LEMBAR
HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*
KARYA ILMIAH : JURNAL ILMIAH

Judul Jurnal Ilmiah (Artikel) : Effect of KOROPASS, an extruded jack bean (Canavalia ensiformis)-derived supplement, on productivity and economic performance of beef cattle

Jumlah Penulis : 3 orang

Status Pengusul : penulis utama

Identitas Jurnal Ilmiah :
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c. Volume, nomor, bulan tahun: March 2020, Vol.13 No.3 pp. 593-596
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e. DOI artikel (jika ada) : 10.14202/vetworld.2020.593-596
f. Alamat web jurnal : http://www.veterinaryworld.org/Vol.13/March-2020/29.html
g. Terindeks di SCOPUS

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(beri ✓pada kategori yang tepat) ☐ Jurnal Ilmiah Nasional Terakreditasi
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Catatan Penilaian artikel oleh Reviewer :
Vet. World dengan SJR IF=0,45; copy manuskrip dapat dilacak pada web jurnal dan www.dx.doi.org
Manuskrip membahas tentang keunggulan jack bean terolah dalam pakan terhadap performans produksi sapi daging lokal. Data yang digunakan dalam pembahasan belum menyertakan parameter metabolisme tubuh sapi. Kualitas jurnal sudah memadai sebagai jurnal internasional, namun cakupan tema manuskrip cukup luas. Beberapa pustaka yang digunakan sebagai acuan tidak mudah diakses secara internasional.

Semarang, April 2020
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Prof.Dr.Ir. Joelal Achmadi, M.Sc.
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Jabatan : Guru Besar
Unit kerja : Fak. Peternakan dan Pertanian

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Semarang, April 2020

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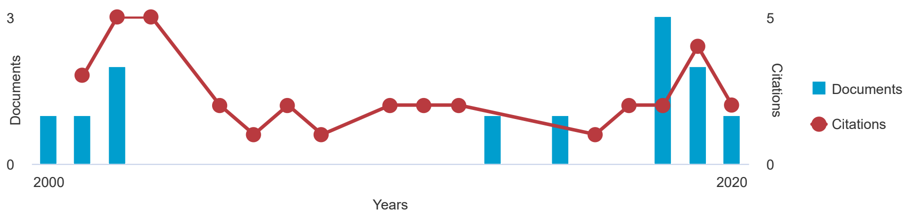

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30. Molecular and histopathological identification of ovine neosporosis (*Neospora caninum*) in aborted ewes in Iraq

Sattar J. J. Al-Shaeli, Ali M. Ethaeb and Hasanain A. J. Gharban

Veterinary World, 13(3): 597-603

Abstract (http://www.veterinaryworld.org/Vol.13/March-2020/30.html)

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Research (Published online: 31-03-2020)

31. Addition of binahong (*Anredera cordifolia*) leaf powder to diets to produce eggs with low cholesterol

Sri Kismiati, Hanny Indrat Wahyuni, Rina Muryani, Dwi Sunarti and Sri Sumarsih

Veterinary World, 13(3): 604-608

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KOROPASS – an extruded jack bean (*Canavalia ensiformis*) – improved productivity and economic performance of beef cattle

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Abstract

Aim: The study evaluated the effect of feeding a graded levels of the extruded jack bean on nutritional status, production performances and economic performance of beef cattle.

Materials and Methods: KOROPASS was prepared from the extruded jack bean. Sixteen male of Friesian Holstein crossbred cattle were divided into four groups, including R_0= total mixed ration (TMR) without KOROPASS, R_1= TMR supplemented with 3% KOROPASS, R_2= TMR supplemented with 6% KOROPASS and R_3= TMR supplemented with 9% KOROPASS. The in vivo experiment lasted 44 days. The TMR contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM) and total protein (TP), feed efficiency, average daily gain and income over feed cost (IOFC) were evaluated.

Results: KOROPASS supplementation increased ($p<0.05$) the consumption of DM, OM and TP of beef cattle. The levels of DM, OM and TP digestibility also increased ($p<0.05$) with the elevated levels of KOROPASS in the rations. Dietary supplementation of KOROPASS increased ($p<0.05$) the metabolizable protein of cattle. Feeding rations supplemented with KOROPASS improved ($p<0.05$) average daily gain and feed efficiency of beef cattle. Dietary supplementation of KOROPASS especially at the level of 9% resulted in the highest ($p<0.05$) IOFC value of beef cattle.

Conclusion: Dietary supplementation of KOROPASS (jack bean based-RPP) improved feed utility, as reflected by the increase in consumption and digestibility of DM, OM and TP. The KOROPASS supplementation also improve feed efficiency, growth and economic performance of cattle.

Keywords: beef cattle, feed utilization, growth, extruded jack bean

Introduction

To date, the increasing demand for beef have not been fulfilled by the local beef farmers in Indonesia. The latest data show that in 2018 Indonesia had to import 400,000 head of beef cattle and 93,000 tons of beef [1]. Low livestock productivity, which leads to low economic performance, is one of the main factors that inhibits the expansion of cattle farming in Indonesia. Indeed, the low quality and quantity of feed consumed has been linked to the low growth performance of beef cattle. In general, the inability of farmers to provide standard feed for beef cattle is mainly caused by the price of high-quality feed that is not affordable, especially feed ingredients that contain high protein such as soybeans, which are still imported. In fact, Indonesia has a variety and easy to get vegetation that prospectively meets the availability of protein needed for feed supplementation, among them are jack bean (*Canavalia ensiformis*) [2]. Nonetheless, the dietary incorporation of jack bean in beef cattle rations has not been practiced so far.

Literatures show that jack bean contains relatively high protein which is around 34.6%, but protein degradation that occurs in the rumen of beef cattle is also high [3]. In addition, jack beans contain hydrogen cyanide (HCN), around 11.05 mg/100 g, which may harm rumen ecosystem of ruminant animals [4]. In the in vitro study by Prasetiyono et al. [2], the extrusion heating process can improve the rumen-protected protein (RPP) of jack bean. Through the latter method, the RPP level increased from 43.35% to 59.16% and the NH_3 level in the rumen decreased from 5.28% mM to 2.71 mM. In general, heating of protein-rich feed ingredients using extrusion heating techniques creates a Mailard reaction (browning reaction), which is the reaction between the reducing sugars and protein [5]. Through the reaction, the extruded feedstuffs will be protected from degradation that occurs in the rumen and escape into the post rumen so that the feedstuffs are absorbed in the small intestine. Hence, feed protein that escapes from rumen degradation will

increase the availability of essential amino acids in the small intestine [6,7]. This would eventually increase the efficiency of protein biosynthesis which is reflected by the improvement in the performance of beef cattle. To best of our knowledge, the use of extruded jack bean to improve the productivity and economic performance of beef cattle has, however, never been studied.

In the current study, jack bean was employed as the source of RPP and was extruded prior to incorporation into corn cobs-based total mixed ration (TMR). The present study aimed to investigate the effect of feeding a graded levels of the extruded jack bean on nutritional status, production performances and economic performance of beef cattle.

Materials and Methods

Jack bean was purchased from Temanggung regency, Central Java Province, Indonesia. To prepare KOROPASS, jack bean was extruded according to the extrusion heating process as described by Prasetiyono et al. [2].

The in vivo experiment was carried out in comply to the standard protocol of raising of livestock stated in law of the Republic of Indonesia number 18, 2009 concerning animal husbandry and health. Sixteen male of Friesian Holstein crossbred cattle (around 1.5 years old with an average body weight of 350 kg) were employed in this present study. They were divided according to their body weight into four treatment groups, each of which consisted of 4 heads. The cattle were placed in the individual pen that had previously been disinfected and treated with albendazole. The treatment groups included: R_0= total mixed ration (TMR) without KOROPASS as control, R_1= TMR supplemented with 3% KOROPASS, R_2= TMR supplemented with 6% KOROPASS and R_3= TMR supplemented with 9% KOROPASS. The in vivo experiment lasted 44 days. Adaptation to the TMR was applied to all beef cattle for 2 weeks prior to the in vivo experiment. The ingredients and chemical composition of TMR are listed in Table 1. The ration contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM) and total protein (TP), feed efficiency as well as

average daily gain were determined according to the standard procedure as described by Harris [8]. In addition, income over feed cost (IOFC) was also measured based on Prasetiyono et al. [9].

The data collected were analyzed using ANOVA on the basis of randomized completely block design following Steel and Torie [10].

Results and Discussion

Our present finding showed that KOROPASS supplementation as the source of RPP increased ($p<0.05$) the consumption of DM, OM and TP of beef cattle (Table 2). This current finding may therefore suggested that dietary supplementation of KOROPASS improved the palatability of corn cobs-based total mixed ration, which is actually the agricultural by-product. The increased protein content of the rations due to supplementation with KOROPASS seemed to be responsible for the increased palatability and thus feed consumption of beef cattle. Indeed, Distel and Villalba [11] revealed that feed consumption can be affected by dietary supplementation, feed quality and the availability of particular food components such as protein. In line with this, Gardinal et al. [12] found that dietary supplementation of urea (non-protein nitrogen) increased feed consumption in beef steers. In this study, the increased levels of the KOROPASS supplementation was attributed to the increased contents of protein in the rations and thus the intake of DM, OM and TP of beef cattle.

Our present data (Table 2) revealed that the level of DM and OM digestibility increased ($p<0.05$) with the elevated levels of KOROPASS supplementation in the rations. It was most likely that dietary supplementation with KOROPASS, which is rich in protein, increased rumen microbial proliferation and activity leading to the increased fermentation rate in the rumen [13]. The latter condition may consequently increase the digestibility of DM and OM of cattle [13,14]. Our current finding also demonstrated that crude protein digestibility increased ($p<0.05$) with the increased KOROPASS supplementation in the cattle rations. As previously discussed, KOROPASS incorporation may increase rumen bacterial proliferation resulting in increased microbial protein (bacterial biomass) in the rumen. Moreover, KOROPASS supplementation may increase the availability and utilization of protein in the intestine as most of protein

in the jack bean could escape from the ruminal fermentation. With regard to the potential of KOROPASS in increasing the rumen bacterial proliferation, this may indicate that KOROPASS which is RPP-based protein may increase the supply of nitrogen for the rumen microbes [15].

Dietary supplementation of KOROPASS increased ($p<0.05$) the metabolizable protein of cattle in the present study (Table 2). Theoretically, the metabolizable protein is the total of protein available to be digested in the post rumen digestive tract and the amount of feed protein escaping from being degraded in rumen as well as microbial protein [16]. On this basis, the increased metabolizable protein in the treated cattle seemed to be contributed by the increased microbial protein (bacterial biomass) as well as protein from the KOROPASS escaping from rumen fermentation. Also, KOROPASS may increase non-ammonia nitrogen compounds, which can enter post rumen digestive tract [17] resulting in increased metabolizable protein [16].

The data (Table 2) in the present study showed that feeding rations supplemented with KOROPASS increased ($p<0.05$) average daily gain of beef cattle. This may imply that KOROPASS supplementation increase tissue biosynthesis in beef cattle. A number of factors may be attributed to the improvement in daily gain of cattle, including the increased consumption and digestibility of DM, OM and protein. Also, the increased metabolizable protein seemed to increase the growth performance of cattle. Indeed, protein is the most important nutrients for tissue biosynthesis and thus the increase in intake and digestibility of protein may positively affected the daily gain of cattle [13]. Energy is another factor that may determine the rate of growth of cattle [18]. In this present study, the increase in DM and OM consumption and digestibility in the KOROPASS treated cattle could be attributed to the increased energy supply for growth.

Dietary supplementation of KOROPASS was associated with the improved ($p<0.05$) feed efficiency of cattle in the present study. It was apparent that dietary supplementation with KOROPASS increased the digestibility of DM, OM and protein and thereby increased the nutrient utilization and feed efficiency of cattle. This present finding was in line with that of previously documented by Uddin et al. [13], in which protein supplementation may be associated with the increased nutrient utilization and growth, and thus improved feed efficiency of cattle.

Income over feed cost has commonly been used to evaluate the profitability and sustainability of cattle farm. In this present study, dietary supplementation of KOROPASS especially at the level of 9% resulted in the highest ($p<0.05$) IOFC value of cattle. On the basis of parameters measured in the present study, it was convincingly proven that RPP derived from KOROPASS increased feed utilization and efficiency as well as growth performance of cattle. In Indonesia, jack bean is abundantly available and has not been widely utilized. This make jack bean affordable as feed component for cattle. With the relatively low price, the application of extruded jack bean as RPP may therefore improve then IOFC of cattle farms.

Conclusion

Dietary supplementation of KOROPASS (jack bean based-RPP) improved feed utility, as reflected by the increase in consumption and digestibility of DM, OM and TP. The KOROPASS supplementation also improve feed efficiency, growth and economic performance of cattle.

Authors' Contributions

BWHEP designed, carried out the experiment and drafted the manuscript, AS and WW carried out the in vivo experiment, conducted data analysis and revised the manuscript.

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Competing Interests

The authors have no conflicts of interest.

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Table-1: Ingredients and nutrient composition of TMR

Ingredients	Proportion (%)
Corncob	20.0
Mineral mix “StV”	1.00
Salt	1.00
Cassava waste	10.0
Pollard	21.0
Molasses	7.00
Calcium carbonate	1.00
Corn straw	5.00
Degraded protein supplement (Go Pro)	2.00
Nutshell	6.00
Corn gluten feed	26.0
Nutrient composition:	
Dry matter	86.0
Ash	7.18
Crude protein	12.2
Ether extract	1.92
Crude fibre	18.0
Total digestible nutrient	60.0
Ca	0.90
P	0.60

Table-2: Effect of KOROPASS supplementation in the TMR on variables measured

Variables	Treatments				SEM	p value
	R_0	**R_1**	**R_2**	**R_3**		
DM consumption (kg/day)	7.83^{d}	8.33^{c}	8.91^{b}	9.69^{a}	0.07	<0.05
OM consumption (kg/day)	6.72^{d}	7.17^{c}	7.69^{b}	8.38^{a}	0.07	<0.05
TP consumption (g/day)	892^{d}	1,020^{c}	1,182^{b}	1,406^{a}	0.04	<0.05
DM digestibility (%)	42.9^{d}	50.6^{c}	58.0^{b}	63.6^{a}	1.16	<0.05
OM digestibility (%)	54.3^{d}	59.6^{c}	66.3^{b}	70.6^{a}	0.94	<0.05
Crude protein digestibility (%)	65.0^{b}	67.1^{b}	75.0^{a}	80.7^{a}	1.86	<0.05
Metabolizable protein (%)	49.0^{b}	52.2^{b}	55.0^{b}	65.2^{a}	3.10	<0.05
Average daily gain (kg/day)	0.72^{c}	0.83^{c}	0.99^{b}	1.24^{a}	0.05	<0.05
Feed efficiency (%)	9.50^{c}	10.24^{bc}	11.53^{ab}	13.14^{a}	0.51	<0.05
IOFC (IDR/head/day)*	6,832^{b}	8,888^{b}	13,151^{b}	20,933^{a}	1,996	<0.05

Numbers with different letters on the same row show difference at $p<0.05$.

