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Nutrient intake, body weight gain, nutrient digestibility and nitrogen utilization of West African dwarf goats fed Siam weed (*Chromolaena odorata)* leaf meal

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Abstract

West African Dwarf (WAD) goat is one of the most prolific goat breeds in Nigeria, and its production fulfils important socio-economic functions. In Nigeria, high cost of feed and inadequate nutrient intake undermines this goat breed in expressing their full potential. Thus, 86-day feeding trial was conducted to evaluate the nutrient intake, body weight gain, nutrient digestibility and nitrogen utilization of WAD goats fed dietary levels of Siam weed (Chromolaena odorata) leaf meal. Sixteen WAD bucks of about 8 – 10 months of age averaging 7.35kg in weight were used fir this experiment. The goats were randomly assigned to four experimental diets (T_1, T_2, T_3, and T_4) containing 0%, 5%, 10% and 15% inclusion levels of Siam weed leaf meal (SWLM) in a completely randomized design. The bucks were fed based on 3.0% body weight per day in the morning (8.00 hour) and later in the evening at 15.00 hours. 1 kg wilted chopped Panicum maximum. Fresh and clean drinkable water were given ad libitum to the goats. Feed intake, body weight changes, nutrient intake, nutrient digestibility and nitrogen utilization parameters were determined accordingly. ***.*** *Results showed significant ($p<0.05$) difference for all the nutrient intake (total dry matter intake, crude protein intake, neutral detergent fibre intake, acid detergent fibre intake and acid detergent lignin intake) parameters examined. Daily weight gain and feed conversion ratio were significantly ($p<0.05$) better for T_2. Dry matter, crude protein and ash digestibilities showed significant ($p<0.05$) differences, with T_2 having better ($p<0.05$) dry matter digestibility and crude protein digestibility. T_2 showed significantly ($p<0.05$) higher nitrogen balance and nitrogen retention values in comparison to other treatments. It was concluded that SWLM is rich in essential nutrients and therefore suitable for inclusion in West African dwarf goat diets at level not beyond 5% for best dry matter intake, crude protein intake, daily weight gain, feed conversion ratio, dry matter digestibility, crude protein digestibility, nitrogen balance and nitrogen retention.*

Keywords: Phytobiotic feed additive, supplemental diets, WAG goats, *Chromolaena odorata,* performance indices.

Apport nutritionnel, gain de poids corporel, digestibilité des nutriments et utilisation de l'azote chez des chèvres West African Dwarf nourries avec de la farine de feuilles d'herbe de Siam (*Chromolaena odorata*)

Résumé

La chèvre West African Dwarf (WAD) est l'une des races caprines les plus prolifiques au Nigéria et sa production remplit d'importantes fonctions socio-économiques. Au Nigéria, le coût élevé de l'alimentation animale et un apport nutritionnel insuffisant empêchent cette race caprine d'exprimer tout son potentiel. Ainsi, un essai d'alimentation de 86 jours a été mené pour évaluer l'apport en nutriments, le gain de poids corporel, la digestibilité des nutriments et l'utilisation de l'azote de chèvres WAD nourries avec des niveaux alimentaires de farine de feuilles d'herbe de Siam (Chromolaena odorata). Seize mâles WAD âgés d'environ 8 à 10 mois et pesant en moyenne 7,35 kg ont été utilisés pour cette expérience. Les chèvres ont été assignées au hasard à quatre régimes expérimentaux (T_1, T_2, T_3 et T_4) contenant des niveaux d'inclusion de 0 %, 5 %, 10 % et 15 % de farine de feuilles d'herbes de Siam (FFHS) dans un plan complètement randomisé. Les boucs ont été nourris à raison de 3,0 % de leur poids corporel par jour le matin (8 heures) et plus tard le soir à 15 heures. 1 kg de Panicum flétri haché maximum. De l'eau potable fraîche et propre a été donnée à volonté aux chèvres. La consommation alimentaire, les changements de poids corporel, l'apport en nutriments, la digestibilité des nutriments et les paramètres d'utilisation de l'azote ont été déterminés en conséquence. Les résultats ont montré une différence significative ($p < 0,05$) pour tous les paramètres d'apport en nutriments (apport total en matière sèche, apport en protéines brutes, apport en fibres de détergent neutre, apport en fibres de détergent acide et apport en lignine de détergent acide). Le gain de poids quotidien et le taux de conversion alimentaire étaient significativement meilleurs ($p < 0,05$) pour T_2. Les digestibilités de la matière sèche, des protéines brutes et des cendres ont montré des différences significatives ($p < 0,05$), le T_2 ayant une meilleure digestibilité ($p < 0,05$) de la matière sèche et des protéines brutes. T_2 a montré des valeurs de bilan azoté et de rétention d'azote significativement ($p <0,05$) plus élevées par rapport aux autres traitements. Il a été conclu que le FFHS est riche en nutriments essentiels et peut donc être inclus dans le régime alimentaire des chèvres West African Dwarf à un niveau ne dépassant pas 5 % pour un meilleur apport en matière sèche, un apport en protéines brutes, un gain de poids quotidien, un taux de conversion alimentaire, une digestibilité de la matière sèche, un digestibilité des protéines, bilan azoté et rétention d'azote.

