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Growth and economic value of goat rations supplemented with ground corn gelatinization product with urea

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Abstract

The aim of this study was to evaluate the growth of goats and the economic value of rations by using ground corn gelatinization products with urea as slow-release urea in ration supplements. The experiment was conducted on twelve male local goats, aged 1-1.5 years with a body weight of 12.839 ± 0.496kg. The ration was prepared with a 60:40 ratio of forage to concentrate. The basal feed was made of Gamal leaves, while the concentrate consisted of soybean meal, ground corn, rice bran, coconut meal, and ground corn gelatinization product with urea. The experimental method used in this study was a 4x3 completely randomized design (CRD) with four treatments. The treatments applied were T0 (control), T1, T2, and T3. T0 was the basal feed + concentrate without ground corn gelatinization product with urea, while T1, T2, and T3 were the basal feed + concentrate with 1.5%, 2.5%, and 3.75% ground corn gelatinization product with urea, respectively. The data collected were statistically analyzed using analysis of variance and Duncan's multiple range test. The results showed that the treatment had a significant effect ($P < 0.05$) on total dry matter consumption, ration utilization efficiency, and economic value of rations. In conclusion, the study found that the use of ground corn gelatinization products with urea is a viable option for enhancing the quality of goat rations.

Keywords: Economic Value; Goat; Ground Corn; Growth; Slow-Release Urea

1. Introduction

The use of protein source feed as a supplement to the ration of ruminants such as goats is economically very expensive and inefficient in terms of the importance of its utilization. Feed resources for livestock in the tropics generally come from natural pastures and are available from low-quality grasses that are in limited supply during the dry season [1], while feeding grass forages, leaves, and concentrates with low nutritional value cannot always meet the nutritional needs of ruminants. According to Beigh et al. [2], effective utilization of available feed resources is key to economic livestock rearing, and with approximately 70% of the cost input for feed in the production system, optimal metabolism, and digestion are important for an efficient and economical production system [3]. Therefore, improving feed-to-milk or meat conversion efficiency can significantly impact the profitability of ruminant rearing [4]. However, while improving production efficiency remains a key objective of all livestock enterprises, feed costs and animal performance need to be assessed independently of market prices to provide benefits not only for producers but also for animal welfare and the environment.

Urea is known to be utilized as a source of nitrogen supplement ruminant rations. Urea is a simple compound that contains 46.7 percent nitrogen while protein source feed generally contains 16 percent protein. Therefore, according to Panday [5], since protein from feed crops such as soybean meal is expensive, it is economically better to use urea as a protein supplement in ruminant diets. Urea is known to be very quickly broken down/hydrolyzed in the rumen into

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ammonia and carbon dioxide and the speed of this breakdown cannot be matched by its utilization by rumen microbes, resulting in inefficiency for ruminants when compared to the utilization of pure protein sources [6] and potentially toxic to livestock. The speed at which urea dissolves in the rumen and the slow utilization of ammonia (NH3) by microbes, leads to the accumulation and absorption of ammonia and much is lost through excretion in the urine [7]. Based on this phenomenon, it is necessary to slow down the rate of ammonia release from the breakdown of urea by combining urea with carbohydrate source feed such as corn through cooking methods. Through the cooking process, gelatinization of feed carbohydrate sources will occur, making it easier for urea to penetrate carbohydrates and combine to produce a product that slows the release of ammonia in the rumen. According to Sutardi [8], cooking cassava flour with urea in a "pressure cooker" can prevent the accumulation of NH3 in the rumen.

Urea is an intermolecular hydrogen bond breaking agent, capable of disrupting intermolecular bonds in starch molecules [9]. According to Hristov et al. [10] and Heldt et al. [11] synchronization of carbohydrate (CHO) degradation rate with N availability is one of several factors that regulate NH3 utilization to increase microbial protein synthesis in the rumen. The results of Jittakot [12] showed that the utilization of urea in the ration can increase milk production by combining starch with urea gelatinized in an extruder cooker. Starch is the main component of cereal grains, so processing methods can improve starch utilization in the digestive tract and increase energy utilization by livestock [13].

