Effect of Ginger-Garlic Mixture on Nutrient Intake and Digestibility of Uda Rams

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Abstract
The use of phytogenic feed additives such as ginger (*Zingiber officinale*) and garlic (*Allium sativum*) offers a natural alternative to antibiotic growth promoters in ruminant nutrition. Despite their known bioactive properties, data on their combined use in indigenous breeds like Uda rams remain limited. A basal diet was formulated and supplemented with three different ginger-garlic mixtures: GGM1 (1:1; ginger to garlic), GGM2 (2:1; ginger to garlic), and GGM3 (1:2; ginger to garlic), each at a rate of 5 g/kg of diet. Sixteen yearling intact Uda rams (average weight: 20.5 kg) were assigned in a completely randomized design to four treatment groups: T1 (Control), T2 (GGM1), T3 (GGM2), and T4 (GGM3). Rams were individually housed, and the trial lasted for nine weeks. Feed intake was measured daily, and digestibility was evaluated through total faecal collection. Nutrient intake and digestibility were evaluated. Data were analysed using one-way ANOVA and treatment means were established with Duncan's Multiple Range Test at P<0.05. The result showed that Rams receiving GGM2 exhibited significantly higher dry matter and crude protein digestibility compared to other treatments. Conversely, a garlic-dominant blend (GGM3) reduced feed intake and digestibility. Dietary supplementation with a 2:1 ginger-garlic mixture enhances nutrient utilization in Uda rams without compromising feed intake. This phytogenic blend offers a practical strategy to improve ruminant feed efficiency.

Keywords: Uda rams, Ginger, Garlic, Nutrient intake, Digestibility

Description of Problem

Livestock production in semi-arid regions, such as northern Nigeria, is challenged by seasonal feed scarcity, poor forage quality, and low nutrient availability, which collectively constrain animal productivity and feed efficiency (1). Uda rams, a dominant breed in these regions, play a vital role in rural livelihoods through meat production, income generation, and cultural significance. However, their productivity remains limited due to poor feed conversion. To enhance growth and feed efficiency, sub-therapeutic antibiotics have been employed in livestock diets. Nonetheless, increasing global concerns over antimicrobial resistance, drug residues, and environmental contamination (2; 3) have prompted a paradigm shift toward natural alternatives, particularly phytogenic feed additives (PFAs), which include herbs, spices, and plant extracts rich in bioactive compounds (4; 5).

Ginger (*Zingiber officinale*) and garlic (*Allium sativum*) are two widely studied PFAs with established antimicrobial, anti-inflammatory, and antioxidant effects (6; 7). Their bioactive constituents (gingerols, shogaols, allicin, and ajoene) have been shown to enhance nutrient digestibility and rumen microbial balance (6; 7; 8; 9). Despite increasing evidence supporting their individual use in monogastric and ruminant diets, studies on their synergistic effects in small ruminants, particularly Uda rams, are sparse. Most available studies focus on mono-herbal applications or utilize purified extracts, which may not be affordable or scalable for smallholder farmers (8; 9). Powdered forms of ginger and garlic, by contrast, offer a cost-effective alternative while retaining bioactivity. However, optimal mixing ratios, effects on intake and digestibility remain underexplored. This study therefore aims to evaluate the effects of dietary inclusion of ginger-garlic mixtures at varying ratios on nutrient intake and apparent digestibility in Uda rams. The findings are intended to contribute to the development of sustainable feeding strategies for improving small ruminant productivity in resource-limited settings.

Materials and Methods

Study Site

The study was conducted at the Livestock Teaching and Research Farm, Department of Animal Science, Usmanu Danfodiyo University, Sokoto, Nigeria. The site is geo-located between latitudes 12°00′N and 13°58′N and longitudes 4°08′E and 6°54′E, at an elevation of approximately 350 m above sea level. Sokoto experiences a semi-arid climate, with average annual rainfall of about 700 mm and temperatures ranging from 13°C (January) to 41°C (April) (10).