Mots-clés : Additif alimentaire phytobiotique, régimes complémentaires, chèvres WAG, *Chromolaena odorata*, indices de performance.

Introduction

Goat production is seen as a dependable enterprise with the potential to satisfy the world's rising need for animal protein in developing countries (Okunade *et al.*, 2014). Jiwuba *et al.* (2020) noted that West African Dwarf (WAD) goat is the most prolific ruminant in southeastern Nigeria capable of increasing animal protein intake in this region. They are multipurpose animals, producing meat, milk, skin and manure. The lack of adequate feed supply to meet the nutrient requirement of goats particularly during the dry season coupled with the high cost of feedstuffs have led to the search for local and non-competitive dry season feed supplement to reduce feed cost and without jeopardizing the performance of the animals. Utilization of several close substitute feed ingredient especially those with phytobiotic properties could solve this problem of high cost of feed supplement as well promote the health and productivity of goats. Local and non-competitive feed supplement may contribute a quota in reducing the production cost of goats, and this could be achieved through the use of leaf meal of tropical browse plants such as Siam weed.

Siam weed (Chromolaena odorata) is a tropical and subtropical species of flowering shrub belonging to the family, *Asteraceae*. *Chromolaena odorata* is a perennial herb that grows rapidly in open spaces. It is a multi-stemmed shrub, which can reach a height of 2.5 m (100 inches). The plant is hairy and glandular, and when crushed, the leaves release a strong, aromatic odour. It is a multipurpose evergreen shrub with considerable leaf yield in both wet and dry seasons. Due to the high protein content of the meal, *Chromolaena odorata* may be an unconventional source of protein (Jiwuba *et al*., 2018) for ruminants. Siam weed is one of those plants rich in phytochemicals like saponins, phytates, tannins, and cyanogenic glycosides (Ogadu, 2018). Saponins have been reported to have anti-inflammatory, antifungal, antibacterial, antiparasitic, anti-cancer, and antiviral effects (Sparg *et al*., 2004; Podolak *et al*., 2010). Recent research indicates that tannins might be an alternative growth promoter (Tosi *et al*., 2013; Redondo *et al*., 2014). As a result, formulating dry season feed supplement with Siam weed leaf meal (SWLM) for WAD goats will help to lower feed costs and increase goat production in the country. The objective of this study was to evaluate the effects of the diets in which brewer's dried grain was replaced by Siam weed leaf meal on the nutrient intake, body weight gain, nitrogen utilization and digestibility coefficient of West African dwarf goats. We assume that inclusion of 5 to 15 % of Siam weed leaf meal will have a positive effect on nutrient intake, body weight gain, nitrogen utilization and digestibility coefficient of West African dwarf goats, due to its high phytobiotic and nutritional properties.

Materials and methods

Location of the study

The experiment was conducted in the Federal College of Agriculture's sheep and goat unit, Ishiagu, Ivo L.G.A., Ebonyi State, Nigeria. The College is about three kilometres from the major town of Ishiagu. The College is located at latitude 5.56^0 N and longitude 7.31^0 E, with an average annual rainfall of 1653 mm, a prevailing temperature of 28.50°C, and a relative humidity of approximately 80%.

Sourcing of Siam weed

Fresh succulent leaves of Siam weed plants without flowers were harvested within the College farms. Thereafter, the leaves were air dried under shed until they became crispy while retaining the greenish colouration. The air-dried leaves were milled using a hammer mill to produce leaf meal before they were incorporated into the diets of WAD goats.

