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# Nutrients Intake and Digestibility by West African Dwarf Goats Fed *Enterolobium cyclocarpum* (Jacq.) Griseb. Basal Diet and Citrus Pulp-Based Diets

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**Abstract:** Wet citrus pulp from sweet orange collected from a fruit juice canning factory at Ibadan, Oyo State, was sun-dried for 7 days on asphalt surface. Sixteen West African Dwarf goats weighing 5.0-5.6 kg were used in a 112 days feeding experiment to determine the effect of citrus pulp in the dry season feed of West African Dwarf goats placed on *Enterolobium cyclocarpum* as basal feed. The dried citrus pulp contained 6.3% crude protein, 17.63% crude fibre, 5.13% ash and 69.32% nitrogen free extractives on DM basis. Citrus seeds, collected separately, contained 11.69% CP, 8% CF, 5% ash and 69.44% NFE. A control diet with contained 88.5% Brewers' Dried Grains (BDG) and three experimental diets in which BDG was replaced by citrus pulp at 25, 50 and 75% levels in the experimental diets, respectively constituted the four treatments. The highest total nutrient intakes ($p>0.05$) occurred at 50% level of dried citrus pulp replacement being 593.19, 116.08, 59.78, 266.12, 182.86, 14.58, 150.26 and 83.26 $gd^{-1}$ for DM, CP, CF, NDF, ADF, ADL, cellulose and hemicellulose, respectively. The digestibility coefficients of DM, CF, Ash, NFE, NDF, ADL, cellulose and hemicellulose increased with increasing levels of dried citrus pulp in the diets and were highest at 75% level of replacement. The inclusion of both citrus pulp and brewers' dried grains in the diet at 50% levels is recommended as dry season feed for ruminant animals using *E. cyclocarpum* as basal feed.

**Key words:** *Enterolobium cyclocarpum*, nutrient intakes, digestibility coefficients

## INTRODUCTION

The systems of small ruminant production in West Africa, especially in Nigeria, are usually characterized by limitations posed by non-availability of year-round feed resources due to usually prolonged dry season. Certain small ruminant production systems are therefore adopted by livestock owners in Nigeria to cope with the problem of feed scarcity. In the extensive management of small ruminants, supplementary feeding in the dry season is not a common feature. The situation so presented indicates that those groups of animals will have abundant feed in the wet season and a shortage of feed in the dry season. Tarawali[1] reported that many animals die of starvation during the dry season. There is also reduction in the milk yield of these animals. Thus, the livestock owners milk their animals to reduce cost of feeds. In order to therefore meet the above shortcoming arising from seasonal weather conditions in the tropics, this study was designed to determine the ability of WAD goats to utilize citrus pulp-based diets. Citrus pulp is a by-product of citrus juice canning industry and it contains about 25% dry matter.

## MATERIALS AND METHODS

This study was conducted in the Small Ruminant Experimental Unit, College of Animal Science and Livestock Production of the University of Agriculture, Abeokuta, Nigeria. Sixteen West African Dwarf (WAD) goats of both sexes, with average live weight of 5.3±kg were used for this study and the animals were housed intensively in well-ventilated individual pens. They were dewormed with albendazole and treated against ectoparasites with Ivomec. The animals were maintained on forage grass (*Panicum maximum*) and concentrate supplement with a gradual replacement of the grass with *E. cyclocarpum* leaves. The control diet contained 88.5% brewers' dried grains (BDG) and in the experimental diets, Dried Citrus Pulp (DCP) replaced 25, 50 and 75% of the BDG. Other ingredients in the diets included non dehydrated molasses, urea, salts and vitamin/mineral