Experimental Feed and Diet Formulation

Fresh ginger rhizomes and garlic bulbs were obtained from Sokoto Central Market. The ginger was washed, sliced, and air-dried under ambient conditions, while the garlic was peeled, sliced, and similarly dried. Both were pulverised separately to fine powder (passed through 1 mm sieve) and mixed in the prescribed ratios of 1:1, 2:1, and 1:2 of ginger to garlic, respectively. The mixtures were homogenized and stored in airtight containers before inclusion in diets. The diet consisted of cowpea husk (25%), wheat offal (25%), rice bran (12%), sorghum husk (7%), groundnut haulms (17.5%), soybean meal (12.5%), and salt (0.5%). Experimental diets were prepared by supplementing the basal diet with 5 g/kg of each ginger-garlic mixture corresponding to their treatment groups.

Experimental Animals and Design

Sixteen intact yearling Uda rams (average body weight: 20.5 kg) were purchased from Sokoto Livestock Market. The animals were allowed a two-week quarantine and acclimatization period. During the period, the animals were treated with Ivermectin® and treated prophylactically with oxytetracycline LA®. They were randomly assigned to four dietary treatments in a completely randomized design (CRD), with four animals per treatment.

The treatment groups were:

- **T1 (Control):** Basal diet only
- **T2 (GGM1):** Basal diet + 5 g/kg ginger-garlic mixture (1:1)
- **T3 (GGM2):** Basal diet + 5 g/kg ginger-garlic mixture (2:1)
- **T4 (GGM3):** Basal diet + 5 g/kg ginger-garlic mixture (1:2)

Each animal was housed individually on a concrete-floored pen with separate feed and water troughs. Clean water and feed were offered using *ad libitum* feeding regime throughout the 9-week feeding trial, followed by a 3-week digestibility trial.

Data Collection

Feed Intake and Digestibility Trial

Daily feed intake was measured by subtracting orts (refusals) from feed offered the previous day. Weekly body weight was recorded using a spring balance prior to morning feeding. At the end of the feeding trial, three animals per treatment were randomly selected for digestibility assessment. A 14-day adaptation to faecal collection harnesses preceded a 7-day total faecal collection. Daily faecal output was weighed, homogenized, and sampled (10% aliquot) for oven-drying at 105°C to constant weight. Dried samples were stored for analysis. Apparent digestibility was calculated as the proportion of ingested nutrients not excreted in faeces.

Laboratory and Statistical Analysis

Proximate analysis of feed and faecal samples was conducted using standard AOAC methods (11). Fibre fractions were determined using the Van Soest method (12). All data were analysed using one-way ANOVA in SPSS (v.26) using the General Linear Model procedure. Treatment means were established using Duncan's Multiple Range Test at a significance level of P<0.05. Data are presented as means ± standard error of mean (SEM).

Results and Discussion

Proximate and Fibre Composition of Experimental Diets

The proximate and fibre compositions of the experimental diets are presented in Table 1. The dry matter (DM) content ranged from 88.37% to 89.11%, while the crude protein (CP) content ranged from 15.05% to 15.72%, indicating a relatively consistent nutrient profile across all diets. These values align with recommendations that feeds for small ruminants should exceed 80% DM for storability (13), and a CP threshold of 7–8% is needed to support adequate rumen microbial function and voluntary intake (14; 15). The fibre fractions were also within optimal ranges. Neutral detergent fibre (NDF) ranged from 38.51% to 38.90%, which is well below the 60% threshold that impairs intake in tropical forages (14), and within the ideal 30–45% range for sheep diets (16; 17). Acid detergent fibre (ADF) values ranged from 25.01% to 25.78%, within the ideal 17–30% range for sheep, indicating favourable digestibility characteristics (16).

Nutrient Intake of Uda Rams

As shown in Table 2, the inclusion of ginger-garlic mixtures significantly (P<0.05) influenced nutrient intake across treatments. Dry matter intake (DMI) value was highest in the control diet (1124.23 g/day) and a lower (P<0.05) value in GGM3 (868.07 g/day). The reduced intake in GGM3 (garlic-dominant mixture) may reflect decreased palatability or antimicrobial suppression of rumen microbial activity, consistent with reports by (18). Garlic's high allicin content may have exerted inhibitory effects at elevated inclusion levels.

Crude protein intake followed a similar trend. The control diet recorded the higher numerical CP intake value (190.73 g/day), though values in GGM1 (178.24 g/day) and GGM2 (177.68 g/day) values were statistically similar (P>0.05). All treatments exceeded the (17) recommended minimum CP intake of 10–12% DM, ensuring adequate nitrogen supply for rumen microbial activity and growth.

