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Liveweight Gain Response of Bali Bulls Fed Leucaena and Cassava Peels to Increasing Levels of Fermented Corn Stover in Diets

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ABSTRAK

Penelitian ini bertujuan untuk menentukan kombinasi optimal pemberian lamtoro dan jerami jagung fermentasi pada tingkat pemberian kulit ubi kayu yang tetap dalam ransum sapi Bali jantan. Sebanyak 20 ekor sapi Bali jantan berusia 1,5-1,8 tahun (190 ± 12,34 kg) dibagi menjadi empat kelompok perlakuan. Pada setiap kelompok perlakuan, sapi jantan diberi pakan empat tingkat jerami jagung fermentasi (10%, 30%, 40% dan 60%) dengan tingkat penurunan lamtoro yang sesuai (70%, 50%, 40% dan 20%) dan tingkat kulit singkong yang tetap (20%). Pemberian jerami jagung fermentasi sebanyak 10% dengan 70% lamtoro memberikan pertambahan bobot hidup tertinggi (Pertambahan bobot badan; 0,41 kg/hari). Terdapat hubungan linier dan kuadrat antara pertambahan bobot badan terhadap pemberian jerami jagung fermentasi. Pertambahan bobot badan kemungkinan besar terkait dengan tingkat konsumsi bahan kering (20 – 21 g/kg BB) dan ketersediaan protein dalam ransum. Hubungan antara konsumsi jerami jagung fermantasi dan pertambahan bobot badan dapat digunakan untuk menentukan kombinasi optimal antara pemberian lamtoro dengan jerami jagung fermentasi dan kulit singkong dalam ransum. Peningkatan penambahan pemberian jerami jagung fermentasi hingga 35% dan penurunan pemberian lamtoro sampai 45% dalam ransum hanya menghasilkan sedikit perubahan pertambahan bobot badan, hal ini memberikan ruang yang lebih besar terhadap penggunaan jerami jagung fermentasi pada sistem penggemukan dengan ketersediaan lamtoro yang terbatas.

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ABSTRACT

The study determined the optimum combination of Leucaena and fermented corn stover to a fixed level of cassava peels in the diet of Bali cattle. Twenty Bali bulls aged 1.5-1.8 years (190 ± 12.34 kg) were divided into four treatment groups. In each treatment group, bulls were fed four levels of fermented corn stover (FCS; 10%, 30%, 40% and 60%) with corresponding declining levels of leucaena hay (70%, 50%, 40% and 20%) and a fixed level of cassava peels (20%). Bulls fed at 10% FCS with 70% leucaena had the highest liveweight gain (LWG; 0.41 kg/d). There was both a linear and quadratic relationship between liveweight gain (LWG) and FCS inclusion. The LWG was most likely related to the dry matter intake (20 – 21 g/kg LW) and the metabolizable protein supply. The relationship between FCS intake and LWG can be used to determine an optimal combination between Leucaena, FCS and cassava peels in the diets but inclusion of FCS up to 35% and leucaena hay down to 45% resulted in little change in LWG and provides a range over which FCS could be used to extend limited quantities of leucaena in systems for fattening bulls.

INTRODUCTION

Leucaena feeding is becoming a common practice in eastern Indonesia since the introduction of *Leucaena leucocephala* cultivar Tarramba to Nusa Tenggara Area of Indonesia in 2001. Leucaena feeding is popular for fattening cattle especially for Bali cattle in the region. Leucaena planting has been widely carried out in eastern Indonesia, especially East Nusa Tenggara and West Nusa Tenggara (Nulik *et al*., 2013). Leucaena planting is done with polybags and stumps, the success of planting is 80-95% (Sutaryono *et al*., 2019). Dahlanuddin *et al*., (2019) reported that the number of smallholder farmers adopting Leucaena feeding has been increasing dramatically in Sumbawa Island of West Nusa Tenggara Province, involving more than 2000 farmers.

