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Carcass, non-carcass characteristics, physicochemical properties, and fatty acids composition of grass-fed Kacang goat at different slaughter weight

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ABSTRACT

Consumers are concerned not just with the fat content in meat, but also with its quality. This study investigated carcass, non-carcass characteristics, physicochemical properties, and fatty acids composition of grass-fed goat at different slaughter weight. Ten heads of yearling goat with 14.60±2.84 kg of slaughtered weight were grouped into 2 that had lighter slaughter weight (LSW): 10 kg to less than 15 kg and heavier slaughter weight (HSW): 15 to 20 kg. The HSW goats produced more carcasses, more meat, and higher meat + fat to bone ratio. Although the weight of rack, loin, leg, fore shank, breast, and edible offal were higher in HSW goats compared to LSW goats, but the percentages were similar. Physical characteristics, fat, and collagen content in the meat were similar. However, the moisture content of LSW goats was higher than that of HSW goats, while the protein content was lower. Saturated fatty acids in the Biceps femoris mostly consisted of stearic acid (25.70% in LSW goats and 19.29% in HSW goats) and palmitic acid (16.70% in LSW goats and 21.24% in HSW goats). Monounsaturated fatty acids were mainly consisted of oleic acid (20.09% in LSW goats and 27.23% in HSW goats). Poly unsaturated fatty acids mostly consisted of arachidonic acid (12.93% in LSW goats and 9.11% in HSW goats). Poly unsaturated fatty acids and saturated fatty acids ratio was 0.25 to 0.39. It can be concluded that carcass characteristics and protein content of HSW goat were better compared to LSW goat.

Introduction

The carcass composition (meat, bone, fat) is influenced by the carcass weight (Never, 2015). A higher body weight of animal tended to have greater carcass weight (Kim *et al*., 2016). The heavier animals have more fat proportion and lower proportion of muscle and bone than lighter animals (Never, 2015).

Nowadays, consumers concern not only the amount of fat content in meat, but more important also the meat quality (Webb and O'Neill, 2008; Belo *et al*., 2009). Belo *et al*. (2009) reported the meat quality indicators included polyunsaturated: saturated fatty acids ratio. Peña *et al*. (2009) stated that chevon is preferable due to less fat content. In addition, USDA reported that cooked goat meats are healthier because of less cholesterol and saturated fatty acids content than other red meats (Peña *et al*., 2009). Niedziółka and Pieniak-Lendzion (2006) reported that goat meat has more unsaturated fatty acids and less saturated fatty acids content compared to lamb. Meat quality is affected by nutritional value of feed consumed (Webb and O'Neill, 2008). In pasture feeding, the ideal fatty acids composition is negatively correlated with the ideal growth performance (Webb and O'Neill, 2008). Goat fed forage had lower body weight at harvest than those fed grain, but the dressing percentages were relatively the same (Johnson *et al*., 2010). However, ruminant meats that have consumed grass contain relatively high level of 18:3 (Schoenian, 2012). Johnson *et al*. (2010) reported that goats fed forage contained lower n-6:n-3 fatty acid ratio than those fed grain (2.66±0.45 vs. 3.28±0.41). Belo *et al*. (2009) also reported low n-6:n-3 fatty acid ratio (1.60) of chevon from Serpentina goat in spring grazing rearing season.

Kacang goats, indigenous goats from Indonesia, have a good adaptation to harsh condition. They are smaller compared to others breed, but Kacang goat produced 46.67% of carcass (Hutama, 2014). Kacang goats are mostly reared traditionally by grazing, therefore their productivity is relatively low. The quality of chevon is more interesting to know for health-conscious consumers and the research about chevon nutritive value of grass-fed Kacang goat in Indonesia is scarcely published. Therefore, this study was set up to investigate carcass characteristics and chevon nutritive value of grass-fed Indonesian Kacang buck.

