62 kg for Cross Merino sheep. The percentage of carcass produced also did not differ significantly and amounted to 39.39% for Sapudi and 42.08% for Cross Merino. The *longissimus dorsi* depth was also measured and showed similar results. In the observed organ variables, the heart of the Sapudi sheep was higher than Cross merino sheep, but the lung weight showed the contrary (Table 2). Our result was different from Abdelrahman *et al.* (2018) that reported the body weight is linier with heart weight that influenced by genetic and raising management. Sapudi and Cross merino sheep are included in Fat-Tailed sheep. The carcass percentage of female Fat-Tailed sheep kept in Lombok has a higher carcass percentage than the research results, which is 44.64±3.58% (Ashari *et al.*, 2018).

Effect of genetic in carcass properties can be estimated by heritability value (h^2), the heritability values of some traits related to carcass parameter has been widely studied such as dressing percentage amounted to 0.48 (Coyne *et al.*, 2019), loin eye area in sheep amounted to 0.26 (Sena *et al.,* 2020), eye muscle depth using ultrasound amounted to 0,297, eye muscle depth at carcass amounted to 0,256 and hot carcass weight amounted to 0,26 (Medrado *et al,.* 2021). Using whole genome sequencing, Liu *et al.* (2022) identified some gene that can be a candidate of sheep selection especially the South Africa Merino sheep, those gene were AHCYL2 for fat deposition, PPARGCIA for growth, FAM184B for body weight and composition, NCAPG and GHR for growth and carcass size.

Proximate characteristics of Sapudi and Cross Merino sheep meat

The moisture, ash, fat, and carbohydrate content did not show any significant difference (Table 3). The protein of the Sapudi (25.06±0.27) was higher than Cross Merino (21.81±1.86) (p-value: 0.014). This result is also higher compared to Falahudin and Imanudin (2019) that male local sheep giving 100% forage produced 19.18% protein in meat. Purbowati *et al.* (2006) studied about local sheep meat composition with a slaughter weight of 25.20 kg was contained protein 19.44%, fat 4.14%, ash 0.99%, and moisture content 75.05% and they also reported that the chemical composition of the *longissimus dorsi* and *bicep femoris* muscles did not show a significant difference. Furthermore, Listrat *et al.* (2016) reported that skeletal muscles generally contain 75% water, 1 to 10% fat, 20% protein, and 1% glycogen.

The gene expression regulation may influence the protein content in each breed. According to Cheng *et al.* (2020), two different breeds showed 32 different gene expressions influenced meat quality related to cellular components, molecular function, and biological processes, including negative regulation of smooth muscle cell migration, myosin filament, myoblast fusion, myosin complex, fibroblast migration, myoblast differentiation, regulation muscle contraction, potassium channel activity in the cardiac muscle cell. Furthermore, Cheng *et al.* (2020) reported that the TNF is a key factor related to the up and down-regulated gene

Table 2. Slaughtered weight, carcass and non-carcass characteristics of Sapudi and Cross Merino sheep

Variables	Sapudi Sheep	Cross Merino
Slaughtered weight (kg)	25.43±1.49^{ns}	25.26±0.92^{ns}
Carcass weight (kg)	10.03±1.01^{ns}	10.62±0.09^{ns}
Carcass percentage (%)	39.39±1.86^{ns}	42.08±1.20^{ns}
Longissimus dorsi dept (mm)	3.15±0.35^{ns}	3.13±0.11^{ns}
Liver weight (kg)	0.30±0.05^{ns}	0.36±0.04^{ns}
Heart weight (kg)	0.17±0.02^{ns}	0.09±0.01^{ns}
Lungs weight (kg)	0.14±0.04^{a}	0.22±0.02^{b}
Kidney weight (kg)	0.04±0.01^{ns}	0.08±0.01^{ns}

^{a,b} different superscript showed significant differences (p≤0.05), ns= statistically not significant.

Table 3. Proximate analysis of Sapudi and Cross Merino sheep meat

Variabel	Sapudi	Cross Merino
Moisture content (%)	70.34±1.23^{ns}	73.20±2.09^{ns}
Ash content (%)	1.20±0.09^{ns}	1.18±0.05^{ns}
Crude fat content (%)	2.20±1.26^{ns}	2.32±0.45^{ns}
Crude protein content (%)	25.06±0.27^{a}	21.81±1.86^{b}

^{a,b} different superscript showed significant differences (p≤0.05), ns= statistically not significant.

expression in sheep breeds' growth, development, and meat quality. The protein content in meat is important because it influences meat quality, such as water holding capacity and meat cooking loss. Denaturation of proteins in meat reduces water-holding capacity and increases exudation and cooking loss (Bowker and Zhuang, 2015).

