ACACIA PODS *(Samanea saman)* AS A SUBSTITUTE FOR CONCENTRATE ON GROWING AND LACTATING GOATS

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ABSTRACT

An experiment to assess the potential of acacia pods (AP) as a substitute for commercial concentrate (CC) on the production performance of growing and lactating goats was conducted. The aim was to investigate the probability of minimizing the cost of feeding goats with CC by using non-conventional feed resources. Fifteen (15) mixed-sex, upgraded growing goats with an average weight of 12±1.5kg and 12 upgraded, multiparous lactating goats on their 4th month of lactation were randomly assigned to the treatment diets containing 0%, 50% and 100% AP in the concentrate portion of a ration containing 70% roughage and 30% concentrate. Proximate analysis revealed that AP contained 90.28% dry matter (DM), 14.05% crude protein (CP), 2.23% ether extract (EE), 14.23% crude fiber (CF) and 65.83% nitrogen-free extract (NFE). Growing goats fed with 50% AP performed better in terms of final body weight, gain in weight, average daily gain and feed conversion efficiency. The average milk production per day appeared to have highly significant results (*P*<0.01), where, 0% AP had the highest average milk production of 646.11 liters. The highest net income was obtained in growing goats fed with 50% AP due to a significant (*P*<0.05) increase in body weight, while 0% AP in lactating goats had the highest net income due to the increase in milk production. It was, therefore, concluded that 50% AP in the concentrate diet could be used to significantly minimize the cost of feeding growing goats with CC. However, substituting AP in the diets of lactating goats had negative effects on their milk performance that reduced net income.

Keywords: acacia pods, proximate analysis, growth performance, milk production

INTRODUCTION

The major constraint of ruminant production in the tropical region is the scarcity of quality feeds during the dry season; mainly due to the seasonality of quality forages. This condition demands the search for inexpensive and locally accessible unconventional feedstuff which should be nutritious, safe, and insignificant in human diets (Ademosun, 1985; Topps, 1992).

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Multi-purpose trees such as acacia species (as well as their pods) have been reported to be a viable alternative feed supplement for goats that would benefit smallholder farmers (Jetana *et al*., 2012) but they required processing to decrease the amount of tannins in them (Mokoboki *et al*., 2005). Tannin has been described to establish a fusion with proteins in the rumen making them indigestible (Robins and Brooker, 2005). Processing acacia species in various ways, such as soaking pods in polyethylene glycol (PEG) (Rubanza *et al*., 2003), boiling pods in water (Mlambo *et al*., 2001), adding charcoal to pods (Poage *et al*., 2000), crushing and saturating pods in wood ash (NaOH) or ammonia solutions (NH3) (Sikosana *et al*., 2002) or by sun-drying (Mlambo *et al*., 2001) can significantly lower their tannin content.

Acacia pods (AP) were ground and substituted for the concentrate feed in the diets of growing and lactating goats in this experiment. Acacia pods were sun-dried for seven days (a comparably safer and inexpensive method). The purpose of the study was to look into the nutritional benefits of acacia pods and their effect on the growth, milk yield, and milk components of goats.

MATERIALS AND METHODS

The experiment was conducted in the experimental area unit of the Small Ruminant Center of Central Luzon State University (CLSU), Science City of Muñoz, Nueva Ecija. It is located in the northern part of Nueva Ecija on latitude N 15˚ 44.2105' and longitude E 120˚ 56.0386 of 72 meters above sea level. Rain falls throughout the year in the Science City of Muñoz, wherein the month with the most rain is in August, with an average rainfall of 15.4 inches. The hot season lasts for 1.7 months, from April to May, with an average daily high temperature above 9˚F. The cool season lasts for 2.5 months, from November to February, with an average daily high temperature below 87˚F.

Samples of feeds formulated with sun-dried AP to replace CC at 0-100% levels were collected and chemically analyzed to determine their dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash content using AOAC (2002) method. Acid detergent fiber (ADF) and neutral detergent fibers (NDF) were determined by the method of Van Soest and Robertson (1988).