Materials and methods

Kacang bucks were kept traditionally for 93 days. They were grazed during the day in native pasture and kept in animal housing at night with grass-fed. Ten heads of them, having the slaughtered weight of 14.60±2.84 kg (10.18 to 19.1 kg) were slaughtered for the study. The goats were grouped into 2 that were having the slaughter weight between 10 kg to less than 15 kg (lighter slaughter weight) and 15 to 20 kg (heavier slaughter weight). Parameters observed were carcass and non-carcass characteristics, physio-chemical characteristics of the chevon, and fatty acids in the Bicep femoris muscles. All goats were slaughtered based on Pratiwi *et al*. (2007) procedures, except that kidneys were included carcass. The contents of water, fat, protein, and collagen in chevon were analysed by near infrared spectroscopy (Prevolnik *et al*., 2004) while fatty acids were determined by gas chromatography (McCurry, 2012). The data were analysed descriptively, and t-test was analysed to compare means using SPSS statistical software version 19. The significance level used was $P < 0.05$.

Results

Carcass characteristics

Carcass characteristics of grass-fed Kacang bucks (Table 1) showed that the heavier slaughter weight of goat, the higher carcass produced and more meat content in the carcass. Moreover, the ratio of meat-fat to bone and edible portion carcass were higher in heavier slaughter weight

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(HSW) goat. The edible portion of carcass (% hot carcass) in HSW group was significantly more (P < 0.05) than that in lighter slaughter weight (LSW) group. The HSW goats produced higher (P < 0.05) portion of rack, loin, leg, fore shank, and breast (Table 2). However, the percentages of those commercial cuts were relatively the same (P > 0.05).

Tabel 1. Carcass Characteristics of Grass-fed Kacang Buck with Different Slaughter Weight.

Parameters	LSW goats	HSW goats	P-value
Slaughter weight (kg)	12.32±1.77	16.87±1.45	0.00
Hot carcass weight (kg)	4.79±0.82	6.53±0.66	0.01
Carcass percentage (%)	38.88±3.33	38.71±1.41	0.92
Carcass composition			
Meat (kg)	2.78±0.76	4.35±0.59	0.01
Fat (kg)	0.36±0.14	0.45±0.10	0.21
Bone (kg)	1.60±0.09	1.65±0.21	0.63
Meat: bone ratio	1.75±0.53	2.66±0.36	0.70
Meat fat: bone ratio	1.98±0.59	2.94±0.41	0.02
Edible portion of carcass* (kg)	3.20±0.84	4.89±0.58	0.01
Edible portion of carcass (% hot carcass)	65.97±5.49	74.73±2.91	0.01

LSW: lighter slaughter weight (the slaughter weight between 10 kg to less than 15 kg), HSW: heavier slaughter weight (the slaughter weight between 15 to 20 kg),
P: level of significance, *Edible portion of carcass included: meat, fat, and kidneys.

Tabel 2. Carcass Commercial Cuts of Grass-fed Kacang Buck Having Different Slaughter Weight.

Carcass cuts*	LSW goats	HSW goats	P-value
Neck (g)	153.42±66.31	214.69±9.92	0.08
(%)	6.75±2.65	7.37±0.88	0.63
Shoulder (g)	454.95±57.46	555.95±101.47	0.09
(%)	20.28±0.59	18.86± 2.24	0.21
Rack (g)	168.08±33.53	225.47±23.55	0.01
(%)	7.49±1.18	7.69±0.59	0.75
Loin (g)	197.19±28.90	261.77±31.15	0.01
(%)	8.79±0.61	8.98±1.37	0.80
Leg (g)	716.83±104.23	922.50±108.33	0.02
(%)	31.90±0.95	31.35±0.86	0.37
Fore shank (g)	297.48±65.37	391.32±49.72	0.03
(%)	13.14±1.04	13.36±1.68	0.81
Breast (g)	218.80±21.11	313.58±74.63	0.03
(%)	9.80±0.84	10.58±1.58	0.36
Flank (g)	40.06±8.79	53.32±16.77	0.16
(%)	1.84±0.59	1.82±0.58	0.95

* Carcass cuts have been converted to hot carcass
LSW: lighter slaughter weight (the slaughter weight between 10 kg to less than 15 kg), HSW: heavier slaughter weight (the slaughter weight between 15 to 20 kg),
P: level of significance.