The hypothesis built from this study is that there will be an increase in economic revenue received from the growth of goats due to the use of ground corn gelatinization products with urea in the ration. Based on this, a study was conducted to evaluate the impact of using ground corn gelatinization products with urea in supplement rations on the growth and economic value of goat rations.

2. Materials and Methods

2.1. Research Materials

A total of 12 (twelve) male local goats, aged 1-1.5 years with a body weight of 12.839 ± 0.496kg were used as experimental animals. The animals were housed in individual pens measuring 0.90 x 0.40 m equipped with food and water containers. The ration was prepared with a forage: concentrate ratio of 60:40. Forage used as basal feed was Gamal leaves. The concentrate consisted of soybean meal, ground corn, rice bran, coconut meal, and ground corn gelatinization product with urea.

2.2. Research Procedure

The product gelatinized ground corn with urea was made by mixing ground corn with urea, where the amount of urea was 3% of the amount of ground corn. The mixture was cooked in an autoclave at 136^0 C, 186 kPa pressure for 30 minutes. The moisture content of the blended material is 50-60 percent. The ration was prepared iso-protein to meet the goat's requirement of 12% crude protein [14]. All feed ingredients were analyzed for nutrient content before the study. Drinking water was given ad libitum. Ration feeding for livestock was carried out in the morning by organizing the feeding as follows: concentrate feed according to the treatment of each animal was given first as much as 50% of the amount rationed, followed by the provision of forage Gamal ad libitum. In the afternoon, the remaining 50% concentrate was given to each goat according to the treatment. The gamal forage given was weighed and the rest was to get gamal consumption. The amount of concentrate was given according to the treatment. Total consumption is a combination of Gamal and concentrate consumption. Weighing of goats was done every week to obtain body weight changes. The price of feed ingredients and the live weight of goats prevailing at the time of the study were used to obtain the economic value of the ration.

2.3. Application of Treatment

The experimental method used in this study with the experimental design used was a 4x3 completely randomized design (CRD). The treatment applied was the use of ground corn gelatinization product with urea in concentrate feed. The basal feed was Gamal leaves *(Gliricidia sepium*). The treatments applied were T0 basal feed + concentrate without ground corn gelatinization product with urea (control), and T1 basal feed + concentrate with 1.5% ground corn gelatinization product with urea. T2 basal feed + concentrate with 2.5% ground corn gelatinization product with urea, and T3 basal feed + concentrate with 3.75% ground corn gelatinization product with urea.

The composition of the research ration according to the treatment is listed in Table 1 and the nutrient content of the feed is listed in Table 2.

Table 1 Composition of research feed ingredients according to treatment

Feed Ingredients	T0	T1	T2	T3
Gamal forage	60	60	60	60
Soybean meal	5	3.75	2.5	1.25
Rice bran	21	17	13	9
Ground corn	12	14	16	18
Coconut meal	2	4	6	8
Ground corn gelatinization product with urea	0	1.25	2.5	3.75
Sum	100	100	100	100

Table 2 Nutrient content of research feed ingredients (%)

Feed Ingredients	Dry Matter	Ash	Crude Protein	Crude Fiber	Ether Extract	NFE
Gamal forage	17.50	8.15	12.23	16.12	5.62	55.99
Soybean meal	85.31	1.02	8.2	4.66	4.08	67.35
Rice bran	89.80	5.74	42	5.50	5.74	30.82
Ground corn	85.80	6.69	25.5	3.29	29.47	20.85
Coconut meal	82.44	9.2	7.37	8.40	7.6	49.8
Ground corn gelatinization product with urea	87.06	1.13	9.68	3.74	2.37	70.14

2.4. Response Variables

The measured response variables include:

- Ration dry matter consumption
- Body weight gain.
- Efficiency of ration utilization
- Income Over Feed Cost (IOFC), is the income earned after deducting feed costs. IOFC measures how much additional income can be generated from feed costs. Variables are measured according to the equation Bailey et al. [15]:

$$IOFC = PLW \times ADG\text{-}DFC,$$

where: IOFC = income over feed cost

PLW = farm-gate price of live weight of goat (IDR/kg)
ADG = Average daily gain
DFC = daily feed cost (IDR/kg)

2.5. Data Analysis

The research data were tabulated and analyzed statistically using analysis of variance (ANOVA) according to a complete randomized design to determine the effect of treatment on the measured variables. If there was an effect of treatment, further tests were conducted using Duncan's multiple-range test [16].

3. Results and Discussion

Data on the growth response of research goats to the treatment of the use of urea-milled corn gelatinization products in concentrate feed are listed in Table 3.

Table 3 Average Dry Matter Consumption, Body Weight Gain, and Ration Use Efficiency of Goats Due to the Use of Ground Corn Gelatinized Products with Urea.

Variable Response	Treatments			
	T0	T1	T2	T3
Gamal consumption, g/h/d	266.71±14.07^{b}	269.69±15.35^{b}	293.70±3.36^{a}	255.67±8.96^{b}
Concentrate consumption,g/h/d	173.37	171.51	174.29	174.76
Total dry matter consumption, g/h/d	440.08±14.07^{b}	441.20±15.36^{b}	467.99±3.56^{a}	430.43±8.97^{b}
Initial Body Weight, kg	13.28±1.37	13.23±0.93	12.63±1.55	12.23±2.06
Final Body Weight, kg	17.57±1.65	17.98±0.47	18.32±1.90	16.15±1.99
Body Weight Gain, g/h/d	77.50±7.12^{b}	79.17±13.41^{ab}	94.72±10.55^{a}	65.28±1.74^{b}
Feed Efficiency	5.73±0.45^{ab}	5.62±0.74^{b}	4.91±0.52^{b}	6.60±0.19^{a}

3.1. Dry matter consumption

Gamal consumption due to supplementation with urea-ground corn gelatinized product instead of soybean meal increased linearly as the gelatinized product was increased to 2.5% in the concentrate, but decreased when the gelatinized product was increased to 3.75%. It is assumed that protein and energy sufficiency reached a maximum at the level of using 2.5% of the gelatinized product. Goats are natural browsers and eat mostly bushes and trees as their main feed [17]. The results of statistical tests showed that the treatment had a significant effect ($P < 0.05$) on the consumption of Gamal forage. Duncan test results showed that the level of use of ground corn gelatinization product with urea in concentrate did not differ between the control treatment and the use of 1.25% (T1) and 3.75% (T3). The treatment using 2.5% (T2) showed the highest consumption of Gamal forage and was significantly ($P<0.05$) higher than the other treatments.

The total dry matter consumption of the study goats showed the same trend as the forage consumption. In general, it is observed that the product of gelatinized ground corn with urea can replace soybean meal in concentrates used as a supplement to goat rations. According to Benedetti et al. [18], the use of slow-release urea (SRU) can improve the synchronization of energy and NH3-N in the rumen, leading to better efficiency of rumen microbial growth. Good rumen microbial growth will improve the digestive process and ration utilization to increase livestock production. The product of gelatinization of ground corn with urea as a source of N and energy after degradation in the rumen plays a role in providing N-NH3 for rumen microbes as a nitrogen source for amino acid synthesis. The average dry matter consumption per head per day for the whole livestock was 444.926±16.12 g/h/d. Dry matter consumption of this ration reached 2.93% of the body weight of the research goats. According to Kearl [19], the dry matter consumption of young goats can reach 3-4% of body weight.

