Effects of rations containing formaldehyde-protected soybean meal on meat production in Kacang goats

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Received: 08-02-2019, Accepted: 07-05-2019, Published online: 25-06-2019

doi: 10.14202/vetworld.2019.890-895 How to cite this article: Adiwinarti R, Budisatria IGS, Kustantinah K, Rusman R, Indarto E (2019) Effects of rations containing formaldehyde-protected soybean meal on meat production in Kacang goats, Veterinary World, 12(6): 890-895.

Abstract

Aim: This study aimed to investigate effects of rations containing formaldehyde-protected soybean meal on meat production in Kacang goats.

Materials and Methods: Fourteen yearling Kacang bucks, weighing 15.8-19.8 kg, were arranged in a completely randomized design. The treatments included a control (PSBM0): 100% untreated SBM; PSBM50: 50% untreated SBM + 50% formaldehyde-protected SBM; and PSBM100: 100% formaldehyde-protected SBM.

Results: The goats disliked the protected SBM. Therefore, differences in their intakes were reflected in their average daily gain (ADG). The ADG and slaughtered weight of the control group were the highest, while those of the PSBM100 and PSBM50 groups were similar. The carcass weights and meat production of the control group were higher than those of the PSBM50 group, but the retained protein to the meat conversion ratio of the PSBM50 group was lower than that of the control. The carcass percentages were similar between the treatments.

Conclusion: The retained protein to meat conversion ratio of Kacang goats fed with 50% formaldehyde-protected SBM showed the lowest value, indicating that these rations efficiently produced meat in the carcass.

Keywords: carcass, chevon quality, daily gain, Kacang goat, soybean meal.

Introduction

Genetic structure and environmental factors both have effects on productivity [1]. Kacang goats are one of the indigenous goat species in Indonesia, raised traditionally in rural areas. The productivity of some Kacang goats is low because the goats are poorly fed and graze on natural grass. The performance of Kacang goats has been improved using soybean meal (SBM) and fish meal in rations [2]. Adiwinarti et al. [2] reported that the dry matter intake of rations containing SBM was higher than those of rations containing fish meal. However, SBM is highly degradable in the rumen [3]. The dry matter digestibility of a rice straw diet supplemented with SBM for goats was 59.5% [4]. In addition, the degradability of SBM, using an in situ technique, in Cashmere goats after incubation for 12 and 24 h was approximately 64.75 and 80.57% of the dry matter, respectively [5].

Many efforts to protect feed from degradation in the rumen have been attempted [6]. Formaldehyde is a chemical used in animal nutrition, is environmentally safe, [7] and can lower protein degradation in the rumen [8]. Mahima et al. [8] reported that the use of 1.5% formaldehyde protected mustard oil cake and increased the in vitro digestibility of indigestible protein in wheat straw. Formaldehyde can also decrease the in vitro degradability of SBM in the rumen. Suhartanto et al. [9] reported that the in vitro dry matter degradability of SBM was 89.9%, while that of 0.5% and 1% formaldehyde-protected SBM was 52.3% and 35.3%, respectively. Although formaldehyde-protected SBM has been applied in cattle [10-13] and sheep [14-17], its application in goats is still limited. However, there has been researching on using formaldehyde protection in goats for sesame cake instead of SBM [18].

Beigh et al. [19] studied total mixed rations (TMR) to improve the intake and nutrient utilization of ruminants. The TMR comprised blended concentrate, roughage [19], a protein source, minerals, vitamins to form balance, and economical rations [19-21]. Feed with low palatability can be mixed in TMR to increase the intake [21]. Feed efficiency increased by approximately 4% when using TMR compared to concentrate and roughage given separately [20].
Therefore, this research studied the effects of SBM protected by 1% formaldehyde in TMR on the growth, carcass production, and chevon quality of Kacang goats. To increase the productivity of goats, the optimum ratio of protected SBM as a function of the physical and chemical properties was explored.