Fifteen (15) upgraded growing goats with an average weight of 12±1.5 kg of mixed sexes at five months of age were distributed over three treatments and replicated five times following a completely randomized design (CRD). Meanwhile, 12 upgraded, multiparous lactating goats, on their fourth month of lactation, were randomly assigned to three dietary treatments with four replications per treatment and one animal per replicate following the method of completely randomized design (CRD).

The animals were given prophylactic treatments against endo-parasites, ectoparasites and bacterial infections seven days before the commencement of the experiment. They were dewormed with Albendazole® to control endo-parasites at 3ml/10kg body weight (BW) repeated after 2 weeks, Ivomectin (Ivomec®) to control ecto-parasites at 0.5ml/25kg BW given subcutaneously and long-acting antibiotics (Tridox®) oxy-tetracycline injection to control bacteria at 1.0ml/10kg BW given intramuscularly and repeated after 3 days.

The animals were individually penned and the amount of feed to be given was based on the animal's body weight following the nutrient requirement of Kearl (1982). The DM requirement of goats was computed based on 3% of the animal's body weight. Seventy percent of the DM requirement of the animals was given as a basal diet of corn silage in all of the treatments and 30% was given as a supplement. The dietary treatments in the supplement portion of the diet were as follows:

T1 – 100% Commercial Concentrate
T2 – 50% Commercial Concentrate + 50% Acacia pods
T3 – 100% Acacia pods

Acacia pods were ground to pass through a 1 mm screen mesh using a hammer mill after sun-drying for seven days following the processing procedure of Uguru *et al*. (2014). Mixed acacia pods and a commercial concentrate (CC) diet were offered twice daily, at 6:00 in the morning before corn silage feeding and 5:00 in the afternoon after feeding with corn silage. Fresh water was made available at all times. Each treatment had a seven-day adjustment period prior to the collection of data and samples for analysis. Feed refusal was weighed before feeding the following day and the feeding trial lasted for 90 days. Data on feed intake, weekly live weight of animals and samples of feeds offered were collected and recorded for chemical and statistical analysis. The data were summarized and the analysis was done using ANOVA (SAS/STAT®, SAS Institute Inc., USA). Significant difference of means was carried out using Tukey's comparison of means HSD.

RESULTS

Table 1 shows the findings of the proximate analysis of the feedstuffs used in the study. The amount of DM of corn silage (CS), AP and CC were 29.37%, 90.28%, and 89.79%, respectively. The amounts of crude protein (CP) of AP and CC were more than twice that of CS at 14.05% and 18.02%, respectively, compared to 6.26%. The proximate amount of ether extract (EE) was also lower in CS than in AP and CC. However, the crude fiber (CF) content of CS was higher compared to AP and CC. On the other hand, the CF content of AP was higher than that of CC at 14.23% and 10.91% respectively. Nitrogen Free Extract (NFE) content of AP was also higher than that of CC at 65.83% compared to 57.50%.

Table 1. Proximate Analysis of different feeds used in the study.

Parameters	Corn Silage	Acacia Pods	Commercial Concentrate
Dry Matter, %	29.37	90.28	89.79
Crude Protein, %	6.26	14.05	18.02
Ether Extract, %	1.53	2.23	4.66
Crude Fiber, %	27.10	14.23	10.91
Neutral Detergent Fiber, %	16.01	23.27	32.59
Acid Detergent Fiber, %	9.60	19.47	15.52
Nitrogen Free Extract, %	57.51	65.83	57.50
Ash, %	7.59	3.67	8.99

Table 2 shows the dry matter consumption and growth performance of growing goats after 90 days of feeding. The inclusion of AP in the diets of growing goats resulted in a numerical decrease in the DM intake for CS ($P>0.05$). However, when compared to T2 and T1, T3's DM intake for the supplement was significantly higher ($P<0.01$). These resulted in non-significant differences in the total DM intake of goats across the treatments.

