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EFFECT OF DENSIFIED COMPLETE FEED USING *ASYSTASIA GANGETICA* ON FEED INTAKE AND GROWTH PERFORMANCE OF GOAT

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Body weight gain; Chemical composition; Densified complete feed; Feed intake; Physical properties.

ABSTRACT. *Densified complete feed (DCF) combining concentrates and roughages is a potential strategy to meet the nutritional requirements of goats. This study aimed to formulate DCF using Asystasia gangetica and evaluate its effects on feed intake and growth performance in Boer crossbred goats. The DCF was prepared through weighing, grinding, mixing, molding, and drying, producing cubes with an average weight of each DCF cube: 45.1 g, dimensions of 4 cm × 4 cm × 4 cm, and hardness of 1.93 kg/cm². Chemical analysis showed 91.7% dry matter, 18.7% crude protein, 7.3% ether extract, and 13.9% ash. Six female goats (initial body weight 16.6 kg) were used in a 14-day feeding trial. The control group received a conventional concentrate diet with six hours of grazing, while the treatment group was fed DCF ad libitum. Average daily feed intake was higher in the treatment group (672.4 g) than in the control group (217.2 g plus 6 hours of grazing). Although body weight gain did not differ significantly (p > 0.05), goats fed DCF showed a numerical increase in weight gain (433.3 g) compared to the control (133.4 g) during the experimental period. This difference was not statistically significant and should be interpreted as a numerical trend only. These findings suggest that DCF can enhance feed intake and may support growth in goats. However, given the short duration and small sample size, the results should be considered preliminary. Further studies with longer feeding periods and larger sample sizes are recommended to confirm these results.*

INTRODUCTION

The livestock industry is a vital component of global agriculture, encompassing a wide range of species including poultry and ruminants. It plays a crucial role in supporting human livelihoods by providing essential food products such as meat, milk, and eggs, as well as valuable by-products including leather and wool (Zayadi, 2021). With the continuous growth of the human population, the demand for livestock products has increased significantly, placing greater pressure on production systems to improve efficiency and sustainability.

One of the major challenges faced by the livestock sector is the high cost of feed, which accounts for approximately 70% of total production expenses. This economic burden has become a limiting factor for farmers, particularly in developing regions. The reliance on imported feed ingredients further exacerbates the issue, exposing farmers to price volatility and supply uncertainties (Bernama, 2021). To address this challenge, the use of locally available agro-industrial by-products has been suggested as a sustainable and cost-effective alternative for feed formulation (Alqaisi *et al.*, 2017; Rosesyaqirah *et al.*, 2026).

In rural farming systems, crop residues and forages are commonly used to reduce dependence on commercial concentrates. However, these feed resources are often nutritionally imbalanced and may not meet the dietary requirements necessary for optimal animal growth and productivity. As a result, there is a need for innovative feeding strategies that integrate both nutritional adequacy and cost efficiency. One such approach is the development of complete feeds that combine multiple ingredients into a single, balanced ration.

Total Mixed Ration (TMR) is widely used for this purpose, as it incorporates concentrates, forages, and feed additives to ensure consistent nutrient intake and support animal performance (Lee *et al.*, 2021). Despite its effectiveness, TMR is typically produced in mash form, which presents challenges in handling, storage, and transportation, particularly when large quantities are involved. To overcome these limitations, densified feed technologies have been developed in several countries.

Densified complete feed blocks or cubes represent an advancement in feed processing, offering improved physical characteristics such as compactness, durability, and extended shelf life. These feeds consist primarily of concentrates and roughages and can incorporate a variety of agricultural residues such as paddy straw, sugarcane bagasse, and sorghum stalks (Karangiya *et al.*, 2016). In addition to enhancing feed utilization, densified feeds are particularly useful during periods of feed scarcity or natural disasters due to their storability and ease of transport (Walli, 2015).

In Malaysia, *Asystasia gangetica* is a widely distributed invasive weed that grows abundantly along roadsides and forest margins. Although often removed due to its interference with crop production, previous studies have demonstrated that this plant possesses considerable nutritional value, including appreciable levels of protein and essential minerals such as calcium, phosphorus, copper, manganese, and zinc (Khalil, 2016). These characteristics suggest its potential as an alternative feed resource for ruminants, particularly goats. Utilizing *A. gangetica* in feed formulation not only provides a low-cost ingredient but also contributes to sustainable weed management.