Formulation of experimental diets

The experimental diets designated as T_1, T_2, T_3 and T_4 were formulated from cassava root sievate, brewers' dried grain, cassava peel, palm kernel meal, soybean meal, bone meal, salt and premix to contain 0, 5, 10, and 15% levels of Siam weed leaf meal (Table 1).

Procurement and adaptation of the experimental goats

Sixteen WAD bucks weighing about 7.35 kg and aged 8 to 10 months were sourced from Omege Echara, Ikwo L.G.A., Ebonyi State. The goats were quarantined for 21 days before the study. Before the trial, the goats were administered Ivermectin (1 mL/10 kg body weight (injected subcutaneously) and Albendazole (0.1 mg/kg BW given orally) to treat external and internal parasites. The goats were vaccinated against *Peste' Petit de' Ruminante'* (PPR) with PPR vaccine at a dosage of 1 ml per 10 kg of body weight. For a preliminary period of 21 days, each animal was fed the experimental diet (control diet) on 3% of their body weight in the morning (8.00 hr) and 1 kg *Panicum maximum* as basal in the evening (15.00 hr). This was done to increase the appetite of each goat for the concentrate feeding.

Table 1: Composition of the Experimental Diets

Ingredients	Dietary levels			
	T_1 (%)	T_2 (5%)	T_3 (10%)	T_4 (15%)
Cassava root seivate	20.00	20.00	20.00	20.00
Cassava peel	30.00	30.00	30.00	30.00
Siam weed leaf meal	0.00	5.00	10.00	15.00
Brewers dried grain	25.00	20.00	15.00	10.00
Palm kernel cake	14.00	14.00	14.00	14.00
Soybean meal	7.00	7.00	7.00	7.00
Common salt	1.00	1.00	1.00	1.00
Bone meal	2.00	2.00	2.00	2.00
Premix	1.00	1.00	1.00	1.00
Total	**100**	**100**	**100**	**100**

Feed intake and body weight changes

The goats were divided into four groups with four goats each at random. The four experimental diets (T_1, T_2, T_3, and T_4) were assigned to the groups in a completely randomized design (CRD). The goats were kept in separate pens equipped with feeders and drinkers on well-cemented floors. For 86 days, each animal was fed a specific treatment diet in the morning (08:00 hr). Feeding was based on 3% body weight per day, with 1 kg wilted chopped *Panicum maximum* supplied at 15:00 hr. Fresh drinkable water was made available on a regular basis. Each animal's voluntary feed intake was calculated daily by subtracting the previous day's feed refusals from the current day's feed supply. The initial live weights of the goats were taken using spring balance at the start of the feeding trial and weekly afterwards in the morning before feeding. At the end of the trial, the goats were weighed to determine their final live weight. Other growth performance indices were calculated accordingly.

Digestibility and nitrogen utilization studies

For the digestibility and nitrogen utilization studies, four WAD bucks of about 8 – 10 months old were used for this experiment. The goats were kept under zero grazing, and supplementary feeding was based on 3% body weight per head per day on DM basis. The goats were then placed to previously disinfected individual metabolism cages measuring 60 cm x 100 cm with faeces and urine collection facilities. In a 4 x 4 Latin square design, they were fed four different experimental diets. The experimental diets were fed to each goat in four phases. The goats were randomly assigned to the four test diets (T_1, T_2, T_3 and T_4) in a 4 x 4 Latin square design following the adjustment phase. The goats were fed the diets twice a day, at a rate of 3% of BW, at 08:00 and 16:00 h. Fresh clean water was made available *ad libitum*. The metabolic cages had a mesh floor with a funnel tray underneath. For 28 days, the goats were fed the experimental diets. Data were collected from days 21 to 28. For each buck, the amount of faeces excreted was measured every day during a seven-day period. Over the course of a week, faeces were collected and bulked for each buck. For each animal, 20% of the faecal samples were bulked. Each buck received four bulked samples, one for each of the four treatment groups, for a total of sixteen bulked faecal samples. After that, the faecal samples were freeze-dried, powdered, and stored for further evaluation. The nitrogen content of faeces was determined.

The urine was collected into a plastic bucket using the funnel tray underneath the crate. In order to avoid nitrogen loss, 240 mL of sulphuric acid (H_2SO_4) was added to the collection bucket each day. The volume of urine collected for each buck was measured every day, and 10% was pooled (for each stage of the digestibility and nitrogen balance studies) during the 7-day period, yielding 16 samples. For subsequent examination, the pooled samples were kept at 4°C. Nitrogen levels in urine samples were examined.

