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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan  
Mob: +92 300 3008585, Fax: +92 41 8815544  
E-mail: [editorpjn@gmail.com](mailto:editorpjn@gmail.com)



## Research Article

# Growth Performance and Carrying Capacity of Soybean By-products for Ongole Crossbreed (PO) Cattle

R. Priyanto, A.M. Fuah, S. Suharti, I.K.G. Wiryawan, M. Ismail and D. Firmansyah

Faculty of Animal Science, University of Bogor Agricultural, Bogor, Indonesia

## Abstract

**Background and Objective:** The objective of this study was to evaluate the growth performance of Ongole Crossbreed (PO) cattle fed soybean by-products as a substitution for roughage. **Methodology:** Twenty PO cattle at 1.5 years of age were used in this study and were given 4 feeding treatments (T1:70% concentrate without tofu waste and 30% grass, T2:70% concentrate containing tofu waste, 15% grass and 15% soybean pods, T3:70% concentrate containing tofu waste and 30% soybean pods and T4:70% concentrate containing tofu waste and 3-0% fermented soybean pods). Each treatment was applied to 5 animals as a replication. The average crude protein content and Total Digestible Nutrients (TDN) of each feed combination were 14 and 70%, respectively. The parameters measured were as follows: (1) Average daily gain, (2) Dry matter intake, (3) Feed efficiency and (4) Rumen characteristics (i.e., rumen microbes, nitrogen retention, protozoa, allantoin and microbial protein synthesis). **Results:** The results indicate that cattle given 70% concentrate containing tofu waste with 30% fermented soybean pods (T4) performed well in terms of final body weight, average daily gain, dry matter intake and feed efficiency compared to the other treatments. At the end of the experiment, cattle that received T4 had a higher ( $p < 0.05$ ) final body weight compared to those that received the other treatments. Additionally, cattle fed 70% concentrate containing tofu waste with 30% fermented soybean pods showed a steady increase in average daily gain and showed better performance relative to those that received the other treatments. Cattle fed 70% concentrate containing tofu waste, 15% grass and 15% soybean pods and 70% concentrate containing tofu waste with 30% fermented soybean pods had higher dry matter intake compared to those that received the other treatments. The average feed efficiency of cattle fed T1 during phase 1 was higher than T2, T3 and T4, which was closely related to the average daily gain and dry matter intake. Along with the increased live weight, there was a significant change in average daily gain, which increased significantly in phase 2 and decreased in phase 3. Significant compensatory growth was observed during phase 2, cattle showed optimum growth, which was indicated by a significant increase in the average daily gain at 0.52-1.55, 0.85-1.31 and 1.09-1.41 kg day<sup>-1</sup> in cattle fed T2, T3 and T4, respectively. During phase 3, the average daily gain of cattle of all feeding treatments decreased by 0.51 kg day<sup>-1</sup> (T1), 0.93 kg day<sup>-1</sup> (T2), 0.50 kg day<sup>-1</sup> (T3) and 0.75 kg day<sup>-1</sup> (T4). Based on the waste production analysis, the carrying capacity of soybean waste for cattle production was approximately 8 AU ha<sup>-1</sup>. **Conclusion:** Overall, this study suggested that the combination of 70% concentrate containing tofu waste with 30% fermented soybean pods resulted in a better performance of Ongole Crossbreed (PO) cattle, especially in final body weight, average daily gain and feed efficiency. Rumen characteristics of cattle fed all feeding treatments showed similar results, meaning that the conditions of the rumen were not significantly influenced by feeding treatment.