Despite the potential benefits of densified complete feeds, information regarding their effectiveness, particularly when formulated with locally available forages such as *A. gangetica,* remains limited. This is especially relevant in Malaysia, where goat production has shown a declining trend in recent years, partly due to high feed costs and limited grazing land (Hashim, 2015; Zayadi, 2021). These constraints highlight the need for practical feeding strategies that can enhance productivity while minimizing production costs. Therefore, this study was conducted to develop a densified complete feed (DCF) using *A. gangetica* as a primary ingredient and to evaluate its effects on feed intake and growth performance in goats. It is hypothesized that the incorporation of *A. gangetica* in DCF will improve feed intake and animal performance compared to conventional feeding systems.

MATERIALS AND METHODS

Feed Ingredients and Preparation of Densified Complete Feed

The feed ingredients used in this study is shown in Table 1. All ingredients were procured locally and formulated into a DCF. The DCF was prepared following a standardized procedure involving grinding, mixing, molding, and drying. Coarse materials, particularly *A. gangetica*, were ground into fine particles prior to mixing. The weighed ingredients were thoroughly homogenized with the addition of clean water at a ratio of 1.4 kg water per kg of feed mixture to achieve appropriate consistency for compaction. The mixture was then transferred into cube mold and compressed to form uniform blocks. The formed cubes were removed from the mold, placed on aluminium foil, and dried in an air-circulation oven at 70°C for

72 h to ensure adequate dehydration and structural stability. The dimension and shape of the DCF are shown in Figure 1.

Figure 1. Preparation and utilization of densified complete feed (DCF): (a) freshly molded cubes before drying, (b) dried cubes ready for feeding, and (c) DCF being consumed by goats.

Table 1. Ingredient and chemical composition (mean value ± standard deviation) of densified complete feed (DCF), commercial pellet, and *Brachiaria humidicola*.

Parameter	Densified complete feed (%, DM basis)	Commercial pellet	*Brachiaria humidicola*
Ingredients			
Asystasia gangetica	36.7	–	–
Corn	20.4	–	–
Rice bran	10.5	–	–
Wheat pollard	6.9	–	–
Molasses	10.0	–	–
Palm kernel cake	6.5	–	–
Palm oil	3.0	–	–
Sodium bentonite	4.0	–	–
Mineral premix	1.0	–	–
Salt	1.0	–	–
Total	100	–	–
Chemical composition (% DM, n = 3)			
Crude protein	18.8 ± 0.98	22.3 ± 1.88	8.7 ± 0.28
Crude fiber	14.5 ± 0.63	3.9 ± 0.21	30.4 ± 0.54
Ether extract	7.3 ± 0.54	2.8 ± 0.29	1.4 ± 0.28
Ash	13.9 ± 4.37	7.2 ± 0.91	3.0 ± 0.70

DM, dry matter; n, number of observations.

The penetrometer model used for hardness measurement was not recorded; however, hardness was determined following a standard protocol by measuring resistance to penetration at three random points per cube and averaging the readings.

Experimental Animals, Experimental Design, and Feeding Management

The feeding trial was conducted under an open-house housing system at AZ Livestock Farm, Machang, Kelantan, Malaysia, for a period of 14 days. All procedures and animal handling during the feeding experiment were conducted according to the guidelines of the Institutional Animal Care and Use Committee of Universiti Malaysia Kelantan. Six Boer crossbred female goats (about 9 months old) with an average body weight (BW) of 16.6 ± 1.47 kg were used. Animals were randomly assigned to two dietary treatments (n = 3 per treatment): (i) a control group fed a farmer-practice diet consisting of a fixed amount of commercial goat pellets with 6 h of daily grazing, predominantly on *B. humidicola*, and (ii) a treatment group fed DCF on an *ad libitum* basis.

During the first week (7 days adaptation period), goats in the treatment group were fed a combination of *B. humidicola* and DCF. In the subsequent 14 days, animals were fed DCF exclusively. Goats were kept in well-ventilated pens with a wooden slatted floor and provided with clean drinking water ad libitum. Animals in each treatment group were initially group-housed during the adaptation period and subsequently individually housed during the measurement period to allow accurate recording of feed intake and performance data. Pens were cleaned regularly to maintain hygiene and animal welfare. Feed was offered twice daily at 08:00 and 14:00 h. The daily feed allowance was adjusted to 3% of body weight. Feed intake was determined by recording the difference between feed offered and refusals daily. Body weight was measured weekly to assess growth performance.