On the other hand, the final weight in T2 was comparable to T1 but significantly higher ($P<0.05$) than in T3. Likewise, compared to T1 and T3, the weight growth and ADG in T2 were significantly higher ($P<0.05$). However, in FCE, T1 and T2 had better ($P<0.01$) FCE compared to T3.

The DM intake of corn silage, AP and CC intake of growing goats are summarized in Figure 1. The DM intake for CS in T1 was numerically higher ($P>0.05$) compared to T2 and T3. However, DM intake for supplements was significantly higher in T3 compared to T1 and T2 which resulted in non-significant differences in the total DM intake of goats across the treatments. Results indicate that as the DM intake for supplements increases, the DM intake for CS is numerically decreased ($P>0.05$).

The calculated nutrient intake of growing goats based on their DM intake is summarized in Table 3. The DM intake of growing goats in T1, T2 and T3 were 539.01g, 559.14g and 566.23g, respectively. The CP intake of T2 was numerically higher compared to those in T1 and T3. The amount of EE and ash intake was lower in T3 compared to those in T1 and T2. Meanwhile, CF and NFE intake of T3 was numerically higher compared to those in T1 and T2.

The dry matter intake and milk production performance of lactating goats after 90 days of feeding are presented in Table 4. The DM intake for CS was significantly decreased by the inclusion of AP in the diets of lactating goats ($P<0.01$). DM intake for supplements in T3 was significantly higher ($P<0.01$) compared to T2 and T1. However, total DM intake was comparable ($P>0.05$) across the treatments. Likewise, milk yield was also significantly decreased by the inclusion of AP resulting in significantly higher milk yield in T1 compared

Table 2. Dry matter intake and growth performance of growing goats.

Parameters	**Treatment**			**SEM**
	1	**2**	**3**	
DM Intake, g				
Corn silage	373.17	359.49	334.51	8.27
Supplement**	165.84[c]	199.66[b]	231.72[a]	7.19
Total DM Intake	539.01	559.15	566.23	7.69
Initial wt., kg	12.03	12.16	12.30	0.40
Final wt., kg*	17.88[ab]	20.43[a]	15.92[b]	0.72
Gain in wt., kg**	5.85[b]	8.28[a]	3.62[b]	0.60
ADG, g**	64.98[b]	91.98[a]	40.27[b]	6.68
FCE**	8.81[b]	6.21[b]	15.12[a]	1.25

[abc]mean values having different superscripts in a row differ significantly.
*Significant ($P<0.05$); **Highly Significant ($P<0.01$).
SEM - standard error of the mean; DM - dry matter; ADG - average daily gain; FCE - feed conversion efficiency

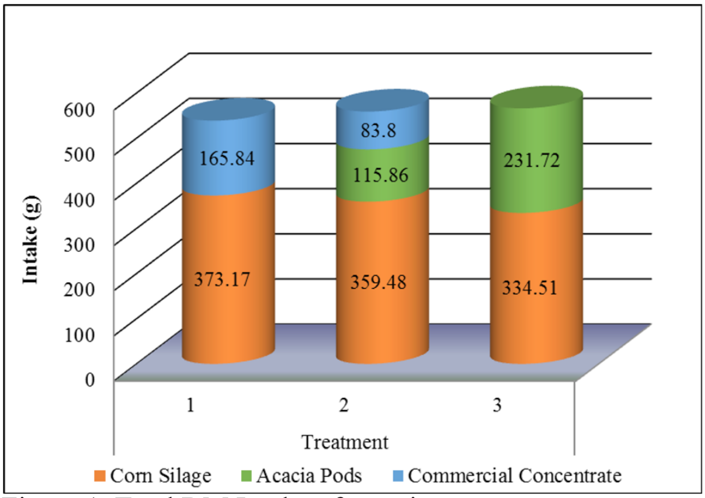

Figure 1. Total DM Intake of growing goats.