**Key words:** Growth performance, Ongole crossbreed, soybean pod

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**Corresponding Author:** R. Priyanto, Faculty of Animal Science, University of Bogor Agricultural, Bogor, Indonesia

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Beef cattle are potential large ruminants in Indonesia that need to be improved both in numbers and productivity to meet the meat requirements of the population<sup>1,2</sup>. At present, the annual meat consumption in 2012 is approximately 2 kg per capita per year<sup>3</sup>, this value is lower than those of the other Association of Southeast Asian Nations (ASEAN) countries, which range from 20-30 kg per capita per year. This condition is caused by the relatively low economic status of the community and the high price of meat products<sup>1</sup>. Therefore, according to Kalangi *et al.*<sup>4</sup>, appropriate policy and efforts to improve the population and the productivity of beef cattle in Indonesia are necessary. The main problem behind the low productivity of beef cattle by farmers in the villages is the lower sufficiency of feed resources, including the low quality of feed nutrients available for the animal<sup>5</sup>. Consequently, a deficit in protein/nitrogen and low feed intake by the animal is critical. There should be alternative strategies to improve the productivity of beef cattle through the provision of sufficient feed stuffs as the main source of protein among others, two options are soybean meal and soybean waste<sup>6,7</sup>. Soybean waste is abundant, especially in central Java during harvesting time (twice in a year, January and June/July). According to Rab *et al.*<sup>8</sup> and Rab<sup>9</sup>, the carrying capacity of soybean waste for cattle was 8.95 cattle per ha year<sup>-1</sup>. This means that when soybean production is abundant, the waste, including tofu waste and pods, is available for cattle with or without specific treatment or technology. According to Gimeno *et al.*<sup>10</sup>, fermentation could increase animal digestibility, although it may increase the risk of acidosis depending on the method of processing. Soybean can be processed to become silage for beef cattle as reported by Rigueira *et al.*<sup>11</sup>. The results revealed that soybean silage using molasses and inoculant bacteria increased dry matter intake.

Presently, the demand of soybean meal as an animal feed is fulfilled by approximately 70% imported feed<sup>12</sup>. Indonesia has considerable potential land for producing soybean to meet the demand of the human population as well as for livestock<sup>13</sup>. Based on RENSTRA<sup>14</sup>, the total potential land used for soybean plantations reached 475508 ha with an average productivity of 2183839 t ha<sup>-1</sup> year<sup>-1</sup>. Soybean can adapt to a variety of land types, including marginal land by using applied technology for land quality improvement<sup>15</sup>. The integration between beef cattle and soybean may become one of the alternative solutions to increase beef cattle production and to improve feed efficiency. Several studies have been carried out to evaluate the use of soybean meal as a feed resource to improve beef cattle production<sup>8,16</sup>. Fuah *et al.*<sup>16</sup> reported that

local cattle fed with soybean by-products had higher cattle performance than cattle fed only grass. The utilization of soybean meal and its waste improved local cattle performance and meat quality was relatively better than cattle receiving only grass. Additional research was carried out to determine an appropriate formulated synchronized ration for Ongole crossbreed Peranakan Ongole (PO) cattle. This study aimed to evaluate the growth performance of Ongole crossbreed (PO) cattle fed soybean by-products as a substitution to roughage.

The results of the study suggested that an application of soybean waste including tofu waste and pods in cattle diets at an appropriate level contributed to good cattle performance. The performance parameters were as follows: final body weight, average daily gain, dry matter intake and feed efficiency. Overall, the results suggested that the combination of 70% concentrate containing tofu waste with 30% fermented soybean pods had better PO cattle performance and improved feed efficiency (an average of 14.11%). There were differences in cattle performance and efficiency found between the 4 feeding treatments, as well as the 3 periods of feeding times. It revealed that soybean waste could be used as an alternative feed resource for local cattle during critical dry seasons when taking into account the source and age of the cattle, feeding management and environmental factors. The results of the study are expected to produce a formulation of complete feed with balanced rations using soybean waste and by-products for beef cattle production. An integrated approach between beef cattle and soybean waste was applied in this study to improve the utilization and efficiency of land resources to produce the feed stuffs for beef production. This application might provide an opportunity and a significant benefit to small farmers utilizing soybean by-products as feed for livestock.

## MATERIALS AND METHODS

The experiment was a preliminary study, conducted over a period of 8 months. Animals were housed at the experimental station for adaption to the environment and feeding treatments.

Four feeding treatments were created using 4 combinations of concentrate with and without tofu waste and concentrate with soybean pods in different compositions. The rations contained an average of 14% crude protein and were fed to 20 Ongole crossbreed (PO) cattle for approximately 3 months. Data collection was focused on cattle performance, feed efficiency, rumen microbes, protein synthesis, nitrogen retention, fermentation characteristics in the rumen and body composition based on urea space.