Price (at the time of study) per kg of TMR= IDR 2,900; KOROPASS= IDR 7,000; beef cattle= IDR 46,000 (price per kg live weight).

DM: dry matter, OM: organic matter, TP: total protein, IOFC: income over feed cost, TMR: total mixed ration, IDR: Indonesian rupiah (Indonesian currency), SEM: standard error of the mean

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KOROPASS - an extruded jack bean (Canavalia ensiformis) - improved productivity and economic performance of beef cattle

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Materials and Methods

Jack bean was purchased from Temanggung regency, Central Java Province, Indonesia. To prepare KOROPASS, jack bean was extruded according to the extrusion heating process as described by Prasetiyono et al. [2].

The in vivo experiment was carried out in comply to the standard protocol of raising of livestock stated in law of the Republic of Indonesia number 18, 2009 concerning animal husbandry and health. Sixteen male of Friesian Holstein crossbred cattle (around 1.5 years old with an average body weight of 350 kg) were employed in this present study. They were divided according to their body weight into four treatment groups, each of which consisted of 4 heads. The cattle were placed in the individual pen that had previously been disinfected and treated with albendazole. The treatment groups included: R_0= total mixed ration (TMR) without KOROPASS as control, R_1= TMR supplemented with 3% KOROPASS, R_2= TMR supplemented with 6% KOROPASS and R_3= TMR supplemented with 9% KOROPASS. The in vivo experiment lasted 44 days. Adaptation to the TMR was applied to all beef cattle for 2 weeks prior to the in vivo experiment. The ingredients and chemical composition of TMR are listed in Table 1. The ration contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM) and total protein (TP), feed efficiency as well as

average daily gain were determined according to the standard procedure as described by Harris [8]. In addition, income over feed cost (IOFC) was also measured based on Prasetiyono et al. [9].

The data collected were analyzed using ANOVA on the basis of randomized completely block design following Steel and Torie [10].

Results and Discussion

Our present finding showed that KOROPASS supplementation as the source of RPP increased ($p<0.05$) the consumption of DM, OM and TP of beef cattle (Table 2). This current finding may therefore suggested that dietary supplementation of KOROPASS improved the palatability of corn cobs-based total mixed ration, which is actually the agricultural by-product. The increased protein content of the rations due to supplementation with KOROPASS seemed to be responsible for the increased palatability and thus feed consumption of beef cattle. Indeed, Distel and Villalba [11] revealed that feed consumption can be affected by dietary supplementation, feed quality and the availability of particular food components such as protein. In line with this, Gardinal et al. [12] found that dietary supplementation of urea (non-protein nitrogen) increased feed consumption in beef steers. In this study, the increased levels of the KOROPASS supplementation was attributed to the increased contents of protein in the rations and thus the intake of DM, OM and TP of beef cattle.

Our present data (Table 2) revealed that the level of DM and OM digestibility increased ($p<0.05$) with the elevated levels of KOROPASS supplementation in the rations. It was most likely that dietary supplementation with KOROPASS, which is rich in protein, increased rumen microbial proliferation and activity leading to the increased fermentation rate in the rumen [13]. The latter condition may consequently increase the digestibility of DM and OM of cattle [13,14]. Our current finding also demonstrated that crude protein digestibility increased ($p<0.05$) with the increased KOROPASS supplementation in the cattle rations. As previously discussed, KOROPASS incorporation may increase rumen bacterial proliferation resulting in increased microbial protein (bacterial biomass) in the rumen. Moreover, KOROPASS supplementation may increase the availability and utilization of protein in the intestine as most of protein

in the jack bean could escape from the ruminal fermentation. With regard to the potential of KOROPASS in increasing the rumen bacterial proliferation, this may indicate that KOROPASS which is RPP-based protein may increase the supply of nitrogen for the rumen microbes [15].

Dietary supplementation of KOROPASS increased ($p<0.05$) the metabolizable protein of cattle in the present study (Table 2). Theoretically, the metabolizable protein is the total of protein available to be digested in the post rumen digestive tract and the amount of feed protein escaping from being degraded in rumen as well as microbial protein [16]. On this basis, the increased metabolizable protein in the treated cattle seemed to be contributed by the increased microbial protein (bacterial biomass) as well as protein from the KOROPASS escaping from rumen fermentation. Also, KOROPASS may increase non-ammonia nitrogen compounds, which can enter post rumen digestive tract [17] resulting in increased metabolizable protein [16].

The data (Table 2) in the present study showed that feeding rations supplemented with KOROPASS increased ($p<0.05$) average daily gain of beef cattle. This may imply that KOROPASS supplementation increase tissue biosynthesis in beef cattle. A number of factors may be attributed to the improvement in daily gain of cattle, including the increased consumption and digestibility of DM, OM and protein. Also, the increased metabolizable protein seemed to increase the growth performance of cattle. Indeed, protein is the most important nutrients for tissue biosynthesis and thus the increase in intake and digestibility of protein may positively affected the daily gain of cattle [13]. Energy is another factor that may determine the rate of growth of cattle [18]. In this present study, the increase in DM and OM consumption and digestibility in the KOROPASS treated cattle could be attributed to the increased energy supply for growth.

Dietary supplementation of KOROPASS was associated with the improved ($p<0.05$) feed efficiency of cattle in the present study. It was apparent that dietary supplementation with KOROPASS increased the digestibility of DM, OM and protein and thereby increased the nutrient utilization and feed efficiency of cattle. This present finding was in line with that of previously documented by Uddin et al. [13], in which protein supplementation may be associated with the increased nutrient utilization and growth, and thus improved feed efficiency of cattle.

Income over feed cost has commonly been used to evaluate the profitability and sustainability of cattle farm. In this present study, dietary supplementation of KOROPASS especially at the level of 9% resulted in the highest ($p<0.05$) IOFC value of cattle. On the basis of parameters measured in the present study, it was convincingly proven that RPP derived from KOROPASS increased feed utilization and efficiency as well as growth performance of cattle. In Indonesia, jack bean is abundantly available and has not been widely utilized. This make jack bean affordable as feed component for cattle. With the relatively low price, the application of extruded jack bean as RPP may therefore improve then IOFC of cattle farms.

Conclusion

Dietary supplementation of KOROPASS (jack bean based-RPP) improved feed utility, as reflected by the increase in consumption and digestibility of DM, OM and TP. The KOROPASS supplementation also improve feed efficiency, growth and economic performance of cattle.

Authors' Contributions

BWHEP designed, carried out the experiment and drafted the manuscript, AS and WW carried out the in vivo experiment, conducted data analysis and revised the manuscript.

Acknowledgment

We thank to Diponegoro University for the research funding.

Competing Interests

The authors have no conflicts of interest.

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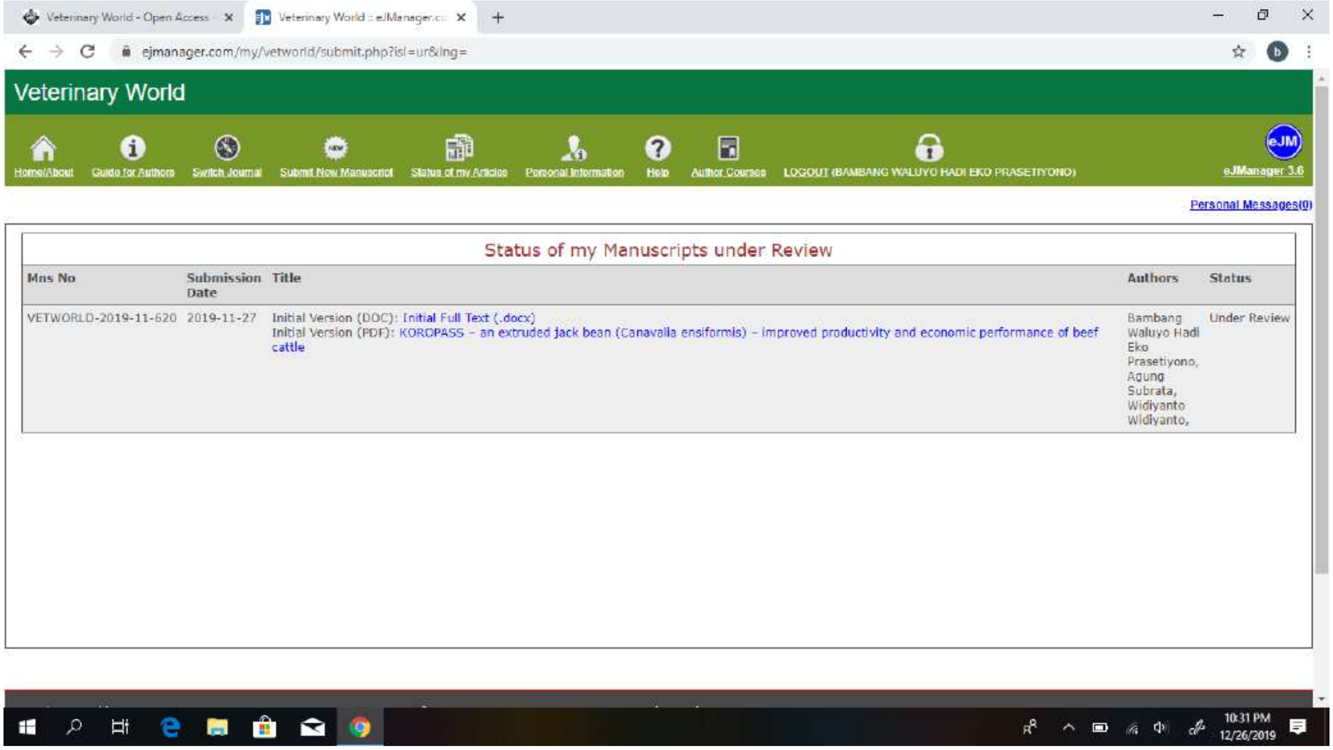
Table-1: Ingredients and nutrient composition of TMR

Ingredients	**Proportion (%)**
Corncob	20.0
Mineral mix “StV”	1.00
Salt	1.00
Cassava waste	10.0
Pollard	21.0
Molasses	7.00
Calcium carbonate	1.00
Corn straw	5.00
Degraded protein supplement (Go Pro)	2.00
Nutshell	6.00
Corn gluten feed	26.0
Nutrient composition:	
Dry matter	86.0
Ash	7.18
Crude protein	12.2
Ether extract	1.92
Crude fibre	18.0
Total digestible nutrient	60.0
Ca	0.90
P	0.60

Table-2: Effect of KOROPASS supplementation in the TMR on variables measured

Variables	**Treatments**				**SEM**	**p value**
	R_0	**R_1**	**R_2**	**R_3**		
DM consumption (kg/day)	7.83^{d}	8.33^{c}	8.91^{b}	9.69^{a}	0.07	<0.05
OM consumption (kg/day)	6.72^{d}	7.17^{c}	7.69^{b}	8.38^{a}	0.07	<0.05
TP consumption (g/day)	892^{d}	$1{,}020^{c}$	$1{,}182^{b}$	$1{,}406^{a}$	0.04	<0.05
DM digestibility (%)	42.9^{d}	50.6^{c}	58.0^{b}	63.6^{a}	1.16	<0.05
OM digestibility (%)	54.3^{d}	59.6^{c}	66.3^{b}	70.6^{a}	0.94	<0.05
Crude protein digestibility (%)	65.0^{b}	67.1^{b}	75.0^{a}	80.7^{a}	1.86	<0.05
Metabolizable protein (%)	49.0^{b}	52.2^{b}	55.0^{b}	65.2^{a}	3.10	<0.05
Average daily gain (kg/day)	0.72^{c}	0.83^{c}	0.99^{b}	1.24^{a}	0.05	<0.05
Feed efficiency (%)	9.50^{c}	10.24^{bc}	11.53^{ab}	13.14^{a}	0.51	<0.05
IOFC (IDR/head/day)*	$6{,}832^{b}$	$8{,}888^{b}$	$13{,}151^{b}$	$20{,}933^{a}$	1,996	<0.05

Numbers with different letters on the same row show difference at $p<0.05$.
Price (at the time of study) per kg of TMR= IDR 2,900; KOROPASS= IDR 7,000; beef cattle= IDR 46,000 (price per kg live weight).
DM: dry matter, OM: organic matter, TP: total protein, IOFC: income over feed cost, TMR: total mixed ration, IDR: Indonesian rupiah (Indonesian currency), SEM: standard error of the mean



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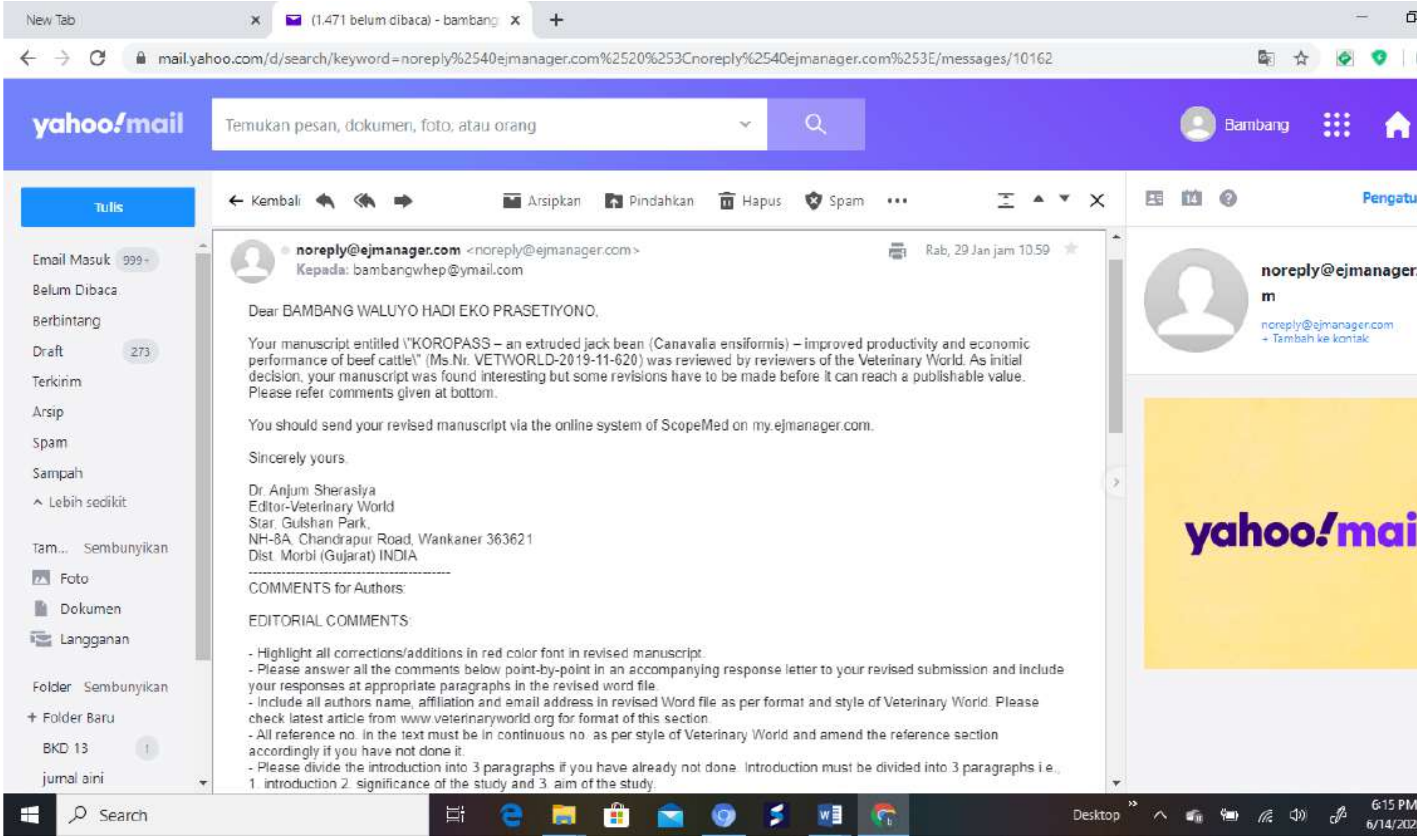

