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Nutritive Value of Mulberry (*Morus* Spp.) Leaves in the Growing Rabbits in Nigeria

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Abstract: The potential of mulberry leaves in rabbit production was investigated in a 12-week long experiment where feed intake, weight gain and nutrient digestibility of the rabbits were monitored. Thirty weaner rabbits (19 females and 11 males; mean weight = 450 ± 0.05 g) of mixed breeds were sorted by weight and randomly allocated to five experimental diets. The percentage of concentrate in the rations was incrementally replaced with mulberry leaves: 100:0, 75:25, 50:50, 25:75, 0:100 and were fed in a completely randomized design. Total dry matter (DM) intake of the concentrate: mulberry diet remained at the level of that of the all-concentrate ration (~38 g/d) until mulberry leaves comprised >50% of the ration before it declined significantly. The intakes of crude protein (CP) and crude fiber (CF) increased significantly while those of ether extract (EE), ash and nitrogen free extract (NFE) decreased significantly with increasing level of mulberry leaves in the diets, following the trends of the concentrations of the nutrients in the materials. The nutrient digestibilities of the diets were high and there were no significant differences among the means for DM (75.67 - 82.33%), organic matter (OM: 77.33 - 86.67%), CP (76.33 - 84.00%), CF (79.67 - 88.67%), and ash (52.00 - 62.67%). Digestibility of EE (55.65 - 86.00%) and NFE (76.00 - 87.33%) significantly declined with increasing level of mulberry leaves in the rations. Weight gain of rabbits on diets containing 25 and 50% mulberry leaves (5.14 and 4.72 g/d, respectively) was not significantly different (P=0.05) from that of the all-concentrate ration (5.72 g/d), but these were significantly higher than those of 25:75 and 0:100 concentrate: mulberry diets (3.43 and 2.27 g/d, respectively). Thus, mulberry leaves can support good feed intake, digestibility and satisfactory weight gain in rabbits, and could reduce reliance on and cost of expensive concentrate diets. However, some level of concentrate feeding is necessary to reach potential weight gains.

Key words: Rabbit, digestibility; mulberry leave

Introduction

Rabbit production is gaining popularity in Nigeria because of low cost. Rabbits can supply the needs of an average family and is a suitable and cheaper alternative to poultry. Being a monogastric herbivore, with digestive system that can cope with fibrous plant matter, such as grasses, legumes or their hays, rabbits can thrive on forage diets although potential weight gains are not attained because of the poor nutritive value of tropical forages (Adegbola *et al*., 1985; Bamikole and Ezenwa, 1999). Even though locally grown feed materials have been identified (Bamikole *et al*., 2000a; Bamikole *et al*., 2000b), formulation of a concentrate diet requires expensive feed ingredients, notably oil cakes, which are the major sources of protein and energy in the diets. Identification of forage that has high nutritive value that could replace or reduce the need for concentrate feeding will keep the cost of rabbit production low and sustain growing interest.

Mulberry leaves have quality attributes that make it a potential replacement for concentrate in rabbit feeds. Because of the high nutritive value of the leaves, they were popular as food for silkworms in sericulture (Subbarayappa and Bongale, 1997). Mulberry can easily be established in the field (Ezenwa *et al*., 1999), and has good coppicing ability (Singh and Makkar, 2002). It has good potential for forage production, and the yield of fresh leaves is reported to be in the range of 16-40 tons/ha/year (Rodriguez *et al*., 1994; Mehla *et al*., 1987). Mulberry leaves are very rich in protein and minerals but low in fiber (Fotadar and Dandin, 1997; Omar *et al*., 1999). The protein is of high quality comparable to or better than soybean meal (NRC, 1984; Marchii, 1989). Excellent results have been obtained with using mulberry leaves as ruminant feed (Rojas and Benavides, 1994; Oviedo *et al*., 1994; Velazquez *et al*., 1994; Esquivel *et al*., 1996; Gonzalez, 1996; Omar *et al*., 1999). Information on feeding mulberry to non-ruminants is scanty but it has been used in pigs (Trigueros and Villalta, 1997), laying hens (Narayana and Setty, 1977), and rabbits (Deshmukh *et al*., 1993). Because of the possibility of obtaining large amounts of high quality forage from mulberry without expensive inputs due to favorable soil and climatic conditions for its growth, mulberry leaves deserve evaluation as feed for rabbits in Nigeria. In this study, the potential of mulberry leaves to replace concentrate was evaluated at different levels of feeding. Feed intake, weight gain and nutrient