**Feeding trial:** Twenty local beef cattle (PO) at 1.5 years of age were used in this study and given 4 feeding treatments that were replicated using 5 animals per treatment. The feeding treatments contained 14% crude protein and 70% TDN and were as follows.

T1: Diet with 70% concentrate (without tofu waste) and 30% grass

T2: Diet with 70% concentrate containing tofu waste, 15% grass and 15% soybean pods

T3: Diet with 70% concentrate containing tofu waste and 30% soybean pods

T4: Diet with 70% concentrate containing tofu waste and 30% fermented soybean pods

The parameters measured were as follows: (1) Growth performance, (2) Average daily gain, (3) Feed consumption based on dry matter, (4) Feed efficiency and (5) Carrying capacity.

## RESULTS AND DISCUSSION

**Growth performance:** The growth performance of cattle during the study indicates that during phase 1, cattle fed 70% concentrate (without tofu waste) -30% natural grass (T1) and 70% concentrate containing tofu waste -30% fermented soybean pods (T4) showed higher ( $p < 0.05$ ) body weight compared to cattle fed 70% concentrate containing tofu waste, -15% grass, -15% soybean pods (T2) and 70% concentrate containing tofu waste -30% soybean pods (T3). There were significant increases in the body weights of cattle fed T2 at the second phase, which resulted in the similar body weight of cattle fed T1, T2 and T3. Meanwhile, cattle fed T4 showed relatively higher body weight than those fed T1 and T3. At the end of the final experiment (phase 3), cattle that received 70% concentrate containing tofu waste -30% fermented soybean pods (T4) had higher ( $p < 0.05$ ) final body weights compared to those fed with other treatments (Fig. 1).

**Average Daily Gain (ADG):** During the first phase, cattle fed T1 [70% concentrate (without tofu waste) -30% natural grass] and T4 (70% concentrate containing tofu waste -30% fermented soybean pods) showed higher ( $p < 0.05$ ) average daily gain compared to cattle fed T2 (70% concentrate containing tofu waste -15% grass -15% soybean pods) and T3 (70% concentrate containing tofu waste -30% soybean pods).

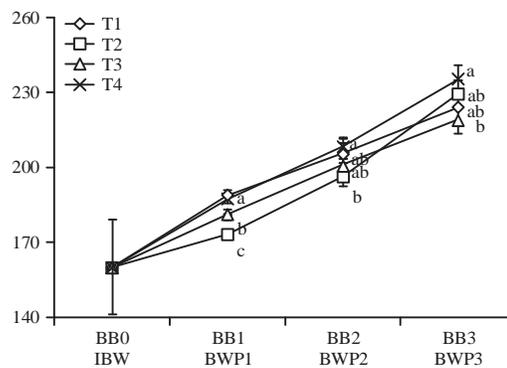


Fig. 1: Growth performance of Ongole Crossbred (PO) cattle fed rations based on soybean waste

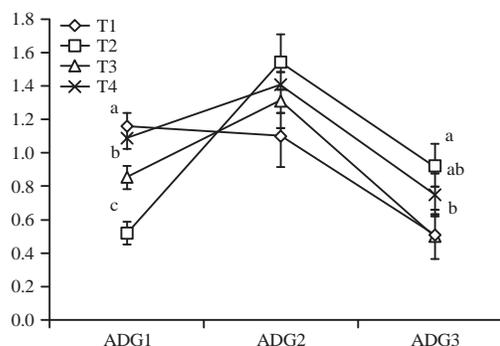


Fig. 2: Average daily gain of Ongole Crossbred (PO) cattle fed rations based on soybean waste

During the second phase, cattle fed T2 had high increases in average daily gain. At the end of the second phase, cattle fed T2 had relatively higher average daily gain than those fed with other treatments.