The commercial pelleted compound feed was purchased from a feed manufacturing company (FFM Marketing Sdn. Bhd., Selangor, Malaysia), and its composition was as provided by the manufacturer.

Chemical Analysis and Physical Properties

Proximate analysis of the experimental diets was determined according to Latimer (2023). Dry matter (DM) was determined by oven-drying samples at 105°C for 24 h. Ash content was determined by incineration in a muffle furnace at high temperature until complete combustion of organic matter. Crude protein (CP) content was determined using the Kjeldahl method, involving digestion with concentrated sulphuric acid in the presence of Kjeltab catalyst tablets, followed by distillation and titration. The liberated ammonia was trapped in boric acid solution and titrated with standard hydrochloric acid. Nitrogen content was calculated and multiplied by a factor of 6.25 to obtain CP. Ether extract (EE) was determined using a Soxtec extraction system with petroleum ether as the solvent. Samples were extracted, and the recovered lipid fraction was quantified gravimetrically.

The DM content of experimental feeds (*B. humidicola*, DCF, and commercial pellets) was measured over a storage period of 0, 7, 14, and 21 days. Samples were stored under standard laboratory conditions, and DM was determined using the oven-drying method at 70°C until constant weight. The hardness of DCF cubes was measured using a penetrometer and expressed as resistance to penetration. The resistance to penetration was recorded as an indicator of structural integrity and physical durability of the feed blocks. Three replications (n = 3) were conducted for each chemical analysis of all samples.

Statistical Analysis

All data were analyzed using IBM SPSS Statistics version 25 (IBM Corp., Armonk, NY, USA). Treatment means were compared using a one-tailed independent t-test, and differences were considered statistically significant at $p < 0.05$. Duncan's Multiple Range Test was used to analyze differences in the effect of storage duration on DM content (%) of experimental feeds.

RESULTS AND DISCUSSION

Development and Optimization of Densified Complete Feed

The formulation of DCF supplemented with *A. gangetica* (36.7%) was successfully developed using a combination of agro-industrial by-products and binders (Table 1). Several trials were conducted to optimize production parameters, particularly ingredient form, water inclusion level, molding method, and drying conditions, as these factors are critical for the structural integrity and overall quality of feed blocks. Previous studies indicated that adding 40–60 L of water per 100 kg feed mixture can improve block compactness (Hadjipanayiotou, 1996), while drying under natural conditions may require up to 3–4 weeks to achieve the desired hardness and stability (Baulube and Adeyinka, 2007). In contrast, some studies reported that multi-nutrient blocks were assessed for hardness and compactness as early as 4 days after moulding, although they were still not fully dried (Mohammed *et al.*, 2007). These differences highlight the influence of environmental conditions and material characteristics, emphasizing the need for local optimization of feed block production.

All ingredients were ground into mash form, which improved binding capacity. Water inclusion levels of ≥800 g/kg were found necessary to achieve acceptable cohesion, with 1400 g/kg producing the most stable cubes. However, the use of seed trays as molds resulted in uneven drying, with incomplete moisture removal from the inner portions of the cubes. This led to undesirable odor development, likely due to microbial activity. Inadequate drying and restricted heat penetration are known to compromise feed hygiene and shelf-life (Hinton, 2002).

Drying temperature also influenced product quality. Although lower temperatures (e.g., 50°C) reduced the risk of thermal damage, prolonged drying time increased the likelihood of spoilage and energy costs. Conversely, higher temperatures may induce structural cracking due to rapid moisture loss (Syariffuddeen *et al.*, 2020). In the present study, drying at 70°C for 72 h was identified as optimal, producing adequately dried cubes with minimal cracking and acceptable physical integrity (Table 2).

The optimized DCF exhibited an average weight of 45.1 g per cube and a uniform cubic shape. The cubes had a characteristic grassy odour derived from *A. gangetica*, complemented by a sweet aroma from molasses (Table 2), which is known to enhance palatability in ruminant diets (Mordenti et al., 2021). Physical characteristics such as hardness, size, and aroma are important determinants of feed acceptability and intake.

Table 2. Properties of densified complete feed.