Table 3. Calculated nutrient intake of growing goats.

Parameters	Treatment		
	1[1]	2[2]	3[3]
Dry Matter, g	539.01	559.14	566.23
Crude Protein, g	53.26	53.89	53.50
Ether Extract, g	13.44	11.99	10.28
Crude Fiber, g	119.24	123.07	123.64
Neutral Detergent Fiber, g	113.79	111.82	107.48
Acid Detergent Fiber, g	61.56	70.07	77.23
Nitrogen Free Extract, g	309.96	331.18	344.91
Ash, g	43.24	39.07	33.89

[1]Corn Silage + 100% Commercial Concentrate
[2]Corn Silage + 50% Commercial Concentrate + 50% Acacia pods
[3]Corn Silage + 100% Acacia pods

to T2 and T3.

The DM intake of corn silage, AP and CC intake of growing goats are summarized in Figure 2. Dry matter intake for supplements was significantly higher in T3 compared to T1 and T2 (P<0.01). These resulted in non-significant differences in the total DM intake of goats across the treatments. Results indicate that as the DM intake for supplements increases, the DM intake for CS is numerically decreased (P>0.05).

The calculated nutrient intake of growing goats based on their DM intake is summarized in Table 5. The DM intake of growing goats in T1, T2 and T3 were 1,052.78g, 1,083.72g and 1,093.48g, respectively. The CP, EE, and Ash intake of T1 was numerically higher compared to those in T2 and T3. Meanwhile, CF and NFE intake of T3 was numerically higher compared to those in T1 and T2.

Table 4. Dry matter intake and milk production performance of lactating goats.

Parameters	Treatment			SEM
	1	2	3	
DM Intake, (g)				
Corn silage**	594.35[a]	537.22[b]	470.58[c]	18.58
Supplement**	458.43[c]	546.63[b]	622.90[a]	25.20
Total DM Intake	1,052.80	1,083.80	1,095.50	11.38
Total Milk Yield/hd, L**	61.73[a]	43.27[b]	24.57[c]	5.57
Ave. Milk Yield/d, ml**	646.11[a]	455.93[b]	254.81[c]	58.05

[abc]mean values having different superscripts in a row differ significantly using Tukey's HSD test..
**Highly Significant (P<0.01).
SEM - standard error of the mean; DM - dry matter

Table 5. Calculated nutrient intake of lactating goats.

Parameters	Treatment		
	1[1]	2[2]	3[3]
Dry Matter, g	1,052.78	1,083.72	1,093.48
Crude Protein, g	119.84	119.53	116.97
Ether Extract, g	30.45	25.97	21.08
Crude Fiber, g	211.12	215.77	216.19
Neutral Detergent Fiber, g	244.56	234.56	220.29
Acid Detergent Fiber, g	128.21	148.92	166.45
Nitrogen Free Extract, g	605.40	649.59	680.67
Ash, g	86.33	73.03	58.57

[1]Corn Silage + 100% Commercial Concentrate
[2]Corn Silage + 50% Commercial Concentrate + 50% Acacia pods
[3]Corn Silage + 100% Acacia pods

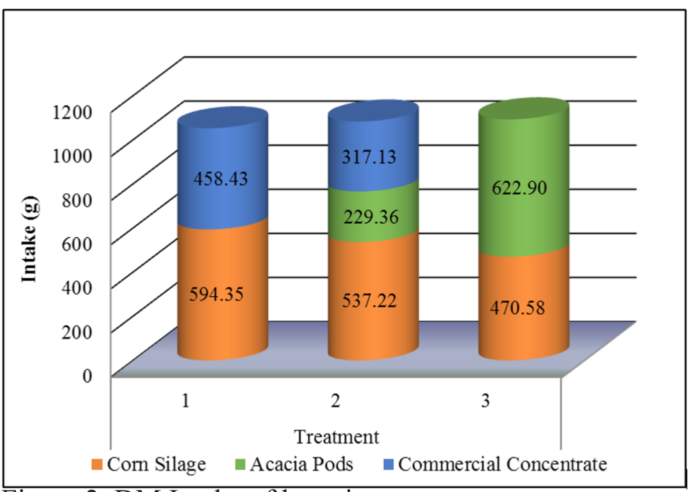

Figure 2. DM Intake of lactating goats.

