

Growth, digestibility and nitrogen utilization of West African Dwarf (WAD) goats fed cabbage (*Brassica oleracea*) leaves waste ensiled with Pineapple (*Ananas comosus*) peels as dry season feed

T. O. Abegunde* and A. O. Akinkunmi

Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria.

tabegunde@oauife.edu.ng

Abstract

Prolonged dry season in parts of Africa is characterized by feed shortages which impact negatively on livestock. This can be overcome by exploring conservation techniques for alternative feedstuffs that are locally available and are commonly regarded as waste. This study was conducted to assess the potential of cabbage leaves waste (CLW) ensiled with pineapple peels (PPL) as feed for WAD goats. Chemical composition of diets, digestibility, nitrogen utilization and Growth performance of WAD goats fed silage diets were determined. A total of 25 growing WAD goats with average weight of 7.7 ± 0.2 kg were randomly allocated to five experimental diets in a completely randomized design. Diets consisted of CLW: PPL at 100:0, 90:10, 80:20, 70:30 and 60:40 inclusion ratios and designated as T1, T2, T3, T4, and T5 respectively. Study lasted 12 weeks. Dry matter (DM) values were similar ($p>0.05$) in T1 (32.30%), T2 (32.70%) and T3 (32.75%) and higher than values observed for T4 (28.00%) and T5 (28.50%). Crude protein (CP) content of silage diets decreased ($p<0.05$) with increase in the inclusion levels of PPL. Nutrient digestibilities of DM and CP were high but were not ($p>0.05$) affected by treatment diets except for crude fibre and acid detergent fibre digestibilities. Goats fed T3 elicited the best growth performance ($p<0.05$) with highest Average Final Live Weight (AFLW), Average Daily Gain (ADG), and least Feed Conversion Ratio (FCR) values. Urinary nitrogen (0.91 – 3.15 g/day) and Nitrogen loss (3.10 – 5.47 g/day) were affected ($p<0.05$) by treatment diets. The study therefore concluded that cabbage leaves waste ensiled with pineapple peels should be fed at inclusion levels of 80:20 ratio respectively for best performance in WAD goat production.

Keywords: Alternative feedstuff, conservation techniques, growth performance, nutrient digestibility.

Introduction

The demand for livestock products is rapidly increasing in most developing countries. However, many developing countries have feed deficits (Wadhwa et al 2013). Therefore, the adequate all year round supply of good and quality feed in the livestock industries is one of the panacea to the limited animal protein intake suffered in most developing countries of the world, Nigeria inclusive (Odeyinka 2014). In Nigeria, rangelands blossom in the rainy season (Bamigboye et al 2013), but at the inception of dry season, most forages become unavailable as a result of rapid drying up and excessive accumulation of lignin, hence the quantity as well as quality of forages from most perennial tropical grasses and legumes decline rapidly during the (long standing) dry season (Odedire and Abegunde 2014), leading to a drastic decrease in the nutritive values of these greens. This challenge therefore, calls for a more favorable and

sustainable alternative such as the utilization of the unconventional agro-industrial by-products and household waste (Purcell 1998).

Cabbage leaves waste and pineapple fruit residues (Nisarani et al 2015; Eval et al 2019) have been reported to serve as excellent sources of nutrients for ruminants and can economize the production of animals. Cabbage (*Brassica oleracea L. var. capitata*) is considered as the most widely grown and most important vegetable among Brassicaceae family consumed worldwide. In Nigeria, a market scrutiny showed that waste of leaves from cabbage species can reach 30-50% of total production (Nguyen and Ledin 2005). Pineapple fruit residue (PFR) accounts for more than 65% of the processed fruits which include the non-edible spent pulp, peels, crown with leaves and pomace, and their disposal is a major problem due to its high moisture and sugar content predisposing it to fungal growth and spoilage (Nisarani et al 2015). Asaolu et al (2016) identified the nutritional potentials of pineapple waste as a source of energy, fiber and antioxidants in ruminant nutrition. Vegetable wastes may be fed freshly chopped or processed, such as when dried, composited or in feed blocks. Vegetable waste could also be transformed into value added products such as in silages. Silage production is a form of forage conservation where a forage, crop residue or agricultural by-product is preserved in its near fresh form for later use during the off-season period, by acids either artificially added or produced by natural preservation, in the absence of air (Moran 2005).