Properties	Values (± standard deviation) and characters
Weight of each densified feed cube	45.1 g ± 0.29
Hardness	1.93 kg/cm^2 ± 0.25
Dimensions	4 cm × 4 cm × 4 cm
Shape	Cubical
Aroma	Fresh, grass-like
Odor characteristics	Earthy and sweet

Chemical Composition of Experimental Feeds

The DM content of DCF was consistently higher than that of pellet and forage, reaching up to 91.7%, whereas *B. humidicola* showed the lowest DM (22%) (Table 1). The low DM content of forage is consistent with previous report (Loi et al., 2019), and variations are largely influenced by environmental conditions, plant maturity, and harvesting practices. The gradual decline in DM content of feeds over time may be attributed to environmental moisture absorption, particularly under humid tropical conditions (Nennich & Chase, 2019).

In terms of nutrient composition, forage exhibited the lowest CP, EE, and ash values among treatments. This aligns with previous findings that nutrient composition of tropical grasses varies with regrowth stage and agronomic conditions (Chobtang *et al.*, 2008). The higher CP value observed in pellet feed reflect its formulated nature, while DCF showed comparatively higher EE and ash contents.

The elevated ash content in the DCF is likely associated with the inclusion of *A. gangetica*, which naturally contains a considerable amount of minerals (Rahman *et al.*, 2025). In addition, possible soil contamination during harvesting and processing may have contributed to the higher ash content. High ash levels in feed are generally undesirable, as they can reduce nutrient digestibility and negatively impact animal performance (Laube, 2023). From a nutritional perspective, excessive mineral intake may also disrupt dietary mineral ratios in ruminants if not properly balanced. Environmental factors, such as rainfall and lodging, may further increase ash contamination in forage-based feeds. To minimize external contamination and improve feed quality, simple processing steps such as washing plant materials prior to drying or careful cleaning during harvesting could be considered in future studies. Overall, the observed variation in chemical composition among feeds underscores the importance of careful ingredient selection and appropriate processing methods in determining feed quality.

Effect of Storage Duration on Dry Matter Content

Dry matter of *B. humidicola* remained relatively stable over 21 days (22.5% to 22.2%), indicating minimal moisture changes during short-term storage. In contrast, DM of DCF and commercial pellets declined significantly over time, from 91.7 % to 86.1% and 89.2% to 85.5%, respectively. The reduction in DM over storage duration is often associated with moisture uptake from the environment, which can accelerate quality deterioration; therefore, storing feeds under dry, cool, and well-ventilated conditions helps maintain dry matter content and overall feed quality (McDonald *et al.*, 2010).

It should be noted that no microbiological or mycotoxin analyses were conducted in this study; therefore, feed safety and microbial stability during storage could not be directly assessed. Future studies are recommended to include microbial load and mycotoxin screening to better evaluate the shelf-life stability and safety of densified complete feeds under tropical storage conditions.

Table 3. Effect of storage duration on dry matter content (%) of experimental feeds.

Type of feeds	Storage duration (mean value ± standard deviation)			
	0 d	7 d	14 d	21 d
Brachiaria humidicola	22.5 ± 0.69	22.5 ± 0.77	22.4 ± 0.37	22.2 ± 0.59
Densified complete feed	91.7 ± 2.51^{b}	91.1 ± 0.54^{b}	90.1 ± 1.08^{b}	86.1 ± 0.62^{a}
Commercial pellet	89.2 ± 0.61^{b}	88.6 ± 0.63^{b}	86.3 ± 5.36^{a}	85.5 ± 0.92^{a}

Means within rows with different superscript letters (a, b) differ significantly ($p < 0.05$).

Feed Intake and Growth Performance

Feed intake differed significantly ($p < 0.05$) between groups (Table 4). Goats fed DCF consumed 562.3 g/d in week 1 and 672.5 g/d in week 2, compared to 231.6 g/d and 202.7 g/d in the control, respectively. Intake in the treatment group increased when cubes were broken into smaller pieces, indicating that physical form and the inclusion of 10% molasses improved palatability (Osman *et al.*, 2020; Mordenti *et al.*, 2021). Overall, average intake over two weeks was 617.4 g/d in the treatment group versus 217.1 plus 6 hours grazing g/d in the control ($p < 0.05$). The control group received a fixed amount of concentrate, which was fully consumed, in addition to ~6 hours of grazing daily. Actual intake from grazing in the control group was not measured, which limits the accuracy of total feed intake estimation and complicates direct comparison with the ad libitum DCF group.

