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EFFECT OF TOTAL MIXED FOUNTAIN GRASS PELLETS ON THE GROWTH PERFORMANCE OF GOATS

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ABSTRACT

Purpose: Feed quality is inconsistent throughout the year. The nutrient composition of feed supplies is affected by the transition from wet to dry seasons, which also decreases digestibility. This study evaluated the effect of varying levels *of* fountain grass *hay* total mixed ration (TMR) pellets on the apparent digestibility, growth performance, and blood profile of Djallonké Goats in the Savanna agroecological zone of Ghana.

Design/Methodology/Approach: The experimental treatments were T0 (unpelleted hay), T1 (75% pelleted hay total mixed ration), T2 (50% pelleted hay total mixed ration), and T3 (25% pelleted hay total mixed ration).

Sixteen (16) weaned male Djallonke goats (5.190 kg) were randomly divided into four treatments (four bucks/treatment) using a completely randomised design (CRD). After adaptation for 14 d, the animals were fed for 84 d and 7 d to determine the digestibility coefficient.

Findings: Goats fed total mixed ratio (TMR) hay pellets exhibited significantly higher ($P < 0.05$) dry matter intake (DMI) and digestibility coefficients than those fed unpelleted hay. The average daily gain (ADG) was significantly higher ($P < 0.05$) in T0 and lowest in T3. Haematological and serological parameters did not differ significantly among the treatments ($p>0.05$).

Research Limitation: This study examined the feed intake, nutrient digestibility, growth performance, and blood profile of Djallonké Goats. Its results cannot be generalised to the entire livestock industry.

Practical Implication: Hay pellets could serve as an alternative feed resource for ruminants, reducing production costs and ensuring the sustainability of the animal industry in Ghana.

Social Implication: This study will help address dry season feeding challenges and ensure the sustainability of the livestock industry.

Originality/value: This study highlights the potential of fountain grass hay as an underutilised native pasture that could improve ruminant production in Northern Ghana.

Keywords: *Digestibility. feeding. goat. hay. pellet*

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INTRODUCTION

Ruminants may receive supplemental nutrients; however, pastures remain the main source of nutrition (Ansah & Issaka, 2018; Seglah *et al*., 2020). Tessema et al. (2011) found that the quantity and quality of fodder are being reduced due to overgrazing, inconsistent weather patterns, and changed land use. The ongoing trend of urbanisation is progressively diminishing the availability of grazing areas essential for maintaining small ruminants. Due to the widespread transformation of pastures into agricultural land, these animals have limited access to suitable foraging areas during the wet season (Shang et al., 2014). Throughout the dry period, the nutritional value of accessible grasses in grazing areas deteriorates, which is attributed to elevated ambient temperatures and reduced soil moisture and nutrient levels (Bogunovi *et al*., 2022). This significantly affects the growth of small ruminants. Consequently, this circumstance has necessitated the exploration of alternative feed resources to ensure the sustainable rearing of these animals.

Sustainable small ruminant husbandry relies heavily on effective nutritional strategies. Pelleted total mixed rations (TMR) are beneficial for goats (Pi et al., 2005; Chen et al., 2019) and sheep (Islam et al., 2017). These rations, which incorporate concentrated ingredients with ground hay, enhance feed uniformity, density, and manageability while minimising waste. This approach also ensures a well-balanced nutrient profile and resolves storage and distribution challenges (Li et al., 2021). Despite the importance of pelleting forage in livestock production, research on the effects of graded levels of pelleted fountain grass hay on goat digestibility, blood profile, and growth performance is limited, and most studies have focused on lambs (Blanco et al., 2014; Karimizadeh et al., 2017; Zhong et al., 2018).