This study therefore investigated the growth performance, digestibility and nitrogen utilization, hematological and serum biochemical responses of WAD goats fed cabbage leaves wastes with graded levels of pineapple peels as additive.

Materials and Methods

Experimental Site: The experiment was carried out at the Sheep and Goat Unit of the Teaching and Research Farm of Obafemi Awolowo University, Ile-Ife, Nigeria. The site is located on latitude 70 33' 0"N and longitude 40 34' 0"E, 271 mþ MSL (mean sea level) of humid climatic zone of south-west Nigeria. Average annual precipitation in Ile-Ife ranges from 1000 to 1500 mm, with mean near surface wind speed of about 1.5m/s (Hayward and Oguntinyinbo 1987)

Experimental Diets: The experimental diets, silage, constituting 60% of the total diet with a compounded concentrate diet for the remaining 40%: TRT 1 = 100%CL + 0%PP; TRT 2 = 90% CL + 10%PP; TRT 3 = 80% CL + 20%PP; TRT 4 = 70% CL + 30%PP; TRT 5 = 60% CL + 40%PP. While CL = Cabbage leaves and PP = Pineapple peels.

Silage production: Cabbage Leaves and pineapple peels were collected from different groceries and vegetable stores in Ile-Ife and its environs. All the cabbage leaves collected were chopped and air dried for 3-4 days. The chopped and wilted cabbage leaves (CL) were mixed together with the pineapple peels (PP) at varying inclusion levels of 0%, 10%, 20%, 30%, 40% of the total silage diet and designated as T1, T2, T3, T4 and T5 respectively. The CL: PP mixtures were packed and compacted to remove as much air as possible, sealed in a thick polythene bag and placed in large drums with large stones placed on them for weight to create an anaerobic condition for proper fermentation. The mixtures were ensiled for twenty-eight (28) days after which they were opened and fed to goats based on 4% of their body weight.

Experimental animals and their management

Twenty-five (25) growing WAD goats with average weight of 7.7 ± 0.2 kg were used in this study. They were randomly assigned to five experimental diets in a completely randomized design. There were 5 goats per treatment with each animal serving as a replicate. The goats were housed in bamboo-built pens with constructed benches. The animals were vaccinated against *Pestes des Petit Ruminante* (PPR) using Tissue Culture Rinderpest Vaccine (TCRV). The goats were then quarantined and treated with antibiotic (Oxytetracycline LA) injection for three days. The goats were also dewormed and treated against ectoparasites. Water was offered *ad libitum*.

Determination of Nutrient Composition

Nutrient composition of experimental materials, silage diets and the concentrate diet were determined using the standard procedures of the AOAC (2000). The fibre fractions were determined using method of Van Soest et al 1991.

Growth Trials

Weighing of goats was done using hanging scale before the commencement of the study and subsequently every week throughout the experimental period. Growth trial lasted for twelve weeks. Components of experimental diets for each group/treatment were calculated as a percentage of the total diet. Silage constituted 60% of the total diet while compounded concentrate diet made up the remaining 40%. Estimation of feed offered was calculated based on 4% body weight of animals. Feed intake was calculated as the difference between feed offered and feed remnants. Diet was offered once daily in the morning.

Digestibility and Nitrogen Utilization

Digestibility trial was conducted for 7 days after an initial adjustment of goats in digestibility cages for 7 days. Cages for digestibility were fitted with facility for separate collection of faeces and urine.

Blood sample collection and analysis

Blood samples were collected from three animals per treatment via jugular vein at the end of the feeding trials (12 weeks). About 5mL of blood was obtained from each animal and divided into two: 2.5mL into plain and EDTA bottles respectively. Blood in the plain bottles were then centrifuged at 3,500 rev/min in the laboratory using Gallenkamp laboratory centrifuge in order to obtain the serum. The centrifugation was carried out according to Mitruka and Rawnsley (1977) procedure. The separated sera were decanted into bijoh (plain) bottles and stored at -10°C temperature. Total erythrocytic counts (RBC) and total leukocytic counts (WBC) were determined with the aid of Neubaur counting chamber (Hemocytometer) and Hb concentration was determined by Sahl's (acid haematin) method (Benjamin 1978). MCHC values were calculated from PCV, Hb and RBC values (Jain 1986). Alanine aminotransferase (ALT) or Serum glutamate pyruvate transaminase (SGPT), Aspartate aminotransferase (AST) or Serum glutamic-oxaloacetic transaminase (SGOT), and other serum parameters such as albumin, globulin, total protein, creatinine and glucose were analyzed spectrophotometrically according to Randox procedure (2000).