Table 6 presents the milk components of goats fed with varying levels of sun-dried AP during the 90-day feeding. The different milk components of goats remained similar (*P*>0.05) across the three treatments during the whole experimental period. However, milk components of goats tended to be affected by substituting CC with 30% AP.

Table 7a shows the technical assumption of producing growing goats in the different treatments. This technical assumption is based on the investment plan of the Small Ruminant Center of CLSU. The operating expenses are composed of water, electricity, vitamins, medicine and other miscellaneous expenses. Feeding goats with T1 resulted in a final weight of 17.88 kg after 90 days of feeding, whereas those fed with T2 and T3 had 20.43 kg and 15.92 kg final weight, respectively.

Table 7b shows the cost and return analysis of producing 15 heads of growing goats during the 90-day feeding trial in the different treatments. Feeding goats with T2 resulted in a higher final weight compared to goats fed with T1 and T3. As a result, higher sales of goats during the 90-day feeding trial were recorded in T2.

Table 6. Milk components of goats.

Parameters	Treatment			SEM
	1	2	3	
Milk Fat, %	4.63	3.89	5.47	0.30
SNF, %	8.71	8.60	9.39	0.19
Milk Protein, %	3.20	3.17	3.45	0.07
Milk Solids, %	0.71	0.71	0.77	0.01
Lactose, %	4.80	4.76	5.16	0.10

SEM - standard error of the mean; SNF - solid non-fat

Table 7a. Technical assumption of producing 15 heads of growing goats.

Parameters	Treatment		
	1	2	3
Final weight of growing goat, kg	17.88	20.43	15.92
Price per kg liveweight		₱180.00	
Commercial concentrate feed consumed, kg DM	2.49	1.26	-
Acacia pods consumed, kg DM	-	1.74	3.48
Corn Silage consumed, kg DM	5.60	5.39	5.02
Price per kg of commercial concentrate feed		₱25.61	
Price per kg of acacia pods		₱5.00	
Price per kg DM of corn silage		₱13.64	
Labor cost per month		₱6,000.00	
Operating expenses		₱2,492.85	

Table 7b. Cost and return analysis of producing 15 heads of the growing goat during the 90-day feeding trial.

Parameters	Treatment		
	1	2	3
Income			
Sales of goats during the 90-day feeding trial	₱48,265.20	₱55,171.80	₱42,984.00
Expenses			
Cost of commercial concentrate feed consumed	₱5,733.74	₱2,897.26	-
Cost of dried acacia pods consumed	-	₱782.06	₱1,564.10
Cost of corn silage consumed	₱6,871.59	₱6,619.50	₱6,159.69
Labor cost	₱18,000.00	₱18,000.00	₱18,000.00
Operating cost	₱7,478.55	₱7,478.55	₱7,478.55
Total	₱38,083.88	₱35,777.37	₱33,202.34
Net Income	₱10,181.32	₱19,394.43	₱9,781.66
ROE	26.73%	51.21%	29.46%

For the expenses, the labor cost accounted for 47.26% of the total expenses on T1. Meanwhile, the feed cost and the operating cost of T1 were 33.09% and 19.63% of the total expenses, respectively. For T2, the labor cost accounted for half (50.31%) of the total expenses, while 20.90% and 28.78% of the total expenses accounted for the operating and feed costs, respectively. For T3, more than half (54.21%) of its total expenses are from the labor cost, and the remaining 45.79% was from the operating and labor cost.

The net income was highest on T2 followed by T1 and T3. This was due to the high final weight of the goats in T2 followed by T1 and T3. Thus, an increase in the sales value of goats was incurred. Meanwhile, the %ROE was highest in T2 followed by T3 and T1. This resulted from T2 and T3's lower feed costs when compared to T1.

