Jurnal Triton, Vol. 16 No. 2 (December, 2025) : 270-283
e ISSN : 2745-3650, p ISSN : 2085-3823
DOI: https://doi.org/10.47687/jt.v16i2.1340

JURNAL TRITON
journal homepage: http://jurnal.polbangtanmanokwari.ac.id

Effect of Sago Pulp *(Arenga pinnata)* Supplementation in Rations on Beef Cattle Performance

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INFO ARTICLE

Article History
Received 02/02/2025
Received in revised 25/04/2025
Accepted 28/04/2025
Available online 01/08/2025
Published 19/12/2025

Keywords
Alternative feed
Beef cattle response
Sago pulp

ABSTRACT

Sago pulp (Arenga pinnata) is an abundant agricultural waste in Indonesia and has potential as an alternative feed ingredient for beef cattle due to its high crude fiber content, making it an economical and sustainable option. This study aimed to explore the effect of sago pulp supplementation in rations on the performance of Simmental, Limousin, and Brangus cattle. The study was conducted from May 10, 2023 to June 1, 2023 at a commercial cattle farm in Gunung Kidul Regency, Yogyakarta Special Region, Indonesia. A total of 15 beef cattles, consisting of 5 cattles each of Limousin, Brangus, and Simmental breeds, were used in this study. This exploratory study was conducted with a uniform inclusion level of 29.2% sago pulp for all cattle. Data were analyzed using ANOVA test, with Honesty Significant Difference (HSD) for further test to separate the means if significant effects were found. The results showed that sago pulp supplementation had no significant effect on Average Daily Gain (ADG), Feed Conversion Ratio (FCR), and Feed Cost per Gain (FCG) ($P > 0.05$). On the other hand, a significant effect was observed on the increase of final body weight in all three cattle breeds, especially Simmental ($P < 0.05$). In conclusion, genetic factors play an important role in the response of cattle to sago pulp supplementation. This study is expected to provide a scientific basis for the use of sago pulp as an alternative feed for beef cattle of various breeds.

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ABSTRAK

Onggok aren (Arenga pinnata) merupakan limbah pertanian yang melimpah di Indonesia dan memiliki potensi sebagai bahan pakan alternatif untuk sapi potong karena kandungan serat kasarnya yang tinggi, menjadikannya pilihan yang ekonomis dan berkelanjutan. Penelitian ini bertujuan mengeksplorasi pengaruh suplementasi onggok aren dalam ransum terhadap performa sapi Simmental, Limousin, dan Brangus. Penelitian ini dilaksanakan pada 10 Mei 2023 hingga 1 Juni 2023 di sebuah peternakan sapi komersial yang terletak di Kabupaten Gunung Kidul, Daerah Istimewa Yogyakarta, Indonesia. Sebanyak 15 ekor sapi potong, terdiri atas 5 ekor masing-masing jenis Limousin, Brangus, dan Simmental, digunakan dalam penelitian ini. Penelitian ini bersifat eksploratif dengan level pemberian onggok aren sebesar 29,2% untuk semua sapi. Data dianalisis menggunakan Uji ANOVA dan uji lanjut Honesty Significant Difference (HSD) untuk memisahkan rata-rata jika ditemukan efek yang signifikan. Hasil penelitian menunjukkan bahwa suplementasi onggok aren tidak memberikan pengaruh signifikan terhadap Average Daily Gain (ADG), Feed Conversion Ratio (FCR), dan Feed Cost per Gain (FCG) ($P > 0,05$). Di sisi lain, efek yang nyata terlihat pada peningkatan final body weight pada ketiga jenis sapi, terutama Simmental ($P < 0,05$). Kesimpulannya, faktor genetik memainkan peran penting dalam respons sapi terhadap suplementasi pakan onggok aren. Penelitian ini diharapkan dapat menjadi dasar ilmiah bagi penggunaan onggok aren sebagai pakan alternatif untuk sapi potong dari berbagai bangsa.

INTRODUCTION

The beef cattle subsector has a strategic role in providing animal protein to meet global food needs (Gustiani & Fahmi, 2022). In Indonesia, beef cattle are key commodity that supports domestic food security through government policies that focus on meeting the surge in beef demand (Aini *et al*., 2021). Increasing population and incomes are driving a surge in demand for animal protein, especially beef, which, along with improving living standards, is strengthening market demand. In this context, government efforts to increase the production and efficiency of this subsector have an important contribution in supporting global food availability (Maharani *et al*., 2024).