Statistical analysis

Data obtained for each parameter were subjected to a one-way analysis of variance using the General Linear Model Procedures of SAS (2001) while differences between means were separated using the Duncan's Multiple Range Test of the same package.

Table 1: Gross composition of the concentrate diet

Ingredients	Proportion (%)
Maize Bran	40.0
PKC	24.5
Wheat Offal	35.0
salt	0.25
Premix	0.25
Calculated values	
Crude protein (%)	13.45
Crude fiber (%)	12.03
Metabolizable energy (Kcal/kg)	1447.60

Results

Table 1 shows the gross composition of concentrate diets, While Table 2 shows the chemical composition of cabbage leaves waste, Pineapple peels, concentrate and silage diets. Results showed that dry matter (DM) of cabbage leaves waste (CLW) and PP were 12.60 and 16.47% respectively while CP values were 23.98 and 7.29% respectively for CLW and PP. The values for CF, EE, ash and NFE for CLW and PP were 14.07 and 11.18, 4.73 and 1.84, 5.61 and 12.76, 38.97 and 71.84 respectively. Results further showed dry matter values for silage diets ranged from 28.00 to 32.75 %. The lowest ($p<0.05$) DM value (28%) were observed in Diet 4 while Diet 3 had the highest value (32.75%). The crude protein values differ ($p<0.05$) and was highest in T1 (23.29%) and lowest in T5 (16.48%). Crude fiber value for T5 was greater (12.74%) compared to other treatments. Ether extract values obtained in this study varied ($p<0.05$) with T5 having the highest ether extract value (4.57), and T1 having the least value (1.45). The ash content increased ($p<0.05$) across the treatment as PP increased in the silage diets. Highest value (12.10%) was observed in diet 5 while diet 2 had the lowest value (10.48%). Nitrogen free extract values obtained in this study ranged from 53.97% (T1) to 57.75% (T4). All fiber fractions values were greater in the diet 5.

Growth performance characteristics of WAD goats fed cabbage-based silage diets are shown in Table 3. Average daily feed intake (ADFI) of the concentrate diet was not affected ($p>0.05$) different across treatments, while for silage diets, the ADFI for T2 (378.45g) was greater ($p<0.05$) than those of other diets. The least value (136.35g) was obtained for T5. Total ADFI values (437.20, 501.68, 480.10, and 454.87g) obtained for goats fed T1, T2, T3, and T4 respectively were similar ($p>0.05$) but higher than value observed for goats fed T5 (323.59g). The AFLW values were the same ($p<0.05$) across all the treatments and not affected by

experimental diets. The TWG (2.62kg) and ADG (31.17g) were greater ($p<0.05$) for goats fed T3. The feed conversion ratios (FCRs) were the same for goats fed T1, T2, T3 and T4 (10.17 – 14.62) but was lower than the FCR value for goats fed T5 (24.37).

Apparent nutrients digestibilities of WAD goats fed experimental diets are presented in Table 4. Results shows that the apparent nutrient digestibilities were high for all the parameters evaluated but were not ($p>0.05$) different across all the treatments except for the digestibility of the crude fibre intake (DCFI) which was greater ($p<0.05$) in goats fed T2 (76.50%), and the least in animal fed T4 (67.37%). Digestibility values for fibre fractions showed that neutral detergent fibre were similar ($p>0.05$) in all the treatments. The acid detergent fibre digestibility of T2, T3, and T5 (66.56, 67.89 and 65.40% respectively) were not different ($p>0.05$) but were higher ($p<0.05$) than values (55.78 and 52.05%) obtained for goats on treatments T1 and T4 respectively.

The data for nitrogen utilization of goats fed experimental diets are presented in Table 5. There were no ($p>0.05$) differences for the evaluated parameters across all the treatments except for the Urinary nitrogen and the Nitrogen loss. The lowest ($p<0.05$) value for the urinary nitrogen (0.91g/day) was observed in the goats fed T3, and the highest values were observed in goats fed T1, T2, T4, and T5 (2.17, 2.34, 2.32, and 3.15 g/day respectively). The total nitrogen loss (5.47g/day) was higher ($p<0.05$) in goats fed T5, than for goats on diets T1, T2 and T4 with no difference ($p>0.05$) between the three treatments (4.05, 4.44, 5.23 g/day respectively). The animals fed T3 had the least nitrogen loss (3.10 g/day). Although, the nitrogen retention was not ($p>0.05$) different across all the treatments, the animals on T3 had the relatively highest nitrogen retention (80.03%).