Fountain grass (*Pennisetum setaceum*) is a viable alternative because it provides sufficient protein to support ruminant development. In Ghana, a significant quantity of fountain grass is grown naturally in wild areas and is often left unutilised or incinerated annually because of a lack of technological expertise. This is particularly prevalent in the northern region of Ghana, where most ruminant livestock live. Pelleted fountain grass could potentially address the dry season shortage and the escalating costs of feed ingredients, which are either imported or in high demand for human consumption. This study investigated the effects of different pelleted hay total mixed ration (TMR) levels on dry matter intake, nutrient digestibility, growth performance, and blood parameters. These results provide valuable insights for optimising goat feeding strategies and enhancing productivity.

LITERATURE REVIEW

Goats are distributed across various geographical regions of the world (Hamada et al., 2013; Keskin & Kaya, 2010). These animals are essential in meeting the demand for animal-derived

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protein, mainly through meat production in tropical and subtropical areas (Melanie et al., 2012; Barkley et al., 2012). With a population second only to cattle (Ahmed et al., 2018; DLS, 2011), goats are primarily reared for their meat, and their skin is a valuable export product (FAO, 2010). In rural settings, the diet of small ruminants primarily consists of agricultural by-products, low-quality hay, tree foliage, and wild grass (Hassan & Talukder, 2011).

Seasonal changes significantly affect the nutritional value of common grasses, with dry periods yielding higher dry matter (DM) content than rainy seasons (Rashid et al., 2016). However, these feed sources often contain excessive fibre and insufficient protein, energy, minerals, and vitamins, failing to meet the nutritional needs of goats (Huque, 2012). This results in poor digestibility and inadequate feed intake, which leads to suboptimal performance (Sultana et al., 2017). Stall-fed goats demonstrate better growth rates than feedlot goats, reaching target weights more efficiently (Rashid et al., 2016). Concentration feed is often essential to supplement their diet to meet the specific nutritional requirements of goats, primarily browsers and roughage consumers. These concentrates are typically available in two forms: mash and pellets.

Although mash feed is cost-effective, its loose nature may result in selective feeding and nutritional imbalances. Exploring alternative feeding strategies under intensive or stall-feeding conditions is essential to improve profitable goat production in Ghana. Complete pellet feed is a processing method expected to enhance goat production profitability by improving nutrient utilisation from agricultural residues. Moreover, complete pellet feed derived from a total mixed ration ensures balanced nutrition for goats by maintaining appropriate roughage and concentrate ratios. This approach provides uniform feed and minimises waste, enhancing digestibility and palatability (Rashid et al., 2016).

Conversely, pellet feed offers advantages, such as improved nutrient distribution and reduced waste, leading to enhanced feed efficiency and growth performance across various livestock species (Zhang et al., 2019). Concentrated feed can significantly influence growth performance and feed utilisation in goats. Studies have demonstrated that pelleted feeds can enhance feed efficiency, growth rates, and overall health of livestock compared to unpelleted alternatives (Ahmed et al., 2020). Diets in pellet form reduce feed waste and improve nutrient intake, resulting in superior growth performance and feed utilisation (Meara et al., 2020).

According to Fairfield (2003), the benefits of pelleting include minimised ingredient separation, easier handling, enhanced feed flow through machinery, reduced selective feeding by animals, increased density, elimination of harmful microorganisms, and the possibility of lowering formulation costs using alternative ingredients. According to Terrill et al. (2007), converting ground hay into pellets enhances storage, transportation, and feeding capabilities. However, they noted that the heat generated during the pelleting process diminishes biological

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activities. Moreover, pelleting reduces the energy content of diets (Lecznieski et al., 2001). Beigh et al. (2017) asserted that pelleting enables the incorporation of less-appetising roughages or by-products into commercial fattening TMR.

The pelleting technique involves converting a finely ground mixture of components into dense, easily flowing clusters called pellets. Despite the initial and operational costs associated with pelleting, subsequent improvements in animal performance often justify these expenses (Lecznieski et al., 2001).

In developing nations, straw or hay is frequently used as an economical neutral detergent fibre (NDF) source, reducing costs and preventing ruminal acidosis. NDF content, hay particle dimensions, and hay proportion are vital for optimal rumen function (Bodas et al., 2009). Reduced fibre particle size lowers rumen pH, diminishes rumination time, and reduces salivary production.