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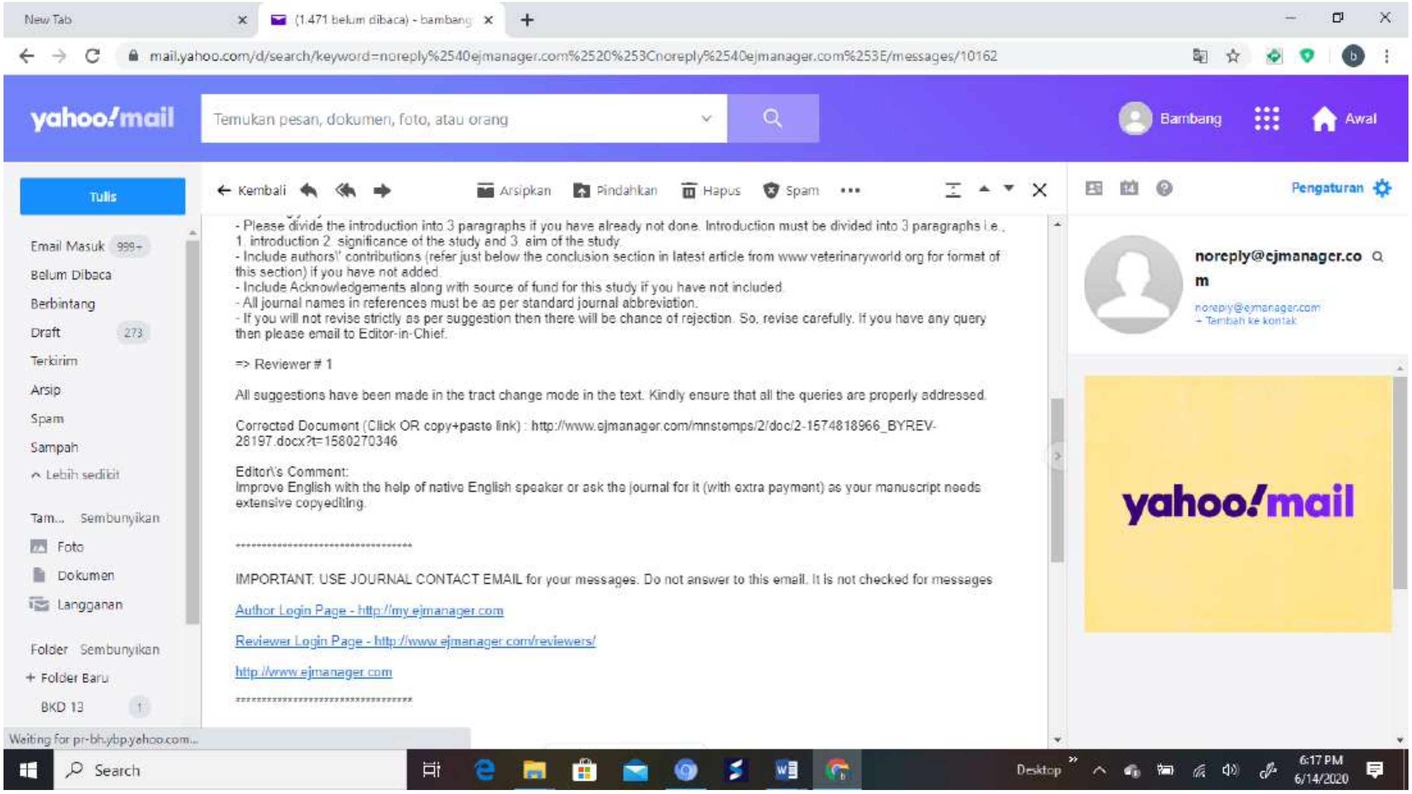

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KOROPASS – an extruded jack bean (*Canavalia ensiformis*) – improved productivity and economic performance of beef cattle

Bambang Waluyo Hadi Eko Prasetiyono*, Agung Subrata and Widiyanto Widiyanto

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Abstract

Aim: The study evaluated the effect of feeding a ~~graded levels of the extruded jack bean~~graded level of the extruded jack bean on nutritional status, production performances and economic performance of beef cattle.

Materials and Methods: KOROPASS was prepared from the extruded jack bean. Sixteen male of Friesian Holstein crossbred cattle were divided into four groups, including R_0= total mixed ration (TMR) without KOROPASS, R_1= TMR supplemented with 3% KOROPASS, R_2= TMR supplemented with 6% KOROPASS and R_3= TMR supplemented with 9% KOROPASS. The *in vivo* experiment lasted 44 days. The TMR contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM) and total protein (TP), feed efficiency, average daily gain and income over feed cost (IOFC) were evaluated.

Results: KOROPASS supplementation increased ($p<0.05$) the consumption of DM, OM and TP of beef cattle. The levels of DM, OM and TP digestibility also increased ($p<0.05$) with the elevated levels of KOROPASS in the rations. Dietary supplementation of KOROPASS increased ($p<0.05$) the metabolizable protein of cattle. Feeding rations supplemented with KOROPASS improved ($p<0.05$) average daily gain and feed efficiency of beef cattle. Dietary supplementation of KOROPASS especially at the level of 9% resulted in the highest ($p<0.05$) IOFC value of beef cattle.

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Conclusion: Dietary supplementation of KOROPASS (jack bean based-RPP) improved feed utility, as reflected by the increase in consumption and digestibility of DM, OM and TP. The KOROPASS supplementation also improve feed efficiency, growth and economic performance of cattle.

Keywords: beef cattle, feed utilization, growth, extruded jack bean

Introduction

To date, the increasing demand for beef have not been fulfilled by the local beef farmers in Indonesia. The latest data show that in 2018 Indonesia had to import 400,000 head of beef cattle and 93,000 tons of beef [1]. Low livestock productivity, which leads to low economic performance, is one of the main factors that inhibits the expansion of cattle farming in Indonesia. Indeed, the low quality and quantity of feed consumed has been linked to the low growth performance of beef cattle. In general, the inability of farmers to provide standard feed for beef cattle is mainly caused by the price of high-quality feed that is not affordable, especially feed ingredients that contain high protein such as soybeans, which are still imported. In fact, Indonesia has a variety and easy to get vegetation that prospectively meets the availability of protein needed for feed supplementation, among them are jack bean (*Canavalia ensiformis*) [2]. Nonetheless, the dietary incorporation of jack bean in beef cattle rations has not been practiced so far.

Literatures show that jack bean contains relatively high protein which is around 34.6%, but protein degradation that occurs in the rumen of beef cattle is also high [3]. In addition, jack beans contain hydrogen cyanide (HCN), around 11.05 mg/100 g, which may harm rumen ecosystem of ruminant animals [4]. In the *in vitro* study by Prasetiyono et al. [2], the extrusion heating process can improve the rumen-protected protein (RPP) of jack bean. Through the latter method, the RPP level increased from 43.35% to 59.16% and the NH_3 level in the rumen decreased from 5.28% mM to 2.71 mM. In general, heating of protein-rich feed ingredients using extrusion heating techniques creates a Mailard reaction (browning reaction), which is the reaction between the reducing sugars and protein [5]. Through the reaction, the extruded feedstuffs will be protected from degradation that occurs in the rumen and escape into the post rumen so that the feedstuffs are absorbed in the small intestine. Hence, feed protein that escapes from rumen degradation will

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increase the availability of essential amino acids in the small intestine [6,7]. This would eventually increase the efficiency of protein biosynthesis which is reflected by the improvement in the performance of beef cattle. To best of our knowledge, the use of extruded jack bean to improve the productivity and economic performance of beef cattle has, however, never been studied.

In the current study, jack bean was employed as the source of RPP and was extruded prior to incorporation into corn cobs-based total mixed ration (TMR). The present study aimed to investigate the effect of feeding a ~~graded levels of the extruded jack bean~~graded level of the extruded jack bean on nutritional status, production performances and economic performance of beef cattle.

Materials and Methods

Jack bean was purchased from Temanggung regency, Central Java Province, Indonesia. To prepare KOROPASS, jack bean was extruded according to the extrusion heating process as described by Prasetiyono et al. [2].

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average daily gain were determined according to the standard procedure as described by Harris [8]. In addition, income over feed cost (IOFC) was also measured based on Prasetiyono et al. [9].

The data collected were analyzed using ANOVA on the basis of randomized completely block design following Steel and Torie [10].

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Authors' Contributions

BWHEP designed, carried out the experiment and drafted the manuscript, AS and WW carried out the in vivo experiment, conducted data analysis and revised the manuscript.

Acknowledgment

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Competing Interests

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Table-1: Ingredients and nutrient composition of TMR

Ingredients	**Proportion (%)**
Corncob	20.0
Mineral mix "StV"	1.00
Salt	1.00
Cassava waste	10.0
Pollard	21.0
Molasses	7.00
Calcium carbonate	1.00
Corn straw	5.00
Degraded protein supplement (Go Pro)	2.00
Nutshell	6.00
Corn ~~gluten feed~~gluten feed	26.0
Nutrient composition:	
Dry matter	86.0
Ash	7.18
Crude protein	12.2
Ether extract	1.92
Crude fibre	18.0
Total digestible nutrient	60.0
Ca	0.90
P	0.60

Table-2: Effect of KOROPASS supplementation in the TMR on variables measured

Variables	**Treatments**				**SEM**	**p value**
	R$_0$	**R$_1$**	**R$_2$**	**R$_3$**		
DM consumption (kg/day)	7.83^{d}	8.33^{c}	8.91^{b}	9.69^{a}	0.07	<0.05
OM consumption (kg/day)	6.72^{d}	7.17^{c}	7.69^{b}	8.38^{a}	0.07	<0.05
TP consumption (g/day)	892^{d}	$1,020^{c}$	$1,182^{b}$	$1,406^{a}$	0.04	<0.05
DM digestibility (%)	42.9^{d}	50.6^{c}	58.0^{b}	63.6^{a}	1.16	<0.05
OM digestibility (%)	54.3^{d}	59.6^{c}	66.3^{b}	70.6^{a}	0.94	<0.05
Crude protein digestibility (%)	65.0^{b}	67.1^{b}	75.0^{a}	80.7^{a}	1.86	<0.05
Metabolizable protein (%)	49.0^{b}	52.2^{b}	55.0^{b}	65.2^{a}	3.10	<0.05
Average daily gain (kg/day)	0.72^{c}	0.83^{c}	0.99^{b}	1.24^{a}	0.05	<0.05
Feed efficiency (%)	9.50^{c}	10.24^{bc}	11.53^{ab}	13.14^{a}	0.51	<0.05
IOFC (IDR/head/day)*	$6,832^{b}$	$8,888^{b}$	$13,151^{b}$	$20,933^{a}$	1,996	<0.05

Numbers with different letters on the same row show difference at p<0.05.

Price (at the time of study) per kg of TMR= IDR 2,900; KOROPASS= IDR 7,000; beef cattle= IDR 46,000 (price per kg live weight).

DM: dry matter, OM: organic matter, TP: total protein, IOFC: income over feed cost, TMR: total mixed ration, IDR: Indonesian rupiah (Indonesian currency), SEM: standard error of the mean

Commented [PKP10]: Feed cost need to be mentioned in one additional row.

KOROPASS – an extruded jack bean (*Canavalia ensiformis*) – improved productivity and economic performance of beef cattle

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Abstract

Aim: The study evaluated the effect of feeding a graded level of the extruded jack bean on nutritional status, production performances and economic performance of beef cattle.

Materials and Methods: The supplement called “KOROPASS” -was prepared from the extruded jack bean (according to the extrusion heating process). Sixteen male of Friesian Holstein crossbred cattle were divided into four groups, including R_0= total mixed ration (TMR) without KOROPASS, R_1= TMR supplemented with 3% KOROPASS, R_2= TMR supplemented with 6% KOROPASS and R_3= TMR supplemented with 9% KOROPASS. The *in vivo* experiment lasted 44 days. The TMR contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM) and total protein (TP), feed efficiency, average daily gain and income over feed cost (IOFC) were evaluated.

Results: KOROPASS supplementation increased ($p<0.05$) the consumption of DM (from 7.83 [R_0] to 8.33 [R_1], 8.91 [R_2] and 9.69 kg/day [R_3]), OM (from 6.72 to 7.17, 7.69 and 8.38kg/day) and TP (from 892 to 1,020, 1,182, and 1,406g/day) of beef cattle. The levels of DM (from 42.9 [R_0] to 50.6 [R_1], 58.0 [R_2] and 63.6% [R_3]), OM (from 54.3 to 59.6, 66.3 and 70.6%) and TP (from 65.0 to 67.1, 75.0 and 80.7%) digestibility also increased ($p<0.05$) with the elevated levels of KOROPASS in the rations. Dietary supplementation of KOROPASS increased ($p<0.05$) the metabolizable protein of cattle. Feeding rations supplemented with KOROPASS improved ($p<0.05$) average daily gain and feed efficiency of beef cattle. Dietary supplementation of KOROPASS especially at the level of 9% resulted in the highest ($p<0.05$) IOFC value of beef cattle.

Conclusion: Dietary supplementation of KOROPASS (jack bean based-RPP) improved feed utility, as reflected by the increase in consumption and digestibility of DM, OM and TP. The KOROPASS supplementation also improve feed efficiency, growth and economic performance of cattle.

Keywords: beef cattle, feed utilization, growth, extruded jack bean

Introduction

To date, the increasing demand for beef have not been fulfilled by the local beef farmers in Indonesia. The latest data show that in 2018 Indonesia had to import 400,000 head of beef cattle and 93,000 tons of beef [1]. Low livestock productivity, which leads to low economic performance, is one of the main factors that inhibits the expansion of cattle farming in Indonesia. Indeed, the low quality and quantity of feed consumed has been linked to the low growth performance of beef cattle. In general, the inability of farmers to provide standard feed for beef cattle is mainly caused by the price of high-quality feed that is not affordable, especially feed ingredients that contain high protein such as soybeans, which are still imported. In fact, Indonesia has a variety and easy to get vegetation that prospectively meets the availability of protein needed for feed supplementation, among them are jack bean (*Canavalia ensiformis*) [2]. Nonetheless, the dietary incorporation of jack bean in beef cattle rations has not been practiced so far.