Analytical procedure

AOAC (2000) procedures were used to analyze all the faecal and urine samples for proximate components. Triplicate sample of the experimental diets were analysed for dry matter (DM), crude protein (CP), crude fibre (CF), ash, ether extract (EE) and nitrogen-free extract (NFE) according to the methods of AOAC (2000). The neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) fractions were determined using Van Soest *et al.* (1991) methods.

Gross Energy (GE) determination

The gross energy was calculated using the formula

$T = 5.72Z1 + 9.50Z2 + 4.79Z3 + 4.03Z4 \pm 0.9\%$; according to Nehring and Haelein (1973).

where;

T = Gross energy;
ZI = Crude protein;
Z2 = Crude fat;
Z3 = Crude fibre;
Z4 = Nitrogen free extract.

Experimental design and statistical analysis

For nutrient intake and body weight change, the experimental design was completely randomized design. Data obtained were analysed using analysis of variance as described by SAS (2008). Significant means were separated using the Duncan Multiple New Range Test (Duncan, 1955) at $p<0.05$. For the digestibility and nitrogen utilization studies, the experimental design used was 4 x 4 Latin square experiment. Data obtained were analysed using analysis of variance (ANOVA) as described by SAS (2008). Significant means were separated using the Duncan Multiple New Range Test (Duncan, 1955) at $p<0.05$.

Results and discussion

Proximate compositions of the Siam weed leaf meal is presented in Table 2. Proximate analysis of SWLM revealed a high dry matter value of 92.24%, which was lower than 95.70% by Jiwuba *et al*. (2018) and higher than 87.40% and 89.51% reported by Aro (1990) and Akinmutimi and Akufo (2006) respectively. The crude protein values of 20.36% obtained in this present study compared well with 21.70%, 22.80% and 20.52% reported by Akinmutimi and Akufo (2006), Bonsu *et al*., (2013) and Jiwuba *et al*. (2018) respectively, but higher the values of 15.27 and 18.67% reported by Ekenyem *et al*. (2009) and Aro (1990) respectively for SWLM. However, the CP value of 20.36% reported for SWLM in this present study is an indication that SWLM is rich in protein and may serve as a protein substitute for ruminants. The crude fibre value of 14.38% compared favourably with 13.72 reported by Akinmutimi and Akufo (2006) but higher than 5.58% reported by Jiwuba *et al*. (2018) and lower than 20.10% by Ekenyem *et al.* (2009) for same leaf meal. The moderate CF makes this leaf meal a potential feedstuff for ruminants. The high ash content of SWLM in the current study is an indication of high mineral profile in Siam weed. This value compared favourably with the ash value of 9.50, 11.50 and 9.64% reported for the same leaf meal by Ekenyem *et al*. (2009), Bonsu *et al*., (2013) and Akinmutimi and Akufo (2006), respectively. The results revealed that *C. odorata* leaf meal is moderately high in tannins, saponins, phytate, alkaloid and flavonoids but lower. Tannins are regarded as nutritionally unfavourable because they precipitate proteins, obstruct digestive enzymes, and influence how well vitamins and minerals are utilized. A small amount of the proper kind of tannins may be advantageous to health (Chung *et al*., 1998). Tannins are known to affect feed intake, growth rate, feed efficiency, and protein digestibility (Ram *et al.,* 2020). Intestinal digestion and microbial enzyme activity such as cellulose synthesis could be inhibited by an excessive tannin concentration in the diet (Aletor, 2005). The concentration of tannins in this study is higher than 0.37% and 0.002% by Igboh *et al.* (2009) and Akintunde *et al.* (2021) respectively, but lower than 2.57% and 41.0 mg/g by Oni *et al*. (2020) and Agaba and Fawole (2016) respectively for same leaf meal. Saponins are surface-active agents (surfactants) with a potently bitter taste that have the ability to produce intense foaming activity in aqueous solutions. Traditionally, animal nutritionists have seen saponins as harmful constituents (Francis *et al.,* 2002). Dietary saponins have biological effects in the digestive tract because the body poorly absorbs them (Cheeke, 1996). According to Potter *et al*. (1993), saponins decrease protein digestibility most likely by forming barely digested saponin-protein complexes. However, the saponins value of 0.79% herein compared with 0.60% by Akintunde *et al.* (2021) but lower than 1.98 and 1.99% reported by Igboh *et al.* (2009) and Oni *et al*. (2020) respectively. Animal performance is decreased by phytates in part due to decreased digestibility and increased endogenous intestinal release of nutrients like minerals and amino acids (Woyengo and Nyachoti, 2013). The concentration of phytates (1.98%) in this study is lower than 2.09% by Akintunde *et al.* (2021), but higher than 0.54% by Igboh *et al.* (2009) and relatively compared with 1.33% by Oni *et al*. (2020) for same leaf meal. Alkaloids on animals have a very diverse range of effects at the cellular level (Taiz and Zeiger, 2008). While the majority of alkaloids interact with chemical agents that are found in the nervous system, others have an impact on the transport of proteins or the actions of different enzymes. In this present study however, the alkaloid value of 1.02% slightly compared with 1.26% by Oni *et al*. (2020) but lower than 1.66% and 12.2 mg/g reported by Akintunde *et al.* (2021) and Agaba and Fawole (2016) respectively for same leaf meal. Flavonoids have potent antibacterial and antioxidant properties as well as favourable effects on the immune system. Flavonoids can enhance the quality of animal products and promote growth and development of animals (Kalantar, 2018). The concentration of flavonoid (2.04%) in this study is lower than 6.30% and 7.7mg/g by Akintunde *et al.* (2021) and Agaba and Fawole (2016) respectively but higher than 1.08% by Oni *et al*. (2020) for same leaf meal.