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Table 1: Composition of experimental concentrate diets (%)

| | Treatments | | | |
|---|---|---|---|---|
| Ingredients | Diet 1 Control | Diet 2 25% DCP 75% BDG | Diet 3 50% DCP 50% BDG | Diet 4 75% DCP 25% BDG |
| Brewers' Dried Grains (BDG) | 88.5 | 66.37 | 44.25 | 22.13 |
| Dried Citrus Pulp (DCP) | 0 | 22.13 | 44.25 | 66.37 |
| Non-dehydrated molasses | 5.0 | 5.0 | 5.0 | 5.0 |
| Urea | 5.0 | 5.0 | 5.0 | 5.0 |
| Salt | 1.0 | 1.0 | 1.0 | 1.0 |
| Premix | 0.5 | 0.5 | 0.5 | 0.5 |
| Total | 100 | 100 | 100 | 100 |
| Calculated analysis | | | | |
| Dry matter | 83.06 | 84.37 | 83.01 | 82.64 |
| Crude protein | 23.88 | 21.68 | 18.05 | 19.44 |
| Crude fibre | 15.57 | 12.44 | 15.52 | 14.61 |
| Ether extract | 1.35 | 1.47 | 2.41 | 2.35 |
| Ash | 14.45 | 16.17 | 11.17 | 10.82 |
| NFE | 32.10 | 39.88 | 46.56 | 41.23 |

premix (Table 1). After the adaptation period, the animals were divided into four treatment groups of four animals each. Each group of animals was then assigned to one of the four different experimental diets formulated. The basal feed of *E. cyclocarpum* was harvested every evening and allowed to wilt before feeding to the animals the following day. Three experimental concentrate diets were compounded in batches on a monthly basis. The animals were weighed at the beginning of the trial and subsequently weekly till the end of the trial. Each animal was kept and fed in a separate cage during the entire experimental period of 112 days.

**Data collection:** Feed remnants were weighed daily in order to estimate daily intake. The animals were transferred into metabolic cages at the end of the 15th week for collection of faeces and urine over a period of 7 days for digestibility and nitrogen balance studies. Daily faecal collections were weighed fresh, transferred into the oven and dried for 3 days at 65°C. The faecal and feed samples were later bulked, milled to pass through 1 mm sieve and stored in separate envelopes and preserved for chemical analyses. Proximate analysis of the feeds, remnant samples and faeces were later carried out according to A.O.A.C.[2] procedures, while Goering and Van Soest[3] procedure was adopted for fibre analysis. Cellulose was taken as the difference between ADF and Lignin while Hemicellulose was taken as the difference between NDF and ADF.

**Statistical analysis:** All data were laid out as Completely Randomized Design and analysed with one-way Analysis of Variance using SPSS[4].

## RESULTS AND DISCUSSION

The feed DM ranged from 56.68-89.00 while CP was 19.43-27.31 (Table 2). The high dry matter composition of the concentrate diets was expected as the larger percentage of the feed ingredients used for compounding the feeds were from dried sources. The higher crude protein contents of the diets as determined were adequate for meeting the protein requirements of the animals as they fell within the range of 9.60 to 15% reported minimum level of requirement for ruminant animals Crowder and Chheda[5]. Odnri[6] reported that protein requirement for growing sheep was between 12 and 13%.

The crude fibre content is still within the range that the animals can utilize. The recommended level as given by Odnri[6] was 10%. Microbial attachment to the feed particles Kudo[7] would ensure effective degradation of the fibre especially since ruminants have been known to cope with diets of fibrous forages so much so that it does not utilize low-fibre diets efficiently Steg[8,9]. The fibre profile shows that the diets contain fair proportions of soluble and insoluble carbohydrates.