Fatty acid and amino acid contents

This study found 11 fatty acids in Sapudi sheep and 10 fatty acids in Cross Merino sheep (Capric acid was not found in Cross Merino sheep), as presented in Table 4 and the chromatogram of fatty acids presented in Figure 4. In general, total fat content in Sapudi sheep meat (4.33%) were significantly higher than in Cross Merino (1.30%). This study showed that of the identified fatty acids statistically significant different including palmitic acid, heptadecanoic acid, heptadecenoic acid, total PUFA and docosadienoic acid. This result is different from the previous study by (Gunawan *et al.*, 2019), in which the *longissimus dorsi* muscle was identified as having 16 fatty acids, with a fat content reaching 4.01 for CC genotype and 8.78% for CT genotype of Indonesian sheep. Fatty acids also provide benefits and an important role in the body's metabolism. Moreover, to provide the most quantitatively dense quantity of energy, fatty acids play significantly relevant physiological functions (Richard *et al.,* 2009). Notably, preferred fatty acids, such as the long-chain, highly unsaturated fatty acids of the omega 6 and omega 3 series, are essential modulators of cell function and precursors of lipid mediators; besides that, fat also acts as delivery of lipid-soluble vitamins and physiology (Howard *et al.,* 2006). However, stearic acids have a neutral impact on health (Alvarenga *et al.*, 2015). Both in Sapudi and Cross Merino, unsaturated fatty acid found higher (53.57±0.91 and 55.84±1.12' respectively) than saturated fatty acid. According to unsaturated fatty acid content, MUFA found to be dominant and this research linier with Abdillah *et al.* (2021) that reported the MUFA often dominates the fatty acid composition in muscle. The PUFA has an essential role in defining meat characteristics and its influence by genotype and sex, which ewes had higher PUFA than rams. Furthermore, high PUFA content is associated with meat's oxidative stability (Uhlířová *et al.*, 2019). The fatty acid metabolism is influenced by several genes such as DGAT1

Table 4. Fatty acid profile of Sapudi and Cross Merino sheep meat

Fatty Acid	Sapudi (%)	Cross Merino (%)
Total fat in sample (%)	4.33±0.75^{a}	1.30±0.36^{b}
Saturated fatty acid (SFA)	46.29±1.03^{ns}	44.15±1.12^{ns}
C 10:0 (caproic acid)*	0.21±0.07^{ns}	Not detected
C 12:0 (lauric acid)	0.57±0.30^{ns}	0.70±0.01^{ns}
C 14:0 (myristic acid)	4.09±0.27^{ns}	4.74±1.17^{ns}
C 16:0 (palmitic acid)	23.80±0.90^{a}	22.33±0.29^{b}
C 17:0 (heptadecanoic acid)	1.00±0.04^{a}	1.64±0.02^{b}
C 18:0 (stearic acid)	16.65±0.62^{ns}	15.91±1.16^{ns}
Unsaturated fatty acid	53.57±0.91^{ns}	55.84±1.12^{ns}
Mono-unsaturated fatty acid (MUFA)	48.71±2.72^{ns}	43.25±6.88^{ns}
C 16:1 (palmitoleic acid)	1.57±0.17^{ns}	1.49±0.32^{ns}
C 17:1 (heptadecenoic acid)	0.64±0.04^{a}	0.78±0.00^{b}
C 18:1 W9C (c-oleic acid)	46.50±2.51^{ns}	41.38±7.01^{ns}
Poly unsaturated fatty (PUFA)	4.99±1.69^{a}	12.59±5.77^{b}
C 18:2 W6C (Cis-linoleic acid)	2.60±1.16^{ns}	5.19±2.77^{ns}
C 22:2 (docosadienoic acid)	2.02±.0.89^{a}	14.80±0.32^{b}
Omega6	2.98±1.60^{ns}	5.19±2.77^{ns}
Omega9	46.50±2.51^{ns}	41.38±7.01^{ns}

^{a,b} Different superscript showed significant differences ($p \leq 0.01$), ns= statistically not significant.