The results presented in Fig. 2 show that cattle fed rations containing soybean waste (pods) needed time to adapt to the ration, which influenced the average daily gain during phase 1, as indicated by the lower results when compared to cattle fed T1 (concentrate and grass). Significant compensatory growth was observed during phase 2 where cattle showed optimum growth, as indicated by the significant average daily gain increase from 0.521.55, 0.85-1.31 and 1.09-1.41 kg day<sup>-1</sup> for cattle fed T2, T3 and T4, respectively. During phase 3, the average daily gain of cattle receiving all feeding treatments decreased by 0.51 kg day<sup>-1</sup> (T1), 0.93 kg day<sup>-1</sup> (T2), 0.50 kg day<sup>-1</sup> (T3) and 0.75 kg day<sup>-1</sup> (T4). According to Loza *et al.*<sup>17</sup>, the decrease in average daily gain was correlated with the fattening process from increasing live weight.

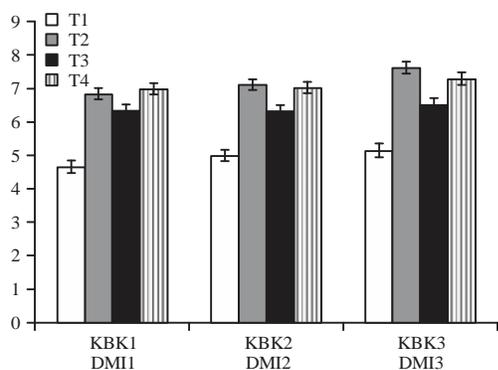


Fig. 3: Average dry matter intake of Ongole Crossbreed (PO) cattle fed rations based on soybean waste

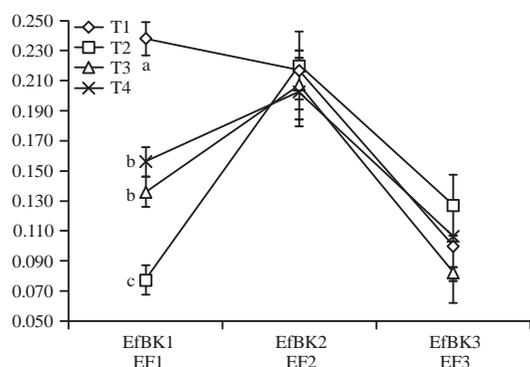


Fig. 4: Average feed efficiency of Ongole Crossbreed Peranakan Ongole (PO) cattle fed rations based on soybean waste

**Dry matter intake:** The average dry matter intake of cattle during the study period (phase 1-3) was relatively constant (Fig. 3). Based on the results, cattle fed T2 and T4 had higher dry matter intake compared to those fed T1 and T3, whereas cattle treated with T3 had higher dry matter intake than those of T1. Dry matter intake was in line with average daily gain and growth performance<sup>18</sup>. Sari *et al.*<sup>19</sup> reported the use of tofu waste and ethanol waste of cassava increased feed consumption, growth performance, daily growth performance and feed conversion of Bali cattle. Although soybean pods contained high dry matter, however, it was moderately palatable, especially when it was fermented. Sruamsiri and Silman<sup>20</sup> found that soybean pods contained high TDN values compared to Guinea grass.

**Feed efficiency:** According to the data analysis, as shown in Fig. 4, feed efficiency of T1 during phase 1 was higher than T2, T3 and T4, while T3 and T4 were similar but higher than T2. During the second phase, significant feed efficiency in

T2 was observed. These results show a similar feed efficiency of all treatments during phase 2. However, in line with the results of the average daily gain (Fig. 2) during phase T3, feed efficiency decreased simultaneously. In addition to feed provisions, feed intake was the major aspect in beef cattle production and feed efficiency became an important indicator to evaluate the benefits and improvements of the outputs. Several studies have focused on how to increase feed efficiency of cattle using genetic and non-genetic means<sup>21-24</sup>. Tedeschi *et al.*<sup>25</sup> reported on different feed efficiencies among groups of cattle using feed efficiency indicators such as CVDS (Cornell Value Discovery System), the Kleiber Ratio (KR), Residual Feed Intake (RFI) and gain-to-feed ratio (G:F, g of ADG kg<sup>-1</sup> of DM). In this study, feed efficiency was influenced by dry matter intake and average daily gain.