However, the crude protein value determined for *E. cyclocarpum* falls within the range of 10 to 37% for

Table 2: Chemical composition of the experimental diets (%)

| | Treatments Levels of replacement of BDG with DCP | | | | |
|---|---|---|---|---|---|
| Parameters | 0% | 25% | 50% | 75% | Enterolobium |
| Dry matter | 88.00 | 89.00 | 89.00 | 88.00 | 56.68 |
| Crude protein | 27.31 | 24.37 | 19.87 | 21.75 | 19.43 |
| Ether extract | 0.38 | 0.91 | 0.68 | 1.03 | 1.36 |
| Ash | 18.00 | 19.00 | 13.00 | 12.78 | 6.00 |
| Nitrogen-free extractives | 29.31 | 36.44 | 43.45 | 39.44 | 59.21 |
| Neutral detergent fibre | 58.76 | 63.28 | 59.84 | 61.26 | 36.46 |
| Acid detergent fibre | 38.87 | 39.67 | 40.27 | 39.28 | 25.54 |
| Acid detergent lignin | 8.62 | 8.13 | 6.72 | 7.98 | 4.74 |
| Cellulose | 30.25 | 31.54 | 33.55 | 31.30 | 20.79 |
| Hemicellulose | 19.89 | 23.61 | 19.57 | 21.98 | 10.93 |

Table 3: Nutrients and fibre intakes of WAD goats fed citrus pulp based diets (g $d^{-1}$)

| | Treatments Levels of replacement of BDG with DCP | | | | |
|---|---|---|---|---|---|
| Nutrients intake | 0% | 25% | 50% | 75% | SEM |
| DM intake | 509.03 | 535.71 | 593.19 | 494.14 | 31.45 |
| CP intake | 113.33 | 113.71 | 116.08 | 99.48 | 11.37 |
| EE intake | 5.13$^{b}$ | 5.09$^{b}$ | 6.60$^{a}$ | 6.10$^{ab}$ | 0.37 |
| Ash intake | 52.48$^{a}$ | 56.18$^{a}$ | 50.53$^{a}$ | 41.55$^{b}$ | 2.55 |
| NFE intake | 246.69 | 276.45 | 317.67 | 257.86 | 17.08 |
| NDF intake | 226.18 | 245.56 | 266.12 | 223.72 | 12.93 |
| ADF intake | 154.30 | 163.38 | 182.86 | 150.31 | 8.85 |
| ADL intake | 31.22 | 31.89 | 32.60 | 29.10 | 1.64 |
| Cellulose intake | 123.08 | 131.49 | 150.26 | 121.21 | 7.18 |
| Hemicellulose intake | 71.88 | 82.18 | 83.26 | 73.41 | 4.13 |

a,b -Means on the same row having different superscripts are significantly ($p<0.05$) different

Table 4: Digestibility of nutrients by WAD goats fed citrus pulp-based diets (%)

| | Levels of replacement of BDG with DCP | | | | |
|---|---|---|---|---|---|
| Parameters | 0% | 25% | 50% | 75% | SEM |
| Dry matter | 77.90 | 72.96 | 73.70 | 80.16 | 1.70 |
| Crude protein | 83.85$^{a}$ | 82.25$^{ab}$ | 79.14$^{bc}$ | 76.93$^{c}$ | 1.22 |
| Ether extract | 75.98$^{a}$ | 70.63$^{ab}$ | 52.22$^{c}$ | 66.97$^{b}$ | 2.78 |
| Ash | 52.97 | 58.47 | 54.33 | 64.77 | 2.70 |
| Nitrogen-free extractives | 77.77$^{b}$ | 72.23$^{b}$ | 73.92$^{b}$ | 82.52$^{a}$ | 1.78 |
| Neutral detergent fibre | 63.35 | 59.69 | 59.57 | 69.16 | 2.47 |
| Acid detergent fibre | 67.07 | 64.12 | 63.69 | 72.58 | 2.24 |
| Acid detergent lignin | 69.51 | 62.71 | 62.00 | 71.11 | 2.21 |
| Cellulose | 66.46 | 64.46 | 64.04 | 72.93 | 2.25 |
| Hemicellulose | 55.34 | 50.93 | 51.22 | 62.09 | 2.85 |

a,b,c -Means on the same row having different superscripts are significantly ($p<0.05$) different