Table 2: Chemical and phytochemical composition of Siam weed leaf meal

Parameters (%)	Siam weed leaf meal
Dry matter	92.24
Crude protein	20.36
Crude fibre	14.38
Ether extract	4.47
Ash	10.56
Nitrogen free extract	42.46
Gross energy (g/kcal)	488.92
Neutral detergent fibre	34.67
Acid detergent fibre	19.18
Acid detergent lignin	6.85
Tannin	0.65
Saponin	0.79
Phytates	1.98
Alkaloids	1.02
Flavonoids	2.04

The chemical composition of the experimental diets is presented in Table 3. Dry matter, CF, EE ash, NFE, GE, NDF, ADF and ADL showed significant ($p<0.05$) difference across the groups. The DM content of T_2 was significantly ($p<0.05$) higher than T_1 and T_4, but similar to T_3. The high DM composition of the diets showed that the diets were rich in different nutrients, since DM is a representation of everything contained in a feed sample except water. The CP compositions of the diets though similar ($p>0.05$) across the treatments are well above the minimum protein requirement of 6 – 8 g/100g for ruminants recommended by Abdu (2013). The CF composition of T_1 was significantly ($p<0.05$) lower than T_3 and T_4 but similar ($p>0.05$) to T_2. However, apart from T_1 (11.83%), the other treatments were above 12% minimum crude fibre requirement for goats as recommended by Rashid (2008) for optimal rumen function. The ether extract showed significant ($p<0.05$) difference with T_2 showing higher ($p<0.05$) value than T_3 and T_4. The ash values were higher ($p<0.05$) in T_2, T_3 and T_4. The high ash contents of the experimental diets especially the treatment groups (T_2, T_3 and T_4) is an indication of high mineral profile of the diets. The higher ($p<0.05$) ash reported in the treatment groups may be attributed to the Siam weed leaf meal. The high ash values of the treatment groups reported in this study was in agreement with earlier reports of Jiwuba *et al*. (2018). The gross energy was significantly ($p<0.05$) influenced with T_1 having the highest ($p<0.05$) value. The lower energy value reported for the SWLM containing diets may be attributed to the inclusion of SWLM in the diets, as grains tend to have higher energy values than leaf meals. NDF, ADF and ADL were all lower ($p<0.05$) in T_1 as compared with T_4. Jiwuba *et al.* (2021) in earlier study noted that low to moderate fibre fraction contents in a diet may indicate high nutritive worth since fibre plays important role in voluntary intake and digestibility. The NDF value reported in the study were above 20% on DM basis as Lalman (2012) observed that ruminant diets should contain at least 20% NDF on a DM basis to maintain optimal roughage digestion. The low to moderate ADL 9.94 to 12.54% reported in this study may imply that the quality of the experimental diets were not compromised.