Farmers feeding *Leucaena* to fattening bulls acknowledge that bulls gain weight rapidly, more so than from a local grass diet. Under the traditional fattening system based on cut and carry of grass and forb, Bali bulls grow at 0.26 kg/day (Dahlanuddin *et al*., 2012). Leucaena feeding doubled the liveweight gain to 0.42-0.61 kg/day (Panjaitan *et al*., 2014). Kariyani *et al*., (2021) reviewed nutritional aspects of feeding *Leucaena* with its high crude protein (CP) content of approximately 22% CP. Feeding *Leucaena* solely is widely practiced especially during the wet season. Even though there are no detrimental nutritional consequences of providing such a high crude protein forage to ruminants, it is a waste of high protein feed. A more efficient utilization would be to add a fermentable energy source into the ration to promote higher liveweight gain, as well as to make a given amount of *Leucaena* feed more animals or over a longer time frame (Harper *et al*., 2019). Generally, farmers experience inadequate supply of leucaena forage towards the end of the dry season. Inclusion of an alternative feed source with *Leucaena* may increase the efficacy of *Leucaena* utilization and enable an increase in the number of cattle fattening in the wet season and maintain the number of fattening cattle in the dry season. Maize is a dominant crop grown in West Nusa Tenggara. There is a lot of agricultural waste, especially corn straw, which can be used as animal feed. The provincial central bureau of statistics reported the harvested area of maize in Sumbawa Island reached 112,476 ha/year (BPS, 2020), and corn stover and cassava peels, which are a waste by-product of cassava can potentially be used as cattle feed (Saputra *et al*., 2021). The utilization of corn stover as a fibre source and cassava peels as a non-structural carbohydrate (energy) source could potentially be used to improve the efficacy of *Leucaena* utilization for cattle feeding as well as promote higher live weight gain. Corn stover is not available throughout the year and it has a relatively poor nutritive value thus fermentation treatment may preserve and enhance its quality as cattle feed. However, information on the inclusion of fermented corn stover for Bali bulls fattened on a *Leucaena* based diet is limited. This study has been undertaken to investigate the response of Bali bulls fed *Lucaena* to the inclusion of increasing levels of fermented corn stover with a fixed level of cassava peels.

MATERIALS AND METHODS

Location, Cattle, and Feeding

This experiment was conducted over a 16-weeks period (September – December 2020) at Taman Teknologi Pertanian (TTP; Agriculture Technology Park), Poto Tano, West Sumbawa District (8°32'30.4"S 116°50'60.0"E).

Twenty Bali bulls (Bos javanicus D'Alton) with an initial liveweight of 190±12.34 kg was used. They were divided into four treatment groups and each group fed one of 4 diets; 10% fermented corn stover + 70% *Leucaena* hay + 20% cassava peels (diet A), 30% fermented corn stover + 50% *Leucaena* hay + 20% cassava peels (diet B), 40% fermented corn stover + 40% *Leucaena* hay + 20% cassava peels (diet C) and 60% fermented corn stover + 20% *Leucaena* hay + 20% cassava peels (diet D).

Harvested *Leucaena* underwent a thorough sorting process, where leaves and branches were separated. Twigs, however, were included in the leaves as they are still edible. After that, selected *Leucaena* (edible parts) were chopped about 3-5 cm in length and sun dried for 2-3 days minimum. The indication that the Leucaena is properly dried is that the colour remained green. This indicates that *Leucaena* hay is of good quality.

The fermented corn stover was prepared by mixing 80% chopped (3-5 cm) corn stover and 20% ground corn grain and mixed with Aspergillus sp. prior to ensiling process for 21 days before used. Cassava peels are the waste product of producing cassava chips and often contain under sized fresh cassava tubers obtained from the production of cassava chips from home processing and then sun-dried and ground to pass a sieve of 1 cm in diameter prior to feeding. *Leucaena* (leaves and small stems) was harvested, chopped to a size of 3-5 cm in length and then sun-dried prior to use.

Data collection was carried out for 16 weeks with 2 weeks of adaptation to the dietary treatments; 13 weeks of measuring water intake, feed intake and daily weight gain; and 1 week of measuring feed digestibility. Samples of feed and feed residues were obtained every day for 13 weeks. Those samples were collected for analysis every 1 month. Meanwhile, cattle were weighed once a week. Clean drinking water was provided twice a day in 10 L bucket and more than 10 L offered each time to allow the bulls to drink to satiety at each drinking time. Digestibility measurement was carried out for seven days to obtain data on feed and drinking water consumption. While collection of rumen fluid was carried out on the last day of that one-week period.