Table 4. Intake and growth performance of Boer crossbred goats under different feeding regimes.

Parameters	Control group*	Treatment group	p-value
Feed intake (g/d)			
At week 1	231.6 ± 6.49	562.3 ± 80.69	0.000
At week 2	202.7 ± 5.60	672.5 ± 184.23	0.000
Average	217.1 ± 15.83	617.4 ± 151.12	0.000
Growth performance			
Initial body weight (kg)	16.8 ± 0.88	16.3 ± 2.10	0.344
Final body weight (kg)	17.0 ± 0.85	16.7 ± 1.84	0.415
Total body weight gain (g)	133.4 ± 104.08	433.3 ± 303.51	0.060
Daily body weight gain (g)	9.5 ± 6.1	31.0 ± 18.03	0.060

* Control: commercial pellet plus ~6 h grazing (intake not measured).

Total BW gain was not significantly different between groups ($p > 0.05$), with initial weights of 16.8 kg (control) and 16.3 kg (treatment) and final weights of 17.0 kg and 16.7 kg, respectively (Table 4). Total gain was numerically higher in the treatment group (433.3 g vs. 133.4 g) and it may indicate insufficient sample size, suggesting a potential positive effect of DCF on growth. However, this difference was not statistically significant, indicating only a numerical trend rather than a confirmed effect.

The higher intake and numerical weight gain in the treatment group may be attributed to increased nutrient intake, particularly CP (~14–16%). Ether extract content (7.3%) is moderate and unlikely to negatively affect performance (Gurung *et al.*, 2021; Bezerra *et al.*, 2022). Molasses also provides fermentable sugars that enhance dietary energy (Jamir *et al.*, 2021). In contrast, lower growth in the control group may reflect limited protein intake from grazing, as *B. humidicola* contains about 9% CP and forage quality may vary (Hussain, 2023). The study suggests that DCF supplementation improved measured feed intake; however, due to the unquantified grazing intake in the control group, direct comparisons between treatments should be interpreted with caution. The DCF showed a numerical advantage in growth, although total BW gain differences were not statistically significant over the two-week period.

This work has a few limitations that future studies should overcome to ascertain the utility and practical implementation of DCF. Conducting a longer feeding trial (e.g., 8–12 weeks) with a larger sample size (≥8–10 animals per treatment) is recommended to increase statistical power for detecting growth differences. Furthermore, total feed intake (including grazing intake to determine the dietary intake of pasture) should be accurately measured for all animals or alternatively maintain animals under controlled feeding conditions enabling greater precision of treatment comparison. More detailed aspects of nutrient utilization (apparent digestibility, rumen fermentation parameters such as pH and volatile fatty acid profile, and blood metabolites) would elucidate the mechanisms controlling intake and subsequent growth responses. There is also a need for economic evaluation, e.g., cost per unit of feed and cost per kg of weight gain to establish whether DCF will be practically viable under farm settings. In addition, assessments of shelf-life and safety such as microbiological counts and the screening for mycotoxins during storage must be performed to evaluate the stability of the feed. Lastly, palatability trials with preference or choice tests between DCF and conventional pellet feeds are suggested to be conducted to quantify animal acceptance independent of intake limitations.

CONCLUSION

The current study effectively created a DCF with *A. gangetica* (36.7%) and showed that it is a viable substitute feeding method for goats. When compared to the traditional feeding system, the DCF demonstrated increased feed intake, suggesting superior palatability and acceptability. Over the brief trial period, goats fed DCF showed a numerically greater body weight gain, but the difference was not statistically significant.

However, the study's small sample size (n = 6) and brief feeding period (14 days) make it difficult to draw firm conclusions about growth performance. As a result, rather than being definitive proof, the results should be regarded as preliminary and suggestive of possible advantages. In addition, the intake of grazed forage in the control group was not quantified, which may confound comparisons of feed intake and growth performance between treatments.

To confirm the effects of DCF on growth performance and to better evaluate its practical applicability in field settings, more research including a greater number of animals and longer feeding times (e.g., 8–12 weeks) is needed. Notwithstanding these drawbacks, the findings indicate that DCF containing *A. gangetica* has encouraging potential as an affordable and sustainable feed source for ruminants.

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