The nutrient intake of West African dwarf goats fed ***Siam weed leaf meal*** is presented in Table 4. The supplement dry matter intake (SDMI) showed significant ($p<0.05$) difference with T_4 having significantly ($p<0.05$) lower value than other treatments. The lower SDMI recorded for T_4 is in tandem with earlier study by Donkoh *et al.* (2002) who blamed the lower intake on feeding higher levels of Siam weed leaf meal to animals due to higher percentage of tannin. Forage dry matter intake (FDMI) showed significant ($p<0.05$) difference, with T_4 having the highest ($p<0.05$) and T_2 having the lowest value. The decreased FDMI recorded for goats in T_2 may nonetheless be attributed to rumen fill and satiety, which, may have arisen after consumption of experimental supplement diets, by goats earlier in the day. Total dry matter intake (TDMI) was significantly ($p<0.05$) higher in T_2 and lowest ($p<0.05$) in T_4. However, it was only T_2 that met the total daily dry matter intake of 416.40g/day recommended by Anugwa *et al*. (2000). The high TDMI associated with 5% SWLM (T_2) inclusion suggests positive associative effect of the components of the SWLM at that level of inclusion. Crude protein intake (CPI) was significantly ($p<0.05$) influenced with T_4 having the lowest value and T_2 the highest. The increasing levels of SWLM in the diets might probably have promoted nutrient harmony in the diets, with the best synchronization of available nutrients at 5% SWLM diet. However, the crude protein intake of the goats fed the four diets were higher than the minimum 41.50g/day recommended for goats (NRC, 1981). The high CPI could probably be because the diets were satisfactory and exceeded the minimum protein requirement of 6 – 8 g/100g for ruminants (Abdu *et al*., 2013) as higher CP content improves intake. NDF, ADF and ADL intakes were influenced ($P<0.05$) by dietary treatments.

Table 3: Chemical composition of the experimental diets

Parameters (%)	Dietary levels				
	T_1 (%)	T_2 (5%)	T_3 (10%)	T_4 (15%)	SEM
Dry matter	92.00^{b}	93.62^{a}	91.57^{ab}	90.00^{b}	0.50
Crude protein	14.30	15.53	15.65	14.81	0.39
Crude fibre	11.83^{b}	12.57^{ab}	13.32^{a}	13.43^{a}	0.20
Ether extract	3.94^{ab}	4.35^{a}	3.72^{b}	3.49^{b}	0.11
Ash	6.57^{c}	11.66^{b}	12.96^{ab}	13.71^{a}	0.86
Nitrogen free extract	57.85^{a}	49.49^{ab}	45.64^{ab}	44.43^{b}	1.95
Gross energy (kcal/g)	520.86^{a}	479.93^{b}	462.71^{b}	435.14^{c}	3.15
Neutral detergent fibre	26.30^{b}	27.39^{b}	29.43^{a}	30.87^{a}	0.56
Acid detergent fibre	19.24^{b}	19.59^{b}	22.08^{a}	22.93^{a}	0.51
Acid detergent lignin	10.13^{b}	9.94^{b}	11.11^{ab}	12.54^{a}	0.39

$^{a-c}$ means with similar superscripts along the same row are not significantly ($p>0.05$)

The higher NDF, ADF and ADL intakes recorded for the treatment groups might be attributed to the levels of these fibre fractions present in the diets. The fibre fractions in feed can be used to predict feed intake (Van Soest *et al*., 1991). NDF, ADF and ADL-rich diets are believed to improve resistance to physical breakdown of feed components as well as encourage rumen fullness, which invariably result in decreased voluntary intake.

Table 5 shows the body weight gain of goats fed ***Siam weed leaf meal***. Final weight and body weight showed no significant (p>0.05) difference. Daily weight gain of the goats showed significant (p<0.05) difference with T_2 having the highest (p>0.05) value and T_4 the lowest. Feed conversion ratio was significantly (p<0.05) higher in $T_{1,}$ T_3 and T_4 in comparison with T_2.The animals on T_2 gave the highest (p<0.05) daily weight gain (g/day) of 53.26 g/d. The goats on the T_4 diet had the significantly lower daily weight gain of 33.60 g/d. The differences in daily weight gain of WAD goats could be attributed to the influence of SWLM in providing essential nitrogen and mineral elements both for effective rumen function and for body metabolism by the animals. Goats fed diet supplemented with 5% SWLM yielded the most superior daily weight gain and feed conversion ratio. The improved performance could be attributed to the comparatively high CP content of the diet, higher DM intake, higher CP intake, high nitrogen balance and higher CP digestibility relative to other treatments. This suggest that SWLM could serve as a good protein source for ruminants as it improved DM intake, CP intake, nitrogen balance and CP digestibility. This result agrees with the positive growth performance reported for WAD goats fed Siam weed leaf meal by Apori *et al*. (2000) and Oni *et al*. (2020).