Literatures show that jack bean contains relatively high protein which is around 34.6% [3], but protein degradation that occurs in the rumen of beef cattle is also high (about 56.7%) [~~3~~2]. In addition, jack beans contain hydrogen cyanide (HCN), around 11.05 mg/100 g, which may harm rumen ecosystem of ruminant animals [4]. In the *in vitro* study by Prasetiyono et al. [2], the extrusion heating process can improve the rumen-protected protein (RPP) of jack bean. Through the latter method, the RPP level increased from 43.35% to 59.16% and the NH_3 level in the rumen decreased from 5.28 mM to 2.71 mM. In general, heating of protein-rich feed ingredients using extrusion heating techniques creates a Mailard reaction (browning reaction), which is the reaction between the reducing sugars and protein [5]. Through the reaction, the extruded feedstuffs will be protected from degradation that occurs in the rumen and escape into the post rumen so that the feedstuffs are absorbed in the small intestine. Hence, feed protein that escapes from rumen degradation will increase the availability of essential amino acids in the small intestine [6,7]. This would eventually increase the efficiency of protein biosynthesis which is reflected by the improvement in the performance of beef cattle. To best of our knowledge, the use of extruded jack bean to improve the productivity and economic performance of beef cattle has, however, never been studied.

In the current study, jack bean was employed as the source of RPP and was extruded prior to incorporation into corn cobs-based total mixed ration (TMR). The present study aimed to investigate the effect of feeding a graded level of the extruded jack bean on nutritional status, production performances and economic performance of beef cattle.

Materials and Methods

Jack bean was purchased from Temanggung regency, Central Java Province, Indonesia. To prepare KOROPASS, jack bean was extruded according to the extrusion heating process as described by Prasetiyono et al. [2].

The *in vivo* experiment was carried out in comply to the standard protocol of raising of livestock stated in law of the Republic of Indonesia number 18, 2009 concerning animal husbandry and health. Sixteen male of Friesian Holstein crossbred cattle (around 1.5 years old with an average body weight of 350 kg) were employed in this present study. They were divided according to their body weight into four treatment groups, each of which consisted of 4 heads. The cattle were placed in the individual pen that had previously been disinfected and treated with albendazole. The treatment groups included: R_0= total mixed ration (TMR) without KOROPASS as control, R_1= TMR supplemented with 3% KOROPASS, R_2= TMR supplemented with 6% KOROPASS and R_3= TMR supplemented with 9% KOROPASS. The quantity of TMR offered to each cattle was 9.11, 9.41, 9.78 and 10.3 kg/day (as-fed basis) for R_0, R_1, R_2 and R_3, respectively. KOROPASS supplemented into TMR was 0, 0.27, 0.56 and 0.89 kg/day (as-fed basis) for R_0, R_1, R_2 and R_3, respectively. The *in vivo* experiment lasted for 44 days. The cattle used in this study was in the growing phase and thus are very responsive to the protein supplementation. Hence, the duration of 44 days (of the experiment) was believed to be sufficient to study the effect of KOROPASS on the performances of cattle. Adaptation to the TMR was applied to all beef cattle for 2 weeks prior to the *in vivo* experiment. The ingredients and chemical composition of TMR are listed in Table 1. The ration contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM) and total protein (TP), feed efficiency as well as average daily gain were determined according to the standard procedure as described by Harris [8]. In addition, income over feed cost (IOFC) was also measured based on Prasetiyono et al. [9].

The data collected were analyzed using ANOVA on the basis of randomized completely block design following Steel and Torie [10].

Results and Discussion

Our present finding showed that KOROPASS supplementation as the source of RPP increased ($p<0.05$) the consumption of DM, OM and TP of beef cattle (Table 2). This current finding may therefore suggest that dietary supplementation of KOROPASS improved the palatability of corn cobs-based total mixed ration, which is actually an agricultural by-product. The increased protein content of the rations due to supplementation with KOROPASS seemed to be responsible for the increased palatability and thus feed consumption of beef cattle. Indeed, Distel and Villalba [11] revealed that feed consumption can be affected by dietary supplementation, feed quality and the availability of particular food components such as protein. In line with this, Gardinal et al. [12] found that dietary supplementation of urea (non-protein nitrogen) increased feed consumption in beef steers. In this study, the increased levels of the KOROPASS supplementation was attributed to the increased contents of protein in the rations and thus the intake of DM, OM and TP of beef cattle.

Our present data (Table 2) revealed that the level of DM and OM digestibility increased ($p<0.05$) with the elevated levels of KOROPASS supplementation in the rations. It was most likely that dietary supplementation with KOROPASS, which is rich in protein, increased rumen microbial proliferation and activity leading to the increased fermentation rate in the rumen [13]. The latter condition may consequently increase the digestibility of DM and OM of cattle [13,14]. Our current finding also demonstrated that crude protein digestibility increased ($p<0.05$) with the increased KOROPASS supplementation in the cattle rations. As previously discussed, KOROPASS incorporation may increase rumen bacterial proliferation resulting in increased microbial protein (bacterial biomass) in the rumen. Moreover, KOROPASS supplementation may increase the availability and utilization of protein in the intestine as most of protein in the jack bean being bypass in nature could escape from the ruminal fermentation. With regard to the potential of KOROPASS in increasing the rumen bacterial proliferation, this may indicate that KOROPASS which is RPP-based protein may increase the supply of nitrogen for the rumen microbes [15].

Dietary supplementation of KOROPASS increased ($p<0.05$) the metabolizable protein of cattle in the present study (Table 2). Theoretically, the metabolizable protein is the total of protein available to be digested in the post rumen digestive tract and the amount of feed protein escaping from being degraded in rumen as well as microbial protein [16]. On this basis, the increased metabolizable protein in the treated cattle seemed to be contributed by the increased microbial protein (bacterial biomass) as well as protein from the KOROPASS escaping from rumen fermentation. Also, KOROPASS may increase non-ammonia nitrogen compounds, which can enter post rumen digestive tract [17] resulting in increased metabolizable protein [16].

The data (Table 2) in the present study showed that feeding rations supplemented with KOROPASS increased ($p<0.05$) average daily gain of beef cattle. This may imply that KOROPASS supplementation increase tissue biosynthesis in beef cattle. A number of factors may be attributed to the improvement in daily gain of cattle, including the increased consumption and digestibility of DM, OM and protein. Also, the increased metabolizable protein seemed to increase the growth performance of cattle. Indeed, protein is the most important nutrients for tissue biosynthesis and thus the increase in intake and digestibility of protein may positively affected the daily gain of cattle [13]. Energy is another factor that may determine the rate of growth of cattle [18]. In this present study, the increase in DM and OM consumption and digestibility in the KOROPASS treated cattle could be attributed to the increased energy supply for growth.

Dietary supplementation of KOROPASS was associated with the improved ($p<0.05$) feed efficiency of cattle in the present study. It was apparent that dietary supplementation with KOROPASS increased the digestibility of DM, OM and protein and thereby increased the nutrient utilization and feed efficiency of cattle. This present finding was in line with that of previously documented by Uddin et al. [13], in which protein supplementation may be associated with the increased nutrient utilization and growth, and thus improved feed efficiency of cattle.

Income over feed cost has commonly been used to evaluate the profitability and sustainability of cattle farm. In this present study, dietary supplementation of KOROPASS especially at the level of 9% resulted in the highest ($p<0.05$) IOFC value of cattle. On the basis of parameters measured in the present study, it was convincingly proven that RPP derived from KOROPASS increased feed utilization and efficiency as well as growth performance of cattle. In Indonesia, jack bean is abundantly available and has not been widely utilized. This make jack bean affordable as feed component for cattle. With the relatively low price, the application of extruded jack bean as RPP may therefore improve then IOFC of cattle farms.

Conclusion

Dietary supplementation of KOROPASS (jack bean based-RPP) improved feed utility, as reflected by the increase in consumption and digestibility of DM, OM and TP. The KOROPASS supplementation also improve feed efficiency, growth and economic performance of cattle.

Authors’ Contributions

BWHEP designed, carried out the experiment and drafted the manuscript, AS and WW carried out the in vivo experiment, conducted data analysis and revised the manuscript.

Acknowledgment

We thank to Diponegoro University for the research funding.

Competing Interests

The authors have no conflicts of interest.

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Table-2: Effect of KOROPASS supplementation in the TMR on variables measured

Variables	**Treatments**				**SEM**	**p value**
	R_0	**R_1**	**R_2**	**R_3**		
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Feed efficiency (%)	9.50^{c}	10.24^{bc}	11.53^{ab}	13.14^{a}	0.51	<0.05
Feed cost (IDR/head/day)	$26,403^{d}$	$29,177^{c}$	$32,274^{b}$	$36,222^{a}$	265	<0.05
IOFC (IDR/head/day)	$6,832^{b}$	$8,888^{b}$	$13,151^{b}$	$20,933^{a}$	1,996	<0.05

Numbers with different letters on the same row show difference at $p<0.05$.

Price (at the time of study) per kg of TMR= IDR 2,900; KOROPASS= IDR 7,000; beef cattle= IDR 46,000 (price per kg live weight).

DM: dry matter, OM: organic matter, TP: total protein, IOFC: income over feed cost, TMR: total mixed ration, IDR: Indonesian rupiah (Indonesian currency), SEM: standard error of the mean

RESPONSE LETTER

<u>Responses to editorial comments:</u>

Dear Prof. Anjum Sherasiya
Editor-in-Chief Veterinary World

Thank you very much for giving us an opportunity to revise our submitted manuscript (Ms. Nr. VETWORLD-2019-11-620) to Veterinary World.

We have highlighted all corrections/additions in red colour font in revised manuscript. We also have answered all the comments point-by-point in an accompanying response letter and included our responses at appropriate paragraphs in the revised manuscript. We have divided the introduction into three paragraphs (introduction, significance of the study and aim of the study). Moreover, we have included all authors name, affiliation and email address in the revised manuscript. All journal names in the reference list have also been as per standard journal abbreviation.

Finally, we realize that our English is poor and therefore **we would like to ask Veterinary World to improve the English of our manuscript with extra payment**.

Once again, thank you very much.

Best wishes,

<u>Responses to reviewer's comments:</u>

Thank you very much for the comments and suggestion from the reviewer. In general, we have corrected and revised the manuscript according to most of the comments and suggestions from the reviewer.

Reviewer's comments: In the abstract section, reviewer asked to clarify the term KOROPASS

Response: It has been revised (line 12-13)

Reviewer's comments: In the abstract section, reviewer asked to mention the methodology to extract KOROPASS

Response: It has been added (line 13)

Reviewer's comments: In the abstract section, reviewer asked to add the values of consumption and digestibility of cattle receiving KOROPASS

Response: It has been added in the revised manuscript (line 20-23)

Reviewer's comments: In the introduction section, reviewer asked to mention the range of protein degradation of jack bean that occurs in the rumen of beef cattle

Response: It has been mentioned (line 46)

Reviewer's comments: In the introduction section, reviewer asked to use consistent unit.

Response: It has been corrected (line 50)

Reviewer's comments: In the material and methods section, the reviewer asked to mention the quantity of TMR offered to each male cattle

Response: It has been added in the revised manuscript (line 76-77)

Reviewer's comments: In the material and methods section, the reviewer asked to mention the absolute quantity of KOROPASS used in the TMR

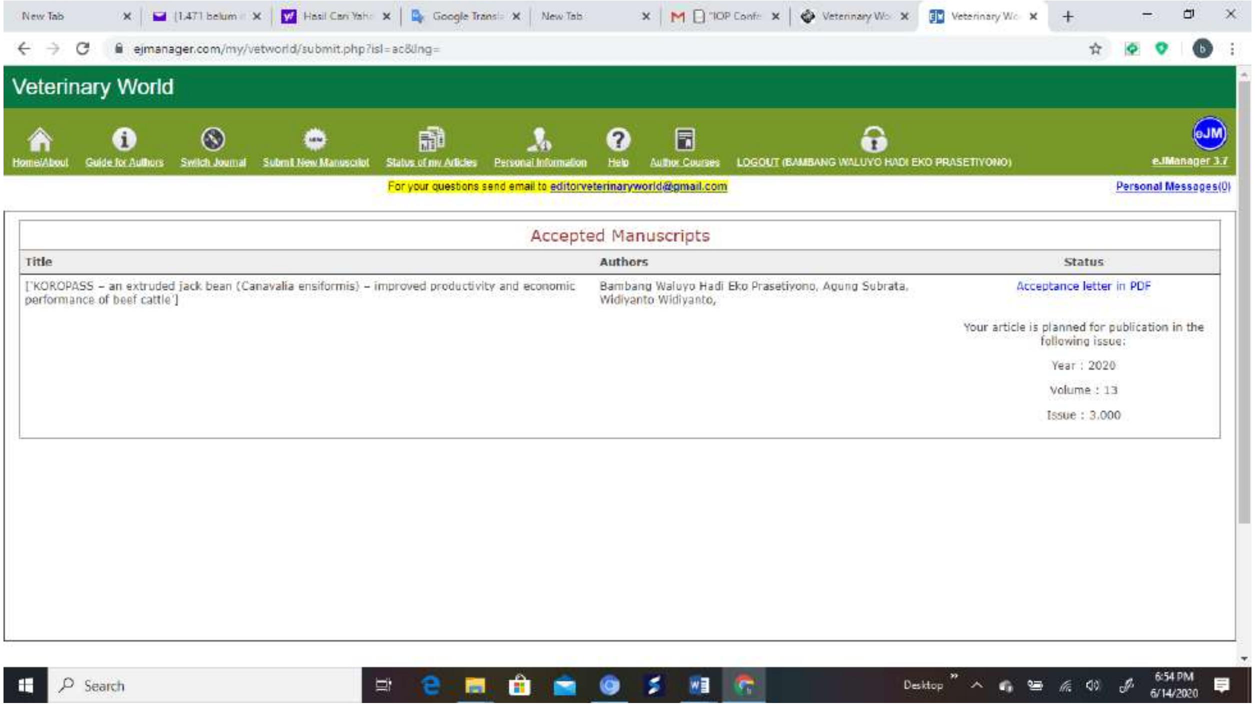
Response: It has been added in the revised manuscript (line 77-78)

Reviewer's comments: In the material and methods section, the reviewer asked about the logic for the experiment to be carried out for 44 days?

Response: The logic for the duration of 44 days has been added in the revised manuscript (line 78-81)

Reviewer's comments: In the Table 2, the reviewer asked to add the feed cost in one additional row.

Response: The feed cost has been added in Table 2.



