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Mineral and Vitamin B Contents of Sapudi and Merino-cross Meat

Himmatul Khasanah[1]*, Desy Cahya Widianingrum[1], Nurul Pratiwi[2]

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ABSTRACT

Lamb is important in providing balanced and healthy nutrition as a source of protein, fat, and essential micronutrients such as iron, zinc, and vitamin B complex. The mineral and vitamin content of meat from local breeds needs to be evaluated as a portrait of the genetic quality data of sheep and as a reference for developing sheep that produce healthy and high-quality meat. This study aimed to analyze the mineral and vitamin B contents of Sapudi sheep and Merino cross sheep meat from the *longissimus dorsi* area to invent genetic quality data for the meat of these two sheep. Three Sapudi and three Merino cross sheep were kept under similar conditions for two months. Meat collection from the *longissimus dorsi* muscle was carried out to analyze vitamin B and mineral content. A *t*-test was then performed to determine meat quality. The results showed that the mineral content of Mn and Cu in Sapudi sheep meat was lower than that in Merino cross meat. The vitamin B2 content in Sapudi sheep (0.11 mg/100 g) was lower than that of Merino cross (0.20 mg/100 g). In comparison, the vitamin B3 content of Sapudi sheep meat was higher (0.51 mg/100 g) than Cross-merino (0.40 mg/100 g). This research concludes that breeding influences nutrient content, and Merino crossbreed sheep are superior to Sapudi sheep in terms of vitamin B and mineral content.

Keywords: genetic resource, Indonesian local lamb, meat quality, mineral, vitamin

INTRODUCTION

Lamb meat is one of popular source of animal protein in Indonesians. In East Java, smallholder breeders and medium-sized corporations raise a variety of sheep extensively. The sheep agriculture company mainly tries to produce males for sale during qurbani (sacrifice), *aqeeqa*, and to meet daily trader demand (satay and processed lamb meat). Lamb meat also helps to maintain balance and good nutrition by providing protein, fat, and critical micronutrients including iron, zinc, and vitamin B12 (Ekmekcioglu *et al*. 2017). Lamb meat can also help prevent malnutrition and improve food security in impoverished countries (Mlambo and Mapiye 2015). Consumers who are aware of good consumption patterns are more likely to choose healthy food sources, particularly red meat. Meat is an essential food source that also contains minerals. Lamb meat contains little calcium but is high in potassium, sodium, zinc, iron, and phosphorus (Belhaj *et al*. 2021). The level of complex B vitamins, which humans require, is another indicator of chemical quality. According to Rekanović *et al*. (2019), meat products are a rich source of macro- and micronutrients, with cooked meat having a higher-level mineral element than dry meat. Environment factors (water resources, forage, and soil conditions) influence the qualities of Gangba lamb meat, including its mineral content (Zhang *et al.* 2021). Furthermore, Mortimer *et al*. (2014) found that genetic factors also influence lamb meat quality. There is limited data on the macro- and micromineral content of lamb meat, and there are no publications on the mineral content of Sapudi lamb meat from Indonesia.

Sapudi sheep are a genetic resource of local Indonesian livestock that are well suited to the Indonesian environment. This was based on the Minister of Agriculture's Decree Number 2389/Kpts/LB.430/8/2012 on the Determination of Sapudi Sheep Clusters in the Madura Islands and Eastern Java. The Sapudi sheep breeding center in East Java is in the Breeding Unit and HMT Livestock in Sidomulyo, Jember, and is managed by the East Java Provincial Livestock Office. Sapudi sheep have the potential to develop into meat producers with great adaptation and disease resistance. This sheep was distinguished by its large tail packed with fat and curled in shape (sigmoid). Several investigations into the peculiarities of Sapudi sheep have revealed that they possess specific qualities. According to Tanzilla (2018), Sapudi sheep are predominantly white on the head and body, males have a convex facial line (64.23%), females have a straight facial line (42.86%), almost all male cattle are hornless, 100% of female cattle are hornless, the ears are 100% upright, and the concave dorsal line is raised backward. There were three

[1] Animal Husbandry Program Study, Faculty of Agriculture, University of Jember, Jember 68121, Indonesia
[2] National Research Inovation Agency of the Republic of Indonesia (BRIN), B.J. Habibie Building, Central Jakarta 10340, Indonesia
* Corresponding Author: Email: himma@unej.ac.id

varieties of tail shapes, with sigmoid curves accounting for 66.67% of males and females, triangular tail shapes accounting for just 8.34% and 2.99%, and straight tail shapes accounting for 25.00% of males and 30.37% of females. Sapudi sheep had a maximum body weight of 22.09 ± 4.74 kg in males and 29.56 ± 3.71 kg in females. Males have a body length of 55.57 ± 5.99 cm, while females have 59.62 ± 3.15. Males had a chest circumference of 63.47 ± 5.18 cm, while females measured 67.87 ± 3.60 cm. Sapudi sheep had shoulder heights of 57.04 ± 3.90 cm and 59.00 ± 3.33 cm for females (Tanzilla 2018).