Table 4: Nutrient intake of West African dwarf goats fed Siam weed leaf meal

Parameters (g/d)	Dietary levels				
	T_1 (%)	T_2 (5%)	T_3 (10%)	T_4 (15%)	SEM
Supplement dry matter intake	351.20^{b}	400.82^{a}	362.77^{b}	313.60^{c}	5.61
Forage DM intake	21.02^{b}	16.07^{c}	21.84^{b}	43.27^{a}	0.27
Total DM intake	372.22^{c}	416.89^{a}	384.61^{b}	356.87^{d}	7.93
Crude protein intake	54.57^{c}	66.49^{a}	62.00^{b}	51.60^{d}	1.26
Crude fibre intake	45.15^{b}	53.82^{a}	52.77^{a}	46.80^{b}	0.86
Ether extract intake	15.04^{b}	18.62^{a}	14.74^{b}	12.16^{c}	0.08
Ash matter intake	25.07^{c}	49.92^{ab}	51.34^{a}	47.77^{b}	1.29
Neutral detergent fibre intake	100.37^{c}	117.27^{a}	11659^{a}	107.56^{b}	2.41
Acid detergent fibre intake	73.43^{c}	83.87^{ab}	87.47^{a}	79.90^{b}	1.48
Acid detergent lignin intake	38.66^{b}	42.56^{a}	44.01^{a}	43.69^{a}	1.83

$^{a-d}$ means within same row with different superscripts are significantly different (P <0.05)

Table 5: Body weight gain of West African dwarf goats fed Siam weed leaf meal

	Dietary levels				
Parameters	T_1 (%)	T_2 (5%)	T_3 (10%)	T_4 (15%)	SEM
Initial body eight (kg)	7.44	6.96	7.57	7.43	0.16
Final body weight (kg)	10.63	11.54	11.04	10.32	0.39
Body weight gain (kg)	3.19	4.58	3.37	2.89	0.22
Daily weight gain (g/d)	37.09^{b}	53.26^{a}	39.19^{b}	33.60^{c}	2.68
Feed conversion ratio	10.04^{a}	7.83^{b}	9.81^{a}	10.62^{a}	0.90

$^{a-d}$ means within the same row with different superscripts are significantly different (P<0.05)

The nutrient digestibility of West African dwarf goats fed Siam weed leaf meal is presented in Table 6. The DM digestibility, CP digestibility and ash digestibility showed significant (P<0.05) difference across the treatments. Ether extract digestibility, NDF digestibility, ADF digestibility and ADL digestibility were not significantly (p>0.05) affected by the *C. odorata* leaf meal. T_2 produced significantly high dry matter digestibility in respect to the other groups. The higher DM digestibility is in agreement with the report of Bakshi and Wadhwa (2004) who reported that high neutral detergent fibre and acid detergent lignin depress dry matter digestibility. This thus suggested that the fibre content of the diet (T_2) did not suppress DM digestibility, but improved the rumen environment of the WAD goats. Crude protein digestibility coefficient values were 78.49, 77.97, 74.14 and 68.52% for T_1, T_2, T_3 and T_4 respectively. The differences observed in crude protein digestibility could be connected to the source of the protein, CP content in the diet (percentage inclusion of SWLM in the diets) and solubility in the rumen. The high CP digestibility recorded for goats fed T_1 and T_2 is an indication that concentrate feed are highly soluble and degradable. In addition, the low CP digestibility recorded for T_4 could be attributed to the presence of tannins in SWLM as a result of high inclusion levels as tannins have been implicated for having the ability to bind to feed protein in the rumen and so protect the protein from being degraded by ruminal microbes. Ash digestibility of the diets fell within the range of 61.88% (T_1) to 73.82% (T_4), which is still enough to meet the mineral requirements for production and maintenance requirements of small ruminants. The differences in ash digestibility of experimental diets may be due to differences in the inclusion levels of SWLM in the diets. Hansen *et al*. (2007) had reported that information on the ash content of a diet is essential for the assessment of its digestibility. However, the generally high ash digestibility values reported in this study could be attributed to the interactions among ingredient components of the experimental diets, which enhanced microbial activity in the rumen.