Table 6 shows the hematological profiles of goats fed cabbage leaves waste ensiled with pineapple peels. PVC (%), RBC ($\times 10^6/\mu\text{l}$), Hb (g/dl) and lymphocytes of the experimental animals were ($p<0.05$) affected by treatments. Same trend was observed for all the parameters above in treatment T1, T3, and T4. Values for PVC, RBC, Hb and Lymphocytes were similar ($p>0.05$) in diets T2 and T5 and higher than others.

Table 7 shows the effects of experimental diets on serum biochemical indices of WAD goats fed silage diets. Total protein, globulin, AST, ALP, creatinine and glucose of the experimental animals were not ($p>0.05$) affected by diets. Serum parameters for WAD goats were not affected by treatments, except for A.G Ratio which was higher ($p<0.05$) in T3. The albumin levels in goats were greater in those fed diet T3 and lower in goats fed diet T1 while ALT values were higher in diet T3 and least ($P<0.05$) in goats fed diet T2.

Discussion

Chemical composition

The crude protein level (13.34%) of the experimental concentrate was observed to be above the 8% needed to provide the minimum ammonia levels required for microbial activity (Norton, 1994). Minson (1983) as well reported that low-cost concentrate diets with more than 8% CP could be a good maintenance ration for ruminant animals during dry season.

Cabbage leaves wastes used in this study had a higher moisture content (87.4%) and a low dry matter (12.6%). This result agrees with the previous researchers (Tobias et al 2010, Kazemi et al 2016) who obtained comparable results (10.2%, 13.82%) respectively for dry matter in their various studies related to the brassica family, but was higher than the DM value (5.64%) reported by Evan et al 2019, while it was lower than the value (50.86%) reported by Akinfemi 2012. The Crude protein content (23.98%) obtained in this study was comparable to the value (20.4%) reported by Wadhwa et al 2006, and higher than the values (16.2%, 18.7%) obtained by other researchers (Kazemi et al 2016, Tobias et al 2010). The Crude protein level obtained in the study was higher than the critical level of 7% below which feed intake will be depressed according to Minson (1990). The Crude fibre value (14.07%) obtained for cabbage leaves waste in this study was lower than the value (18.6%) obtained by Gupta et al 1993. The ether extract value of 4.73% obtained from the study was consistent with the values (5.1%, 3.5%, 2.6%) reported by Tobias et al 2010, Kazemi et al 2016 respectively. The Dry matter (16.47%), Crude protein (7.29%), Crude fibre (11.8), Ether Extract (1.84%), Ash (12.76%), NFE (71.84%) values of the pineapple peels obtained from this study was comparable with the results (21.84%, 5.08%, 11.57%, 1.18%, 6.21%, 67%) respectively obtained by Asaolu et al 2016, and with the values (13.85%, 7.01%, 64.03% for DM, CP and NFE respectively) obtained by Suksathit et al (2011). The difference in the proximate compositions obtained in this study and those reported by other researchers may be due to several factors which can affect chemical composition of feed such as stage of growth, species or variety, soil types and growth environment (Chumpawadee et al 2007).

Silage diets

The dry matter was higher in all the silage diets compared to the individual silage ingredients (CL: 12.6; PP: 16.47), but lower ($p<0.05$) with the increasing inclusion level of the Pineapple peel as a result of its high moisture content. The crude protein of the silage diets as well significantly ($p<0.05$) decreased with the inclusion levels of pineapple peels due to the higher crude protein content of cabbage (23.98%) relative to the pineapple peels (7.29%) that were used, this agrees with the findings of Rezende et al (2015) when wasted cabbage was ensiled with different levels of ground corn and silage inoculant. However, the CP content range (16.48% – 23.29%) of all the silage diets meets the minimum protein requirement for ruminant livestock which is 8g/100 g DM (NRC 1981). The CP ranges of the diets were sufficiently high to warrant utilization of the plant residues as a feed resource for ruminant animals. The NFE which is the major representative of the carbohydrate component was greater ($p<0.05$) in both T3 and T4, which can be attributed to the interplay between the high sugar content of both cabbage leaves as well as pineapple peels, this agrees with the work of Evan et al (2019). The NDF (18.67%-31.39%), ADF (7.82%-17.78%) and ADL (1.83%-3.17%) increased progressively with increasing levels of pineapple peels in diets and was greater ($p<0.05$) in T5 which can be attributed to the higher crude fibre fractions in fermented/ensiled pineapple peels.