Previous research on the amino acid and fatty acid composition of Sapudi and Cross-merino lambs found that Cross-merino lambs had higher levels of glycine, arginine, serine, tyrosine, phenylalanine, lysine, and threonine than Sapudi lambs. A total of 51 fatty acids were discovered, with 14 and 13 types of fatty acids detected in Sapudi and Cross-Merino, respectively. Sapudi's fatty acid content is higher than that of Cross-merino's. The two lambs had a complete fat and amino acid profile. The breed determines the amino acid and fatty acid levels in lamb meat. Wang *et al*. (2021) found that the genetics of sheep affect quality, including nutrient content, meat compactness, and mineral content, and that this can be utilized as a criterion for selecting sheep for quality enhancement in Australia. The goal of this study was to determine the macro and micro mineral and vitamin B content of Sapudi and Cross-merino lamb meat. This study is significant because it provides fundamental information on the features of local sheep genetic resources and serves as a reference for breeding.

METHODS

Livestock Rearing and Sampling

The sample consisted of three Sapudi sheep and three Cross-merino sheep aged one year and weighing 25.26 ± 1.49 kg. Sheep were kept in uniform conditions for 2 months, with a 1-week adaptation period. The provision of complete concentrated feed is 3% of the body weight (Khasanah *et al*. 2021). Livestock slaughter was carried out halally at the Jember Slaughterhouse technical implementation unit by cutting the neck, respiratory tract, food ducts, and blood vessels of the carotid artery and jugular vein. The meat sample used for analysis was the longissimus dorsi area.

Mineral Content Determination

The mineral content was determined using inductively coupled plasma optical emission spectrometry (ICP-OES). The standard curve of the mineral mixture had six concentration points. A 0.5 g sample of meat was dipped in 600 μL and 7.5 mL HCl in vessel tubes and allowed to stand for 15 min. The tubes were closed, and the sample was processed in a microwave digester. The destruction results were then transferred to a 50 mL measuring flask, where a standard yttrium solution of 100 mg/L was added. The solution was then filtered through filter paper, and the intensity of the solution sample was measured using the ICP-EOS system. The wavelengths utilized were Ca: 317,933 nm; Cu: 327.395 nm; g Fe: 238.204 nm; Na: 568.821 nm; P: 214.914 nm; Zn: 213.857 nm; K: 766.491 nm; Mn: 257.610 nm; and Y: 371.029 nm (Maria *et al*. 2007). The mineral content was calculated using the following formula:

$$mineral\ content\ (ppm) = \frac{\frac{A_{spl}-a}{b} \times V \times fp}{W_{spl}\ or\ V_{spl}}$$

where:

A_{spl} = Intensity of the sample
a = Intercept of standard calibration curves
b = Slope of standard calibration curves
fp = Dilution factor
V = Volume of final flask sample (mL)
W_{Spl} = Sample weight (g)
V_{Spl} = Sample volume (mL)

Vitamin B Determination

The vitamins were B1, B2, B3, B6, and B12. Were measured using UPLC-PDA (Antakli *et al*. 2015), and vitamin B12 was assessed using LC-MS/MS (Ren *et al*. 2015). In a 10 mL amber measuring flask, vitamin B standards were prepared in series at 6-point concentrations. The sample (3 g) was placed on a 25 mL amber volumetric flask, after which NaH_2PO_4 0.05 M pH 6.3) was added to half of the flask capacity. The sample was sonicated for 15 min, and 25 mL of NaH_2PO_4 (pH 6.3) was added and homogenized. The sample solution was transferred to a 2 mL tube and centrifuged at 14,000 rpm for 3 minutes. The sample was filtered via a 0.20 μm filter into a 2 mL sample vial and placed into the UPLC machine. The instrument settings included a C18 column, mobile phase A with 0.1% H_3PO_4 and B with acetonitrile, and a gradient pump system set to 40°C. The PDA wavelengths for vitamins B1, B2, and B3 were 245 nm, 265 nm, and B6 was 283 nm, respectively. Vitamin B levels were calculated using the following formula:

$$vitamin\ B\ content = \frac{\left(\frac{Aspl-a}{b}\right) x\ FP\ x\ Va}{W_{Spl}\ or\ V_{Spl}\ x\ 10}$$

where

A_{Spl} = Sample area
a = Intercept of standard calibration curves
b = Slope of standard calibration curves
FP = Dilution factor
Va = Final volume of solution
W_{Spl} = Sample weight (g)
V_{Spl} = Sample volume (mL)

The vitamin B12 determination was performed as cobalamin by preparing a standard series of at least 7 concentration points in a 2 mL vial and diluting them with a standard solvent. The sample (up to 1 g) was placed in a 50 mL falcon tube, followed by extracting solvent, homogenization, and sonication. The sample was centrifuged, activated using SPE, and then diluted with methanol. The eluate was evaporated using a nitrogen evaporator and then vortexed. The solution was filtered, placed in a 2 mL amber vial, and then injected into the LC-MS. The HSS T3 column of mobile phase A used 10 mM ammonium and 0.1% formic acid in distilled water and mobile phase B used 10 mM formic acid and 0.1% formic acid in methanol with a gradient pump system. Vitamin B12 levels were calculated using the following formula:

$$Cyannocobalamin\ content = \frac{\frac{(A\ spl - a)}{b} - V\ x\ FP}{sample\ weight\ x\ 10}$$

where
A_{Spl} = Sample area
a = Intercept of standard calibration curves
b = Slope of standard calibration curves
FP = Dilution factor
V = Final volume of solution

Data Analysis

The analysis data were collected and tabulated before being statistically evaluated using an independent *t*-test using SPSS 26 software (Chicago, USA).

RESULTS AND DISCUSSION

B Vitamins Level

B vitamins are water-soluble that is required as a coenzyme in cellular functions related to energy metabolism in the mitochondria via FMD and flavin adenine dinucleotide (FAD), which act as electron carriers (Massey 1994) and as an antioxidant in the prevention of oxidative stress (Ashoori and Saedisomeolia 2014). Table 1 displays the results of the vitamin B content analysis of Sapudi and Cross-merino lamb meat. According to the using the UPLC-PDA method, vitamins B1, B6, and B12 were not detected in either sample; nevertheless, the results of the three vitamins were below the detection limit. Vitamin B2 (riboflavin) and B3 (niacin) were found. Sapudi sheep had a much lower vitamin B2 content than Cross-merino sheep; however, there was no statistically significant difference in vitamin B3 levels. Vitamin B2 is known to work as an antioxidant, preventing oxidative stress, particularly lipid peroxidation and reperfusion oxidative injury. Furthermore, vitamin B2 has been linked to various disorders, including cancer (Yang *et al*. 2013), anemia (Northrop-Clewes and Thurnham 2013), CVD (Ahn *et al.* 2019), and cataracts (Schmidinger *et al.* 2013).

Niacin is typically found in two forms: nicotinic acid (NA) and nicotinamide (Gerald 2012). Niacin can also refer to various chemicals that contain nicotinic acid, nicotinamide, or molecules that have been transformed into NA. Vitamin B3 (niacin) is one of the therapeutic medicines linked with the alteration of increased HDL and decreased LDL, which are associated with high lipoprotein and hypertriglyceridemia (Mackay *et al*. 2012). Nicotinamide adenine dinucleotide (NAD^+) is an essential vitamin B3 derivative cofactor that is phosphorylated to nicotinamide adenine dinucleotide phosphate ($NADP^+$) and reduced to NAD(P)H. This form is a cofactor that participates in all major bioenergy activities via anabolic and catabolic pathways. The form also influences the alteration of post-translational proteins involved in cell metabolism and signaling (Makarov *et al*. 2019).