Table 5. Amino acid profile of Sapudi and Merino sheep meat

Amino acid	Sapudi (mg/kg)	Cross Merino (mg/kg)
Glycine	7141.77±41^{a}	7501.59±219.82^{b}
Alanine	11126.54±45.39^{ns}	11374.38±567.32^{ns}
Arginine	9456.86±79.05^{a}	10609.29±464.55^{b}
Aspartic Acid	19342.8±111.51^{ns}	19802.87±1443.96^{ns}
Glutamic Acid	32077.55±245.56^{ns}	34332.46±2132.83^{ns}
Proline	6224.39±12.09^{ns}	5741.51±743.46^{ns}
Serine	7406.19±78.33^{a}	8124.07±234.05^{b}
Cystein	2946.62±522.46^{ns}	3353.42±66.54^{ns}
Tyrosine	4724.17±56.33^{a}	5523.84±564.88^{b}
NEAA	100446.90±985.88^{a}	106855.63±2012.63^{b}
Phenilalanine	5814.93±39.56^{ns}	6962.66±882.3^{b}
Histidine	4480.43±47.12^{ns}	4591.89±229.44^{ns}
Isoleusine	7560.89±73.66^{ns}	7914.17±363.1^{ns}
Leusine	14017.01±122.56^{a}	15007.36±611.95^{b}
Lysine	25699.4±166.11^{ns}	26779.1±1291.9^{ns}
Methionine	1974.23±129.37^{ns}	2151.59±80.34^{ns}
Threonine	8840.83±105.22^{a}	9723.38±328.78^{b}
Valine	8483.71±67.1^{ns}	8607.71±684.14^{ns}
EAA	177318.32±1462.10^{a}	1888813.49±3425.56^{b}
EAA/NEAA	1.76±0.00^{ns}	1.77±0.00^{ns}

NEAA = nonessential amino acid, EAA = essential amino acid.
^{a,b} Different superscript showed significant differences ($p \leq 0.05$), ns= statistically not significant.

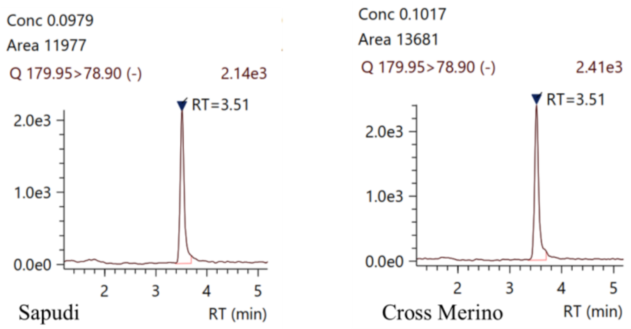

Figure 1. Chromatograms of methionine of sheep's *B. femoris.*

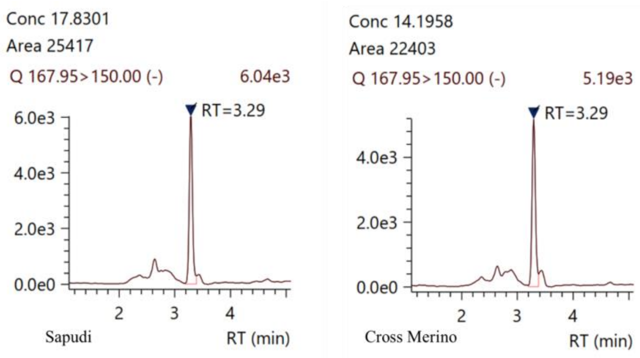

Figure 2. Chromatograms of cyctein of sheep's *B. femoris.*

associated with triglyceride synthesis; FADS1 and FADS2 (Koletzko *et al.*, 2019), which are modified PUFA desaturase; and A MADS-box gene and EgMADS21 (Li *et al.*, 2020) which influenced in down-regulates DGAT2 expression and decreased polyunsaturated fatty acids. Abdillah *et al.* (2021) also reported that a SNP g.49170107 G>T of CYP2A6 gene associated with erucic acid (C22:1n9) and to be found GT genotype has higher value. The composition of lauric, myristic, and palmitic acids (saturated fatty acids) of the Sapudi and Cross Merino showed low levels. This result was in line with Purbowati *et al.* (2005), who reported that the fatty acid composition of lamb meat was also influenced by slaughtered weight and age; the younger sheep tended to have a higher lauric acid content than older sheep with a higher slaughter weight whose lowest saturated fatty acid content was at nine months of age with a slaughtered weight of 25 kg. In our study, no myristolic acid was found, while Purbowati *et al.* (2005) reported that the myristolic acid content of local male sheep meat at 3, 7, and 9 months was 26.17 mg/100g, 27.36 mg/100g, and 17.53mg/100g, respectively.