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Accepted Manuscripts

Title	Authors	Status
['KOROPASS – an extruded jack bean (Canavalia ensiformis) – improved productivity and economic performance of beef cattle']	Bambang Waluyo Hadi Eko Prasetiyono, Agung Subrata, Widiyanto Widiyanto,	Acceptance letter in PDF Your article is planned for publication in the following issue: Year : 2020 Volume : 13 Issue : 3.000

noreply@ejmanager.com <noreply@ejmanager.com>
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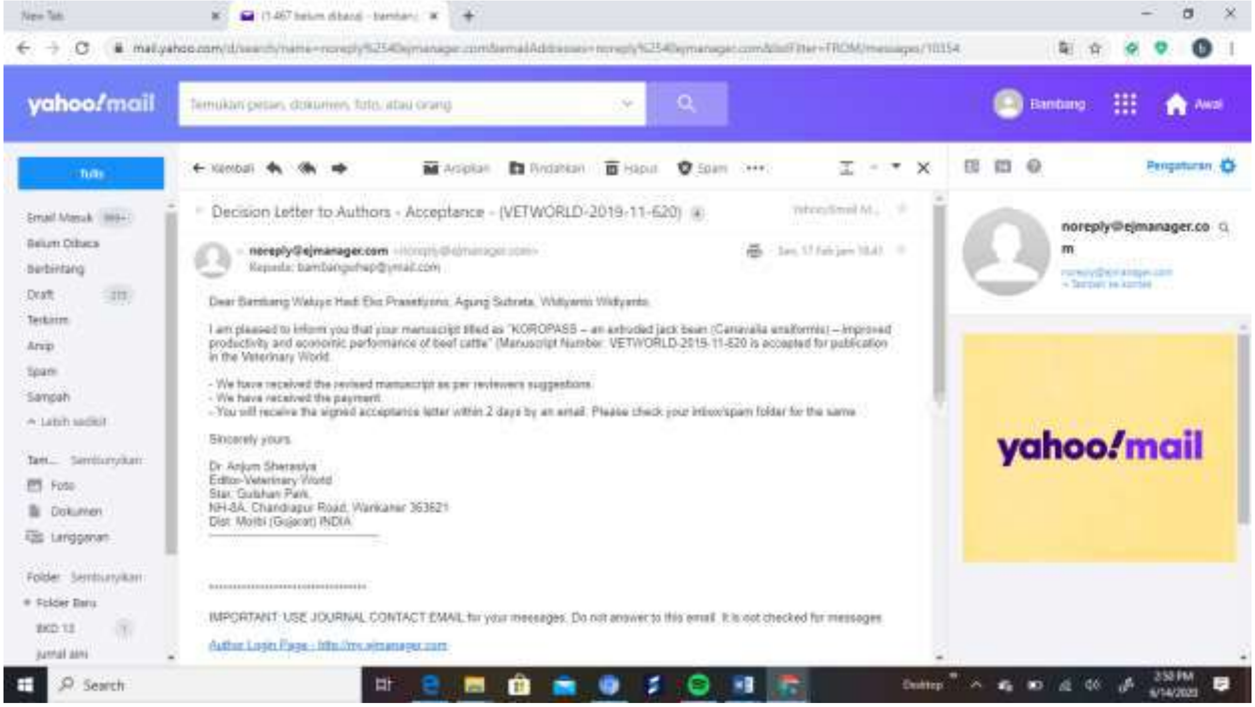

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Indonesia.
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RESEARCH ARTICLE

Effect of KOROPASS, an extruded jack bean (*Canavalia ensiformis*)-derived supplement, on productivity and economic performance of beef cattle

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Bambang Waluyo Hadi Eko Prasetiyono, Agung Subrata and Widiyanto Widiyanto

Department of Animal Science, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang, Central Java, Indonesia.

Corresponding author: Bambang Waluyo Hadi Eko Prasetiyono, e-mail: bambangwhep@ymail.com

Co-authors: AS: agung.subrata42@gmail.com, WW: wid_ds@yahoo.com

Received: 27-11-2019, **Accepted:** 17-02-2020, **Published online:** ***

doi: * How to cite this article**: Prasetiyono BWHE, Subrata A, Widiyanto W (2020) Effect of KOROPASS, an extruded jack bean (*Canavalia ensiformis*)-derived supplement, on productivity and economic performance of beef cattle, *Veterinary World*, 13(3): 0-0.

Abstract

Aim: This study evaluated the effect of feeding a graded amount of extruded jack bean (*Canavalia ensiformis*) on nutritional status, production performances, and economic performance of beef cattle.

Materials and Methods: The supplement called “KOROPASS” was prepared from the extruded jack bean (according to the extrusion heating process). Sixteen male Friesian-Holstein crossbred cattle were divided into four groups and fed on KOROPASS as per the regimen: R_0 (total mixed ration [TMR] without KOROPASS), R_1 (TMR supplemented with 3% KOROPASS), R_2 (TMR supplemented with 6% KOROPASS), and R_3 (TMR supplemented with 9% KOROPASS). The *in vivo* experiment lasted 44 days. TMR contained 12% crude protein and 60% total digestible nutrient. The consumption and digestibility of dry matter (DM), organic matter (OM), and total protein (TP), feed efficiency, average daily gain, and income over feed cost (IOFC) were evaluated.

Results: KOROPASS supplementation significantly increased ($p<0.05$) beef cattle consumption of DM (from 7.83 [R_0] to 8.33 [R_1], 8.91 [R_2], and 9.69 kg/day [R_3]), OM (from 6.72 to 7.17, 7.69, and 8.38 kg/day, respectively), and TP (from 892 to 1020, 1182, and 1406 g/day, respectively). The elevated levels of KOROPASS significantly increased ($p<0.05$) digestibility in terms of the levels of DM (from 42.9 [R_0] to 50.6 [R_1], 58.0 [R_2], and 63.6% [R_3]), OM (from 54.3 to 59.6, 66.3, and 70.6%, respectively), and TP (from 65.0 to 67.1, 75.0, and 80.7%, respectively). Dietary supplementation of KOROPASS significantly increased ($p<0.05$) metabolizable protein, average daily gain, and feed efficiency of beef cattle. Finally, dietary KOROPASS supplementation, especially at 9%, resulted in the highest ($p<0.05$) IOFC value of beef cattle.

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Conclusion: Dietary supplementation of KOROPASS improved feed utility, as reflected by the increase in consumption and digestibility of DM, OM, and TP. Further, KOROPASS supplementation improved feed efficiency, growth, and economic performance of beef cattle. The findings indicate the potential value of KOROPASS as a feed supplement for beef cattle.

Keywords: beef cattle, extruded jack bean, feed utilization, growth.

<H1>Introduction

The increasing demand for beef in Indonesia has outpaced the local beef production. In 2018, Indonesia had to import 400,000 heads of beef cattle and 93,000 tons of beef [1]. Low livestock productivity, which leads to low economic performance, is one of the main factors inhibiting the expansion of cattle farming in Indonesia. The low quality and quantity of the feed consumed by beef cattle is linked to their low growth features. In general, the inability of farmers to provide standard feed for beef cattle is mainly caused by the high prices of quality feed, especially feed ingredients that contain high levels of protein, such as soybeans, which are still imported and are not affordable for farmers.

Indonesia has diverse and readily available vegetation, such as jack bean (*Canavalia ensiformis*), that can be a source of the protein needed for feed supplementation [2]. However, the dietary incorporation of jack bean in beef cattle feed has not been explored.

Jack bean contains relatively high levels of protein (34.6%) [3]. However, the rate of protein degradation in the rumen of beef cattle is also high (approximately 56.7%) [2]. In addition, the hydrogen cyanide content of jack beans is approximately 11.05 mg/100 g, which may harm the rumen ecosystem of cattle [4]. An *in vitro* study reported that the extrusion heating process can improve the rumen-protected protein (RPP) of jack bean [2]. The authors described that extrusion heating increased the RPP level from 43.35% to 59.16% and decreased the rumen level of NH_3 from 5.28 mM to 2.71 mM. In general, heating of protein-rich feed ingredients using extrusion heating techniques results in the Maillard reaction (browning reaction) between the reducing sugars and protein [5]. The reaction protects the extruded feedstuffs from degradation in the rumen and, therefore, increases the availability of nutrients for absorption in the small intestine [6,7]. This would facilitate the efficiency of protein biosynthesis, which is reflected in the improved growth of beef cattle. To the best of our knowledge, the use of extruded jack bean to improve the growth, productivity, and economic performance of beef cattle has never been reported.

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In the present study, jack bean was used as the source of RPP and was extruded before incorporation into a corncob-based total mixed ration (TMR). The effects of feeding a graded level of the extruded jack bean on nutritional status, production performances, and economic performance of beef cattle were investigated.

Commented [A4]: Do you mean reproduction? Or growth? Please rephrase for better clarity.

Commented [A5]: What is meant by economic performance? You mean their sale value due to better growth? Please rephrase for better clarity.

<H1>Materials and Methods

<H2>Ethical approval

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The *in vivo* experiment was carried out in compliance with the standard protocol of raising of livestock stated in law of the Republic of Indonesia number 18, 2009 regarding animal husbandry and health.

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<H2>Materials

Jack bean was purchased from Temanggung Regency, Central Java Province, Indonesia. The jack bean-based preparation designated KOROPASS was obtained following a previously described extrusion heating process using jack bean [2].

<H2>Experimental design

Sixteen male Friesian-Holstein crossbred cattle (approximately 1.5 years old, average body weight: 350 kg) were divided according to body weight into four treatment groups (n=4 per group). The cattle were placed in individual pens disinfected and treated with albendazole. The treatment groups included TMR without KOROPASS as control (R_0), and TMR supplemented with 3% KOROPASS (R_1), 6% KOROPASS (R_2), and 9% KOROPASS (R_3). The quantity of TMR was 9.11, 9.41, 9.78, and 10.3 kg/day (as-fed basis) for R_0, R_1, R_2, and R_3, respectively. The quality of KOROPASS used to supplement TMR was 0, 0.27, 0.56, and 0.89 kg/day (as-fed basis) for R_0, R_1, R_2, and R_3, respectively. The *in vivo* experiment lasted for 44 days. The cattle were in the growth phase and were very responsive to the protein supplementation. The 44-day duration of the experiment was considered sufficient to study the effect of KOROPASS on the performance parameters. All the beef cattle were adapted to TMR for 2 weeks before the *in vivo* experiment. The ingredients and chemical composition of TMR are listed in Table-1. The ration contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM), and total protein (TP); feed efficiency; and average daily gain were determined as previously described [8]. In addition, income over feed cost (IOFC) was also measured based on Prasetiyono *et al*. [9].

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<H2>Statistical analysis

The data collected were analyzed using analysis of variance on the basis of a randomized completely block design [10].

<H1>Results and Discussion

KOROPASS supplementation as the source of RPP significantly increased ($p<0.05$) the consumption of DM, OM, and TP in the beef cattle (Table-2). The findings suggest that dietary supplementation by KOROPASS improved the palatability of TMR derived from corncobs, an agricultural by-product. The increased protein content of the KOROPASS supplemented TMR seemed to be responsible for the increased palatability and better feed consumption by the beef cattle. The findings support earlier study which reported that feed consumption can be affected by dietary supplementation, feed quality, and the availability of particular food components, such as protein [11]. Consistent with this, dietary supplementation with urea (non-protein nitrogen) increased feed consumption in beef steers [12]. The increased levels of the KOROPASS supplementation attributed to the increased contents of protein in the rations and thus the improved intake of DM, OM, and TP of beef cattle.

The degree of DM and OM digestibility increased significantly ($p<0.05$) in relation to the increased KOROPASS content in the TMR (Table-2). It is likely that dietary supplementation with the protein-rich KOROPASS increased rumen microbial proliferation and activity, leading to the increased fermentation rate in the rumen [13], which, in turn, may contribute to improve the digestibility of DM and OM in cattle [13,14]. In addition, increased KOROPASS supplementation significantly improved the digestibility of crude protein ($p<0.05$). Moreover, KOROPASS supplementation increased the availability and utilization of protein in the intestine, as most of the jack bean protein could escape ruminal fermentation. These findings indicate that the KOROPASS could increase the supply of nitrogen to rumen microbes and support the findings of an earlier [15].

Dietary supplementation of KOROPASS significantly increased ($p<0.05$) the metabolizable protein of cattle (Table-2). Theoretically, the metabolizable protein is the total amount of protein available for digestion in the post-rumen digestive tract, which includes feed protein that escaped rumen degradation as well as microbial protein (bacterial biomass) [16]. Therefore, the increased metabolizable protein in the cattle fed on KOROPASS supplemented fee might be contributed by the increased microbial protein (bacterial biomass) as well as protein from the KOROPASS escaping from rumen fermentation.

KOROPASS supplemented TMR significantly increased ($p<0.05$) the average daily gain of beef cattle (Table-2). The results imply that KOROPASS supplementation increased tissue biosynthesis in beef cattle. Several factors may contribute to the improved daily gain, such as the increased consumption and digestibility of DM, OM, and protein. Furthermore, the increased metabolizable protein is likely to increase the growth performance of cattle. Protein is the most important nutrient for tissue biosynthesis. Thus, the increased intake and digestibility of protein is expected to positively affect the daily gain of cattle [13,17]. Energy is another factor that may determine the rate of growth of cattle [18]. The increases in DM and OM consumption and digestibility in the KOROPASS treated cattle could be attributed to the increased energy supply for growth.

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Dietary supplementation of KOROPASS was associated with significantly improved ($p<0.05$) feed efficiency of the cattle. Dietary supplementation with KOROPASS increased the digestibility of DM, OM, and protein, which increased the nutrient utilization and feed efficiency of cattle. These findings are consistent with prior observations [13], in which protein supplementation may have been associated with the increased nutrient utilization and growth and thus improved feed efficiency of cattle.

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Instead, you may include other studies, where supplementing with other protein sources might have shown similar results in cattle or other animals, and then discuss your feed regime with that.

IOFC is used to evaluate the profitability and sustainability of cattle farms. In the present study, dietary supplementation with KOROPASS, especially at 9%, resulted in a significantly higher ($p<0.05$) IOFC value of the cattle. The measured parameters convincingly demonstrated that RPP derived from KOROPASS increased feed utilization and efficiency, as well as growth performance of cattle. Jack bean is abundantly available in Indonesia. However, it remains underutilized and unexplored as an affordable feed component for cattle. Given its’ relatively low price and high nutritional value, the use of extruded jack bean as an RPP source is an attractive option to improve the IOFC of cattle farms.

<H1>Conclusion

Dietary supplementation of KOROPASS jack bean-based RPP improved feed utility, as reflected by the increased consumption and digestibility of DM, OM, and TP, and improved feed efficiency, growth, and economic performance of beef cattle.

<H1>Authors' Contributions

BWHEP designed, carried out the experiment, and drafted the manuscript; AS and WW carried out the *in vivo* experiment, conducted data analysis, and revised the manuscript. All authors read and approved the final manuscript.

<H1>Acknowledgments

Commented [s13]: Kindly provide Grant number

We thank to Diponegoro University for the research funding.

<H1>Competing Interests

The authors declare that they have no competing interests.

<H1>Publisher's Note

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Tables

Table-1: Ingredients and nutrient composition of TMR.

Ingredients	**Proportion (%)**
Corncob	20.0
Mineral mix “StV”	1.00
Salt	1.00
Cassava waste	10.0
Pollard	21.0
Molasses	7.00
Calcium carbonate	1.00
Corn straw	5.00
Degraded protein supplement (Go Pro)	2.00
Nutshell	6.00
Corn gluten feed	26.0
Nutrient composition:	

Dry matter	86.0
Ash	7.18
Crude protein	12.2
Ether extract	1.92
Crude fiber	18.0
Total digestible nutrient	60.0
Ca	0.90
P	0.60
TMR=Total mixed ration	

Table-2: Effect of KOROPASS supplementation in the TMR on variables measured.