Collecting data on daily feed intake was conducted over a 13-week period and feed digestibility was measured for seven consecutive days at the end of the experimental period. Subsamples of each ingredient were taken once a month for one week. The subsamples were then dried, bulked and analysed for dry matter (DM), organic matter (OM), crude protein (CP), and neutral detergent fibre (NDF) (AOAC, 2005).

All bulls used in this experiment were weighed every 1 weeks to get the live weight gain. All animals were weighed at the same time each week before the morning feed to measure live weight gain and calculate feed allocation. Rumen fluid samples from all animals were collected 3 hours after feeding at the end of week 16. The pH of bulk rumen fluid was determined immediately with an electronic portable pH meter (Senz-pH, TTBH Pte Ltd; Singapore).

Design and Data Analysis

This study was designed using a randomized complete block design. The number of cattle used was 20, which were divided into 4 treatment groups with each treatment comprise 4 cattle placed into individual pen as replicates.

All data were analysed using One Way Analysis of Variance (ANOVA) and conducted using SPSS version 20. The linear and quadratic equations were generated using Microsoft excel.

Ethical statement

This research was accepted in the Animal Ethic Committee Approval number AFS/517/17/INDONESIA. From the Committees University of Queensland.

Table 1. Nutrient Composition of the Diets

Feed Ingredients	**Chemical Composition (%DM)**				
	DM	**OM**	**CP**	**EE**	**NDF**
Corn Stover	90.1	92.4	4.4	0.39	71.6
Fermented Corn stover	74.6	91.3	5.7	0.76	65.1
Leucaena	84.6	92.0	19.2	2.90	51.6
Cassava peels	91.0	90.5	4.0	0.75	52.3
Feed Treatments					
Diet A	84.9	91.6	14.8	2.25	53.1
Diet B	82.9	91.5	12.1	1.82	55.8
Diet C	81.9	91.4	10.8	1.61	57.1
Diet D	79.9	91.3	8.1	1.18	59.8

RESULT AND DISCUSSION

Result

The live weight gain (LWG, kg/day) of Bali bulls decreased in response to increasing level of fermented corn stover inclusion (Table 2). A significant difference only occurred when fermented corn stover was offered over above 40% of the total diets. A linear decrease in liveweight gain was observed to fermented corn stover inclusion and the equation was:

$y = -0.0021x + 0.432$ ($R^2 = 0.940$)

where y is LWG kg/day, and x is % level of inclusion of fermented corn stover.

A quadratic form was also investigated, and the equation was:

y = -0.00001x2 - 0.0013x +0.4216 (R2 = 0.947)

where y is LWG kg/day, and x is % level of inclusion of fermented corn stover.

There was no statistical advantage to using the quadratic form and so the linear form was accepted. The LWG data with linear regression fitted had a maximum LWG (0.43 kg/d) at zero inclusion of fermented corn stover whilst the LWG data with polynomial regression form resulted in a maximum LWG of 0.46 kg/d at 35.5% inclusion of fermented corn.

Table 2. Fed Fermented Corn Stover, Leucaena and Cassava Peels on Bali cattle Performance

Parameter	% Fermented corn stover in the diet			
	10	30	40	60
IW (kg)	195±13	202±7	188±13	191±15
ALG (kg/d)	0.41^a±0.03	0.36^{ab}±0.03	0.39^a±0.09	0.30^b±0.04
DMI (g/kg LW/d)				
Cassava peels	5.82^a±0.74	5.54^a±0.76	5.41^a±0.57	5.46^a±0.31
Fermented corn stover	2.21^d±0.37	5.04^c±0.96	6.61^b±0.62	8.08^a±1.01
Leucaena hay	13.04^c±3.91	8.94^b±2.51	7.91^{ab}±0.56	5.87^a±0.38
Total	21.07^a±4.70	19.52^a±4.13	19.94^a±1.67	19.41^a±1.59
OMI (g/kg LW/day)				
Cassava peels	5.27^a±0.67	5.01^a±0.69	4.90^a±0.52	4.95^a±0.29
Fermented corn stover	2.02^d±0.34	4.60^c±0.88	6.03^b±0.57	7.37^a±0.92
Leucaena hay	11.97^c±3.59	8.21^b±2.31	7.27^{ab}±0.52	5.39^a±0.35
Total	19.26^a±4.31	17.82^a±3.78	18.20^a±1.53	17.71^a±1.45
WI (kg/day)	21.62^a±1.25	20.36^{ab}±1.72	19.22^b±1.88	18.36^b±2.18
TWI (kg/day)	22.35^a±1.28	20.61^a±2.19	20.48^a±2.16	20.0 ^{a}±2.01
DMD (%)	59.5^c±3.65	54.7^b±3.85	55.6^b±2.40	50.2^a±2.32
OMD (%)	61.8^c±3.44	57.1^b±3.66	57.5^b±2.79	52.6^a±3.35
DOMI (g/kg LW/day)	12.4^a±1.03	11.9^a±1.15	11.8^a±0.83	11.6^a±0.67
Rumen pH	6.40^a±0.10	6.42^a±0.20	6.38^a±0.10	6.40^a±0.12