Amino acids are one of the essential requirements of nutrients that can be met by consuming meat and are essential for nutritional balance and health. Amino acid content can be used for assessing the nutritional quality of meat. Amino acids are reported to play a part in determining sensory quality by forming precursors for taste and flavor during cooking which is carried out in the Maillard reaction (Belhaj *et al.*, 2021). The Essential Amino Acid (EAA) must be acquired from food, which is essential for keeping the nitrogen balance in the body for health. The Amino acid composition is associated with the meat taste because the amino acids are generally divided into bitter, sweet, and umami amino acids (Chen *et al.,* 2015; Gao *et al.,* 2018). On the other hand, amino acids are also divided into neutral, base, and acidic amino acids and their acidity or basicity may influences in pH value of meat (Gan *et al.,* 2020).

The data in Table 5 describes those seven amino acids differ significantly between the two observed sheep consisting of 4 non-essential amino acids (glycine, arginine, serine, and tyrosine) and 3 essential amino acids (phenylalanine, leucine, and threonine). Figure 1 and Figure 2 showed the chromatograms of methionine and cysteine using HPLC analysis, while Figure 3 showed the others amino acid analysis using UPLC. Sapudi sheep generally showed a lower amino acid profile than Cross Merino. The glutamic acid has the highest value by 32077.55±245.56 mg/kg and 34332.46±2132.83 mg/kg in Sapudi and Cross Merino sheep, respectively. These results similar to previous studies that glutamic acid was found to have the highest value in Tibetan lamb longissimus lumborum (Belhaj *et al.*, 2021). The second and third highest amino acid values were followed by lysine and aspartic acid. While the lowest amino acid was methionine amounted to 1974.23±129.37 mg/kg and 2151.59±80.34mg/kg followed by cysteine at 2946.62±522.46 mg/kg