Studies have demonstrated that pelleting increases apparent metabolisable energy but does not affect amino acid digestibility (Svihus *et al.*, 2005; Roza *et al*., 2018). Findings from Agolisi et al. (2023) indicated that the process of pelleting dried rumen digesta as feed for ruminants led to the absence of *Escherichia coli* and a decrease in the overall microbial count. Smaller dry roughage particles accelerate digestive passage and may partially reduce fibre breakdown (Yansari et al., 2004; Kammes & Allen, 2012). To maximise animal growth, pelleting is the most extensively employed thermal processing method for preparing animal diets (Dozier et al., 2010).

Larger particles adversely affect dry matter intake (DMI) and performance, particularly in fattening animals. Blanco et al. (2014) noted that despite abundant long barley straw in a concentrate-based diet, lambs could not exceed a consumption of 50 g/kg of total dry matter. This underscores the constraints of including straw or hay in the diet of tiny ruminants. Zhang et al. (2019) reported that fattening lambs consuming ground and pelleted hay in total mixed rations (TMR) exhibited increased dietary fibre intake and average daily gain (ADG). Malik et al. (2020) asserted that the quantity of straw in a goat's diet significantly influences an animal's dry matter intake (DMI) and development. Terrill et al. (2007) pelleted S. lespedeza hay as a natural dewormer and observed its enhanced efficacy against parasitic nematodes in goats.

MATERIALS AND METHODS

Experimental Site

The study was conducted from December 2021 to April 2022 at the livestock facility and research laboratory of the Department of Ecological Agriculture at Bolgatanga Technical University, Ghana.

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Experimental Feeds and Laboratory Analysis

Fresh fountain grasses were harvested from the grassland on the campus of Bolgatanga Technical University using sickles and chopped to a length of 3 cm with a straw chopper. The chopped grass was sundried to obtain a moisture content of 20% (a moisture tester was used to measure the moisture content). The hay was milled through a 2 mm sieve using a centrifugal mill (Retseh 200 GmbH, Hann, Germany). The milled hay was mixed with 25, 50, and 75 agro-industrial by-products to obtain a total mixed ration (TMR), as shown in Table 1. All total mixed rations (TMR) were sun-dried to 13% moisture content and stored for the trial. The chemical compositions of the unpelleted hay and TMR pellets were analysed following AOAC (2000) procedures. The Kjeldahl method was used to determine nitrogen, which was then multiplied by 6.25 to calculate crude protein. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were assessed by adding sodium sulfite and alpha-amylase (Van Soest et al., 1991) using an Ankom200 fibre analyser.

Table 1: Experimental ingredients

	Inclusion level (%)			
Ingredients	T0	T1	T2	T3
Maize bran		10	35	60
Cassava peels		5	5	5
Rice bran		6	6	6
Shea nut cake		2.5	2.5	2.5
Hay	100	75	50	25
Premix		1	1	1
Salt		0.5	0.5	0.5
Total	100	100	100	100

T0 (unpelleted hay), T1 (75% hay-pelleted TMR), T2 (50% hay-pelleted TMR), and T3 (25% hay-pelleted TMR)

Goats, Treatment and Feeding Management

Sixteen (16) young male Djallonké goats (3-4 months old, initial body weight 5.190 kg) were randomly allocated to four dietary treatments: T0 (unpelleted hay), T1 (75% hay-pelleted TMR), T2 (50% hay-pelleted TMR), and T3 (25% hay-pelleted TMR), in a Completely Randomised Design (CRD) with four replications. Each animal received a daily ration of 3% body weight (BW) weekly. The diets comprised a 70:30 mixture (70% rice straw and 30% hay/TMR). Hay/TMR pellets and rice straw were administered at 7:00 and 4:00 p.m. The animals were housed individually in enclosures with concrete floors, rice husk bedding, and ad libitum access to water. The animals were acclimatised for 14 days and fed for 84 days. Daily concentrate and rice straw samples were refrigerated, bulked, and oven-dried (60ºC for 48 h) for dry matter (DM) percentage calculation to estimate the total DM intake. Faeces were collected for five days using faecal bags, with feed and faeces samples analysed for DM and crude protein (CP) to estimate apparent nutritional digestibility.