Non-carcass characteristics

The HSW goats had higher non carcass weight than LSW goats, although the non-carcass total in the percent of hot carcass of those goats were not significantly different (Table 3). Non carcass characteristics of Kacang buck in this study showed that HSW goats had higher blood, liver, and testicles than LSW goats. The edible offal total of HSW goats also higher than those of LSW goats, but in the percentage was relatively the same.

Physio-chemical characteristics

Physio-chemical characteristics of the chevon are presented in the Table 4. The values of physical characteristics in all goats were similar (P > 0.05). The fat and collagen content in all goats' meat were also relatively the same. The moisture content in HSW goats was lower (P < 0.05) than those in LSW goats, but the protein content was higher.

Table 3. Non-Carcass (Offal) Characteristics of Grass-fed Goat Having Different Slaughter Weight.

Parameters (g)	LSW goats	HSW goats	P-value
Non carcass weight (kg)	7.53±1.15	10.34±0.87	0.00
Non carcass percentage (%)	61.12±3.33	61.29±1.41	0.92
Edible offal (g):			
Blood	488.58±124.18	802.35±131.12	0.01
Brain	85.42±2.92	82.12±13.32	0.60
Head fat and meat	189.59±91.00	247.78±78.56	0.31
Eyes	47.78±10.59	35.63±7.02	0.07
Ears	69.96±15.31	81.46±22.31	0.37
Tongue	54.29±5.06	52.59±7.81	0.69
Tail fat and meat	4.82±2.11	7.28±1.71	0.08
Subcutaneous fat	57.48±25.71	56.78±35.70	0.97
Meat fragment from feet	63.76±15.16	76.28±10.88	0.17
Lungs & trachea	146.84±15.46	154.29±18.88	0.51
Heart	100.26±14.18	96.68±14.19	0.7
Liver	191.78±39.41	283.02±26.31	0.00
Spleen	12.78±3.89	17.88±6.88	0.19
Weasand / empty oesophagus	39.16±17.75	43.12±6.85	0.65
Tripe / empty stomach	495.91±60.82	601.93±64.07	0.03
Empty intestine	566.88±110.76	704.39±144.59	0.13
Abdominal fat	61.31± 62.56	114.81± 63.98	0.22
Pancreatic gland	39.21±31.12	18.30±9.90	0.24
Diaphragm	39.86± 22.62	1.21±24.07	0.60
Testicles	91.78± 54.99	186.15±15.07	0.01
Edible offal total (g):	2,847.45±306.72	3,684.15±300.09	0.00
(% of offal)	38.11±3.74	35.71±2.67	0.28
(% of slaughter weight)	23.33±2.87	21.90±1.91	0.38

LSW: lighter slaughter weight (the slaughter weight between 10 kg to less than 15 kg), HSW: heavier slaughter weight (the slaughter weight between 15 to 20 kg),
P: level of significance

Table 4. Physio-chemical Characteristics of Grass-fed Chevon Having Different Slaughter Weight.

Parameters	LSW goats	HSW goats	P-value
Physical characteristics			
pH	6.16±0.09	6.26±0.06	0.07
Water-holding capacity (WHC) (%)	32.64±2.35	32.05±1.33	0.64
Cooking loss (%)	26.36±4.09	25.46±1.84	0.66
Tenderness (kg/cm^2)	6.89±0.32	6.82±0.59	0.82
Chemical characteristics			
Moisture/ water content (%)	75.57±1.45	73.27±0.59	0.01
Protein content (%)	18.68±1.11	20.47±0.72	0.02
Fat content (%)	3.07±0.61	3.53±0.43	0.21
Collagen (%)	2.16±0.14	2.10±0.05	0.89

LSW: lighter slaughter weight (the slaughter weight between 10 kg to less than 15 kg), HSW: heavier slaughter weight (the slaughter weight between 15 to 20 kg),
P: level of significance