Table 8a shows the technical assumption of milking 12 heads of lactating goats during the 90-day feeding trial and feeding them with different treatments. This technical assumption is based on the investment plan of the Small Ruminant Center at CLSU. The operating expenses are composed of water, electricity, vitamins, medicine, and other miscellaneous expenses. Feeding goats with T1 resulted in a total milk yield of 61.73L per head after 90 days of feeding, whereas those fed with T2 and T3 had 43.27L and 24.57L total milk yield per head after 90 days of feeding, respectively.

Table 8b shows the cost and return analysis of milking 12 heads of lactating goats during the 90-day feeding trial and feeding them with different treatments. Feeding goats with T1 resulted in a higher total milk yield compared to goats fed with T2 and T3, thus highest sales of milk during the 90-day feeding trial were recorded in T1.

For the expenses, the labor cost accounted for 38.36% of the total expenses on T1. Meanwhile, the feed cost and the operating cost of T1 were 45.69% and 15.94% of the total

Table 8a. Technical assumption of milking 12 heads of lactating goats during the 90-day feeding trial.

Item	**Treatment**		
	1	**2**	**3**
Total milk yield per head for 90 days, L	61.73	43.27	24.57
Price per liter of milk		₱120.00	
Commercial concentrate feed consumed, kg DM	5.50	3.81	-
Acacia pods consumed, kg DM	-	2.75	7.47
Corn silage consumed, kg DM	7.13	6.45	5.65
Price per kg of commercial concentrate feed		₱25.61	
Price per kg of acacia pods		₱5.00	
Price per kg DM of corn silage		₱13.64	
Labor cost per month		₱6,000.00	
Operating expenses		₱2,492.85	

Table 8b. Cost and return analysis of milking 12 heads of lactating goats during the 90-day feeding trial.

Parameters	**Treatment**		
	1	**2**	**3**
Income			
Sales of milk	₱88,891.20	₱62,308.80	₱35,380.80
Expenses			
Cost of Concentrate feed	₱12,679.62	₱8,771.44	
Cost of dried acacia pods consumed		₱1,238.54	₱3,363.66
Cost of corn silage consumed	₱8,755.49	₱7,913.90	₱6,932.21
Labor cost	₱18,000.00	₱18,000.00	₱18,000.00
Production cost	₱7,478.55	₱7,478.55	₱7,478.55
Total	₱46,913.66	₱43,402.42	₱35,774.42
Net Income	₱41,977.54	₱18,906.38	(₱393.62)
ROE	89.48%	43.56%	(1.10%)

expenses, respectively. For T2, the labor cost accounted for 41.47% of the total expenses, while 17.23% and 41.29% of the total expenses accounted for the operating and feed costs, respectively. For T3, half (50.31%) of its total expenses are from the labor cost, and the remaining 49.68% was from the operating and labor cost.

The net income was highest on T1 followed by T2 while T3 incurred a negative net income of ₱393.62. This was due to the high total milk yield of dairy goats in T1. Thus, an increase in the sales value of milk was incurred. Meanwhile, the %ROE was highest in T1 followed by T2 and a negative 1.10% ROE was incurred by T3. Therefore, the lower cost of feeding T2 and T3 to lactating goats did not completely offset the higher overall cost. Consequently, substituting the commercial concentrate feed of goats with AP would decrease its net income and would result in negative ROE.