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Collection of blood for haematological and serum analyses

Blood was drawn from the animals in the morning before they were fed. A sterilised needle and syringe were used to extract 10 ml of blood from the jugular vein. The collected blood was transferred into two bottles: one containing an anticoagulant and the other containing plain bottles without anticoagulants. A 3-part blood analyser was used to perform the full blood count analysis. Blood samples were coagulated and centrifuged at 1000 rpm for 10 min for serological testing. The resulting serum was extracted using a sterile pipette and transferred to separate bottles.

Data Analysis

The data were subjected to statistical analysis of variance utilising GenStat 18.2 edition with the following model: $Yij=\mu+Ti+eij$, where Yij represents the observed variation, μ denotes the population means, Ti signifies the effect of replacement levels i in the diets, and eij represents the error term. Significant differences among the treatment means were assessed using LSD at a 5% significance level using software, as mentioned earlier.

RESULTS

Chemical composition

Table 2 presents the chemical compositions of the experimental diets. No significant differences ($P > 0.05$) were observed in dry matter (DM), which ranged from 95.47% to 96.33%. However, significant differences ($P < 0.05$) were observed in crude protein (CP), neutral detergent fibre (NDF), and acid detergent fibre (ADF). The CP levels varied between 10.07% and 16.61%. NDF content ranged from 44.25% to 69.38%, while ADF values ranged from 13.47% to 33.62%.

Table 2: Chemical composition of the experimental diets

	Inclusion level (%)					
Parameter (%/gDM)	T0	T1	T2	T3	SED	P. value
Dry matter	96.33	96.13	96.00	95.47	3.11	0.231
Organic matter	86.33^{c}	87.33^{c}	88.67^{b}	91.00^{a}	0.98	0.004
Crude Protein	16.61^{a}	14.62^{b}	10.97^{c}	10.07^{c}	0.01	<.001
Ether Extract	8.440^{c}	8.01^{c}	12.51^{c}	12.03^{b}	0.02	<.001
Ash	13.67^{a}	12.67^{a}	11.33^{b}	9.000^{c}	0.98	0.004
NDF	69.38^{a}	67.33^{a}	51.94^{b}	44.25^{c}	1.22	<.001
ADF	33.62^{a}	29.68^{a}	19.16^{ab}	13.47^{b}	3.38	0.038

NDF = neutral detergent fibre, ADF = acid detergent fibre

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Dry matter intake, digestibility and growth performance

Table 3 presents the effects of feeding young goat hay and varying levels of pelleted hay TMR on feed intake, digestibility, and growth performance. Dry matter intake exhibited significant variation among dietary groups ($p < 0.001$), with goats on T3 demonstrating higher DMI ($P < 0.05$) than those on T0 (unpelleted hay). Crude protein intake (CPI g/d) also differed significantly ($P < 0.001$), ranging from 26.69% to 35.15%/g DM, with T0 having the highest and T3 the lowest crude protein (CPI). Digestible Dry matter (DMD), digestible crude protein (DCP), neutral detergent fibre, and acid detergent fibre digestibility were significantly different across the dietary treatments ($P < 0.05$). The initial body weights were similar across all treatments, and the final live weight and body weight gain did not differ significantly ($P > 0.05$). However, the average daily gain (ADG) exhibited was significantly different. The feed conversion ratio (FCR) remained statistically unchanged among the treatments ($P < 0.05$).