BPS (2023) reported that Indonesia's population has increased from 266.91 million in 2019 to 278.83 million in 2023, accompanied by fluctuations in per capita beef consumption from 2.57 kg to 2.93 kg. However, the supply of beef was not able to keep up with the increase in demand, resulting in a growing deficit each year, from minus 258.69 thousand tons in 2022 to minus 374.10 thousand tons in 2023 (BPS, 2023). This imbalance between production and consumption results in an insufficient supply of beef to meet the needs. This imbalance reflects the need for efforts to improve the efficiency of beef production, such as optimizing feed management and selecting superior cattle breeds to improve livestock performance (Mayulu, 2023).

Feed management in beef cattle must be carried out appropriately to achieve optimal productivity (Anwar *et al*., 2021). Feed management includes the selection of feed types, the amount of feed given according to needs, the balance ratio between forage and concentrate, the frequency and proper manner of feeding (Andini *et al*., 2023), and the availability of excellent quality of diet (Indonesia Ministry of Agriculture, 2024). However, the availability of excellent diet

quality at an affordable cost remains a major challenge for most beef cattle farmers in Indonesia. Highly expensive feed increases production costs, reduces profitability, and limiting the expansion of the livestock industry. This situation frequently becomes challenging for farmers to provide feed according to the needs of beef cattle (Simamora & Matoneng, 2024). Therefore, it is important to discover alternative feeds that are more cost-effective and able to reduce reliance on commercial feed without reducing livestock performance.

One strategy to reduce feed costs is to replace relatively expensive feed ingredients with alternative ingredients that are more affordable, while still considering the nutrient value and availability of these substitutes (Akbar & Adrian, 2023). Efficiency in feed processing is crucial to reduce feed costs, due to its contribution up to 60-70% of production costs in feed (Maharani *et al*., 2024), suggesting that feeding is the main source of energy for growth, development, and reproduction for livestock (Jabar *et al*., 2023). Strategies to reduce the reliance on imported feed ingredients and conventional feed can involve utilizing alternative feed sources derived from non-conventional agricultural waste in rural areas. While agricultural waste as feed is often interpreted as having low nutrient quality and containing antinutrients, it is economically advantageous due to its low cost, making it affordable option for farmers (Lopi & Kota, 2023).

Sago pulp (*Arenga pinnata*) is an agricultural waste with promising potential as animal feed, especially for beef cattle which is abundantly available in Indonesia. Antika *et al*. (2023) reported that Klaten Regency produces as much as 2.19 tons of sago pulp daily, however it is not well-utilized. This waste is a by-product of palm sugar processing in the form of residual pulp and fiber with high organic biomass content, thereby it has become promising alternative feed source (Febrianti *et al*., 2020). Sago pulp contains high amounts of crude fiber, making it a cost-effective and sustainable feed alternative. The nutritional content of sago pulp is nearly similar with rice straw. It was reported that the Crude Fiber (CF) content of sago pulp is 41.66% and the Nitrogen-Free Extract (NFE) content is 57.63% (Djaeni *et al*., 2024; Ariyani *et al*., 2021). Meanwhile, rice straw contains 37.98% CF, and 41.16% NFE (Sandiah *et al*., 2022). The digestibility of CF and NFE in ruminants indicates the high digestibility of feed nutrients in the rumen (Aling *et al*., 2020). In addition, Febrianti *et al*. (2020) reported that fermentation of sago pulp significantly increased feed digestibility, with hemicellulose content reaching 22.93%, while unfermented sago pulp contained hemicellulose content of 21.67%. Based on the comparison, sago pulp shows higher efficiency as an alternative animal feed compared to rice straw.

Furthermore, the high CF content of sago pulp reaches 32.68%, making it an economically viable alternative to replace traditional feed ingredients such as grass or corn (Djaeni *et al*., 2024). This elevated CF content plays a significant role in the mechanical digestion process within the mouth, which directly affects feed intake, animal health, and

body weight gain (Wahditiya *et al*., 2024). However, the protein content of sago pulp is relatively low, at only 1.56% (Djaeni *et al*., 2024). This limitation can be addressed by selecting beef cattle with superior genetic potential and performances, enabling them to utilize suboptimal feed more efficiently despite the low nutritional content.