Growth performance

According to Ajayi et al (2005) and Ososanya (2010), feed intake is a crucial factor in the utilization of feed by livestock. The total average daily feed intake in this study decreased with time although the intakes of the animals were initially improved by the inclusion level of the

pineapple peels, but was later depressed. The same trend was observed in the total ADFI values for goats. Although the utilization of experimental diets improved ($p<0.05$) weight gain across all the diets, but the average daily weight gains values (13.24-31.17g/day) which were obtained for the goats in this study were lower than the value (73.4g/day) that was obtained by Nguyen et al (2005) when fresh cabbage leaves supplemented with soybean waste and paragrass was fed to Bach Thao goats. In addition, the growth performance results obtained in this study were comparable to the findings of Nkosi et al (2016) when dried wasted cabbage leaves were used for dorper lambs with ADWG of 223-271 g/day. As expected, the animals under Treatment 3 had the best growth performance which can be attributed to the least FCR observed for that treatment. This is indicative of the best inclusion level of pineapple peels with cabbage leaves. The animals under Treatment 5 with the highest inclusion level of pineapple peels showed least ($p<0.05$) growth performance (13.24 g/day ADWG) compared to the other treatments. This may be as a result of its higher FCR (24.337) and fiber fraction (NDF, ADF, ADL) values.

Nutrient digestibility

The high values for most of the parameters obtained from this study buttresses the finding of Evan et al (2019), that cabbage was rapidly fermented in the rumen due to its lower NDF content. The Dry Matter, ether extract and NDF digestibilities (85.31-86.42%, 92.97-94.7%, 63.33-73.11% respectively) obtained in this study were higher than those obtained for South African Dorper lambs (62-69%, 52-64%, 47-56% respectively) as reported by Nkosi et al (2016) when sun-dried discarded cabbage residues were used at various inclusion levels, although a depression in digestibility of these organic matters were observed with the increasing inclusion level of the sun-dried cabbage wastes in diets. Wadhwa et al (2006) observed comparable values (82.1%, 88.7%, 89.2%, 76.5% and 80.8%) for the digestibility of DM, OM, CP, NDF and ADF respectively in his work with buck goats using fresh cabbage. Though, there were no ($p>0.05$) differences in crude protein content of all the treatments in this study, there was a positive correlation between the crude protein content of each treatment and their respective crude protein digestibility which buttressed the earlier finding of Sayed (2009), who noted that an increase in the level of dietary protein consumption may modify the way the rumen ferments food and allow for higher protein digestibility. Additionally, it supports the findings of Geerts et al (2004), who discovered that a diet's ability to provide nutrients increased as its crude protein concentration did. The values (85.80-89.56% and 85.31-88.77%) for CP and DM digestibility respectively were comparable to the results (94.4% and 91.9% for CP and DM respectively) obtained by Evan et al (2019) as earlier stated above.

Nitrogen utilization

Maximizing the efficiency of dietary N consumption to increase development is one of the key goals of protein nutrition research in ruminants (Frutos et al 2004). Considered to be the most common indicator of ruminant protein nutrition status is the nitrogen retention (Owen and Zinn 1988). The least N-excretion in urine, least total N-loss, and the highest N-retention values observed for animals on T3 shows the adequacy of the 20% inclusion level of pineapple fruit residues with cabbage leaf wastes. Aboh et al (2013) reported similar results when DM digestibility were depressed when pineapple peels were included at levels greater than 20% in the diet of rabbits.