Materials and Methods

Ethical approval

The procedures concerning the use of animals in this experiment were approved by the Animal Ethics Committee of the Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang, Indonesia.

Materials

Fifteen Kacang bucks, a year of age (indicated by having a total of two permanent incisors), were arranged in a completely randomized design. However, one of the goats in the PSBM100 group died during the research; therefore, only 14 goats were used in this research. Their body weights ranged from 15.8 to 19.8 kg, with an average of 17.6±1.2 kg. The rations consisted of 30% *Pennisetum purpureum*, 30% *Gliricidia* leaves, 19.2% cassava waste products, 13.8% wheat bran, 7% SBM, and 1% mineral mix. In addition, it contained 14-15% crude protein and 56-60% total digestible nutrients.

Methods

A completely randomized design was used in this experiment. The treatments included a control or PSBM0 group: 100% untreated SBM; PSBM50 group: 50% untreated SBM + 50% formaldehyde-protected SBM; and PSBM100 group: 100% formaldehyde-protected SBM.

The SBM was protected with 1% formaldehyde. Formalin, containing 37% formaldehyde diluted 4 times with water, was sprayed on the SBM, and then the treated SBM was fermented overnight. Afterward, the SBM was aerated for 1 day and sun-dried for 2 days. The goats were weighed weekly, over 94 days, and the average daily gain (ADG) was calculated using linear regression [2].

The retained protein was calculated from the protein intake minus the fecal and urinary protein. Between the 8th and 10th weeks of the experiment, daily feces and urine were collected, weighed, and sampled. The procedures used for the fecal and urine sampling were based on those of Darlis et al. [4] and Elamin et al. [22], respectively.

Goats were weighed and slaughtered after a 12 h fast, with free access to drinking water. The goats were slaughtered, according to Pratiwi et al. [23], but carcasses in this research included the kidney and surrounding fat. Carcasses were weighed and deboned to evaluate the total bone, fat, meat, meat to bone ratio, and retained protein to meat conversion ratio. The retained protein to meat conversion ratio was calculated as the retained protein divided by the meat product.

Biceps femoris muscles were used for the physical and chemical quality assays, which were based on the methods of Mirdhayati et al. [24]. The physical qualities of chevon included the pH, water-holding capacity (WHC), cooking loss, and tenderness obtained from Warner-Bratzler shear force value, which were observed based on the methods of Shirima et al. [25] and Moawad et al. [26]. The chemical qualities of chevon included the water, fat, protein, and collagen content, which were determined using near-infrared spectroscopy [27]. Data were analyzed as a completely randomized design using one-way ANOVA [28].

Results

The ADG, carcass, and meat production

The dry matter intake (DMI) of the PSBM50 group was lower (p<0.01) than that of the control (PSBM0) group, however, the DMI of the PSBM50 and PSBM0 groups was not significantly different (p>0.05) from that of the PSBM100 group (Table-1). Differences in their intakes were reflected in their live weight (Figure-1), ADG, slaughter weight, carcass weight, and meat weight (Tables-1 and 2). The live weight, ADG, slaughtered weight, carcass weight, and meat weight of the PSBM0 group were higher than those of the PSBM50 and PSBM100 groups (Figure-1), while those of the PSBM50 and PSBM100 groups were about same (Tables-1 and 2).

The carcass and meat weight of the PSBM50 group were lower than those of the PSBM0 group. Surprisingly, although the meat weight of the PSBM50 group was lower than that of the PSBM0 group, the retained protein to the meat conversion ratio of the PSBM50 group was the lowest (Table-3). The lower the value of the retained protein to meat conversion ratio, the better the ration, because this indicates that the amount of retained protein required to convert a gram of meat was lower.