Fatty acids composition in chevon

Fatty acids content in Biceps femoris of goats having different slaughter weight was similar (Table 5). Saturated fatty acids (SFA) in chevon mostly consisted of stearic acid (C18:0) and palmitic acid (C16:0). Monounsaturated fatty acids (MUFA) were mainly consisted of oleic acid

(C18:1). Poly unsaturated fatty acids (PUFA) in LSW goats mostly consisted of arachidonic acid (C20:4), linoleic acid (C18:2), and linolenic acid (C18:3) while those in HSW goats were arachidonic acid (C20:4), eicosapentaenoic acids /EPA (C20:5), and linolenic acid (C18:3). The ratio of unsaturated fatty acid to fat content between LSW and HSW goats was relatively the same (Table 6).

Table 5. Fatty Acids Composition in the Biceps Femoris of Grass-fed Chevon Having Different Slaughter Weight.

Fatty acids (%)	LSW goats	HSW goats	P-value
Saturated Fatty Acids (SFA):			
$C_{10:0}$ / capric acids	0.10±0.22	0.00±0.00	0.35
$C_{12:0}$ / lauric acids	0.44±0.98	0.00±0.00	0.35
$C_{14:0}$ / myristic acids	0.86±1.21	0.33±0.73	0.42
$C_{16:0}$ / palmitic acids	16.70±9.61	21.24±2.81	0.34
$C_{18:0}$ / stearic acids	25.70±12.41	19.29±2.76	0.29
Monounsaturated Fatty Acids (MUFA):			
$C_{16:1}$ / palmitoleic acids	0.00±0.00	0.15±0.34	0.35
$C_{18:1}$ / oleic acids	20.09±13.19	27.23±16.01	0.46
$C_{22:1}$ / erucic acids	0.86±1.18	0.00±0.00	0.14
Poly Unsaturated Fatty Acids (PUFA)			
$C_{18:2}$ / linoleic acids	2.20±4.64	0.00±0.00	0.32
$C_{18:3}$ / linolenic acids	0.86±1.92	0.44±0.99	0.68
$C_{20:4}$ / arachidonic acids	12.93±6.11	9.11±3.24	0.25
$C_{20:5}$ / eicosa pentaenoic acids / EPA	0.00±0.00	0.52±1.17	0.35
Saturated fatty acid (SFA)	43.80±7.19	40.85±3.09	0.42
Monounsaturated fatty acid (MUFA)	20.95±12.56	27.38±16.08	0.47
Poly unsaturated fatty acid (PUFA)	15.99±9.76	10.08±3.55	0.24
Unsaturated fatty acid (UFA)	36.93±8.66	37.46±13.50	0.89
UFA / SFA	0.86±0.22	0.93±0.37	0.73
PUFA / SFA	0.39±0.27	0.25±0.08	0.29

LSW: lighter slaughter weight (the slaughter weight between 10 kg to less than 15 kg),
HSW: heavier slaughter weight (the slaughter weight between 15 to 20 kg),
P: level of significance

Table 6. Unsaturated Fatty Acids to Fat Ratio of Grass-fed Chevon Having Different Slaughter Weight.

Parameters	LSW goats	HSW goats	P-value
Unsaturated fatty acid (%)	36.93±8.66	37.46±13.50	0.89
Fat content (%)	3.07±0.61	3.53±0.43	0.21
Unsaturated fatty acid to fat content ratio	12.37±3.56	10.57±3.72	0.46

Discussion

The higher some indicators of carcass in HSW goats indicated that the heavier slaughter weight of grass-fed Kacang buck was better than LSW goats. Kacang buck in this study produced lower carcass percentage than in Mirdhayati *et al*. (2014) and Adiwinarti *et al*. (2016) research because of different management system but higher compared to Sumardianto *et al*. (2013) research. Dressing percent of carcass in Afar goats (Terefe *et al*., 2013) and in Turkish Indigenous Hair and Honamli goats (Aktas *et al*., 2015) were higher compared to this study.