Hematological and Serum performances

All values for hematological parameters evaluated in these findings were within the normal range for WAD goats according to the normal reference values established by Fraser and Mays (1986). This justifies the fact that all the anti-nutritive factors present in the silage diets were not deleterious to the animals, though there may be some other health implications as was observed in the serum values. Values for TP, Albumin, Globulin, Creatinine and Glucose were all within the normal range of values for WAD goats, the values obtained for parameters such as AST and ALP were higher than the normal range. ALT across all the treatments were lower than the normal range for WAD goats as established by Fraser and Mays (1986), this deviation from norm might be an indication of some abnormal liver function and might be attributed to the effect of some other anti-nutritional factors such as the cyanogenic glucosinolates and the S-methyl-L-cysteine sulfoxide that were present in the cabbage leaves and can also be found in other *Brassica* families. Nkosi et al (2016) observed slow but progressive growth depressions when cabbage was included in the diets of South African dorper's lambs.

Table 2: Chemical composition of cabbage leaves waste, Pineapple peels, silage diets and Concentrate

Parameters (%)	Cabbage	PP	Conc.	T1	T2	T3	T4	T5	SEM	PROB
DM	12.60	16.47	94.63	32.30 ^a	32.70 ^a	32.75 ^a	28.00 ^b	28.50 ^b	0.63	<0.0001
CP	23.98	7.29	13.34	23.29 ^a	20.13 ^b	18.23 ^c	17.93 ^{cd}	16.48 ^d	0.65	0.0001
CF	14.07	11.18	14.92	10.42 ^b	10.28 ^b	10.38 ^b	10.35 ^b	12.74 ^a	0.28	0.0005
EE	4.73	1.84	7.87	1.45 ^d	2.58 ^c	2.90 ^c	3.26 ^b	4.57 ^a	0.28	<0.0001
Ash	5.61	12.76	7.89	10.86 ^{bc}	10.48 ^c	11.17 ^b	10.70 ^{bc}	12.10 ^a	0.17	0.0019
NFE	38.97	71.84	55.98	53.97 ^b	56.53 ^{ab}	57.32 ^a	57.75 ^a	54.10 ^b	0.54	0.0308
Fibre Fraction										
NDF	nd	Nd	39.86	18.67 ^d	23.14 ^c	24.59 ^b	22.46 ^c	31.39 ^a	1.12	<0.0001
ADF	nd	Nd	31.32	7.82 ^d	9.84 ^c	15.98 ^b	8.13 ^d	17.78 ^a	1.11	<0.0001
ADL	nd	Nd	1.70	1.82 ^{bc}	1.83 ^{bc}	2.30 ^b	1.29 ^c	3.17 ^a	0.18	<0.0001

a, b, c, d:

Means within row with the different superscript are significantly different (P<0.05). SEM: Standard error mean; PROB: Probability. CL: Cabbage leaves; PP: Pineapple peels, DM-Dry Matter; CP-Crude Protein, CF-Crude Fibre, EE-Ether Extract, NFE- Nitrogen Free Extracts, T1: 100% CL; T2: 90% CL + 10% PP; T3: 80% CL + 20% PP; T4: 70% CL + 30% PP, T5: 60% CL and 40% PP; nd: Not done; Conc.: Concentrate

Table 3: Growth performance characteristics of WAD goats fed cabbage leaves waste ensiled with pineapple peels

Parameters (Diets)	T1	T2	T3	T4	T5	SEM	PROB
ADFI							
Concentrate	187.25	123.23	184.18	190.62	187.25	11.29	0.3199
Silage	249.95 ^b	378.45 ^a	295.92 ^{ab}	264.24 ^b	136.34 ^c	20.23	0.0008
Total ADFI (g)	437.20 ^{ab}	501.68 ^a	480.10 ^a	454.87 ^{ab}	323.59 ^b	22.02	0.1018
AILW (kg)	7.59	7.75	7.63	7.80	7.74	0.45	0.9999
AFLW (kg)	9.53	9.49	10.25	10.02	8.85	0.45	0.9737
TWG (kg)	1.94 ^{bc}	1.74 ^c	2.62 ^a	2.22 ^b	1.11 ^d	0.12	<0.0001
ADG (g/day)	23.05 ^{bc}	20.73 ^c	31.17 ^a	26.37 ^b	13.24 ^d	1.40	<0.0001
FCR	13.60 ^b	14.62 ^b	10.17 ^b	12.05 ^b	24.37 ^a	1.44	0.1018

^{a, b, c, d}: Means within each row with different superscript are significantly different ($p < 0.05$)
T1 = 100% CL ; T2 = 90%CL + 10%PP; T3 = 80%CL + 20%PP; T4 = 70%CL + 30%PP; T5 = 60%CL + 40%PP. CL = Cabbage leaves; PP = Pineapple peels; SEM ($\pm$): Standard error of mean; PROB: Probability level; ADFI: Average daily feed intake; AILW: Average initial live weight; AFLW: Average final live weight; TWG: Total weight gain; ADG: Average daily gain; FCR: Feed conversion ratio.