^{ab} *values with different superscripts differ significantly (P<0.05).*
Aberration: IW (Initial weight), ALG (Average live weight gain), DMI (Dry matter intake), OMI (Organic matter intake), WI (Water intake), TWI (Total water Intake), DMD (Dry matter digestibility), OMD (Organic matter digestibility), DOMI (Digestibility Organic matter intake)

There was no change in feed intake with increasing level of fermented corn stover in the diets (Table 2). The total intake of fermented corn stover inclusion at level 10% in the diets was 21.1±4.70 g/kg LW/day while at level 60% in the diets was 19.4±1.59 g/kg LW/day. The inclusion of fermented corn stover did not affect both total DMI and OMI (Table 2). Digestibility of dry matter and organic matter decreased with an increasing level of fermented corns stover in the diets (Table 2). However, there were no difference in DOMI in response to increasing level of fermented corn stover inclusion.

The imbibed water intake (IWI) decreased with an increase in fermented corn stover inclusion however there was no change in total water intake (TWI) by increasing level of fermented corn stover inclusion in the diets. The TWI was as high as 22.4 kg/day. There was no change in rumen fluid pH in response to increasing level of fermented corn stover in the diets. The rumen pH values in all treatments were within a narrow range of 6.38-6.42.

Discussion

Fermented corn stover (FCS) can be included up to 35% in a *Leucaena* basal diet (35% FCS, 45% *Leucaena* and 20% cassava peels) to maintain a liveweight gain of approximately 0.39-0.46 kg/day. The nature of the response curve and the statistical method chosen to look at the response provide differing conclusions as to the maximum level of inclusion. Nevertheless Table 2 and the regression equations suggest that FCS could be included up to approximately 35% without any major decline in LWG. Values above that level of inclusion may result in a marked decline in LWG. The LWG result obtained in this experiment was consistent with the live weight gain commonly reported for Bali bulls fed high leucaena diets (Dahlanuddin *et al*., 2014; Panjaitan *et al*., 2014; Soares *et al*., 2018). Fermented corn stover up to 35% could be added to *Leucaena* based diets with a high energy source such as cassava peels to prolong the feeding of a limited amount of *Leucaena* especially during the dry season without any detrimental effect on live weight gain (Harper *et al*., 2019). Cassava has a great potential as a low-priced source of soluble energy, and most importantly the mixture of energy sources in the form of cassava can increase profits for fattening farmers (Cowley *et al*., 2020a; Cowley *et al*., 2020b).

The LWG of cattle recorded in this experiment was still below the highest values recorded for Bali bulls. Higher growth rates of 0.56–0.61 kg/d were reported by Quigley *et al*., (2014) when a Leucaena-based diet was supplemented with energy sources (maize grain or rice bran) at about 40% of diet. Dahlanuddin *et al*., (2018) also reported a higher liveweight gain of 0.66 kg/d for similar class of Bali bulls fed Leucaena and supplemented with maize grain at 40% of diet. In this experiment, the cassava peels as an energy source feed have been supplemented at a much lower level (20% of diets). A higher level of cassava peels may be necessary to get higher live weight gains. However, this may require extra N as cassava peels are low in CP (Table 1) (Kariyani *et al*., 2021). The current experiment provides a reference for optimum level of fermented corn stover inclusion to reach a target live weight gain or calculate how many cattle can be carried on a fixed supply of Leucaena, corn stover and cassava peels.