The **nitrogen utilization of** West African dwarf goats fed ***Siam weed leaf meal is presented in Table 7. Nitrogen intake, urinary nitrogen, faecal nitrogen, total nitrogen excreted and nitrogen absorbed were statistically similar*** (p>0.05), while nitrogen balance and nitrogen retention were significantly (p<0.05) influenced. The report of the present study agreed with the report of Oni *et al*. (2020) who reported no significant effect of *Chromolaenas odorata* leaf meal supplementation on total nitrogen intake, faecal nitrogen, urinary nitrogen, total nitrogen excreted and nitrogen absorbed of WAD goats. The high nitrogen balance observed for T_2 diet may be because of high crude protein digestibility, high rumen ammonia, induced microbial protein synthesis and indeed utilization of resultant microbial protein by WAD goats. Nitrogen retention was higher in goats fed 5% SWLM and lowest in goats fed 15% SWLM. The lower nitrogen retention in goats on T_4 diet can be attributed to anti-nutritional factors present in SWLM at higher level of inclusion, indicating that *C. odorata* did not alter nitrogen metabolism in the rumen at 5% and 10% levels of inclusion.

Table 6: Nutrient digestibility of West African dwarf goats fed Siam weed leaf meal

Parameters (%)	Dietary levels				SEM
	T_1 (%)	T_2 5%)	T_3 (10%)	T_4 (15%)	
Dry matter digestibility	73.82^{b}	79.35^{a}	72.77^{b}	66.81^{c}	0.84
Crude protein digestibility	78.49^{a}	77.97^{a}	74.14^{ab}	68.52^{b}	0.78
Crude fibre digestibility	69.53	62.38	64.86	63.89	1.72
Ether extract digestibility	54.73	56.17	54.86	55.99	8.36
Ash digestibility	61.88^{c}	68.29^{b}	72.86^{a}	73.82^{a}	2.01
Neutral detergent fiber digestibility	43.83	42.65	45.02	37.92	6.17
Acid detergent fibre digestibility	30.37	29.51	32.83	30.51	3.73
Acid detergent lignin digestibility	21.87	23.03	20.65	19.94	4.19

$^{a-c}$ means within the same row with different superscripts are significantly different (P<0.05)

Table 7: Nitrogen utilization of West African dwarf goats fed Siam weed leaf meal

	Dietary levels				
Parameters (%)	**T_1 (%)**	**T_2 (5%)**	**T_3 (10%)**	**T_4 (15%)**	**SEM**
Total nitrogen intake (g/day)	10.84	11.91	11.62	10.59	0.47
Urinary Nitrogen (g/day)	1.43	1.35	1.39	1.63	0.06
Faecal Nitrogen (g/day)	2.28	2.36	2.45	2.22	0.10
Total Nitrogen excreted (g/day)	3.71	3.71	3.84	3.85	0.14
Nitrogen balance(g/day)	7.13^{bc}	8.20^{a}	7.78^{b}	6.74^{c}	0.86
Nitrogen retention (%)	65.77^{b}	68.85^{a}	66.95^{b}	63.64^{c}	1.42
Nitrogen absorbed (g/d)	8.56	9.55	9.17	8.37	0.63

$^{a-c}$ means within the same row with different superscripts are significantly different (P<0.05)

Conclusion

In conclusion, Siam weed leaf meal is of good nutritional and ethno-veterinary values and can be included in the goat diets. It is recommended that inclusion level beyond 15% may not be well tolerated by the West African dwarf goats for best performance, digestibility and nitrogen utilization. The result revealed that inclusion of Siam weed leaf meal at 5% produced the best dry matter intake, crude protein intake, daily weight gain, feed conversion ratio, dry matter digestibility, crude protein digestibility, nitrogen balance and nitrogen retention. Thus, the implication of these findings is that optimizing Siam weed leaf meal inclusion level in the diet of West African dwarf goats will depend on the growth performance variable, digestibility and nitrogen utilization and could be helpful in enhancing their overall performance.

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