DISCUSSION

The quality of the ingredient to be used as feed to the animals was determined based on its proximate composition and fiber fraction. Results of the proximate analysis of AP were numerically greater than those of Barcelo and Barcelo's (2012) analysis but did not differ significantly from those of Gerpacio's (1980) analysis. Additionally, AP has high DM and CP content, which makes it a crucial feed component to select when formulating a diet. Barcelo and Barcelo (2012) reported lower values for DM, CP and CF and greater values for ash and EE. The CP content of AP was greater than 10%, showing that it can support medium-level ruminant production. Additionally, AP is a good source of energy for animals and is high in carbohydrates (NFE). The CF concentration, on the other hand, is low, indicating that the majority of carbohydrates are readily absorbed. Hosmani *et al*. (2005) reported a similar chemical composition wherein they showed that AP is comparable to any cereal grain by-products, including deoiled rice bran. In the current study, AP had an ash content of 3.67% However, according to Akintayo (2004), any plant material to be utilized in the feed formulation should have an ash content of less than 2.5%. This suggests that samples with a higher ash content should not be utilized as the only feeding component, but should instead be combined with other ingredients for better outcomes.

NDF and ADF, on the other hand, measured the structural components of plant cells. The NDF values are a reliable indication of forage bulkiness and are used to determine the animals' forage intake (Chitra and Balasubramanian, 2016). As a result, the animal consumes less DM as the value of NDF increases. Whereas, ADF values represent a percentage of the forage that is largely indigestible. An increase in ADF values indicates that forage digestibility and animal nutrition availability have decreased (Chitra and Balasubramanian, 2016). The higher amount of NFE, on the other hand, indicates that AP is high in carbohydrates and can be used as a source of energy. The APs' high levels of DM, protein and energy-rich carbohydrates were determined by chemical analysis, which increases the possibility that they could be used as a component of livestock feed.

The DM intake for CS, in the case of growing goats, did not differ significantly across the treatment though it tended to increase with the inclusion of AP. On the other hand, despite DM intakes for supplements differing significantly between treatments, adding AP to goats' diets did not affect their average daily feed intake of 3% of their BW. It was observed in T3, which had the highest supplement intake, that the DM intake of CS decreased as supplement DM intake increased. This may be related to the substitution effect in DM intake in ruminants fed concentrate and roughage rations. Doyle (1987) noticed a similar pattern and concluded that substitution always happened as supplement consumption increased.

Total replacement of CC with AP resulted in lower final weights of growing goats ($P<0.05$) compared to those fed with T2. However, there was no significant difference between T1 and T2, which had corresponding AP levels of 0% and 50%. FCE of goats fed 100% AP, however, was significantly poorer than that of goats fed 0% and 50% AP. Additionally, goats fed T3 diet had lower (P<0.01) weight and ADG gains than goats fed T1 and T2, which could be the result of high CF intake that may have decreased digestibility. These confirmed the proximate analysis's conclusion that AP may be used as a partial substitute for CC, but it shouldn't be utilized as the only ingredient in feed; rather, it should be combined with other substances for the best outcomes. Shetawi *et al*. (2001), Mousa and El-Shabrawy (2003) and Yousef (2005) observed comparable patterns, reporting that a greater amount of AP inhibited goat weight gain.

Additionally, utilizing AP as the only feeding component in T3 goats resulted in decreased growth rate, which may be related to substances like tannic acid that prevent goats' optimal growth performance (Salem *et al*., 2006). According to Kushwaha *et al*. (2012), the average tannin content of DM AP was 5.5%. On the other hand, growing goats consumed up to 12.74g more tannin when their diets contained a higher percentage of AP (30%). These imply that higher levels of AP may show a decrease in feed digestibility, which was not observed in AP at 15%. As a result, it was discovered that goats' FCE decrease was strongly correlated to their consumption of tannic acid (Raquipo and Angeles, 2012). This shows that despite high voluntary feed intake, growth performance was hindered by anti-nutritional factors and the potential existence of secondary chemicals in AP.

Condensed tannin is one of these antinutritional components that protect plants from breaking down in the rumen. According to Robins and Brooker (2005), they combine with proteins in the rumen and become indigestible. The aforementioned was in agreement with the findings of Salem *et al*. (2006), who stated that feeding ruminants feed containing tannins may result in a decrease in the voluntary intake of nutrients and may also impact the digestion of nutrients (especially protein).