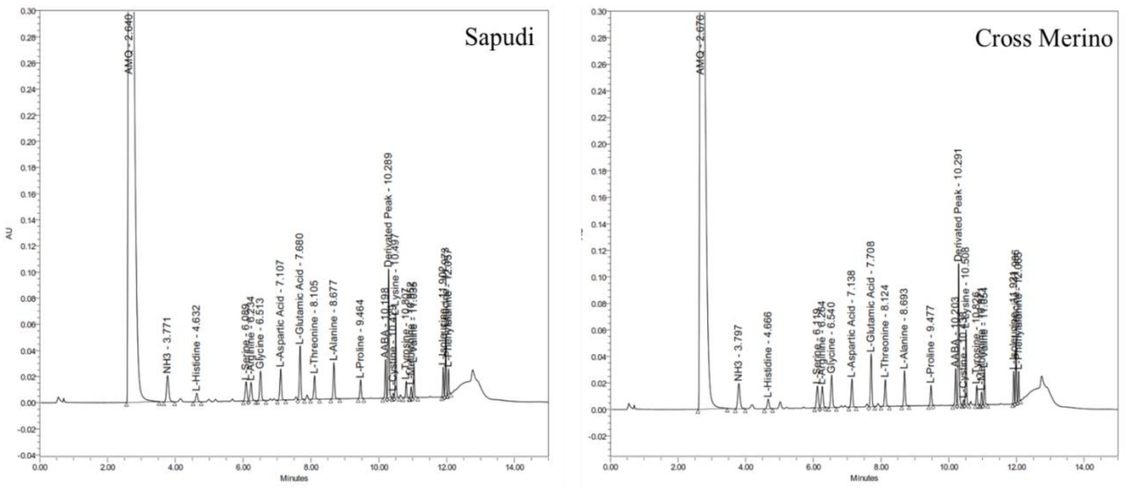

Figure 3. Chromatograms of amino acids of sheep's *B. femoris.*

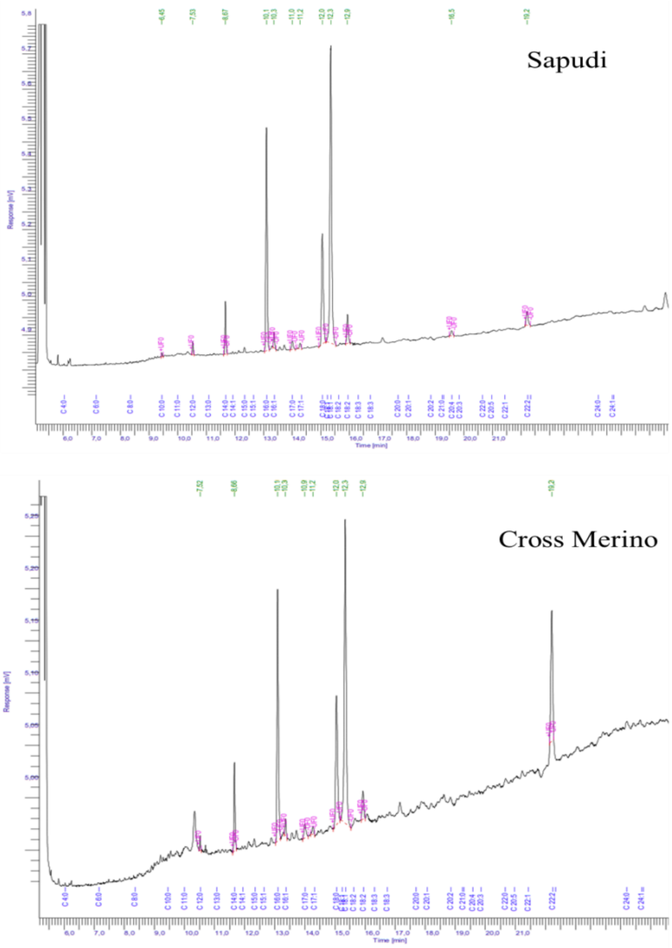

Figure 4. Chromatograms of fatty acids of sheep's *B. femoris*

and 3353.42±66.54 mg/kg for Sapudi and Cross Merino, respectively. The non-essential amino acid (NEAA) value was significantly higher in Cross Merino sheep, but the EAA for both sheep showed equal value. This studied considered that breed affects the amino acid value of sheep meat reared under the same environmental and feed conditions. In comparison with the research of Przybylski *et al.* (2017) in the meat of Corriedale sheep, the examined meats had a high protein quality. In contrast, compared to Belhaj *et al.* (2021) that sheep reared in an extensive system and greeny feed had higher amino acid content.

Conclusions

Selection of genotype/breed has a significant effect on the variation of crude protein content, fatty acid and amino acid value. Sapudi breed tended to have a higher proportion of total fat content, fatty acids content, and lower amino acid content compared to Cross Merino. The essential and non-essential amino acids were significantly different in the two observed breeds. This information is necessary to improve the quality of local sheep meat to produce healthy food sources through appropriate breeding strategies. Therefore, this could a benefit for farmers and consumers.

Acknowledgement

The authors would like to thank to Lembaga Penelitian dan Pengabdian Masyarakat (LP2M) University of Jember as a sponsor for this research with scheme number 2910/UN25.3.1/LT/2021.

References

Abdelrahman, S. S., M. S. E. Abdalla, T. M. Darderi, and E. A. E. Ali, 2018. Association of body weight, scrotal circumference, heart girth and penile development with spermatogenesis in the Nubian bucks. J. Vet. Med. Anim. Health. 10: 217-223.

Abdillah, G. K., K. Listyarini, R.S. Harahap, A. Gunawan, and C. Sumantri. 2021. Association of Cytochrome P450 2A6 (CYP2A6) gene polymorphisms with fatty acid traits in Indonesian Native sheep. Buletin Peternakan 45: 148-154. DOI: 10.21059/buletinpeternak.v45i3.65604

Aksoy, Y., Ü Çiçek, U. Şen, E. Şirin, M. Uğurlu, A. Önenç, M. Kuran and Z. Ulutaş. 2019. Meat production characteristics of Turkish native breeds: II. meat quality, fatty acid, and cholesterol profile of lambs. Archi. Anim. Breed. 62: 41-48.DOI: https://doi.org/10.5194/aab-62-41-2019

Alvarenga, T. I. R. C., Y. Chen, I. F. FurushoGarcia and J. R. O. Perez. 2015. Manipulation of omega-3 PUFAs in lamb: phenotypic and genotypic views. Compr. Rev. Food Sci. Food Saf. 14: 189-204. DOI: https://doi.org/10.1111/1541-4337.12131

AOAC. 2005. Official Methods of Analysis of the Association of Official Analytical Chemists. Association of Official Analytical Chemist, Marlyand.

Arif, Y. N., N. F. Isnaniyah, A. Pramono, and J. Riyanto. 2022. To determine the effect of using a complete feed containing protected soybean groats in the production of Javanese Thin-Tailed male sheep carcasses. Buletin Peternakan 46: 16-22.