Local cattle breeds are generally more adaptable to suboptimal feed compared to imported beef cattle (Sutarno & Setyawan, 2016). However, their performance tends to be lower when fed low-quality feed (Saili, 2020; Tahuk *et al*., 2018). This suggests that, despite the adaptability of local breeds, imported beef cattle may perform better under similar feeding conditions.

Among all imported beef cattle breeds, the most commonly raised breeds in Indonesia are Simmental, Limousin, and Brangus (Agus, 2018; LukmanHy *et al*., 2023). However, their carcass weight are, in fact, lower than high-performance breeds such as Belgian Blue (Galiç & Kara, 2023). Despite its superior yield, the Belgian Blue exhibit poor adaptability to tropical environments (Chalid *et al*., 2023), limiting its suitability for local production system. Therefore, due to their relatively better adaptability and performance under tropical conditions, Simmental, Limousin, and Brangus remain the most viable choices for beef production in Indonesia.

Imported beef cattle breeds such as Simmental, Limousin, and Brangus have different characteristics in growth, feed conversion, and carcass quality, potentially showing different responses to feed quality (Lase *et al*., 2021). Genetically, these cattle exhibit faster body weight growth, better feed efficiency, and higher carcass weight compared to local cattle such as Bali cattle, Madura cattle and Peranakan Ongole (PO) cattle. The carcass weight of imported cattle is significantly higher than that of local cattle. Brangus cattle have an average carcass weight between 900-1000 kg, Simmental cattle typically weigh around 717.6 kg, and Limousin can reach up to 550 kg. In contrast, local cattle breeds such as Bali cattle have an average carcass weight of 175.25 kg, Madura cattle weight approximately 112 kg, and PO cattle average 236.25 kg (Mayulu, 2023; Hetharia, 2021; Agustina & Faqih, 2023; Putri *et al*., 2021).

In this context, studies that specifically examine the effect of sago pulp on beef cattle performances, especially in comparison between cattle breeds, is still highly limited. The lack of study or literature on the utilization of sago pulp in beef cattle can be caused by several factors. One of the primary challenges is the limited awareness among farmers about its potential to improve feed efficiency. In addition, the high CF content in sago pulp, which reaches 41.66%, presents a significant obstacle due to its low digestibility without specific treatments such as fermentation (Hermawati *et al*., 2021). The fermentation process serves to break the bonds of lignocellulose and lignohemicellulose, thereby reducing the CF content in sago pulp (Febrianti *et al*., 2020). These factors contribute to the limited adoption and promotion of sago pulp as a source of feed ingredients within the livestock industry.

This study aims to address a critical knowledge gap regarding the effects of sago pulp supplementation on the performance of beef cattle from different breeds. Specifically, it seeks to investigate the effect of sago pulp supplementation in rations on the performance of Simmental, Limousin and Brangus cattle. By comparing the growth rate, feed conversion efficiency and economic viability among these breeds, the study is expected to generate valuable insights into the potential benefit of sago pulp supplementation. The findings of this study will provide a scientific foundation for promoting sago pulp as an alternative feed ingredient for beef cattle across various breeds.

METHOD

The research was conducted from May 10 to June 1, 2023 at a commercial cattle farm located in Gunung Kidul Regency, Special Region of Yogyakarta, Indonesia. The research location is at the coordinates of South latitude 7°52'42" and East longitude 110°44'24", with an altitude of 300 meters above sea level (MASL). Daily temperatures range from 25-30°C, with humidity levels reaching 69%. All protocols for the use of livestock were approved by the farm to conduct exploratory research. This study employed 15 cattle from two breeds, *Bos indicus* and *Bos taurus*. The cattle breeds used were Simmental, Limousin, and Brangus, each with 5 cattles.