The lower feed intake (20-21 g/kg LW) in this experiment was most likely contributed to the lower live weight gain. This in agreement to Soares *et al.* (2018) who reported slightly higher LWG when Bali bulls were fed fresh leucaena solely or fed fresh leucaena replaced with corn stover at 25% and 50% which resulted in dry matter intakes of 28, 26, and 24 g/kg LW/day. In addition to liveweight gain, a similar trend in intake occurred whereby increasing corn stover level decreased total dry matter intake. However, similar dry matter intake on a similar class of Bali bulls with higher LWG was reported by Dahlanuddin *et al.*, (2018) when Bali bulls were supplemented with corn grain at 1% DM of liveweight. This may be associated with the CP and energy content in the diets. The total dry matter intake in this experiment was not statistically different. The digestibility of DM and OM responded in a similar manner with a decrease in response to an increasing level of fermented corn stover. This suggests that digestibility of fermented corn stover was lower than the other ingredients. However, the digestible organic matter intake was not changed despite liveweight gain declining. The use of a higher digestibility ingredient than fermented corn stover is warranted or alternatively a higher level of cassava peels in the final ration.

The decline in CP content may explain the decline in LWG with no change in DOMI. CP content declined as the inclusion level of fermented corn stover increased. Whilst the 60% inclusion of fermented corn stover resulted in a low CP content of 8% CP this was not considered deficient as value of 7% CP is often considered the minimum to meet intake and rumen ammonia requirements. The CP content of diet 60% fermented corn stover is 8.1% CP and with an OMD of 52.6% it has a CP/DOM ratio of 140 g CP/kg DOM which is above the minimum required for rumen microbe function generally assumed to be 130 g MCP/kg DOM (or TDN) (Poppi & McLennan, 1995). With degradability estimates of the ingredients the value of rumen degradable protein (RDP/kg DOM) is 115 g RDP/kg DOM and with rumen recycling taken into account the value is 148 g RDP/kg DOM at this CP level of 8% CP. Numerous studies have shown that there is no response to urea or any degradable N source above the value of approximately 130 g/kg DOM and if we assume recycling then the urea N recycling ensures that RDN is well above minimum RDN. Any undegradable CP (UDP) and variation above that will give a LWG response. Adding extra N in the form of urea to balance the CP content would do nothing in this scenario to determine the upper level of inclusion. For that reason, urea was not used to balance CP. Since the DOMI/kg LW was similar then the LWG response was more likely due to differences in metabolizable protein supply most likely influenced by the UDP fraction of the *Leucaena*. The aim of the experiment was to determine the upper level of corn stover inclusion before LWG was affected. As there was no difference in LWG between the 10, 30 and 40% stover inclusion, the reason for the decline at 60% inclusion is most likely a difference in metabolizable protein supply not energy supply and that is a consequence of ingredient mix and a consequence of trying to determine the upper level of inclusion.

The rumen fluid pH was not changed in response to increasing level of fermented corn stover and was within a normal range of 5.5 – 7.0 (Kamra, 2005; McDonald *et al.*, 2011). Mudita *et al.*, (2016) reported the pH rumen of Bali cattle about 7.0 to 7.32 with bio supplement treatment. Putra *et al.* (2017) also recorded the pH value Bali cattle rumen fluid was 7.20 to 7.33 under in vitro condition. The normal rumen pH is commonly observed in the rumen when high fiber such as corn stover is fed to the animals, and the level of soluble carbohydrate in the diet is low.

Total water intake was not changed in response to increasing level of fermented corn stover though the trend is close to total dry matter intake as expected. Water is often limiting when feeding dried feed by smallholder farmers in the village thus water needs to be provided to around 23 L/d to ensure enough daily water consumption.

CONCLUSION

In conclusion, the fermented corn stover inclusion in a ration (up to approximately 35%), to replace a proportion of leucaena, maintained liveweight gain of Bali bulls. This can extend the utilization of leucaena to reach the slaughter liveweight of at least 300 kg for Bali bulls and thus provide additional options for smallholder cattle farmers in mixed crop-livestock farming systems to improve their production.

RECOMMENDATION

In order to produce an efficient cattle fattening business, it is necessary to add a maximum of 20-35% of fermented corn straw to the total feed. Therefore, the best suitable feed formulation is a combination of 60% leucaena and 20% cassava peel.

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CONTRIBUTION STATEMENT

In this article, Dedi Supriadi acts as the main contributor, while Dahlanuddin, Ryan Aryadin Putra, Karen Harper, and Dennis Poppi as member contributors, and Tanda Panjaitan as member contributors and correspondence contributors.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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