Variables	**Treatments**	**SEM**	**p value**

	R_0	**R_1**	**R_2**	**R_3**		
DM consumption (kg/day)	7.83^d	8.33^c	8.91^b	9.69^a	0.07	<0.05
OM consumption (kg/day)	6.72^d	7.17^c	7.69^b	8.38^a	0.07	<0.05
TP consumption (g/day)	892^d	1,020^c	1,182^b	1,406^a	0.04	<0.05
DM digestibility (%)	42.9^d	50.6^c	58.0^b	63.6^a	1.16	<0.05
OM digestibility (%)	54.3^d	59.6^c	66.3^b	70.6^a	0.94	<0.05
Crude protein digestibility (%)	65.0^b	67.1^b	75.0^a	80.7^a	1.86	<0.05
Metabolizable protein (%)	49.0^b	52.2^b	55.0^b	65.2^a	3.10	<0.05
Average daily gain (kg/day)	0.72^c	0.83^c	0.99^b	1.24^a	0.05	<0.05

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Feed efficiency (%)	9.50^{c}	10.24^{bc}	11.53^{ab}	13.14^{a}	0.51	<0.05
Feed cost (IDR/head/day)	26,403^{d}	29,177^{c}	32,274^{b}	36,222^{a}	265	<0.05
IOFC (IDR/head/day)	6832^{b}	8888^{b}	13,151^{b}	20,933^{a}	1996	<0.05

Numbers with different letters on the same row show difference at p<0.05. Price (at the time of study) per kg of TMR=IDR 2900, KOROPASS=IDR 7000, Beef cattle=IDR 46,000 (price per kg live weight). DM=Dry matter, OM=Organic matter, TP=Total protein, IOFC=Income over feed cost, TMR=Total mixed ration, IDR=Indonesian rupiah (Indonesian currency), SEM=Standard error of the mean

Technical/Copyediting by Sinjore – 14/03/2020

RESEARCH ARTICLE

Effect of KOROPASS, an extruded jack bean (*Canavalia ensiformis*)-derived supplement, on productivity and economic performance of beef cattle

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Bambang Waluyo Hadi Eko Prasetiyono, Agung Subrata and Widiyanto Widiyanto

Department of Animal Science, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang, Central Java, Indonesia.

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Abstract

Aim: This study evaluated the effect of feeding a graded amount of extruded jack bean (*Canavalia ensiformis*) on nutritional status, production performances, and economic performance of beef cattle.

Materials and Methods: The supplement called "KOROPASS" was prepared from the extruded jack bean (according to the extrusion heating process). Sixteen male Friesian-Holstein crossbred cattle were divided into four groups and fed on KOROPASS as per the regimen: R_0 (total mixed ration [TMR] without KOROPASS), R_1 (TMR supplemented with 3% KOROPASS), R_2 (TMR supplemented with 6% KOROPASS), and R_3 (TMR supplemented with 9% KOROPASS). The *in vivo* experiment lasted 44 days. TMR contained 12% crude protein and 60% total digestible nutrient. The consumption and digestibility of dry matter (DM), organic matter (OM), and total protein (TP), feed efficiency, average daily gain, and income over feed cost (IOFC) were evaluated.

Results: KOROPASS supplementation significantly increased ($p<0.05$) beef cattle consumption of DM (from 7.83 [R_0] to 8.33 [R_1], 8.91 [R_2], and 9.69 kg/day [R_3]), OM (from 6.72 to 7.17, 7.69, and 8.38 kg/day, respectively), and TP (from 892 to 1020, 1182, and 1406 g/day, respectively). The elevated levels of KOROPASS significantly increased ($p<0.05$) digestibility in terms of the levels of DM (from 42.9 [R_0] to 50.6 [R_1], 58.0 [R_2], and 63.6% [R_3]), OM (from 54.3 to 59.6, 66.3, and 70.6%, respectively), and TP (from 65.0 to 67.1, 75.0, and 80.7%, respectively). Dietary supplementation of KOROPASS significantly increased ($p<0.05$) metabolizable protein, average daily gain, and feed efficiency of beef cattle. Finally, dietary KOROPASS supplementation, especially at 9%, resulted in the highest ($p<0.05$) IOFC value of beef cattle.

Conclusion: Dietary supplementation of KOROPASS improved feed utility, as reflected by the increase in consumption and digestibility of DM, OM, and TP. Further, KOROPASS supplementation improved feed efficiency, growth, and economic performance of beef cattle. The findings indicate the potential value of KOROPASS as a feed supplement for beef cattle.

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Keywords: beef cattle, extruded jack bean, feed utilization, growth.

<H1>Introduction

The increasing demand for beef in Indonesia has outpaced the local beef production. In 2018, Indonesia had to import 400,000 heads of beef cattle and 93,000 tons of beef [1]. Low livestock productivity, which leads to low economic performance, is one of the main factors inhibiting the expansion of cattle farming in Indonesia. The low quality and quantity of the feed consumed by beef cattle is linked to their low growth features. In general, the inability of farmers to provide standard feed for beef cattle is mainly caused by the high prices of quality feed, especially feed ingredients that contain high levels of protein, such as soybeans, which are still imported and are not affordable for farmers.

Indonesia has diverse and readily available vegetation, such as jack bean (*Canavalia ensiformis*), that can be a source of the protein needed for feed supplementation [2]. However, the dietary incorporation of jack bean in beef cattle feed has not been explored.

Jack bean contains relatively high levels of protein (34.6%) [3]. However, the rate of protein degradation in the rumen of beef cattle is also high (approximately 56.7%) [2]. In addition, the hydrogen cyanide content of jack beans is approximately 11.05 mg/100 g, which may harm the rumen ecosystem of cattle [4]. An *in vitro* study reported that the extrusion heating process can improve the rumen-protected protein (RPP) of jack bean [2]. The authors described that extrusion heating increased the RPP level from 43.35% to 59.16% and decreased the rumen level of NH_3 from 5.28 mM to 2.71 mM. In general, heating of protein-rich feed ingredients using extrusion heating techniques results in the Maillard reaction (browning reaction) between the reducing sugars and protein [5]. The reaction protects the extruded feedstuffs from degradation in the rumen and, therefore, increases the availability of nutrients for absorption in the small intestine [6,7]. This would facilitate the efficiency of protein biosynthesis, which is reflected in the improved growth of beef cattle. To the best of our knowledge, the use of extruded jack bean to improve the growth, productivity, and economic performance of beef cattle has never been reported.

In the present study, jack bean was used as the source of RPP and was extruded before incorporation into a corncob-based total mixed ration (TMR). The effects of feeding a graded

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Commented [T6R5]: “rumen-protected protein” as you can also see in https://www.nature.com/articles/s41598-018-37800-3 level of the extruded jack bean on nutritional status, growth, feed cost ~~production performances,~~ and income over feed cost ~~economic performance~~ of beef cattle were investigated.

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<H1>Materials and Methods

<H2>Ethical approval

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The *in vivo* experiment was approved by the animal ethics committee of the Faculty of Animal and Agricultural Sciences, Diponegoro University (~~number xxxxxxx~~No. 3084/UN7.5.5/KP/2017, 22 May 2017). ~~carried out in compliance with the standard protocol of raising of livestock stated in law of the Republic of Indonesia number 18, 2009 regarding animal husbandry and health.~~

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<H2>Materials

Jack bean was purchased from Temanggung Regency, Central Java Province, Indonesia. The jack bean-based preparation designated KOROPASS was obtained following a previously described extrusion heating process using jack bean [2].

<H2>Experimental design

Sixteen male Friesian-Holstein crossbred cattle (approximately 1.5 years old~~, average body weight: 350 kg~~) were divided according to body weight into four treatment groups (n=4 per group). The cattle were placed in individual pens disinfected and treated with albendazole. The treatment groups included TMR without KOROPASS as control (R$_0$), and TMR supplemented with 3% KOROPASS (R$_1$), 6% KOROPASS (R$_2$), and 9% KOROPASS (R$_3$). The quantity of TMR was 9.11, 9.41, 9.78, and 10.3 kg/day (as-fed basis) for R$_0$, R$_1$, R$_2$, and R$_3$, respectively. The quality of KOROPASS used to supplement TMR was 0, 0.27, 0.56, and 0.89 kg/day (as-fed basis) for R$_0$, R$_1$, R$_2$, and R$_3$, respectively. The *in vivo* experiment lasted for 44 days. The cattle were in the growth phase and were very responsive to the protein supplementation. The 44-day duration of the experiment was considered sufficient to study the effect of KOROPASS on the performance parameters, as previously conducted by Prasetiyono *et al*. [8]. All the beef cattle were adapted to TMR for 2 weeks before the *in vivo* experiment. The ingredients and chemical composition of TMR are listed in Table-1. The ration contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM), and total protein (TP); feed efficiency; and average daily gain were determined as previously described [9~~8~~]. In addition, income over feed cost (IOFC) was also measured based

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The average body weight: 350 kg has been deleted from the material and methods section as it may make confuse

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on Prasetiyono *et al*. [~~9~~8].

<H2>Statistical analysis

The data collected were analyzed using analysis of variance on the basis of a randomized completely block design [10].

<H1>Results and Discussion

In this study, the effect of block was not significant and therefore the block effect was not considered. KOROPASS supplementation as the source of RPP significantly increased ($p<0.05$) the consumption of DM, OM, and TP in the beef cattle (Table-2). The findings suggest that dietary supplementation by KOROPASS improved the palatability of TMR derived from corncobs, an agricultural by-product. The increased protein content of the KOROPASS supplemented TMR seemed to be responsible for the increased palatability and better feed consumption by the beef cattle. The findings support earlier study which reported that feed consumption can be affected by dietary supplementation, feed quality, and the availability of particular food components, such as protein [11]. Consistent with this, dietary supplementation with urea (non-protein nitrogen) increased feed consumption in beef steers [12]. The increased levels of the KOROPASS supplementation attributed to the increased contents of protein in the rations and thus the improved intake of DM, OM, and TP of beef cattle.

The degree of DM and OM digestibility increased significantly ($p<0.05$) in relation to the increased KOROPASS content in the TMR (Table-2). It is likely that dietary supplementation with the protein-rich KOROPASS increased rumen microbial proliferation and activity, leading to the increased fermentation rate in the rumen [13], which, in turn, may contribute to improve the digestibility of DM and OM in cattle [13,14]. In addition, increased KOROPASS supplementation significantly improved the digestibility of crude protein ($p<0.05$). Moreover, KOROPASS supplementation increased the availability and utilization of protein in the intestine, as most of the jack bean protein could escape ruminal fermentation. These findings indicate that the KOROPASS could increase the supply of nitrogen to rumen microbes and support the findings of an earlier [15].

Dietary supplementation of KOROPASS significantly increased ($p<0.05$) the metabolizable protein of cattle (Table-2). Theoretically, the metabolizable protein is the total amount of protein available for digestion in the post-rumen digestive tract, which includes feed protein that escaped rumen degradation as well as microbial protein (bacterial biomass) [16]. Therefore, the increased metabolizable protein in the cattle fed on KOROPASS supplemented fee might be contributed by the increased microbial protein (bacterial biomass) as well as protein from the KOROPASS escaping from rumen fermentation.

KOROPASS supplemented TMR significantly increased ($p<0.05$) the average daily weight gain of beef cattle (Table-2). The results imply that KOROPASS supplementation increased tissue biosynthesis in beef cattle. Several factors may contribute to the improved daily gain, such as the increased consumption and digestibility of DM, OM, and protein. Furthermore, the increased metabolizable protein is likely to increase the growth performance of cattle. Protein is the most important nutrient for tissue biosynthesis. Thus, the increased intake and digestibility of protein is expected to positively affect the daily gain of cattle [13,17]. Energy is another factor that may determine the rate of growth of cattle [18]. The increases in DM and OM consumption and digestibility in the KOROPASS treated cattle could be attributed to the increased energy supply for growth.

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Dietary supplementation of KOROPASS was associated with significantly improved (p<0.05) feed efficiency of the cattle. In accordance with our findings, Uddin et al. ~~Dietary supplementation with KOROPASS increased the digestibility of DM, OM, and protein, which increased the nutrient utilization and feed efficiency of cattle. These findings are consistent with prior observations~~ [13] documented that ~~, in which~~ protein supplementation may have been associated with the increased nutrient utilization and growth and thus improved feed efficiency of cattle.

IOFC is used to evaluate the profitability and sustainability of cattle farms. In the present study, dietary supplementation with KOROPASS, especially at 9%, resulted in a significantly higher (p<0.05) IOFC value of the cattle. The measured parameters convincingly demonstrated that RPP derived from KOROPASS increased feed utilization and efficiency, as well as growth performance of cattle. Jack bean is abundantly available in Indonesia. However, it remains underutilized and unexplored as an affordable feed component for cattle. Given its’ relatively low price and high nutritional value, the use of extruded jack bean as an RPP source is an attractive option to improve the IOFC of cattle farms.

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Instead, you may include other studies, where supplementing with other protein sources might have shown similar results in cattle or other animals, and then discuss your feed regime with that.

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<H1>Conclusion

Dietary supplementation of KOROPASS jack bean-based RPP improved feed utility, as reflected by the increased consumption and digestibility of DM, OM, and TP, and improved feed efficiency, growth, and economic performance of beef cattle.

<H1>Authors' Contributions

BWHEP designed, carried out the experiment, and drafted the manuscript; AS and WW carried out the *in vivo* experiment, conducted data analysis, and revised the manuscript. All authors read and approved the final manuscript.

<H1>Acknowledgments

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We thank to Diponegoro University for the research funding (No. 275-049/UN7.5.1/PG/2017~~xxx~~).