Ashari, M., R. A. Suhardiani and R. Andriati. 2018. Carcass production and physical composition of fat tile sheep at traditional management in Lombok. Jurnal Ilmu dan Teknologi Peternakan Indonesia 4: 191-198. DOI: https://doi.org/10.29303/jitpi.v3i1.30

Belhaj, K., F. Mansouri, M. Sindic, M. L. Fauconnier, M. Boukharta, H. Serghini Caid, and A. Elamrani. 2021. Proximate composition, amino acid profile, and mineral content of four sheep meats reared extensively in Morocco: A comparative study. The Scientific World Journal. 2021: 6633774.

Bowker, B., and H. Zhuang. 2015. Relationship between water-holding capacity and protein denaturation in broiler breast meat. Poult. Sci. 94: 1657-1664.

Calder, P. C. 2015. Functional roles of fatty acids and their effects on human health. J. Parenteral. Enteral. Nutrit. 39: 18S-32S.

Chen, Z. Y., Y. Z. Feng, C. Cui, H. F. Zhao, and M. M. Zhao. 2015. Effects of koji-making with mixed strains on physicochemical and sensory properties of chinese-type soy sauce. J. Sci. Food Agric. 95: 2145–2154.

Cheng, S., X. Wang, Q. Wang, L. Yang, J. Shi, and Q. Zhang. 2020. Comparative analysis of *longissimus dorsi* tissue from two sheep groups identifies differentially expressed genes related to growth, development and meat quality. Genomics. 112: 3322-3330.

Chikwanha, O. C., P. Vahmani, Muchenje V., Dugan M. E., and Mapiye C. 2018. Nutritional enhancement of sheep meat fatty acid profile for human health and wellbeing. Food Res. Intern. 104: 25-38. DOI: https://doi.org/10.1016/j.foodres.2017.05.005

Clinquart, A., M. P. Ellies-Oury, J. F. Hocquette, L. Guillier, V. Santé-Lhoutellier, and S. Prache. 2022. On-farm and processing factors affecting bovine carcass and meat quality. Animal. 100426.

Coyne, J. M., R. D. Evans, and D. P. Berry. 2019. Dressing percentage and the differential between live weight and carcass weight in cattle are influenced by both genetic and non-genetic factors. J. Anim. Sci. 97: 1501-1512.

Crăciun, O. C., R. Lazăr, and P. C. Boișteanu. 2012. Research regarding the biological value of meat protein from sheep. Lucrări Științifice-Universitatea de Științe Agricole și Medicină Veterinară, Seria Zootehnie. 57: 55-60.

Dahl-Lassen, R., J. van Hecke, H. Jørgensen, C. Bukh, B. Andersen, and J. K. Schjoerring. 2018. High-throughput analysis of amino acids in plant materials by single quadrupole mass spectrometry. Plant Methods. 14: 1-9. DOI: https://doi.org/10.1186/s13007-018-0277-8

De Smet, S., K. Raes, and D. Demeyer. 2004. Meat fatty acid composition as affected by fatness and genetic factors: a review. Anim. Res. 53: 81-98.

Directorate General of Livestock and Animal Health. 2020. Statistik Peternakan dan Kesehatan Hewan. Kementrian Pertanian, Jakarta.

Ekmekcioglu, C., P. Wallner, M. Kundi, U. Weisz, W. Haas, and H. P. Hutter. 2018. Red meat, diseases, and healthy alternatives: A critical review. Crit. Rev. Food Sci. Nutr. 58: 247-261.

Esteves, G. I., V. Peripolli, J. B. Costa Jr, C. B. Tanure, A. M. Menezes, J. R. Souza, L. Kindlein, G. P. Bergmann, H. Louvandini, C. McManus. 2019. Effects of genetic group, pregnancy and age on carcass traits, meat quality and fatty acid profile in female sheep. Revista Colombiana de Ciencias Pecuarias. 32: 21-33.

Falahudin, A., and O. Imanudin. 2019. Kualitas daging domba yang diberi pakan silase limbah sayuran. JIPT. 6: 140-146.

Galli, G. M., R. R. Gerbet, L. G. Griss, B. F. Fortuoso, T. G. Petrolli, M. M. Boiago, C. F Souza, M. D. Baldissera, J. Mesadri, R. Wagner, G. da Rosa, R. E. Mendes, A. Gris, and A. S. da Silva. 2020. Combination of herbal components (curcumin, carvacrol, thymol, cinnamaldehyde) in broiler chicken feed: Impacts on response parameters, performance, fatty acid profiles, meat quality and control of coccidia and bacteria. Microb. Pathogenesis 139: 103916.