![Figure-1](https://example.com/figure1.png)

*Figure-1:* Body weight of Kacang goats receiving formaldehyde-protected soybean meal 0% (PSBM0), 50% (PSBM50), and 100% (PSBM100).
Table-1: The DMI, ADG, slaughter weight, carcass weight, and carcass percentage.

| Parameters                  | PSBM0 (control) | PSBM50 | PSBM100 | p-value |
|-----------------------------|------------------|--------|---------|---------|
| DMI, g                      | 701.3±81.6a      | 541.1±41.6a | 606.9±65.9ab | 0.008   |
| ADG, g                      | 78.9±10.3a       | 41.5±15.2a  | 56.5±5.0a    | 0.001   |
| Slaughter weight, kg        | 25.1±1.3a        | 21.7±1.1b   | 23.0±0.6a    | 0.001   |
| Carcass weight, kg          | 11.6±1.0a        | 9.5±0.8a    | 10.1±0.4ab   | 0.006   |
| Carcass percent, %          | 46.2±3.6         | 43.8±2.1    | 43.8±2.1     | 0.337   |

DMI=Dry matter intake; ADG=Average daily gain. a,b within a row, means without a common uppercase superscript differ (p<0.01). 1PSBM0 (control) means 100% untreated SBM. 2PSBM50 means 50% untreated SBM+50% formaldehyde-protected SBM. 3PSBM100 means 100% formaldehyde-protected SBM. SBM=Soybean meal.

Table-2: Carcass components and meat to bone ratio.

| Parameters                  | PSBM0 (control) | PSBM50 | PSBM100 | p-value |
|-----------------------------|------------------|--------|---------|---------|
| Meat, kg                    | 8.1±0.9a         | 6.5±0.6a | 7.2±0.1ab | 0.013   |
| Meat, %                     | 71.1±3.1         | 69.6±1.3 | 73.1±1.4 | 0.086   |
| Fat, kg                     | 1.1±0.2          | 0.94±0.1 | 0.7±0.3  | 0.099   |
| Fat, %                      | 9.5±2.5          | 9.2±0.7  | 7.4±2.6  | 0.320   |
| Bone, kg                    | 2.2±0.2          | 2.0±0.1  | 1.9±0.2  | 0.112   |
| Bone, %                     | 19.4±1.6         | 21.2±1.5 | 19.5±1.7 | 0.182   |
| Meat+fat to bone ratio      | 4.2±0.4          | 3.7±0.3  | 4.2±0.4  | 0.187   |
| Meat to bone ratio          | 3.7±0.4          | 3.3±0.3  | 3.8±0.3  | 0.124   |

a,b Within a row, means without a common uppercase superscript differ (p<0.05). 1PSBM0 (control) means 100% untreated SBM. 2PSBM50 means 50% untreated SBM+50% formaldehyde-protected SBM. 3PSBM100 means 100% formaldehyde-protected SBM. SBM=Soybean meal.

Table-3: Retained protein to meat conversion ratio.

| Parameters                  | PSBM0 (control) | PSBM50 | PSBM100 | p-value |
|-----------------------------|------------------|--------|---------|---------|
| Retained protein, g         | 59.5±19.3a       | 24.1±2.8ab | 42.4±2.4ab | 0.002   |
| Meat, g                     | 8078.6±978.9a    | 6472.5±615.7a | 7226.7±141.0ab | 0.013   |
| Retained protein to meat conversion ratio | 0.007±0.002a | 0.004±0.001ab | 0.006±0.000ab | 0.002 |

a,b Within a row, means without a common uppercase superscript differ (p<0.01). 1Within a row, means without a common uppercase superscript differ (p<0.05). 1PSBM0 (control) means 100% untreated SBM. 2PSBM50 means 50% untreated SBM+50% formaldehyde-protected SBM. 3PSBM100 means 100% formaldehyde-protected SBM. SBM=Soybean meal.