The study was conducted in a 1.5 ha rearing facility, where 14% of the total area was used for housing. The cages were designed to be enclosed with ventilation at the top to prevent the entry of wild animals, and were equipped with blower fans and automatic lights to ensure optimal air circulation and lighting. The floor is made of concrete with carpeting. The roof of the cage uses a gable model, and the type of cage applied is a combination of head-to-head and tail-to-tail to facilitate waste handling and feeding. The cage size is 11 × 19 × 6.5 m, with a feed bunk size of 1.15 × 0.5 × 0.3 m, a water bunk of 0.5 × 0.5 × 0.3 m, and a gutter width of 0.2 m.

All the cattle received the similar feeding per head is 2% of body weight, with a 40% : 60% concentrate-to-forage ratio, including 29.2% sago pulp to optimize livestock growth and reduce production costs. The concentrate was administered twice daily, at 07:00 AM (morning) and 03:00 PM (afternoon). The forage, consisting of fresh elephant grass (on an as fed basis), was provided once daily in the afternoon. The feed composition and nutrient content are detailed in Tabel 1. The diet nutrient composition was well-formulated based on the average body weight of all cattles to meet their nutritional requirements, as outlined in the Nutrient Requirements of Ruminants in Developing Countries (Kearl, 1985). This feeding strategy aims to provide a balance nutrient intake to support optimal productivity and production efficiency of beef cattle.

Feed intake was recorded similar among all cattle; thus, it is not provided in this study. Feed intake was measured daily by calculating the given feed minus the leftovers. Daily feed intake is measured starting from the first day of the rearing period, with the corresponding Average Daily Gain (ADG) used as an indicator. The cattle are individually recorded

each day to evaluate the feed intake. A lower FCR indicates better economic efficiency during rearing, as reflected in FCR and FCG values. Final body weight is determined at the end of the fattening period to assess the overall effectiveness of feed consumption.

Tabel 1. Composition and Nutrien Contents of Basal Diet

Feedstuffs	%
Commercial concentrates	14.6
Sago pulp	29.2
Beer dregs	14.6
Cassava dregs	39.0
Molasses	1.0
Salt and minerals	1.0
Vitamins	0.5
Bacterial starters	0.1
Total	100
Chemical Composition	
Dry matter (DM)	85
Crude protein (CP)	8.74
Total digestible nutrient (TDN)	55
Crude fiber (CF)	29.28
Calcium (Ca)	0.49
Phosphorus (P)	0.49

This study evaluated the performance of Limousin, Brangus, and Simmental cattle based on the parameter of ADG, Final Body Weight (BW), Feed Conversion Ratio (FCR), and Feed Cost per Gain (FCG). Data were analyzed using ANOVA test with IBM® SPSS Statistics 25.0. Honesty Significant Difference (HSD) test was then used to separate means when ANOVA revealed significant effects. This test was used to determine the effect of sago pulp supplementation on Limousin, Brangus, and Simmental cattle, using a significance level of $P < 0.05$. If the P value is close to 0.01, the result indicates a highly significant effect on these three cattle breeds.

RESULTS AND DISCUSSION

Average Daily Gain (ADG)

Average Daily Gain (ADG) is the main indicator in measuring daily weight gain in beef cattle (Hilmia *et al*., 2024). The results showed that sago pulp supplementation had no significant effect on ADG of all cattle breeds ($P > 0.05$) (Table 2). This indicates that the effect of sago pulp supplementation on Limousin, Brangus, and Simmental cattle was relatively similar, although the results shows ADG variations among all cattles (Figure 1).

Previous studies have reported that ADG values in Limousin, Brangus, and Simmental cattle, respectively, ranged from 1.14-1.15 kg/head/day, 0.92 kg/head/day, to 1.24 kg/head/day (Nannucci *et al*., 2021; Kurniawan, 2024; Setiawan & Arifin, 2024). ADG value is influenced by feed quality, consumption levels, and palatability which play roles in optimizing body weight gain during the fattening period (Safitri *et al*., 2024). In addition to feed factors, a study by Putra & Fajrina (2020) noted that

genetics also contributed significantly to body weight.