browse plants in Nigeria (Mecha and Adegbola [10,11]. The DM intake from the feed decreased with increasing levels of both citrus pulp and brewers' dried grains in the diets. The highest dry matter intake though not significant was recorded in treatment 3 with 50:50 ratios of citrus pulp and BDG in the diets (Table 3). This may probably be explained with the findings of Bhattacharya and Harb[12] that average daily intake of rations tended to decrease as the proportion of citrus pulp increased. Also, at 75% replacement level of citrus pulp (Treatment 4), the palatability of the feed should have greatly reduced because of the high inclusion of citrus pulp and the possible residual volatile essential oil of the peel it contains which was reported to be bitter Mba[13]. This result agrees with the report of Bhattacarya and Harb[12] that the palatability of a ration containing citrus pulp tended to decline when the pulp in the ration is beyond 40%.

The goats in all the treatments were consuming adequate dry matter to sustain production NRC[14]. Also, the decreased DM intake in treatments 1 and 2 may be attributed to higher contents of brewers' dried grains in the diets. This agrees with the reports of Adu[15] that DM intake decreased with increasing level of BDG in the diets. Despite this, the goats derived the minimum CP requirement in excess of 5 $g.d^{-1}$ NRC[14] from the diets. Thus the diets could be said to have potentials as supplements to contribute to nitrogen intake of livestock especially ruminants. Generally, fibre (NDF, ADF and Lignin) intakes were not significantly ($p>0.05$) different among the treatment diets. The higher NDF, ADF and ADL reported in this study were as a result of dried materials which constituted the treatment diets. Drying (sun drying or oven drying) was found to affect the chemical composition of tree legumes and feeds in a related study resulting in higher NDF, ADF and NDF-N levels in leaves Roger[16,17]. Cellulose and hemi-cellulose intakes were dependent on the intake of NDF, ADF and ADL and the proportion of each in the diets. Thus, any factor that affects the level of fibre components intake is expected to have a corresponding influence on cellulose and hemi-cellulose intake Arigbede[18]. The intake of cellulose was not significantly different ($p>0.05$) but was consistently higher than hemicellulose because of higher content of cellulose in the diets.

The digestion coefficients in this trial (Table 4) agree with the report of Bhattacharya and Harb[12] which reported that digestion coefficients for dry matter varied from 75-81% at 0, 20, 40 and 60% levels of citrus pulp inclusion However, the crude protein digestibility was significantly ($p<0.05$) lower at 75% level of citrus pulp replacement. This result agrees with Bhattacharya and Harb[12] who reported that digestion coefficients of crude protein in the ration containing 60% citrus pulp was significantly lower ($p<0.05$) than that of other rations. Similar reports of DM digestibility were also made by Harms[19] and Cottyn and Boucque[20] who reported DM digestibility of 83 at 65% levels of citrus pulp supplementation. Generally, the digestibility values were higher at 75% levels of citrus pulp replacement not because it is more nutritious but rather because of very low DM intake by goats on this treatment. Thus, the little intakes were fully maximized within the body system. This was evidenced by the very small amount of faeces and urine output by the animals. The higher nutrient digestibility values recorded at 75% level of citrus pulp replacement also agree with the report of Mba[13] that there were general tendencies for digestibility values to increase with increasing levels of citrus pulp supplementation in the diets.

## CONCLUSION

Dried citrus pulp has the potential to fill the gap of dry season feed scarcity in terms of productivity, nutrient composition and nutritive value. With the official ban in the importation of fruit juice and other citrus by-products in Nigeria, it is envisaged that large quantities of citrus waste which could be processed into dry season feed for ruminant animals would be available. The inclusion of both citrus pulp and brewers' dried grains in the diet at 50% levels could be recommended as dry season feed for ruminant animals using *E. cyclocarpum* as basal feed. Further studies might however be necessary to establish the nutritive potentials of citrus pulp with other agro-industrial by products apart from BDG. Also, the feeding values of *E. cyclocarpum* as an indigenous multipurpose tree should be further investigated.

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