The carcass and meat weight of the PSBM50 and PSBM0 groups were not significantly different (p>0.05) from the PSBM100 group (Tables-1 and 2). In fact, the carcass and meat percentage were similar between the treatments (Tables-1 and 2). The averages of the carcass and meat percentages were 44.6 and 71.2%, respectively. The fat, bone, meat + fat to bone ratio, and meat to bone ratio were also similar between the treatments (Table-2), with average values of 0.9 kg (8.7%), 2.0 kg (20.0%), 4.0, and 3.6, respectively.

The chevon quality

The physical qualities of the chevon were almost the same between the treatments, with average values of pH 6.0, WHC 39.8%, cooking loss 37.2%, and tenderness 6.8 kg/cm² (Table-4). The chemical qualities of the chevon were also the same between the treatments, with average values of moisture 72.8%, protein 21.6%, fat 2.6%, and collagen content 1.9% (Table-4).

Discussion

The ADG, carcass, and meat production

The ADG of the goats was influenced by the feed intake. Goats that consumed more feed showed a higher body weight gain. The lower intake of goats fed with rations containing formaldehyde-protected SBM (PSBM50 and PSBM100) indicates that Kacang goats did not like the palatability of the rations because goats are selective feeders, as stated by Rahman et al. [29]. Although the DMI of the goats fed formaldehyde-protected SBM (541.1 and 606.9 g for PSBM50 and PSBM100, respectively) in this research were lower than those of the goats in Rahman et al. [29], their ADG was higher (41.5 and 56.5 g for PSBM50 and PSBM100, respectively, vs. 30.8-43.5 g for Rahman et al. research). The ADG of the goats fed PSBM0 (78.9 g) was higher than that of the Kacang goats reported by Restitrisnani et al. [30] (23.5-69.4 g). However, Rahman et al. [31] reported that crossbred Boer goats fed with soy waste products and *P. purpureum* had a weight gain of 80.2 g/d.

The range of carcass weights of Kacang goats in this research (9.5-11.6 kg) was relatively similar to that of Kacang goats in Gafar et al. [32] (10.7-12.2 kg). However, Kacang goat carcasses were heavier than Indian local goat carcasses, as Solanki et al. [33] reported that Indian local goats had carcass weights of 6.1-7.2 kg at 6-7 months and slaughter weights of 13.2-15.0 kg. In contrast, Hwangbo et al. [34] reported that Korean Black goats had carcass weights.
of 16.3-17.0 kg at 6 months and slaughter weights of 31.0-31.7 kg. Based on these studies, it can be concluded that carcass weights are influenced by the slaughter weight, age at slaughter, and breed. In addition, Yusuf et al. [35] reported that a heavier carcass was due to higher feed intake and better weight gain. Kacang goats are a local Indonesian goat that has a small body size (Kacang means that the goat is as small as a peanut); therefore, the carcass weight is also low. However, because they are prolific and adaptable to poor feeding management, Kacang goats are widely reared by farmers in villages.

The carcass percentages were similar between the treatments. This indicates that the carcass percentage was influenced by the carcass and slaughter weights. The carcass percentages of Kacang goats in this study (43.8-46.2%) were lower than those of Kacang goats reported by Gafar et al. [32] (53.3-56.8%), or other breeds reported by Johnson et al. [36] (49.4-49.9%) and Hwangbo et al. [34] (51.6-54.4%). However, they were relatively similar to those reported by Hutama [37] (46.7%), Solanki et al. [33] (46.0-48.2%), Singh et al. [38] (44.7-47.6%), Yusuf et al. [35] (40.3-48.1%), and Aktaş and Saatci [39] (43.9-46.1%), while they were higher than those reported by Sumardianto et al. [40] (40.9%) and Adiwinarti et al. [41] (38.8%). The differences between the carcass percentages, which varied between 35% and 53%, were caused by the different feeding, feeding management systems, genotype, sex, and age [39]. However, Das and Rajkumar [42] reported that the dressing percentage was mostly influenced by the slaughter weight [34,39].