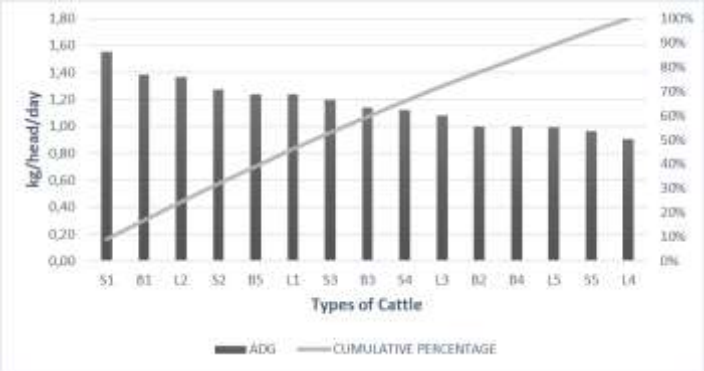

Figure 1. Distibution of cattle potential based on ADG (kg/head/day) of various beef cattle breeds, namely Limousin (L), Brangus (B), and Simmental (S)

This finding is thought to be due to the uniform amount of dry matter (DM) provided across treatments. However, there is no literature supporting effect of sago pulp supplementation on ADG performance in various beef cattle breeds. Although the results did not indicate a statistically significant difference, the descriptive analysis revealed that Simmental had ADG of 1.22 kg/head/day, with Simmental 1 individual achieving the highest ADG among all group (Figure 1). These findings are in accordance with Setiawan & Arifin (2024), who recorded Simmental ADG of 1.24 kg/head/day, which is still within the range of ADG of Simmental cattle between 0.6 to 1.5 kg/head/day.

Table 2. ANOVA Test on Each Type of Cattle with Average Daily Gain (ADG) (kg/head/day), Feed Conversion Ratio (FCR), Final Body Weight (BW) (kg), and Feed Cost per Gain (FCG) (Rp/kg)

Type of Cow	ADG (kg/head/day)	FCR	Final BW (kg)	FCG (Rp/kg)
Limousin	1.12±0.08	10.54±0.77	521.8±21.18^{a}	43.480,01±3.194,48
Brangus	1.15±0.07	10.16±0.62	618.2±40.62^{ab}	41.903,55±2.578,08
Simmental	1.22±0.09	9.65±0.74	697.8±41.07^{b}	39.810,72±3.042,36

Notes: Columns without the same superscript are significantly different ($P < 0.05$) in the 5% Honesty Significant Difference (HSD) test

Feed Convertion Ratio (FCR)

Feed Conversion Ratio (FCR) is a parameter used to measure the efficiency of beef cattle in converting the amount of feed digested into one kilogram of live body weight (Sari, 2022). The results showed that supplementation of sago pulp in the ration did not significantly affect the FCR of beef cattle ($P > 0.05$) (Table 1). Previous research reported that the FCR value of Limousin cattle was 11.13; Brangus 10.47; and Simmental 12.90 (Sholeh *et al*., 2023; Kurniawan, 2024). Factors affecting FCR include livestock breeds, feed nutrient content, age, health status, environmental conditions, and maintenance management (Hilmia *et al*., 2024). Genetically, livestock breeds with more efficient feed conversion ability show lower FCR.

Conversely, an increase in FCR value reflects a decrease in ration utilization efficiency (Suryani *et al*., 2020).

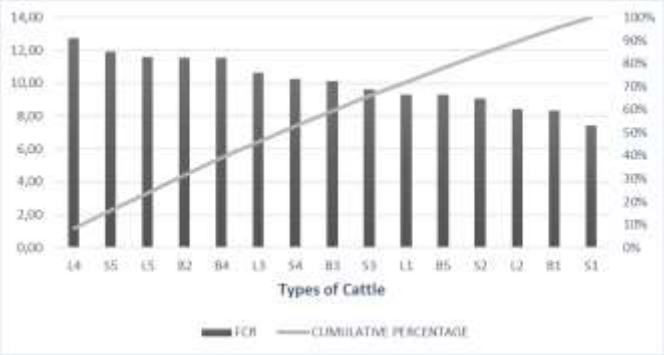

Figure 2. Distibution of cattle potential based on FCR of various beef cattle breeds, namely beef cattle breeds, namely Limousin (L), Brangus (B), and Simmental (S)