Table 3: Feed intake, nutrient digestibility and growth performance of goats

	Inclusion level (%)					
Parameter (%/gDM)	T0	T1	T2	T3	SED	P. value
DMI(g/h/d)	299.0^{b}	301.9^{b}	315.1^{a}	316.0^{a}	0.011	<.001
CPI (g/h/d)	35.15^{a}	28.01^{b}	26.67	26.29^{c}	0.020	<.001
Digestible DM	0.701	0.720	0.750	0.780	0.981	0.004
Digestible CP	0.691^{c}	0.722^{b}	0.73^{b}	0.78^{a}	1.39	0.002
Digestible NDF	0.528^{a}	0.563^{a}	0.601^{b}	0.651^{c}	1.02	<.001
Digestible ADF	0.521^{d}	0.548^{c}	0.581^{b}	0.617^{a}	1.38	0.005
Initial body weight (kg)	5.240	5.220	5.160	5.130	0.610	0.401
Final weight (kg)	9.840	9.450	9.330c	9.430	0.980	0.112
Body weight change (kg)	4.600	4.230	4.200	4.100	0.330	0.150
Average daily gain (g)	53.46^{a}	50.36^{ab}	50.00^{ab}	48.81^{b}	6.860	0.040
FCR (gDMI/gADG)	5.591^{b}	5.995^{a}	6.302^{a}	6.474^{a}	0.345	0.081

DMI = dry matter intake, CPI = crude protein intake, DM = dry matter, CP = crude protein ADG = average daily gain

Haematology and serum profile

The blood profile parameters for all goats fed unpelleted hay and graded levels of pelleted hay TMR did not differ significantly among the dietary treatments, except for albumin and total protein levels, which exhibited significant differences ($P < 0.05$). The red blood cell (RBC) count ranged from 3.140 to 3.77, whereas the white blood cell (WBC) count ranged from 3.680 to 4.330. Haemoglobin (Hb) levels ranged from 13.160 to 14.170 g/dl. The dietary treatments resulted in a slight decrease in albumin compared to the T0 dietary treatments, with values ranging from 24.10 to 26.82 g/dL. Total protein (TP) ranged from 60.51 to 75.60 g/dL, with a

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marginal decrease observed in the graded levels of pelleted hay. The 0% DRD diet (T0) exhibited the highest final creatine value, whereas the 5% DRD diet had the lowest value.

Table 4: Haematology and serological parameters of goats

	Inclusion level (%)					
Parameter	T0	T1	T2	T3	SED	P. value
RBC ($x10^9$/l)	4.142	4.140	4.670	4.770	0.800	0.574
WBC ($x10^9$/l)	4.680	4.220	4.330	4.910	1.261	0.900
Haemoglobin (g/dl)	14.17	14.07	13.62	13.16	2.220	0.380
Packed cell volume (%)	11.69	11.69	12.33	10.76	2.920	0.760
Albumin (g/dl)	26.82^a	25.65^{ab}	24.74^b	24.10^b	1.07	0.005
Total Protein (g/dl)	75.60^a	60.92^b	60.51^b	60.60^b	5.62	0.048
Creatine (g/dl)	86.66	85.24	74.72	85.21	31.2	0.235
Blood Urea Nitrogen (mg/dl)	7.57	7.10	7.21	7.12	1.50	0.866

RBCs=
Red blood cells; WBCs= White blood cells; HGB= Haemoglobin, PCV = packed cell volume

DISCUSSION

Dry matter intake, nutrient digestibility coefficients and growth performance

This investigation revealed that pelleting enhanced dry matter intake (DMI) in goats, consistent with earlier research (Papi et al., 2011; Retnani et al., 2022; Malik et al., 2023). The observed increase is linked to larger intake or bite-size owing to higher bulk density (Lailer et al., 2005), reduced gut fill effects, and accelerated passage rate (Zhang et al., 2019).

The superior DMI in pelleted total mixed ration (TMR) compared to unpelleted hay is primarily attributed to the diminished rumen fill response, resulting from smaller particle size and compression in pellet form. Reduced gut-fill effects enable greater intake to achieve satiety (Li et al., 2021). Conversely, the lower DMI in goats consuming unpelleted hay is ascribed to ingesting more fibrous particles, as these animals can selectively consume such particles (Malik et al., 2021).