Gan, M., L. Shen, L. Chen, D. Jiang, Y. Jiang, Q. Li, G. Y Chen, G. Ge, Y. Liu, X. Xu, X. Li, S. Zhang, and L. Zhu. 2020. Meat quality, amino acid, and fatty acid composition of liangshan pigs at different weights. Anim. 10: 822.

Gao, X., J. Zhang, J. M. Regenstein, Y. Yin, C. Zhou. 2018. Characterization of taste and aroma compounds in tianyou, a traditional fermented wheat flour condiment. Food Res. Int. 106: 156–163.

Grill, L., F. Ringdorfer, R. Baumung, and B. Fuerst-Waltl. 2015. Evaluation of ultrasound scanning to predict carcass composition of Austrian meat sheep. Small. Ruminant. Res. 123: 260-268.

Gunawan, A., R. S. Harahap, K. Listyarini, and C. Sumantri. 2019. Identifikasi keragaman gen DGAT1 serta asosiasinya terhadap karakteristik karkas dan sifat perlemakan domba. JITRO. 6: 259-266.

Howard, B.V., L. Van Horn, J. Hsia, J. E. Manson, M. L. Stefanick, S. Wassertheil-Smoller, L. H. Kuller, A. Z. LaCroix, R. D. Langer, and N. L. Lasser. 2006. Low-fat dietary pattern and risk of cardiovascular disease: The women's health initiative randomized controlled dietary modification trial. JAMA: 295: 655–666.

Juárez, M., S. Lam, B. M. Bohrer, M. E. Dugan, P. Vahmani, J. Aalhus, A. Juárez, O. López-Campos. N. Prieto, J. Segura. 2021. Enhancing the nutritional value of red meat through genetic and feeding strategies. Foods. 10: 872.

Koletzko, B., E. Reischl, C. Tanjung, I. Gonzalez-Casanova, U. Ramakrishnan, S. Meldrum, S. Karen, H. Joachim and H. Demmelmair. 2019. FADS1 and FADS2 polymorphisms modulate fatty acid metabolism and dietary impact on health. Annu. Rev. Nutr. 39: 21-44.

Komariah, D. J. Setyono, and Aslimah. 2015. Karakteristik kuantitatif dan kualitatif kambing dan domba sebagai hewan qurban di mitra tani farm. Buletin Peternakan 39: 84-91.

Li, S. Y., Q. Zhang, Y. H. Jin, J. X. Zou, Y. S. Zheng, and D. D. Li. 2020. A MADS-box gene, EgMADS21, negatively regulates EgDGAT2 expression and decreases polyunsaturated fatty acid accumulation in oil palm (Elaeis guineensis Jacq.). Plant Cell Reports. 39: 1505-1516.

Listrat, A., B. Lebret, I. Louveau, T. Astruc, T., M. Bonnet, L. Lefaucheur, B. Picard and J. Bugeon. 2016. How muscle structure and composition influence meat and flesh quality. The Scientific World Journal. 2016: 3182746

Liu, Z., C. Bai, L. Shi, Y. He, M. Hu, H. Sun, H. Peng, W. Lai, S. Jiao, Z. Zhao, Ma, H., and S. Yan. 2022. Detection of selection signatures in South African Mutton Merino sheep using whole-genome sequencing data. Anim Genet. 53: 224-229.

Medrado, B. D., V. B. Pedrosa, and L. F. B. Pinto. 2021. Meta-analysis of genetic parameters for economic traits in sheep. Livest Sci. 247: 104477.

Mlambo, V. and C. Mapiye. 2015. Towards household food and nutrition security in semi-arid areas: What role for condensed tannin-rich ruminant feedstuffs?. Food Res. Int. 76: 953-961.

Mwangi, F. W., E. Charmley, C. P. Gardiner, B. S. Malau-Aduli, R. T. Kinobe, and A. E. Malau-Aduli. 2019. Diet and genetics influence beef cattle performance and meat quality characteristics. Foods. 8: 648.

Pelmus, R. S., H. Grosu, H., M. C. Rotar, M. A. Gras, C. Lazar, and F. Popa. 2020. The genetic influence on sheep meat quality, growth and body weight: A review. Asian J. Dairy Food Res. 39: 225-231.

Przybylski, W., E. Żelechowska, M. Czauderna, D. Jaworska, K. Kalicka, and K. Wereszka. 2017. Protein profile and physicochemical characteristics of meat of lambs fed diets supplemented with rapeseed oil, fish oil, carnosic acid, and different chemical forms of selenium. Arch. Anim. Breed. 60: 105-118.