These findings are probably due to the uniform ration for each type of cattle. Although no significant effect was observed, the FCR value obtained was within the favorable range, with an optimal range of values for fattening beef cattle falling between 8.56 to 13.29 (Sholeh *et al*., 2023). Descriptively, Simmental cattle achieved the best FCR value at 9.65 kg of feed DM for every 1 kg of beef produced. Despite the result indicate no signficant difference, descriptively, Simmental 1 cattle were recorded with an FCR that was 8.4% lower than that of Limousin (Figure 2). This suggests a trend toward a potentially different feed conversion efficiency between the two breeds, although the observed difference was not statistically significant. In addition, the FCR of Simmental cattle in this study was lower than that of Sholeh *et al*. (2023), which reported a Simmental cattle FCR value of 12.90. These difference indicates that sago pulp supplementation is able to improve feed conversion efficiency, resulting in a better FCR in Simmental cattle. Although no research directly macthing these findings, this study is in line with the results reported by Hilmia *et al*. (2024), stated that FCR is also influenced by genetic factors of cattle breeds. A favorable FCR in Simmental cattle indicates a superior genetic ability to convert feed efficiently.

Final Body Weight (BW)

Final body weight is a visual indicator that reflects physiological condition and growth rate (Cho *et al*., 2020). Under the similar environmental conditions, body weight fluctuations are influenced by individual genetic differences and cattle breeds (Hilmia *et al*., 2024). The results showed that sago pulp supplementation had a significant effect on final weight, with a significant difference between the final weight of Limousin and Simmental cattle ($P < 0.05$) (Table 2). However, there was no significant difference between Limousin and Brangus cattle, nor between Simmental and Brangus cattle ($P > 0.05$). This variation suggests that genetic factors play an important role in determining final weight among

Limousin, Brangus and Simmental cattle breeds.

Figure 3 shows that Simmental 1 cattle achieved a final weight of 697.8 ± 41.07 kg. In line with previous studies, Simmental cattle were recorded to have the higher body weight compared to Limousin (1,000 kg), and Brangus (455.5kg) (Jumarding *et al*., 2023; (Göncü *et al*., 2020), with a reported average body weight of 1.150 kg for Simmental. These findings align with the general trend observed in Simmental cattle, although no statistical comparison was made in this study.

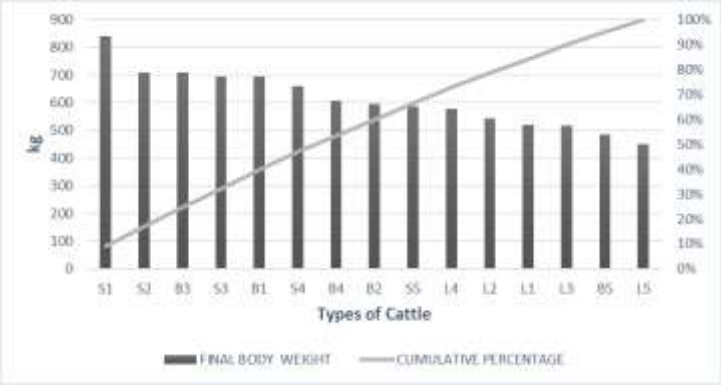

Figure 3. Distibution of cattle potential based on Final BW (kg) of various beef cattle breeds, namely Limousin (L), Brangus (B), and Simmental (S)

Although diet nutrition plays an important role in livestock growth (Anwar *et al*., 2021), the feeding management in this study applied similar level of total dry matter (DM), and no significant differences in feed consumption were found between cattle breeds. Therefore, the higher final body weight in Simmental cattle is thought to be more influenced by genetic factors, where Simmental cattle have a larger rumen volume, higher voluntary intake, and faster metabolic rate than Limousin and Brangus cattle (Hermawansyah *et al*., 2023), thus indicating greater digestive efficiency of Simmental cattle, which contributes to the increase in final body weight.

Feed Cost per Gain (FCG)

Feed Cost per Gain (FCG) is a parameter that represents the feed cost required to produce a kilogram of body weight gain (Widharto, 2021). FCG value is calculated by summing ration consumption (kg/head/day) multiplied by ration price (Rp/kg) divided by body weight gain (kg/head/day) (Wea *et al*., 2021). This index is designed to assess the ability of cattle to convert feed at minimal feed cost, while ensuring livestock health and sustainability of farm profits (Ojo *et al*., 2024). The results showed that sago pulp supplementation in the ration did not significantly affect the FCG of beef cattle ($P > 0.05$) (Table 2). Unfortunately, there is no previous study that discusses the effect of sago pulp supplementation on differences in FCG in various types of cattle.