The higher ratio of meat-fat to bone in the HSW than in the LSW goats because of heavier carcass weight, as reported by Terefe *et al*. (2013). The slaughter weight of the grazing goat in this study was lower (16.87 kg) compared to Terefe *et al*. (2013) study (23.93 kg), but the meat-fat to bone ratio and lean meat to bone ratio in this study was a little bit higher (2.94 and 2.66 vs. 2.82 and 2.53). The carcass weight and the commercial cuts weights in this study were lower than other breeds research (Singh *et al*., 2010; Aktas *et al*., 2015; Akbas and Saatci, 2016).

Higher non carcass weight and edible offal total of HSW than those of LSW goats were because of higher body weight. This finding is in This finding is in accordance with research by Singh *et al*. (2010). Edible offal total of grazing yearling Afar goat with no supplementation (2.99 kg) reported by Terefe *et al*. (2013) was lower than HSW goats in this study because of different edible offal concept. Meat by-products considered as edible are different based on market demand (Toldrá *et al*., 2012; Awan *et al*., 2015). In this study, the edible offal total (% of slaughter weight) was higher than Awan *et al*. (2015) that stated edible by-product of the slaughter animal about 12%.

The pH value of Kacang chevon that was relatively high might be caused by lack of nutrition in the grazing system that cause the low glycogen levels in the muscle. High pH of Ethiopian goat was produced from extensive management system (Sebsibe *et al*., 2007). The pH will influence water-holding capacity (WHC) and cooking loss, but those parameters were relatively the same as other goat meat research by Peña *et al*. (2009) and Das and Rajkumar (2010). However, the WHC of Das and Rajkumar (2010) research was lower; therefore, the cooking loss was higher than this research. Heavy goat tended to have low percentage of cooking loss and less tender (Pratiwi *et al*., 2007). These findings were disagreement with this study. The chevon tenderness in this research was similar to Das and Rajkumar (2010) research.

Water content of chevon in this study was higher compared to in Baiti *et al*. (2013) research that stated about 58.09% to 58.25% in goat fed roughage and concentrate (CP=12%). The water and protein content of chevon in this study were similar to the research of Pratiwi *et al*. (2007) and Das and Rajkumar (2010). Pratiwi *et al*. (2007) also stated that heavier slaughter weight goat contained less moisture and more protein. Previous studies found that lean meat contained about 19.6%-20.7% (Musnandar *et al*., 2011) to 19-23% of protein (Judge *et al*. (1989).

The similarities of fatty acids composition in LSW and HSW goats was in accordance with Peña *et al*. (2009) research that reported fatty acids profiles were not affected by the body weight at slaughter. The compositions of SFA, MUFA, and PUFA in Kacang chevon were similar to the research of Mirdhayati *et al*. (2014), but the ratio of PUFA/SFA was higher in this study (0.25 to 0.39 vs. 0.15 to 0.23). The ratio of PUFA/SFA in this study was also higher than other goats breed reported by Pratiwi *et al*. (2007) and Moawad *et al*. (2013), however, it was lower compared to Peña *et al*. (2009) study. This indicated that pasture feeding is better than concentrate feeding in case of fatty acid composition as stated by Webb and O'Neill (2008). Paengkoum *et al*. (2013) reported that high unsaturated fatty acids were produced in goats fed Mulato II and Verano stylo by grazing.

Unsaturated fatty acids (mono and poly unsaturated fatty acids) are healthy fats. Usually, the higher the slaughter weight, the higher the fat content in the carcass. However, the more fat content does not mean contain higher unsaturated fatty acids contents. This study showed that different slaughter weight produced relatively similar fat content (%), unsaturated fatty acid (%), and unsaturated fatty acid to fat content ratio.

Conclusion

Goats with a higher slaughter weight exhibit superior carcass traits and meat protein levels compared to those with a lower slaughter weight. Grass-fed Kacang bucks in this study have a PUFA/SFA ratio ranging from 0.25 to 0.39.

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Conflict of interest

The authors have no conflict of interest to declare.

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