The study found higher digestibility coefficients for dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), and acid detergent fibre (ADF) in hay-pelleted TMR. Pelleting affected nutrient digestibility coefficients in comparison to unpelleted hay. This outcome contradicts that of Malik et al. (2023), who noted lower nutrient digestibility coefficients for DM, NDF, and ADF when goats were fed total mixed ration hay mash and pelleted total mixed ration. Similarly, Li et al. (2021) reported a slight decrease in the dry matter digestibility coefficient of pelleted TMR.

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The quantity of dry matter and nutrient intake are key factors influencing the growth performance of animals (Malik et al., 2023). The higher average daily gain (ADG) observed in the unpelleted hay was mainly due to increased crude protein intake. Goats fed TMR-pelleted hay exhibited lower ADG than those fed unpelleted hay, which was attributed to lower crude protein intake in pelleted hay TMR. A gradual reduction in the feed conversion ratio (FCR) was observed, although this decrease did not significantly affect the FCR. Malik et al. (2023) reported similar feed efficiency ratios when goats were fed unpelleted hay TMR or pelleted TMR. Li et al. (2021) also noted comparable feed conversion ratios when sheep were fed pelleted and unpelleted TMR.

Haematology and serum profile of Djallonke goat

The comparable concentrations of haematological parameters in goats indicated that the total mixed ration of pelleted hay did not adversely affect their health. Red and white blood cells are critical indicators of feed toxicity (Oyawoye & Ogunkunle, 2004). The observed red blood cell counts fell within the normal range of 4–12 × 109/L, as specified in the Merck Manual (2010) and Research Animal Resources (2009) for goats and sheep. The total white blood cell count values (4.22 to 4.910 x1012/L) were also within the physiological range of 4 to 12 x1012/L recommended by Merck Veterinary Manual (2010). Packed cell volume and haemoglobin values aligned with the normal physiological range for healthy goats, suggesting the effective synthesis of haematological indices across dietary treatments. These parameters are essential for evaluating circulating erythrocytes, diagnosing anaemia, and indicating the bone marrow's capacity for red blood cell production in mammals (Chineke *et al*., 2006). Dietary treatment significantly influenced serological parameters, including plasma total protein and albumin concentrations (mg/dL). However, all values were below the normal range of 29-43 g/dl in goats (Merck et al., 2010). A slight decrease in albumin concentration was observed in the TMR-pelleted hay, with such levels declining in the dietary treatment compared to the unpelleted hay. Serum protein levels differed significantly among dietary treatments but remained within the normal range of 62 – 79 g/dl for goats (Merck, 2010). Blood urea nitrogen levels in the study were within the normal range of 4 – 8.6 g/dL as per the Merck Manual (2010). The generally normal range of serological parameters measured in rams suggests that enzyme secretion was not adversely affected, indicating the potential of TMR hay pellets in goat production.

CONCLUSION

This investigation demonstrates that pelleting total mixed ration (TMR) can enhance dry matter intake in goats by mitigating gut fill effects and increasing passage rates. However, it may not consistently improve the growth performance. The pelleted TMR exhibited higher nutrient digestibility coefficients for dry matter, crude protein, NDF, and ADF than the unpelleted hay.

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Unpelleted hay had a higher average daily gain owing to a greater crude protein intake. Haematological and serological analyses revealed no adverse effects on caprine health.

The utilisation of hay pellets can serve as an alternative feed resource for ruminants, potentially leading to reduced production costs and ensuring the sustainability of the animal industry in Ghana. This study aims to address dry season feeding challenges and contribute to the sustainability of the livestock industry. Furthermore, this study elucidates the potential of Pennisetum setaceum hay as an underutilised native pasture that could enhance ruminant production in Northern Ghana.

Implementing fountain grass hay production offers transformative potential for Northern Ghana's agricultural sector while supporting broader social development goals. This approach addresses immediate agricultural needs while contributing to long-term community sustainability. This research bridges critical knowledge gaps in sustainable livestock management while providing practical solutions for dry season feeding challenges in Northern Ghana.

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