However, no correlation between consumption and the level of polyphenolic metabolites was discovered in several investigations on the acceptability that were conducted with cattle and sheep (Pinto *et al.*, 2005; Sandoval *et al*., 2005). According to Navas *et al.* (2001), the positive effects on animal performance and nutrient use efficiency shown when different animals were supplemented with AP may be related to its impact on the ratio of protein to energy in the nutrients absorbed and the balance between glucogenic and acetogenic short chain fatty acids.

The DM intake for CS and supplement of lactating goats differed significantly across treatments. Supplementation of AP in the diets of lactating goats significantly reduced the DM intake of CS by 9.6% and 20.8% in T2 and T3, respectively. Conversely, DM intake of the supplement was highest in T3 followed by T2 and T1 at 622.9g, 546.63g, and 458.43g, respectively. However, no significant difference was observed in the total DM intake of lactating goats in all treatments. Studies by Stockdale (2000) and Heard *et al*. (2004) reported a replacement effect between the intake of concentrate and roughage and well-documented this association between the DM intake of CS and supplements. Additionally, the substitution impact increased as the quantity of concentrate consumed increased (Ba *et al*., 2008).

On the other hand, T1 reached the highest (P<0.01) total milk yield during the 90-day feeding trial followed by T2 and then T3. These results can be attributed to the increase in CP and EE intake of goats fed with T1. However, these were in contrast to Pamo *et al*. (2006) and Lengarite *et al*. (2012) who observed that adding AP supplements up to 30% of the concentrate component of the diet increased goats' milk yield. The results might be due to the AP's intrinsic traits, which include hard, inedible seeds and a licorice-like flavor. It may also be linked to albuminoid material and tannins, which could inhibit feed nutrient utilization and reduce milk production (Barcelo and Barcelo, 2012).

Though, there were no significant differences (P>0.05) recorded in the milk components, numerically higher milk components of goats fed with T3 were recorded. The average milk protein of goats did not differ significantly across the treatments. Barman and Rai (2008), however, claimed that adding AP enhanced milk protein. Additionally, Harris *et al*. (1998) noted a 10% increase in milk protein concentration with the addition of AP to the diet of the animal. The average milk fat content was 4.630, 3.889, and 5.468 in T1, T2 and T3, respectively. Dubey (2007) also reported that the introduction of 16.7% AP did not affect the fat content of the milk. Similarly, Barman and Rai (2008) observed that 20% AP inclusion did not alter the milk fat content, but 40% AP inclusion resulted in a decrease in milk fat content. The average SNF contents of milk were 8.709%, 8.598% and 9.389% in T1, T2 and T3, respectively, and values remained consistent throughout the whole trial period irrespective of the dietary treatments. The average total solids content in milk was 0.714, 0.711, and 0.766% in T1, T2 and T3, respectively which was consistent throughout the treatment groups. Barman and Rai (2008) and Dubey (2007) found a similar pattern when feeding 4% and 3% of AP, respectively.

The higher sales value of goats in T2 was a reflection of the higher final body weight of goats in T2 compared to goats in T1. Treatment 2 having higher net income compared to T1 in growing goats was mainly due to the increase in their final body weight that reflected the increase in their sales value. Though T3 reduced the cost of feed, its benefit did not offset the decrease in the final body weight of goats that resulted in their decrease in sales value compared to goats in T1.

Meanwhile, T1 had the largest net profit among the lactating goat treatments because it produced more milk than the other treatments. These findings were in contrast to those reported by Jetana *et al*. (2012) who found that substituting CC with AP decreased feed costs per kilogram of milk produced and increased economic efficiency.

The lower level of AP (50%) was consequently determined to be a potential alternative for CC. Additionally, AP could be utilized to enhance the supply of animal protein, drastically lower the high cost associated with feeding goats with conventional sources of protein and increase goat producers' profit margins. However, replacing CC with AP in lactating goats' diets had a detrimental impact on their milk production, which decreased net income.

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