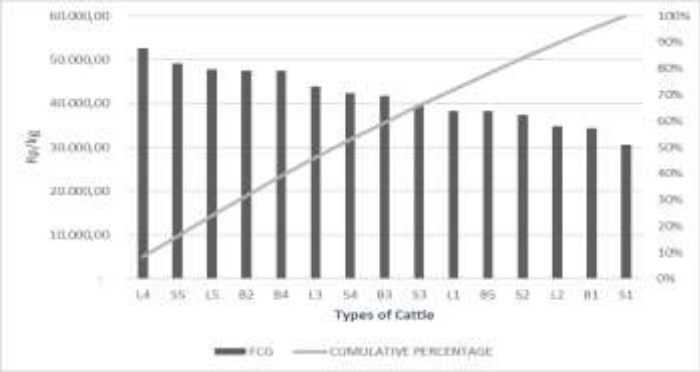

Figure 4. Distibution of cattle potential based on FCG of various beef cattle breeds, namely beef cattle breeds, namely Limousin (L), Brangus (B), and Simmental (S)

According to Fitria *et al*. (2022), FCG is influenced by feed intake, ADG, and feed cost. In this study, feed intake and feed cost were similar for each cattle breed, so ADG was the main factor affecting the difference in FCG results between cattle breeds.

Table 3 shows that the FCG values of Limousin, Brangus and Simmental cattle were Rp 43,480.01/kg; Rp 41,903.55/kg; and Rp 39,810.72/kg, respectively. These findings suggest that these breeds exhibit similar feed efficiency with the cost required to produce 1 kg of body weight of around Rp 39,810.72-Rp 43,480.01. Economically, Simmental cattle rearing is more efficient with an FCG value 8.4% lower than Limousin cattle, thus saving feed costs. Cahyono *et al*. (2023) reported that Simmental cattle with an average age of 2 years fed with forage, rice bran, pollard and corn cobs had an FCG of Rp 22,258.20. Meanwhile, Rahmawati *et al*. (2022) observed that Limousin cattle with an initial body weight of 380 kg and a diet consisting of corn cobs, corn kernels, straw, cassava waste, cassava leaves, soybean meal, drops, urea, peanut straw, soybean straw, elephant grass, and corn leaves had FCG values in the range of IDR 19,780.00 to IDR 25,027.00. However, to our best knowledge, there has been no specific study evaluating the FCG value in Brangus cattle. Regardless, the FCG value in this study is higher than that of Cahyono *et al*. (2023) and Rahmawati *et al*. (2022), which is thought to be due to the high price of cassava pulp used in the proportion in the ration more than other feed ingredients.

CONCLUSION AND RECOMMENDATIONS

This study showed that supplementation of sago pulp as an alternative feed ingredient for beef cattle has varying potential depending on the type of cattle used, namely Limousin, Brangus and Simmental. Although sago pulp supplementation did not have a significant effect on Average Daily Gain (ADG), Feed Conversion Ratio (FCR), and Feed Cost per Gain (FCG), a noticeable impact was observed in the increase of Final Body Weight (BW) of the three cattle breeds, especially Simmental. Simmental cattle performed best with the highest final body weight, and the most efficient FCR and FCG

values. This indicates that genetic factors play an important role in the cattle's response to the supplementation of palm sugar cane feed. This study confirms the need for further exploration involving more samples from different cattle breeds and different levels of sago pulp supplementation to improve the validity of the results.

CONTRIBUTIONS STATEMENTS

The authors contributed to the research and manuscript preparation as follows. The study was conceptualized by AAY and MYF, while data curation was conducted by PHS and HFK. Formal analysis was performed by MYF and OR, and the methodology was developed collaboratively by NP, AAP, and HFK. AAY was responsible for software implementation. In addition, validation was carried out by NP and OR, and the investigation was conducted by AAY and MYF. The original draft of the manuscript was written by PHS, NP, and AAP, whereas AAY contributed to the review and editing process. Finally, all authors have read and approved the final version of the manuscript.

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