Purbowati, E., C. I. Sutrisno, E. Baliarti, S. P. S. Budhi, and W. Lestariana. 2006. Komposisi kimia otot *longissimus dorsi* dan *Biceps femoris* domba lokal jantan yang dipelihara di pedesaan pada bobot potong yang berbeda. Anim. Prod. 8: 1-7.

Purbowati, E., E. Baliarti, S. P. S. Budhi, and W. Lestariana. 2005. Profil asam lemak daging domba local jantan yang dipelihara di pedesaan pada bobot potong dan lokasi otot yang berbeda. Buletin Peternakan 29: 62-70.

Ran-Ressler, R. R., S. Bae, P. Lawrence, D. H. Wang, and J. T. Brenna. 2014. Branchedchain fatty acid content of foods and estimated intake in the USA. British. J. Nutr. 112: 565-572.

Ratnayake, W. M. N., S. L. Hansen, M. P. Kennedy. 2006. Evaluation of the CP-Sil. 88 and SP2560 GC columns used in the recent approval of AOCS Official Method Ce 1h-05: Determination of cis-, trans-, saturated, monounsaturated, and polyunsaturated fatty acids in vegetable or non-ruminant animal oils and fats by capillary GLC method. J. Am. Oil. Chem. Soc. 83: 475–488.

Richard, D., P. Bausero, C. Schneider, F. Visioli. 2009. Polyunsaturated fatty acids and cardiovascular disease. Cell. Mol. Life Sci. 66: 3277–3288.

Rovadoscki, G. A., S. F. N. Pertile, A. B. Alvarenga, A. S. M. Cesar, F. Pértille, J, Petrini, J., V. Franzo, W. V. B. Soares, G. Morota, L. Spangler, L. F. B. Pinto, C. G. P. Carvalho, D. P. D. Lanna, L. L. Coutinho, and G. B. Mourão. 2018. Estimates of genomic heritability and genome-wide association study for fatty acids profile in Santa Inês sheep. BMC Genom. 19: 1-14.

Sena, L. S., L. A. S. Figueiredo Filho, G. V. dos Santos, A. de Sousa Júnior, N. P. da Silva Santos, B. F. Britto, J. L. R. Sarmento, and L. F. Brito. 2020. Genetic evaluation of tropical climate-adapted sheep for carcass traits including genomic information. Small Rumin Res. 188: 106-120.

Setiyono, A. H. A. Kusuma, and Rusman. 2017. Pengaruh bangsa, umur, jenis kelamin terhadap kualitas daging sapi potong di daerah istimewa Yogyakarta. Bulletin Peternakan 47: 176-186

Şirin, E., Y. Aksoy, M. Uğurlu, Ü. Cicek, A. Önenc, Z. Ulutaş, U Şen and M. Kuran. 2017. The relationship between muscle fiber characteristics and some meat quality parameters in Turkish native sheep breeds. Small. Ruminant. Res. 150: 46-51.

Sodiq, A. and E. S. Tawfik. 2004. Productivity and breeding strategies of sheep in Indonesia: a review. JARTS. 105: 71-82.

Suryadi, D., S. Rahayu, C. Firmansyah, and S. Kuswaryan. 2016. Preferensi konsumen terhadap daging domba di Jawa Barat. Sosiohumaniora. 18: 25-31.

Uhlířová, L., E. Tůmová, D. Chodová, Z. Volek, and V. Machander. 2019. Fatty acid composition of goose meat depending on genotype and sex. Asian-Australas. J. Anim. Sci. 32: 137.

Waters. 2012. Acquity UPLC H-Class and H-Class Bio Amino Acid Analysis System Guide. Available at : https://www.waters.com/webassets/cms/support/docs/acq_uplc_h-class_aaa_sysgd_rev_b.pdf. Accessed 19 April 2022

Widianingrum, D. C. and H. Khasanah. 2021. Tren perkembangan, kondisi, permasalahan, strategi, dan prediksi komoditas peternakan Indonesia (2010-2030). Proceeding: the 2ndConference of Applied Animal Science. Department of Animal Science. Jember State Polytechnic. ember, September 25-26. DOI: https://doi.org/10.25047/animpro.2021.1

Wu, L., S. I. Candille, Y. Choi, D. Xie, L. Jiang, J. Li-Pook-Than, T. Hua and M. Snyder. 2013. Variation and genetic control of protein abundance in humans. Nature. 499: 79-82.