The levels of vitamins B2 and B3 in Sapudi and Cross-merino sheep (Indonesian sheep) were lower than those reported (Zhu *et al*. (2020), who found vitamins B2, B3, and B9 in the meat of Subei Gansu sheep (China sheep). Furthermore, it has been found that different portions of the muscle influence the levels of vitamins B2, B3, E, and B9 (folic acid) in meat. Vitamin B2 levels were highest in the square-cut shoulder (0.438 mg/100 g) and lowest in the breast and flap (0.177 mg/100 g). Meanwhile, the leg-chump off had the maximum vitamin B3 content (8,560 mg/100 g), whereas the topside, tripe, neck, delicate loin, short loin chop, and shoulder rack had lower levels (5,746–6,745 mg/100 g) (Zhu *et al*. 2020). Vitamins B1, B6, B9, and B12 were not found or were below the detection limit (B1 = 0.03 mg/100 g; B6 = 0.06 mg/100 g; B9 = 50 mcg/100 g; B12 = 0.08 mcg/g).

Mineral Contents

The mineral content of Sapudi and Cross-merino lamb meat differed significantly in various factors, particularly Mn and Cu levels. Mn in Cross-merino sheep was superior to that in Sapudi sheep. This is consistent with the Cu content of Cross-merino sheep, which outperformed Sapudi sheep. This study's mineral data on various observational variables, including potassium, sodium, phosphorus, selenium, zinc, iron, and calcium levels, revealed no significant differences. Table 2 shows that selenium was not detected in Sapudi sheep. It is possible that the mineral selenium is too low to be detected.

Minerals are incredibly beneficial to the human body, particularly in the formation of muscles, conditions, and enzyme cofactors. Cross-merino lamb meat includes more minerals, particularly Mn and Cu. Autukaitė *et al*. (2020) found that blood mineral content varies by country/location. A detailed investigation of

Table 1 Vitamin B2 and B3 contents of Sapudi and Cross-merino lamb

Variable	Sapudi (mg/100 g)	Cross-merino (mg/100 g)
Vitamin B2 (Riboflavin)	0.11 ± 0.01[a]	0.20 ± 0.01[b]
Vitamin B3 (Niacin)	0.51 ± 0.01 [a]	0.40 ± 0.13[b]

Remark: Different superscripts showed significant differences at the 1% level (*p*<0.01).

Table 2 Mineral content of Sapudi and Cross-merino lamb

Variable	Sapudi (ppm)	Cross-merino (ppm)
Potassium	250.10 ± 14.471	258.37 ± 1.31
Sodium	69.53 ± 14.79	67.12 ± 9.52
Phosphorus	1431.46 ± 73.53	1468.89 ± 24.45
Calcium	91.40 ± 5.59	99.86 ± 8.51
Manganese	0.45 ± 0.17[a]	1.44 ± 0.77[b]
Selenium	Not detected*	12.78 ± 0.96
Zink	4.10 ± 0.70	4.22 ± 0.58
Iron	1.96 ± 0.11	2.21 ± 0.51
Copper	4.25 ± 0.06[a]	5.04 ± 0.50[b]

Remark: Different superscripts show significant differences at the 1% level (*p*<0.01).

the iron and copper content of Australian lamb (part of *longissimus lumbrum*) found that the amounts of both minerals were 2.03 mg/100 g and 2.43 mg/100 g (Mortimer *et al*. 2014). Further research in Australian sheep discovered the mineral copper at 3.5 mg/100 g.

Breeding attempts to boost lean meat yield have resulted in a decrease in Fe content and an increase in Mg content (Knight *et al*. 2020). In addition to genetic considerations, the minerals in meat are controlled by the nutrition consumed by sheep (Mortimer *et al*. 2014). The mineral composition of meat is also influenced by the slaughter site and age of the sheep. According to Lin *et al*. (1988), the mineral concentration increases with increasing age. They also found that the foreshank and shoulder regions contained more zinc than the other components. Furthermore, Osorio *et al*. (2007) revealed that cattle fed milk replacers and suckling lambs performed differently in terms of mineral content in meat, with cattle breastfed by their mothers containing more potassium, phosphorus, and copper, and less zinc and manganese (Table 2). Our findings show that the nation has a considerable impact on the mineral and vitamin content of lamb meat. However, the composition of carcasses varies substantially depending on numerous aspects, including rearing system, nutrition, ethnicity, age, sex, slaughter weight, and pre-slaughter management (Corazzin *et al.* 2019).

CONCLUSION

Sapudi sheep meat contains less vitamin B2 but more vitamin B3, less manganese and copper than Cross-merino. The vitamin and mineral composition of lamb meat varies depending on the breed. Local sheep breeds, which are genetic resources of Indonesia, can be used to provide nutritious and high-quality sheep meat.

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