Meat produced from the PSBM0 (control) group was more than that of the PSBM50 group (Table-2) due to the higher DMI, protein intake, and retained protein. However, the retained protein to the meat conversion ratio of the PSBM50 group was significantly lower (p<0.01) than that of the PSBM0 (control) group (Table-3). This indicated that the PSBM50 ration has the potential to increase meat production, but further research is needed to increase the DMI of the PSBM50 ration.

Table 4: Physical and chemical quality of the chevon.

| Parameters | PSBM0 (control) | PSBM50 | PSBM100 | p-value |
|------------|-----------------|--------|---------|---------|
| Physical quality | | | | |
| pH | 6.0±0.1 | 6.0±0.1 | 6.0±0.1 | 0.890 |
| WHC, % | 39.1±1.9 | 40.2±2.0 | 40.4±3.9 | 0.740 |
| Cooking loss, % | 37.2±2.5 | 38.0±2.3 | 36.3±3.1 | 0.620 |
| Tenderness, kg/cm² | 6.9±0.1 | 6.8±0.3 | 6.8±0.3 | 0.820 |
| Chemical quality | | | | |
| Moisture, % | 72.3±0.8 | 72.9±1.1 | 73.2±0.9 | 0.383 |
| Protein, % | 22.2±0.9 | 21.5±0.7 | 21.0±0.8 | 0.150 |
| Fat, % | 2.8±0.4 | 2.5±0.6 | 2.3±0.5 | 0.420 |
| Collagen, % | 1.9±0.2 | 2.0±0.2 | 2.0±0.1 | 0.653 |

WHC=Water-holding capacity. 1PSBM0 (control) means 100% untreated SBM. 2PSBM50 means 50% untreated SBM+50% formaldehyde-protected SBM. 3PSBM100 means 100% formaldehyde-protected SBM. SBM=Soybean meal.
Hwangbo et al. [34] reported that the chemical compositions of chevon in Korean black goats were not different between the treatments (the level of protein content started from 14% to 20%). The water content was influenced by the fat content. The high water content in this study might be caused by the low-fat content of the chevon [24,34]. Mirdhayati et al. [24] reported that the water content of Kacang goats was 73.8-74.5% and the fat content was 0.4-0.5%, while Hwangbo et al. [34] reported that the moisture content of the Korean Black goat, fed TMR, was 74.3-74.8% and the fat content was 1.4-1.7%. The protein content (21.0-22.2%) was lower than that reported by Mirdhayati et al. [24] (23.2-23.5%), but relatively similar to that reported by Hwangbo et al. [34] (21.7-22.5%), and higher than that reported by Adiwinitari et al. [41] (19.6-19.7%).

Conclusion

Goats fed PSBM0 had the best ADG, slaughter weight, carcass weight, and meat products due to the higher DMI. However, goats fed PSBM50 rations were the most efficient meat producers, which was indicated by the lowest retained protein to meat conversion ratio.

Authors’ Contributions

RA conducted the experiment, acquisition of data, and drafting of the manuscript. IGSB advised in the design of the experiment, data analysis, and interpretation. KK developed the feeding concepts and supervised the experiment. RR advised on the analysis and interpretation of the post-mortem data. EI supervised nutrition analyses. All the authors accepted the final manuscript.

Acknowledgments

The authors are very grateful for the financial support of the Directorate Research and Community Service, Directorate General of Higher Education, the Ministry of Research, Technology, and Higher Education, Republic of Indonesia (Research Grant “Penelitian Unggulan Perguruan Tinggi” Universitas Gadjah Mada, No. 001/SP2H/LT/DRPM/IV/2017). The authors are also grateful for the assistance with collecting data of the “Kacang goat” team and Diponegoro University, Meat Science Laboratory assistants. Finally, we would like to thank Prof. Shigeru Hayakawa (Kagawa University, Japan) for proofreading the manuscript.

Competing Interests

The authors declare that they have no competing interests.

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Available at www.veterinaryworld.org/Vol.12/June-2019/25.pdf

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