The differences in cattle performance and feed efficiency between the treatments were related to the growth stages of the cattle during the adaptation period, compensatory growth and maintenance stages. During the first phase, the feed efficiency of the cattle was low because the animals were in the adaptation period and increased in the second phase and then decreased again, during compensatory growth, the animals adapted to the soybean waste were used in the study in the second phase and growth became stable during the third phase.

**Carrying capacity:** The utilization of agricultural waste as feed for ruminants has been widely recognized due to the ability of ruminants to convert feed materials containing crude fiber into useful products that are beneficial for ruminant growth and reproduction<sup>26</sup>. In calculating the carrying capacity of the soybean waste from plantations, some assumptions are needed as suggested by Rab *et al.*<sup>8</sup>. The report of NRC<sup>27</sup> stated that the feed needs of 1 AU of ruminant based on dry matter ingredients was 6.25 kg ha<sup>-1</sup>. Using 30% pod conversion and tofu waste at 15.97% as references, the requirements of 1 AU ruminant and the carrying capacity of soybean waste were calculated. According to the Rab *et al.*<sup>8</sup>, the carrying capacity of soybean waste for cattle was 8.95 cattle ha<sup>-1</sup> year<sup>-1</sup>. The abundant production of soybean waste is a potential alternative feed for livestock, especially for ruminants as a substitute for roughages during critical dry seasons.

Based on the feed requirements of ruminants and the results of the study, the calculations and estimations were made for the carrying capacity of soybean waste for local beef cattle and are presented in Table 2. The carrying capacity was calculated using the data of soybean pod and tofu waste production (Table 1). These results are based on the rations in the experimental study using 70% concentrate and

Table 1: Animal feed requirements with the composition of 30% pods and 15.97% tofu waste in the rations

Variables	Needs of DM (kg head <sup>-1</sup> day <sup>-1</sup> )
1 (one) AU*	6.25
Body weight: 164.58 kg head <sup>-1</sup>	4.94
Pods 30% ration	1.48
Tofu waste 15.97% ration	0.79

DM: Dry matter, AU: Animal unit, \*Needs of 1 AU (NRC<sup>27</sup>)

Table 2: Production and carrying capacity of soybean waste as cattle feed

Soybean pod	Values
Production: 1) Soybean pod (DM: t ha <sup>-1</sup> )*	1.75
2) Tofu waste*	0.44
Carrying capacity: 1) Soybean pods (AU)	6.47
2) Tofu waste	1.53

DM: Dry matter, \*source: Rab *et al.*<sup>8</sup>

30% fermented soybean pods. The carrying capacity of the ruminant animal waste is 6.47 AU for soybean pods and 1.53 AU for tofu waste. It is clear that 1 ha of soybean leather waste per year can accommodate as much as 6.47 AU cattle with the assumption that the rations are composed of 30% soybean pod skins and the average weight of cattle are 164.58 kg head<sup>-1</sup>. Rab *et al.*<sup>8</sup> reported that using 15% soybean pod in cattle rations could accommodate 8.95 AU year<sup>-1</sup>. This suggests that soybean waste is a potential source to be used as animal feed. One method to improve the nutritional value of soybean waste is the fermentation of pods to increase digestibility.

## CONCLUSION

The conclusions of the study are as follows:

- The growth response of Ongole crossbreed (Peranakan Ongole) cattle to soybean waste ration was quite significant, indicating a high adaptation of cattle to the local feed, this was revealed by a steady increase in body weight along with the simultaneous average daily gain during the study
- The final body weight of cattle fed 70% concentrate containing tofu waste and 30% fermented soybean pods had better performance in term of final body weight (235.33 kg), average daily gain (0.99 kg h<sup>-1</sup> day<sup>-1</sup>), dry matter intake (7.15 kg h<sup>-1</sup> day<sup>-1</sup>) and feed efficiency (14.11%) compared to the other treatments
- The overall results suggested that soybean waste could be used as an alternative feed resource to substitute forages for local cattle, especially during critical dry seasons, while taking into account the application of feed technology such as fermentation and complete feed formulation

- The high carrying capacity of soybean waste for cattle production (8 AU ha<sup>-1</sup>) could be a good prospect for utilizing agricultural waste for cattle production with appropriate technology such as fermentation to improve digestibility

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