<H1>Competing Interests

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OM consumption (kg/day)	6.72^{d}	7.17^{c}	7.69^{b}	8.38^{a}	0.07	<0.05

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TP consumption (g/day)	892^{d}	1,020^{c}	1,182^{b}	1,406^{a}	0.04	<0.05
DM digestibility (%)	42.9^{d}	50.6^{c}	58.0^{b}	63.6^{a}	1.16	<0.05
OM digestibility (%)	54.3^{d}	59.6^{c}	66.3^{b}	70.6^{a}	0.94	<0.05
Crude protein digestibility (%)	65.0^{b}	67.1^{b}	75.0^{a}	80.7^{a}	1.86	<0.05
Metabolizable protein (%)	49.0^{b}	52.2^{b}	55.0^{b}	65.2^{a}	3.10	<0.05
Average daily gain (kg/day)	0.72^{c}	0.83^{c}	0.99^{b}	1.24^{a}	0.05	<0.05
Feed efficiency (%)	9.50^{c}	10.24^{bc}	11.53^{ab}	13.14^{a}	0.51	<0.05
Feed cost (IDR/head/day)	26,403^{d}	29,177^{c}	32,274^{b}	36,222^{a}	265	<0.05
IOFC (IDR/head/day)	6832^{b}	8888^{b}	13,151^{b}	20,933^{a}	1996	<0.05
Numbers with different letters on the same row show difference at $p<0.05$. Price (at the						

time of study) per kg of TMR=IDR 2900, KOROPASS=IDR 7000, Beef cattle=IDR 46,000 (price per kg live weight). DM=Dry matter, OM=Organic matter, TP=Total protein, IOFC=Income over feed cost, TMR=Total mixed ration, IDR=Indonesian rupiah (Indonesian currency), SEM=Standard error of the mean

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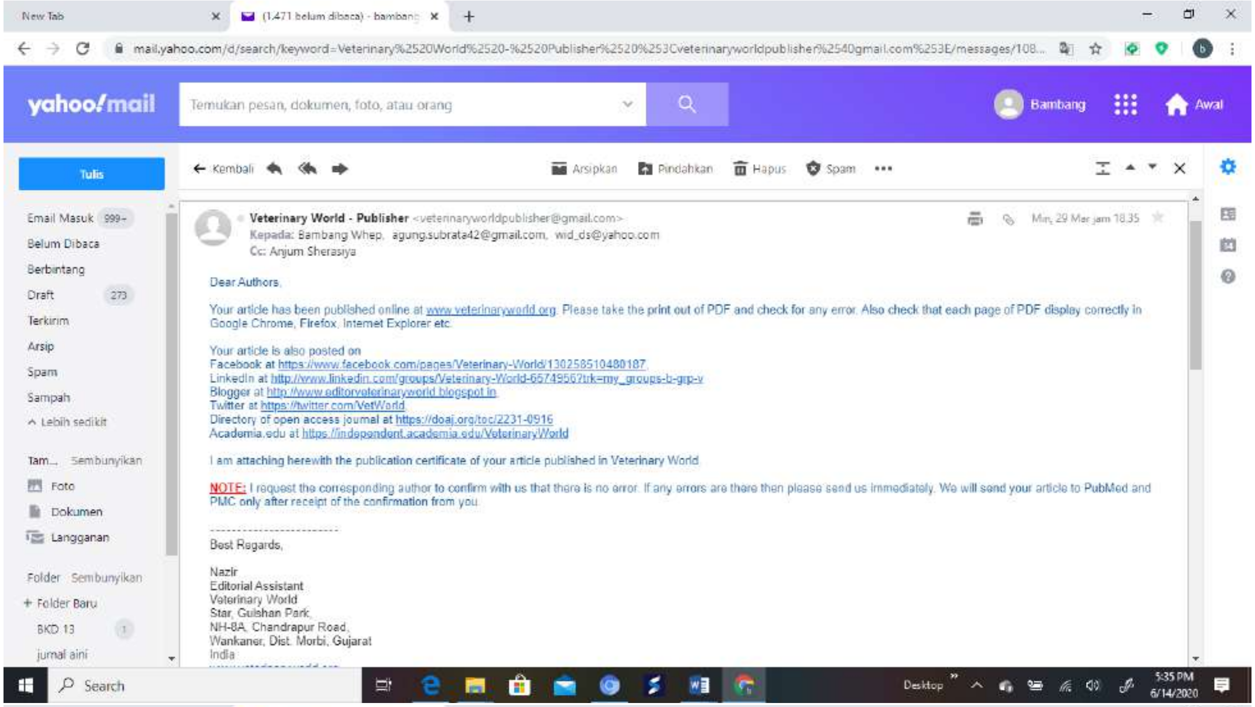

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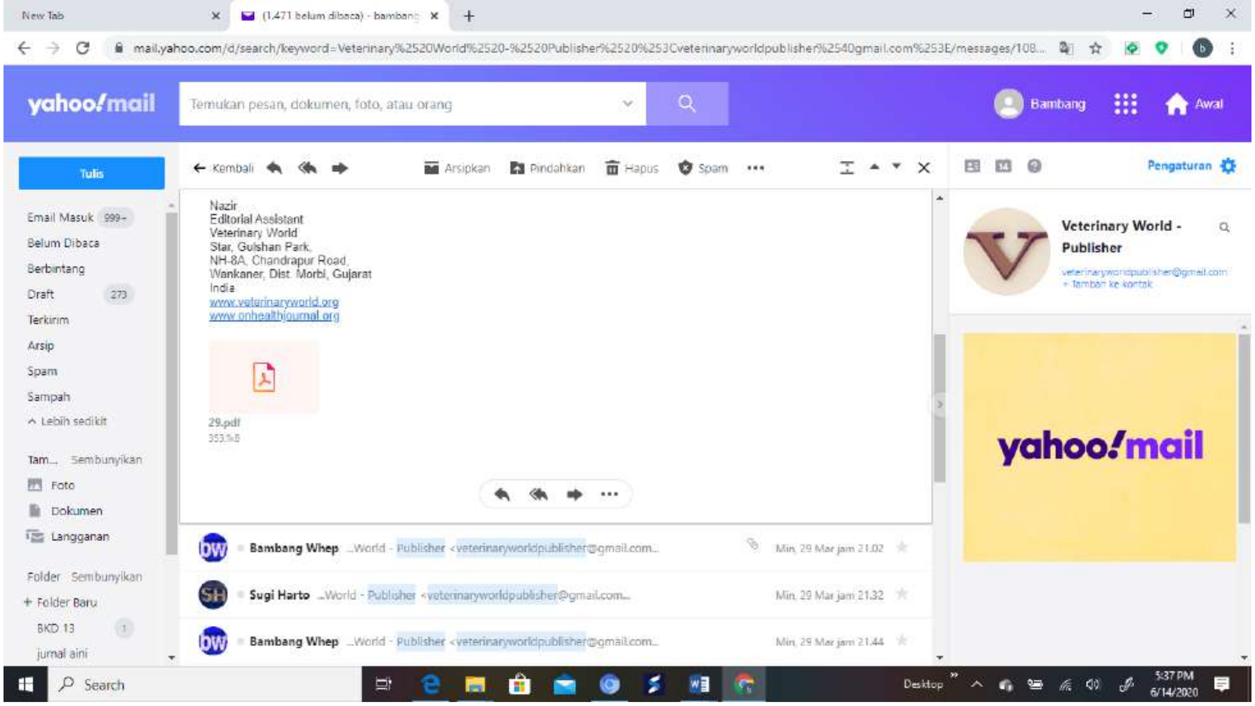

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RESEARCH ARTICLE
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Effect ofKOROPASS, an extruded jack bean (*Canavalia ensiformis*)-derived supplement, on productivity and economic performance of beef cattle

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Abstract

Aim: This study evaluated the effect of feeding a graded amount of extruded jack bean (*Canavalia ensiformis*) on nutritional status, production performances, and economic performance of beef cattle.

Materials and Methods: The supplement called "KOROPASS" was prepared from the extruded jack bean (according to the extrusion heating process). Sixteen male Friesian-Holstein crossbred cattle were divided into four groups and fed on KOROPASS as per the regimen: R_0 (total mixed ration [TMR] without KOROPASS), R_1 (TMR supplemented with 3% KOROPASS), R_2 (TMR supplemented with 6% KOROPASS), and R_3 (TMR supplemented with 9% KOROPASS). The *in vivo* experiment lasted 44 days. TMR contained 12% crude protein and 60% total digestible nutrient. The consumption and digestibility of dry matter (DM), organic matter (OM), and total protein (TP), feed efficiency, average daily gain, and income over feed cost (IOFC) were evaluated.

Results: KOROPASS supplementation significantly increased ($p<0.05$) beef cattle consumption of DM (from 7.83 [R_0] to 8.33 [R_1], 8.91 [R_2], and 9.69 kg/day [R_3]), OM (from 6.72 to 7.17, 7.69, and 8.38 kg/day, respectively), and TP (from 892 to 1020, 1182, and 1406 g/day, respectively). The elevated levels of KOROPASS significantly increased ($p<0.05$) digestibility in terms of the levels of DM (from 42.9 [R_0] to 50.6 [R_1], 58.0 [R_2], and 63.6% [R_3]), OM (from 54.3 to 59.6, 66.3, and 70.6%, respectively), and TP (from 65.0 to 67.1, 75.0, and 80.7%, respectively). Dietary supplementation of KOROPASS significantly increased ($p<0.05$) metabolizable protein, average daily weight gain, and feed efficiency of beef cattle. Finally, dietary KOROPASS supplementation, especially at 9%, resulted in the highest ($p<0.05$) IOFC value of beef cattle.

Conclusion: Dietary supplementation of KOROPASS improved feed utility, as reflected by the increase in consumption and digestibility of DM, OM, and TP. Further, KOROPASS supplementation improved feed efficiency, growth, and economic performance of beef cattle. The findings indicate the potential value of KOROPASS as a feed supplement for beef cattle.

Keywords: beef cattle, extruded jack bean, feed utilization, growth.

Introduction

The increasing demand for beef in Indonesia has outpaced local beef production. In 2018, Indonesia had to import 400,000 heads of beef cattle and 93,000 tons of beef [1]. Low livestock productivity, which leads to low economic performance, is one of the main factors inhibiting the expansion of cattle farming in Indonesia. The low quality and quantity of the feed consumed by beef cattle are linked to their low growth features. In general, the inability of farmers to provide standard feed for beef cattle is mainly caused by the high prices of quality feed, especially feed ingredients that contain high levels of protein, such as soybeans, which are still imported and are not affordable for farmers.

Indonesia has diverse and readily available vegetation, such as jack bean (*Canavalia ensiformis*), that can be a source of the protein needed for feed supplementation [2]. However, the dietary incorporation of jack bean in beef cattle feed has not been explored.

Jack bean contains relatively high levels of protein (34.6%) [3]. However, the rate of protein degradation in the rumen of beef cattle is also high (approximately 56.7%) [2]. In addition, the hydrogen cyanide content of jack beans is approximately 11.05 mg/100 g, which may harm the rumen ecosystem of cattle [4]. An *in vitro* study reported that the extrusion heating process could improve the rumen-protected protein (RPP) of jack bean [2]. The authors described that extrusion heating increased the RPP level from 43.35% to 59.16% and decreased the rumen level of NH_3 from 5.28 mM to 2.71 mM. In general, heating of protein-rich feed ingredients using extrusion heating techniques results in the Maillard reaction (browning reaction) between the reducing sugars and protein [5]. The reaction protects the extruded feedstuffs from degradation in the rumen and, therefore, increases the availability of nutrients for absorption in the small intestine [6,7]. This would facilitate the efficiency of protein biosynthesis, which is reflected in the improved growth of beef cattle. To the best of our knowledge, the use of extruded jack bean to improve the growth, productivity, and economic performance of beef cattle has never been reported.

In the present study, jack bean was used as the source of RPP and was extruded before incorporation into a corncob-based total mixed ration (TMR). The effects of feeding a graded level of the extruded jack bean on nutritional status, growth, feed cost and income over feed cost of beef cattle were investigated.

Materials and Methods

Ethical approval

The *in vivo* experiment was approved by the animal ethics committee of the Faculty of Animal and Agricultural Sciences, Diponegoro University (No. 3084/UN7.5.5/KP/2017, 22 May 2017).

Materials

Jack bean was purchased from Temanggung Regency, Central Java Province, Indonesia. The jack bean-based preparation designated KOROPASS was obtained following a previously described extrusion heating process using jack bean [2].

Experimental design

Sixteen male Friesian-Holstein crossbred cattle (approximately 1.5 years old) were divided according to body weight into four treatment groups (n=4 per group). The cattle were placed in individual pens disinfected and treated with albendazole. The treatment groups included TMR without KOROPASS as control (R_0), and TMR supplemented with 3% KOROPASS (R_1), 6% KOROPASS (R_2), and 9% KOROPASS (R_3). The quantity of TMR was 9.11, 9.41, 9.78, and 10.3 kg/day (as-fed basis) for R_0, R_1, R_2, and R_3, respectively. The quality of KOROPASS used to supplement TMR was 0, 0.27, 0.56, and 0.89 kg/day (as-fed basis) for R_0, R_1, R_2, and R_3, respectively. The *in vivo* experiment lasted for 44 days. The cattle were in the growth phase and were very responsive to protein supplementation. The 44-day duration of the experiment was considered sufficient to study the effect of KOROPASS on the performance parameters, as previously conducted by Prasetiyono *et al*. [8]. All the beef cattle were adapted to TMR for 2 weeks before the *in vivo* experiment. The ingredients and chemical composition of TMR are listed in Table-1. The ration contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM), and total protein (TP); feed efficiency; and average daily gain were determined as previously described [9]. In addition, income over feed cost (IOFC) was also measured based on Prasetiyono *et al*. [8].

Statistical analysis

The data collected were analyzed using analysis of variance on the basis of a randomized complete block design [10].

Results and Discussion

In this study, the effect of block was not significant, and therefore the block effect was not considered. KOROPASS supplementation as the source of RPP significantly increased ($p<0.05$) the consumption of DM, OM, and TP in the beef cattle (Table-2). The findings suggest that dietary supplementation by KOROPASS improved the palatability of TMR derived from corncobs, an agricultural by-product. The increased protein content of the KOROPASS supplemented TMR seemed to be responsible for the increased palatability and better feed consumption by the beef cattle. The findings support earlier study which reported that feed consumption can be affected by dietary supplementation, feed quality, and the availability of particular food components, such as protein [11]. Consistent with this, dietary supplementation with urea (non-protein nitrogen) increased feed consumption in beef steers [12]. The increased levels of the KOROPASS supplementation attributed to the increased contents of protein in the rations and thus the improved intake of DM, OM, and TP of beef cattle.

The degree of DM and OM digestibility increased significantly ($p<0.05$) in relation to the increased KOROPASS content in the TMR (Table-2). It is likely that dietary supplementation with the protein-rich KOROPASS increased rumen microbial proliferation and activity, leading to the increased fermentation rate in the rumen [13], which, in turn, may contribute to improving the digestibility of DM and OM in cattle [13,14]. In addition, increased KOROPASS supplementation significantly improved the digestibility of crude protein ($p<0.05$). Moreover, KOROPASS supplementation increased the availability and utilization of protein in the intestine, as most of the jack bean protein could escape ruminal fermentation. These

Table-1: Ingredients and nutrient composition of TMR.

Ingredients	Proportion (%)
Corncob	20.0
Mineral mix "StV"	1.00
Salt	1.00
Cassava waste	10.0
Pollard	21.0
Molasses	7.00
Calcium carbonate	1.00
Corn straw	5.00
Degraded protein supplement (Go Pro)	2.00
Nutshell	6.00
Corn gluten feed	26.0
Nutrient composition	
Dry matter	86.0
Ash	7.18
Crude protein	12.2
Ether extract	1.92
Crude fiber	18.0
Total digestible nutrient	60.0
Ca	0.90
P	0.60

TMR=Total mixed ration

Table-2: Effect of KOROPASS supplementation in the TMR on variables measured.