Table 4: Apparent nutrient digestibility of WAD goats fed cabbage leaves waste ensiled with pineapple peels

Parameters (%) Diets	1	2	3	4	5	SEM ($\pm$)	PROB
DDMI	86.84	88.77	86.42	85.31	86.53	0.57	0.4610
DCPI	89.56	89.32	85.95	85.80	86.78	0.64	0.1465
DCFI	73.92 ^{ab}	76.50 ^a	73.55 ^{ab}	67.37 ^b	72.70 ^{ab}	1.28	0.2434
DEEI	92.97	93.88	94.07	93.07	93.16	0.29	0.7298
DASH	65.62	71.35	69.50	64.89	68.02	1.30	0.5489
DNFE	92.09	93.74	91.63	91.72	92.65	0.34	0.2921
Fibre fraction							
DNDFI	63.33	72.11	67.59	63.59	73.11	1.56	0.1139

DADFI	55.78 ^{ab}	66.56 ^a	67.89 ^a	52.05 ^b	65.40 ^a	2.20	0.0407
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a, b, c, d: Means within each row with different superscript are significantly different ($p < 0.05$).
T1 = 100% CL + 0%PP; T2 = 90%CL + 10%PP; T3 = 80%CL + 20%PP; T4 = 70%CL + 30%PP; T5 = 60%CL + 40%PP. CL = Cabbage leaves; PP = Pineapple peels; SEM = Standard error of mean; Prob = Probability level; DDMI: Digestibility of dry matter intake; DCPI: Digestibility of crude protein intake; DCFI: Digestibility Coefficient of crude fibre intake; DEEI: Digestibility of ether extracts intake; DASH: Digestibility of ash; DNFE: Digestibility of nitrogen free extract; DNDFI: Digestibility of Neutral detergent fibre DADFI: Digestibility of Acid detergent fibre.

Table 5: The Nitrogen Utilization Performance of WAD Goats fed Experimental Diets

Parameter(s)/Diets	T1	T2	T3	T4	T5	SEM	Prob
Nitrogen intake (g/day)	18.33	19.49	16.17	19.84	17.88	1.27	0.9306
Feecal nitrogen (g/day)	1.88	2.10	2.19	2.90	2.32	2.28	0.6129
Urinary nitrogen(g/day)	2.17 ^a	2.34 ^a	0.91 ^b	2.32 ^a	3.15 ^a	0.23	0.0132
Nitrogen loss (g/day)	4.05 ^{ab}	4.44 ^{ab}	3.10 ^b	5.23 ^{ab}	5.47 ^a	0.34	0.0301
Nitrogen balance(g/day)	14.28	15.05	13.07	14.61	12.41	1.10	0.9576
Nitrogen retention (%)	76.05	77.46	80.03	73.78	68.59	1.64	0.2337

a, b, c, d: Means within each row with different superscript are significantly different ($p < 0.05$)
T1 = 100% CL ; T2 = 90%CL + 10%PP; T3 = 80%CL + 20%PP; T4 = 70%CL + 30%PP; T5 = 60%CL + 40%PP. CL = Cabbage leaves; PP = Pineapple peels; SEM ($\pm$): Standard error of mean; PROB: Probability level

Table 6: Haematological profile of WAD goats fed cabbage leaves waste ensiled with pineapple peels

Parameters	T1	T2	T3	T4	T5	SEM	PROB
PCV (%)	21.67 ^b	30.33 ^a	23.67 ^b	23.33 ^b	29.67 ^a	1.13	0.0093
RBC ($\times 10^6/\mu\text{l}$)	9.59 ^b	12.30 ^a	10.13 ^b	9.67 ^b	11.94 ^a	0.38	0.0160
WBC ($\times 10^3/\mu\text{l}$)	4750	5217	5233	3767	6917	664.08	0.7323
HB (g/dl)	7.03 ^b	9.83 ^a	7.70 ^b	7.50 ^b	9.87 ^a	0.39	0.0160
Platelets (μl)	79667	74667	74333	10067	80333	5922.89	0.6773
Lymphocytes (%)	53.67 ^b	66.67 ^a	57.00 ^b	57.00 ^b	65.33 ^a	1.59	0.0056
Neutrophils (%)	44.00 ^a	29.67 ^b	39.67 ^a	39.33 ^a	32.00 ^b	1.60	0.0026
Monocytes (%)	1.33	0.67	1.33	1.00	0.67	0.17	0.6009