The results of statistical tests showed that the treatment had a significant effect ($P < 0.05$) on the total dry matter consumption of the ration. This harmony in providing nitrogen and energy from gelatinization products will increase the activity of rumen microbes digesting feed because it is sufficient for the nutrients, especially ammonia needed. This is as stated by Stiles et al. [20] that cooked starch will release energy and carbon skeletons at the same time as urea hydrolysis and the synchronous release rate will result in optimal ammonia utilization by rumen microbes. The same thing was also stated by Highstreet et al. [7], that feed sources containing slow-release NPN such as this gelatinized product can improve energy balance in ruminants. Dry matter consumption in this study was different from that reported by Sevim and Önol [21] who fed SRU plus non-structural carbohydrates. It is suspected that the use of different quality basal diets affected the results obtained.

Goats treated with the use of ground corn gelatinization product with urea at 2.5% (T2) had significantly ($P<0.05$) higher consumption of total dry matter in the ration than those treated with 1.25% and 3.75%. When associated with the replacement of pure protein sources, the use of slow-release urea products can replace soybean meal in the ration

without affecting the growth performance of beef cattle or milk production of dairy cows [22];[23]. In this study, the product of gelatinized ground corn with urea can replace soybean meal up to 50% in concentrate feed.

3.2. Body Weight Gain and Ration Efficiency

The results of statistical tests showed that the treatment had a significant effect ($P < 0.05$) on the body weight gain of the research goats. The same range of initial body weight of the research animals, at the final weight there are differences due to the application of the use of ground corn gelatinization products with urea as slow-release urea in concentrate feed as a supplement for goats.

Utilization of slow-release urea degradation products increased body weight gain of goats up to the level of 2.5% in concentrate feed. The results of this study are similar to those reported by Paengkoum and Bunnakit [24] in cattle fed a slow-release urea product (caspurea) as a substitute for soybean meal up to 50%. The use of gelatinized products up to 3.75% resulted in decreased body weight gain. According to Goulart et al. [25], slow-release urea can effectively increase the utilization of nitrogen degradation by rumen microorganisms and improve the ability of rumen microbes to synthesize protein. Meanwhile, according to Calsamiglia et al. [26], the absence of synchronization between NH3 production in the rumen and the availability of fermentable energy can hurt microbial protein synthesis efficiency. Microbial protein is known to be the main source of protein for ruminant growth. Paengkoum and Bunnakit [24] reported research in cattle fed a slow-release urea product (caspurea) as a substitute for soybean meal in concentrate feed resulting in an increase in body weight up to 50% replacement of soybean meal. Even Uhi [27] obtained an increase in sheep body weight gain of 40 g/e/h when given a 30% catalytic supplement (98% sago gelatin + 2%ammonium sulfate + 0.2 ppm CO + 35 ppm ZN) compared to soybean meal supplementation.

Ration use efficiency was significantly ($P<0.05$) influenced by the treatment of using concentrate feed containing ground corn gelatinization products with urea as a supplement to goat rations. The treatment of using ground corn gelatinization product with urea at 2.5% (T2) was the most efficient. Ration use became more efficient with increasing portions of ground corn gelatinization product with urea. An extensive literature review has demonstrated the efficacy of SRU as a source of NPN that enhances rumen N capture efficiency, microbial protein synthesis, fiber digestion, and thereby improving ruminant milk and meat production [28].

In this study, the efficiency of ration use increased with increasing portions of gelatinized products in the ration, According to the report of Salami et al. [29] there was a 3% increase in feed efficiency with the replacement of SRU with pure protein sources in the ration of dairy cows, where consumption decreased but milk production increased. The simulation analysis of Salami et al. [30] showed that the use of slow-release urea can increase weight gain and feed efficiency in beef cattle and improve economic and environmental impacts on beef cattle production. Although the amount of this gelatinization product in the ration is small, it is very beneficial for increasing animal weight gain, as stated by Guo et al. [31]. The results of this study are also in line with a recent meta-analysis study which showed that partial replacement of plant protein sources with slow-release urea in rations improved the production performance of growing and finished beef cattle [30].