Variables	**Treatments**				**SEM**	**p value**
	R_0	**R_1**	**R_2**	**R_3**		
DM consumption (kg/day)	7.83^{d}	8.33^{c}	8.91^{b}	9.69^{a}	0.07	<0.05
OM consumption (kg/day)	6.72^{d}	7.17^{c}	7.69^{b}	8.38^{a}	0.07	<0.05
TP consumption (g/day)	892^{d}	1,020^{c}	1,182^{b}	1,406^{a}	0.04	<0.05
DM digestibility (%)	42.9^{d}	50.6^{c}	58.0^{b}	63.6^{a}	1.16	<0.05
OM digestibility (%)	54.3^{d}	59.6^{c}	66.3^{b}	70.6^{a}	0.94	<0.05
Crude protein digestibility (%)	65.0^{b}	67.1^{b}	75.0^{a}	80.7^{a}	1.86	<0.05
Metabolizable protein (%)	49.0^{b}	52.2^{b}	55.0^{b}	65.2^{a}	3.10	<0.05
Average daily gain (kg/day)	0.72^{c}	0.83^{c}	0.99^{b}	1.24^{a}	0.05	<0.05
Feed efficiency (%)	9.50^{c}	10.24^{bc}	11.53^{ab}	13.14^{a}	0.51	<0.05
Feed cost (IDR/head/day)	26,403^{d}	29,177^{c}	32,274^{b}	36,222^{a}	265	<0.05
IOFC (IDR/head/day)	6832^{b}	8888^{b}	13,151^{b}	20,933^{a}	1996	<0.05

Numbers with different letters on the same row show difference at $p<0.05$. "a" represents the highest value, and "d" represents the lowest values. Price (at the time of study) per kg of TMR=IDR 2900, KOROPASS=IDR 7000, Beef cattle=IDR 46,000 (price per kg live weight). DM=Dry matter, OM=Organic matter, TP=Total protein, IOFC=Income over feed cost, TMR=Total mixed ration, IDR=Indonesian rupiah (Indonesian currency), SEM=Standard error of the mean

findings indicate that the KOROPASS could increase the supply of nitrogen to rumen microbes and support the findings of an earlier [15].

Dietary supplementation of KOROPASS significantly increased ($p<0.05$) the metabolizable protein of cattle (Table-2). Theoretically, the metabolizable protein is the total amount of protein available for digestion in the post-rumen digestive tract, which includes feed protein that escaped rumen degradation as well as microbial protein (bacterial biomass) [16]. Therefore, the increased metabolizable protein in the cattle fed on KOROPASS supplemented fee might be contributed by the increased microbial protein (bacterial biomass) as well as protein from the KOROPASS escaping from rumen fermentation.

KOROPASS supplemented TMR significantly increased ($p<0.05$) the average daily weight gain of beef cattle (Table-2). The results imply that KOROPASS supplementation increased tissue biosynthesis in beef cattle. Several factors may contribute to the improved daily gain, such as the increased consumption and digestibility of DM, OM, and protein. Furthermore, the increased metabolizable protein is likely to increase the growth performance of cattle. Protein is the most important nutrient for tissue biosynthesis. Thus, the increased intake and digestibility of protein is expected to positively affect the daily gain of cattle [13,17]. Energy is another factor that may determine the rate of growth of cattle [18]. The increases in DM and OM consumption and digestibility in the KOROPASS treated cattle could be attributed to the increased energy supply for growth.

Dietary supplementation of KOROPASS was associated with significantly improved ($p<0.05$) feed efficiency of the cattle. In accordance with our findings, Uddin *et al.* [13] documented thatprotein supplementation may have been associated with increased nutrient utilization and growth and thus improved feed efficiency of cattle.

IOFC is used to evaluate the profitability and sustainability of cattle farms. In the present study, dietary supplementation with KOROPASS, especially at 9%, resulted in a significantly higher ($p<0.05$) IOFC value of the cattle. The measured parameters convincingly demonstrated that RPP derived from KOROPASS increased feed utilization and efficiency, as well as growth performance of cattle. Jack bean is abundantly available in Indonesia. However, it remains underutilized and unexplored as an affordable feed component for cattle. Given its' relatively low price and high nutritional value, the use of extruded jack bean as an RPP source is an attractive option to improve the IOFC of cattle farms.

Conclusion

Dietary supplementation of KOROPASS jack bean-based RPP improved feed utility, as reflected by the increased consumption and digestibility of DM, OM, and TP, and improved feed efficiency, growth, and economic performance of beef cattle.

Authors' Contributions

BWHEP designed, carried out the experiment, and drafted the manuscript; AS and WW carried out the *in vivo* experiment, conducted data analysis, and revised the manuscript. All authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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The increasing demand for beef in Indonesia has outpaced local beef production. In 2018, Indonesia had to import 400,000 heads of beef cattle and 93,000 tons of beef [1]. Low livestock productivity, which leads to low economic performance, is one of the main factors inhibiting the expansion of cattle farming in Indonesia. The low quality and quantity of the feed consumed by beef cattle are linked to their low growth features. In general, the inability of farmers to provide standard feed for beef cattle is mainly caused by the high prices of quality feed, especially feed ingredients that contain high levels of protein, such as soybeans, which are still imported and are not affordable for farmers.

Indonesia has diverse and readily available vegetation, such as jack bean (*Canavalia ensiformis*), that can be a source of the protein needed for feed supplementation [2]. However, the dietary incorporation of jack bean in beef cattle feed has not been explored.

Jack bean contains relatively high levels of protein (34.6%) [3]. However, the rate of protein degradation in the rumen of beef cattle is also high (approximately 56.7%) [2]. In addition, the hydrogen cyanide content of jack beans is approximately 11.05 mg/100 g, which may harm the rumen ecosystem of cattle [4]. An *in vitro* study reported that the extrusion heating process could improve the rumen-protected protein (RPP) of jack bean [2]. The authors described that extrusion heating increased the RPP level from 43.35% to 59.16% and decreased the rumen level of NH_3 from 5.28 mM to 2.71 mM. In general, heating of protein-rich feed ingredients using extrusion heating techniques results in the Maillard reaction (browning reaction) between the reducing sugars and protein [5]. The reaction protects the extruded feedstuffs from degradation in the rumen and, therefore, increases the availability of nutrients for absorption in the small intestine [6,7]. This would facilitate the efficiency of protein biosynthesis, which is reflected in the improved growth of beef cattle. To the best of our knowledge, the use of extruded jack bean to improve the growth, productivity, and economic performance of beef cattle has never been reported.

In the present study, jack bean was used as the source of RPP and was extruded before incorporation into a corncob-based total mixed ration (TMR). The effects of feeding a graded level of the extruded jack bean on nutritional status, growth, feed cost and income over feed cost of beef cattle were investigated.

Materials and Methods

Ethical approval

The *in vivo* experiment was approved by the animal ethics committee of the Faculty of Animal and Agricultural Sciences, Diponegoro University (No. 3084/UN7.5.5/KP/2017, 22 May 2017).

Materials

Jack bean was purchased from Temanggung Regency, Central Java Province, Indonesia. The jack bean-based preparation designated KOROPASS was obtained following a previously described extrusion heating process using jack bean [2].

Experimental design

Sixteen male Friesian-Holstein crossbred cattle (approximately 1.5 years old) were divided according to body weight into four treatment groups (n=4 per group). The cattle were placed in individual pens disinfected and treated with albendazole. The treatment groups included TMR without KOROPASS as control (R_0), and TMR supplemented with 3% KOROPASS (R_1), 6% KOROPASS (R_2), and 9% KOROPASS (R_3). The quantity of TMR was 9.11, 9.41, 9.78, and 10.3 kg/day (as-fed basis) for R_0, R_1, R_2, and R_3, respectively. The quality of KOROPASS used to supplement TMR was 0, 0.27, 0.56, and 0.89 kg/day (as-fed basis) for R_0, R_1, R_2, and R_3, respectively. The *in vivo* experiment lasted for 44 days. The cattle were in the growth phase and were very responsive to protein supplementation. The 44-day duration of the experiment was considered sufficient to study the effect of KOROPASS on the performance parameters, as previously conducted by Prasetiyono *et al*. [8]. All the beef cattle were adapted to TMR for 2 weeks before the *in vivo* experiment. The ingredients and chemical composition of TMR are listed in Table-1. The ration contained 12% crude protein and 60% total digestible nutrient (TDN). The consumption and digestibility of dry matter (DM), organic matter (OM), and total protein (TP); feed efficiency; and average daily gain were determined as previously described [9]. In addition, income over feed cost (IOFC) was also measured based on Prasetiyono *et al*. [8].

Statistical analysis

The data collected were analyzed using analysis of variance on the basis of a randomized complete block design [10].

Results and Discussion

In this study, the effect of block was not significant, and therefore the block effect was not considered. KOROPASS supplementation as the source of RPP significantly increased ($p<0.05$) the consumption of DM, OM, and TP in the beef cattle (Table-2). The findings suggest that dietary supplementation by KOROPASS improved the palatability of TMR derived from corncobs, an agricultural by-product. The increased protein content of the KOROPASS supplemented TMR seemed to be responsible for the increased palatability and better feed consumption by the beef cattle. The findings support earlier study which reported that feed consumption can be affected by dietary supplementation, feed quality, and the availability of particular food components, such as protein [11]. Consistent with this, dietary supplementation with urea (non-protein nitrogen) increased feed consumption in beef steers [12]. The increased levels of the KOROPASS supplementation attributed to the increased contents of protein in the rations and thus the improved intake of DM, OM, and TP of beef cattle.

The degree of DM and OM digestibility increased significantly ($p<0.05$) in relation to the increased KOROPASS content in the TMR (Table-2). It is likely that dietary supplementation with the protein-rich KOROPASS increased rumen microbial proliferation and activity, leading to the increased fermentation rate in the rumen [13], which, in turn, may contribute to improving the digestibility of DM and OM in cattle [13,14]. In addition, increased KOROPASS supplementation significantly improved the digestibility of crude protein ($p<0.05$). Moreover, KOROPASS supplementation increased the availability and utilization of protein in the intestine, as most of the jack bean protein could escape ruminal fermentation. These findings indicate that the KOROPASS could increase

Table-1: Ingredients and nutrient composition of TMR.

Ingredients	Proportion (%)
Corncob	20.0
Mineral mix "StV"	1.00
Salt	1.00
Cassava waste	10.0
Pollard	21.0
Molasses	7.00
Calcium carbonate	1.00
Corn straw	5.00
Degraded protein supplement (Go Pro)	2.00
Nutshell	6.00
Corn gluten feed	26.0
Nutrient composition	
Dry matter	86.0
Ash	7.18
Crude protein	12.2
Ether extract	1.92
Crude fiber	18.0
Total digestible nutrient	60.0
Ca	0.90
P	0.60

TMR=Total mixed ration

Table-2: Effect of KOROPASS supplementation in the TMR on variables measured.

Variables	Treatments				SEM	p-value
	R_0	R_1	R_2	R_3		
DM consumption (kg/day)	7.83^{d}	8.33^{c}	8.91^{b}	9.69^{a}	0.07	<0.05
OM consumption (kg/day)	6.72^{d}	7.17^{c}	7.69^{b}	8.38^{a}	0.07	<0.05
TP consumption (g/day)	892^{d}	$1,020^{c}$	$1,182^{b}$	$1,406^{a}$	0.04	<0.05
DM digestibility (%)	42.9^{d}	50.6^{c}	58.0^{b}	63.6^{a}	1.16	<0.05
OM digestibility (%)	54.3^{d}	59.6^{c}	66.3^{b}	70.6^{a}	0.94	<0.05
Crude protein digestibility (%)	65.0^{b}	67.1^{b}	75.0^{a}	80.7^{a}	1.86	<0.05
Metabolizable protein (%)	49.0^{b}	52.2^{b}	55.0^{b}	65.2^{a}	3.10	<0.05
Average daily gain (kg/day)	0.72^{c}	0.83^{c}	0.99^{b}	1.24^{a}	0.05	<0.05
Feed efficiency (%)	9.50^{c}	10.24^{bc}	11.53^{ab}	13.14^{a}	0.51	<0.05
Feed cost (IDR/head/day)	$26,403^{d}$	$29,177^{c}$	$32,274^{b}$	$36,222^{a}$	265	<0.05
IOFC (IDR/head/day)	6832^{b}	8888^{b}	$13,151^{b}$	$20,933^{a}$	1996	<0.05

Numbers with different letters on the same row show difference at $p<0.05$. "a" represents the highest value, and "d" represents the lowest values. Price (at the time of study) per kg of TMR=IDR 2900, KOROPASS=IDR 7000, Beef cattle=IDR 46,000 (price per kg live weight). DM=Dry matter, OM=Organic matter, TP=Total protein, IOFC=Income over feed cost, TMR=Total mixed ration, IDR=Indonesian rupiah (Indonesian currency), SEM=Standard error of the mean

the supply of nitrogen to rumen microbes and support the findings of an earlier [15].

Dietary supplementation of KOROPASS significantly increased ($p<0.05$) the metabolizable protein of cattle (Table-2). Theoretically, the metabolizable protein is the total amount of protein available for digestion in the post-rumen digestive tract, which includes feed protein that escaped rumen degradation as well as microbial protein (bacterial biomass) [16]. Therefore, the increased metabolizable protein in the cattle fed on KOROPASS supplemented feed might be contributed by the increased microbial protein (bacterial biomass) as well as protein from the KOROPASS escaping from rumen fermentation.

KOROPASS supplemented TMR significantly increased ($p<0.05$) the average daily weight gain of beef cattle (Table-2). The results imply that KOROPASS supplementation increased tissue biosynthesis in beef cattle. Several factors may contribute to the improved daily gain, such as the increased consumption and digestibility of DM, OM, and protein. Furthermore, the increased metabolizable protein is likely to increase the growth performance of cattle. Protein is the most important nutrient for tissue biosynthesis. Thus, the increased intake and digestibility of protein is expected to positively affect the daily gain of cattle [13,17]. Energy is another factor that may determine the rate of growth of cattle [18]. The increases in DM and OM consumption and digestibility in the KOROPASS treated cattle could be attributed to the increased energy supply for growth.

Dietary supplementation of KOROPASS was associated with significantly improved ($p<0.05$) feed efficiency of the cattle. In accordance with our findings, Uddin *et al.* [13] documented that protein supplementation may have been associated with increased nutrient utilization and growth and thus improved feed efficiency of cattle.

IOFC is used to evaluate the profitability and sustainability of cattle farms. In the present study, dietary supplementation with KOROPASS, especially at 9%, resulted in a significantly higher ($p<0.05$) IOFC value of the cattle. The measured parameters convincingly demonstrated that RPP derived from KOROPASS increased feed utilization and efficiency, as well as growth performance of cattle. Jack bean is abundantly available in Indonesia. However, it remains underutilized and unexplored as an affordable feed component for cattle. Given its' relatively low price and high nutritional value, the use of extruded jack bean as an RPP source is an attractive option to improve the IOFC of cattle farms.

Conclusion

Dietary supplementation of KOROPASS jack bean-based RPP improved feed utility, as reflected by the increased consumption and digestibility of DM, OM, and TP, and improved feed efficiency, growth, and economic performance of beef cattle.

Authors' Contributions

BWHEP designed, carried out the experiment, and drafted the manuscript; AS and WW carried out the *in vivo* experiment, conducted data analysis, and revised the manuscript. All authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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Bambang Waluyo Hadi Eko Prasetiyono, Agung Subrata and Widiyanto Widiyanto

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