Intakes of crude fibre and fibre fractions (CF, ADF and NDF) also declined with increasing garlic inclusion. The suppression observed in GGM3 may be attributed to reduced feed intake or a direct antimicrobial effect of garlic on fibrolytic bacteria (19). These findings suggest that excessive garlic disrupts fibre metabolism, while balanced ginger-garlic inclusion (GGM1 and GGM2) maintains nutrient intake.

4.3 Apparent Nutrient Digestibility

Table 3 presents the apparent digestibility coefficients of the experimental diets. Dry matter digestibility (DMD) value was numerically higher in GGM2 (71.32%) and lower (P<0.05) in GGM3 (62.72%). This suggests that a 2:1 ginger-garlic mixture optimally supports digestive processes, likely due to the ginger’s digestive enzyme stimulation and garlic’s moderated antimicrobial effects (19; 20; 21). Crude protein digestibility (CPD) value also peaked (P<0.05) in GGM2 (79.46%) and was lower numerically in T1 (76.44%). The moderate level of garlic in GGM2 may have provided beneficial microbial modulation, whereas excessive garlic (GGM3) likely inhibited rumen proteolytic activity (21). Fibre fraction digestibility values (ADFD and NDFD) were also superior (P<0.05) in GGM2 (56.84 and 73.86%, respectively), highlighting the synergistic effects of the ginger-garlic blend at this ratio.

Table 1 Proximate and Fibre component (%) of Experimental diets

Proximate composition	T1	T2	T3	T4
Dry Matter	88.71	88.37	89.11	88.78
Crude Protein	15.05	15.72	15.33	15.45
Crude Fibre	20.38	20.81	20.67	20.33
Acid Detergent Fibre	25.54	25.26	25.01	25.78
Neutral Detergent Fibre	38.83	38.76	38.51	38.90

Table 2 Nutrient intake (g/day) of Uda ram feed experimental diets

Parameters	T1	T2	T3	T4	SEM
Dry Matter	1124.23^{a}	1001.95^{b}	1032.83^{a}	868.07^{c}	30.96
Crude Protein	190.73^{a}	178.24^{a}	177.68^{a}	151.07^{b}	4.98
Crude Fibre	258.28^{a}	235.95^{a}	239.57^{a}	198.78^{b}	7.25
Acid Detergent Fibre	323.67^{a}	286.40^{b}	289.89^{b}	252.07^{c}	8.61
Neutral Detergent Fibre	492.10^{a}	439.46^{b}	446.35^{b}	380.36^{c}	13.41

^{abcd} Means on the same row having different superscripts were significantly different (P<0.05)

Table 3 Apparent nutrient digestibility of Uda rams fed experimental diets

Parameters (%)	T1	T2	T3	T4	SEM
DM	67.84^{a}	68.43^{a}	71.32^{a}	62.72^{b}	1.06
CP	76.44^{b}	77.74^{ab}	79.46^{a}	76.94^{b}	0.42
CF	53.35^{c}	60.63^{ab}	65.80^{a}	55.87^{b}	1.61
ADF	57.99^{a}	55.87^{ab}	56.84^{a}	51.20^{b}	1.03
NDF	69.13^{b}	70.42^{ab}	73.86^{a}	64.93^{c}	1.09

^{abcd} Means on the same row having different superscripts were significantly different (P<0.05)

Conclusion and Application

Dietary inclusion of 5 g/kg (0.5%) of a 2:1 ginger-garlic blend significantly improved nutrient digestibility in Uda rams without adversely affecting intake. The garlic-dominant, GGM3 reduced both intake and digestibility. Thus, GGM2 may represent an optimal inclusion ratio for improved nutrient utilization in ruminants. This offers a practical alternative to antibiotic growth promoters as the use of powdered ginger-garlic blends offers a low-cost, accessible strategy to improve sheep feed efficiency. A 2:1 ginger-garlic blend could reduce reliance on antibiotics, promoting sustainable and safer animal production. Findings provide a scientific basis for the development of phytogenic-based feeding strategies, warranting consideration by extension services, feed manufacturers, and policymakers in national livestock development programs.

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