Eosinophils (%)	2.00	3.00	2.00	2.67	2.00	0.19	0.2941
MCV (fl)	22.34 ^b	24.66 ^a	23.34 ^{ab}	24.09 ^{ab}	24.84 ^a	0.32	0.0951
MCHC (%)	32.36	32.42	32.49	32.06	33.27	0.24	0.6411
MCH (pg)	73.138	79.93	75.93	77.29	82.65	1.40	0.2507

^{a,b,c,d}: Means within each row with different superscript are significantly different ($P < 0.05$). T1 = 100%CL; T2 = 90% CL + 10%PP; T3 = 80% CL + 20% PP; T4 = 70% CL + 30% PP; T5 = 60% CL + 40% PP. CL = Cabbage leaves; PP = Pineapple peels; SEM ($\pm$): Standard error of mean; PROB: Probability level; Hb: hemoglobin; PCV: Packed Cell Volume; RBC: Red Blood Cell; WBC: White Blood Cell; MCV: Mean Corpuscular Volume; MCH: Mean Corpuscular Hemoglobin; MCHC: Mean Corpuscular Hemoglobin Concentration.

Table 7: Serum biochemical responses of WAD goats fed cabbage leaves waste ensiled with pineapple peels

Parameters	T1	T2	T3	T4	T5	SEM	Prob
Total protein (g/dl)	7.37	7.20	8.00	7.57	7.63	0.13	0.3641
Albumin (g/dl)	2.63 ^b	2.80 ^{ab}	3.10 ^a	2.70 ^{ab}	2.93 ^{ab}	0.07	0.1755
Globulin (g/dl)	4.73	4.40	4.90	4.87	4.70	0.08	0.2989
A.G Ratio	0.56 ^{bc}	0.64 ^a	0.63 ^a	0.55 ^c	0.62 ^{ab}	0.01	0.0379
AST (μ l)	292.67	253.00	301.33	303.00	296.33	12.16	0.7398
ALT (μ l)	12.667 ^{ab}	10.33 ^b	14.00 ^a	13.00 ^{ab}	13.00 ^{ab}	0.50	0.1875
ALP (μ l)	267.33	202.67	262.67	252.67	264.00	10.99	0.3310
Creatinine (mg/dl)	1.07	1.07	1.20	1.10	1.10	0.03	0.5552
Glucose (mg/dl)	55.67	61.00	51.00	59.33	57.00	1.67	0.4137

^{a,b,c,d}: Means within each row with different superscript are significantly different ($p < 0.05$). T1 = 100%; T2 = 90% CL + 10%PP; T3 = 80% CL + 20% PP; T4 = 70% CL + 30% PP; T5 = 60% CL + 40% PP; CL = Cabbage leaves; PP = Pineapple peels; SEM ($\pm$): Standard error of mean; PROB: Probability level; A.G: Albumin-Globulin ratio; ALT: [Alanine](#) aminotransferase or [Serum glutamate pyruvate transaminase](#) (SGPT); AST: [Aspartate](#) aminotransferase or Serum glutamic-oxaloacetic transaminase (SGOT).

Conclusion

The nutritional value of the waste cabbage leaves ensiled with pineapple peels was sufficient as a supplement and satisfied the minimal nutrient needs for growing WAD goats. Diet 3 (T3) consisting of 80% CL and 20% PP gave the best growth performance in terms of ADWG and FCR. Over the duration of the investigation, some serum parameters were negatively affected; consequently, feeding of CL and PP silage over prolonged period might trigger some health implications.

Recommendation

Silage diets made from cabbage leaves waste and pineapple peels at inclusion levels of 10%, 20%, 30% and 40% can be well adopted in ruminant nutrition to overcome the off-season feed deficit and weight loss in WAD goats, but an inclusion level of 20% seems to give the best growth performance. Cabbage leaves waste with pineapple peels silage should only be used as supplementary diet and not for prolonged period due to the likely health implications of some inherent ANFs like glucosinolates and the S-methyl-L-cysteine sulphoxide.

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