3.3. Income Over Feed Cost (IOFC)

IOFC is a gross margin concept that can be used as an early indicator of whether a fattening operation is feasible in the short term [32]. The average concentrate ration consumption of goats is shown in Table 4 and the average IOFC value obtained in each treatment using ground corn gelatinization product with urea is listed in Table 5.

Table 4 Average Concentrate Ration Consumption of Goats (in Dry matter)

Treatments	Ration Consumption (kg/h/d)						
	Gamal	Soybean meal	Rice bran	Coconut meal	Ground corn	Gelatinization of milled corn-urea	DM Total
T0	0.2670	0.0231	0.0889	0.0088	0.0526	0	0.442
T1	0.2697	0.0173	0.0720	0.0176	0.0613	0.0033	0.438
T2	0.2937	0.0115	0.0550	0.0026	0.0701	0.0112	0.462
T3	0.2557	0.0058	0.0381	0.0353	0.0789	0.0168	0.430

Table 5 Average Income Over Feed Cost (IOFC) value of research goats

Treatments	DM Total	Total feed (IDR/h/d)	Daily gain (Kg/h/d)	Daily gain value (IDR)	IOFC (IDR/h/d)
T0	0.442	1357.51	0.078	1937.5	**579.99[b]**
T1	0.438	1380.02	0.079	1979.2	**599.14[b]**
T2	0.462	1279.74	0.095	2368.3	**1088.59[a]**
T3	0.430	1358.35	0.065	1631.7	**273.32[b]**

Description: Price of feed ingredients: Gamal = IDR 1500/kg; soybean meal = IDR 15000/kg; rice bran = IDR 3500/kg; coconut meal = IDR 6000/kg; milled corn = IDR 5500/kg; milled corn-urea = IDR 6500/kg; goat selling price = IDR 25000/kg live weight; Different superscripts in the IOFC column indicate significant differences (P<0.05) after tested with Duncan's multiple range test.

The economic value of rations to produce body weight gain of research goats can be predicted from the efficiency of ration use, but through the calculation of IOFC, it can be known how much the actual costs must be incurred by deducting the cost of feed with the selling value of goats per live weight prevailing in the market at that time.

In this study, the IOFC value increased as the amount of gelatinized product in concentrate feed increased as a supplement to the goats' ration. The highest IOFC value based on the prevailing price at the time of the study of IDR 199088.59/h/d, achieved by goats treated with 2.5% gelatinized product (T2) in concentrate feed showed the highest body weight gain with the lowest total feed usage value among the treatments.

Providing rations with good quality (T2) causes an increase in feed costs, but results in higher body weight gain so that the income earned increases. When compared with goats that received 5% soybean meal in concentrate (T0), the increase in IOFC value in the T2 treatment reached IDR 508.60/h/d. The use of ground corn gelatinization product with urea at 1.25% (T1) and 3.75% (T3) IOFC value is not different from the use of 5% soybean meal. The results of this study are those obtained by Uhi [27] that the use of catalytic supplements at 20% in sheep rations received an IOFC value of IDR 838/h/d higher than sheep that received soybean meal as a supplement in their rations (IDR 573/h/d). With the increasing price of soybean meal, the use of slow-release urea as a substitute for protein sources in goat rations needs to be considered because it produces a favorable IOFC value, according to the opinion of Whitelaw et al. [33] and Wanapat and Wachirapakorn [34]. Tyagi et al. [35] concluded from their review on the use of slow-release urea that this product can be useful for ruminants and can be applied in practical animal feeding.

4. Conclusions

The use of ground corn gelatinization product with urea as a slow-release urea product in concentrate rations up to 2.5% or replacing soybean meal by 50% can improve growth, ration efficiency, and economic value of local goat rations.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of Ethical Approval

The present research work does not contain any studies performed on animal/human subjects by any of the authors.

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