Table 1: Ingredient composition (g/kg) of the concentrate feed

Ingredient	Composition
Maize	150.0
Soya bean	95.0
Palm kernel cake	177.0
Wheat bran	160.5
Dried brewers grain	385.0
Mineral & Vitamin mix*	2.5
Bone meal	15.0
Oyster shell	10.0
Salt	5.0

*Composition of the mineral and vitamin mix per 2.5 kg: Vitamin A, 5,000,000 IU; Vitamin E, 6,000.IU; Vitamin K_3, 8,000 IU; Vitamin D_3, 600,000 IU; Vitamin B_1, 1,000 IU; Vitamin B_2, 1,500 IU; Niacin, 12,000 IU; Pantothenic acid, 4,000 IU; Vitamin B_6, 1,500 IU; Vitamin B_{12}, 800 IU; Folic acid, 300 IU; Biotin, 10 IU; Choline-Choloride, 150,000 IU; Manganese, 60,000 IU; Iron, 10,000 IU; Zinc, 15,000 IU; Copper, 800 IU; Iodine; 400 IU; Cobalt, 80 IU; Selenium, 40 IU.

digestibility of rabbits on diets of sole mulberry leaves and concentrate as well as those consisting of different percentages of mulberry leaves and concentrate were determined.

Materials and Methods

The experiment was carried out at the Rabbitry Unit of the University of Benin Farm Project. Mulberry leaves were obtained from 4-year old trees at the demonstration plots of the Forestry and Wildlife Department of the University. Leaves were from current year's growth and harvested between July and October. Thirty 6 – 7 weeks old weaner rabbits (19 females and 11 males) of mixed breeds weighing 405 – 505 g (mean = 450 g) were used. The animals were housed individually in raised hutches measuring 60 x 63 x 77 cm. The entire house and the hutches were previously cleaned and disinfected before the animals arrived. On arrival at the unit, the animals were given prophylactic treatment, which involved antibiotics (Neo-terramycin) and anti-stress (Aminovit) administered in drinking water for five days. They were also dewormed using coopane dewormer (a brand of piperazine) at the rate of 2 g per litre of water.

Five experimental diets, consisting of different percentages of concentrate and mulberry leaves (DM basis): 100:0 (all concentrate); 75:25; 50:50; 25:75 and 0:100 (all mulberry leaves) were fed. The concentrate was formulated to meet nutrient requirements of a growing rabbit. Mulberry leaves were fed fresh. A completely randomized design was used for the study. The rabbits were sorted by sex and weight, and randomly allocated to experimental diets. Experimental feeds were served in troughs hung at a reasonable height in the hutches to minimize feed wastage by the animals. Two feed troughs were used for rabbits that received both mulberry leaves and concentrate as these were served separately. Quantity of each feed component in the mixed diet was calculated based on the specified ratio of each treatment and on dry matter basis. Total feed served was the fresh matter equivalent and was offered at *ad libitum* level by providing each animal with 50 g DM/kg live weight per day which provided for daily allowance of at least 5% above the previous day's consumption. Water was provided *ad libitum* in a weighted clay saucer. Daily ration was offered in two equal portions at 0800 and 1400hrs, respectively.

Data collection began after two weeks of adaptation of the rabbits to experimental diets and hutches. Feed consumption was recorded daily as the difference between the quantity of feed offered and refusal. Animals were weighed weekly to monitor growth rate, while feed conversion efficiency (FCE) was determined as the ratio of mean daily weight gain (DWG) to daily feed intake (DFI): DWG/DFI. Samples of mulberry leaves and concentrate offered and the refusals were taken daily and dried in the oven at 60^{o}C to constant weight for DM determination. At the end of growth trial (ten weeks), the animals were transferred to metabolism cages that permitted total faeces collection. Following one week of adaptation to the new cages, faeces were collected daily for five days. Total faeces voided per day were weighed for each animal and dried in the oven at 60^{o}C to constant weight for DM determination. Dry samples of mulberry leaves, concentrate, refusals and faeces were milled and kept for laboratory analysis. Proximate analyses of milled samples were done according to the standard procedures of AOAC (1990, reference ID numbers 930.15, 954.01 and 942.05). Data were subjected to statistical analysis using completely randomized design. Treatment mean differences were declared significant at $P < 0.05$, and ranked by the Duncan multiple range test (SAS, 1995).

Results

The ingredient composition of the concentrate feed is presented in Table 1. The diet was formulated to meet the basic nutrient requirement of a growing rabbit. Table 2 shows the proximate composition of the concentrate and that of mulberry leaves. The composition of mulberry leaves compares favorably with that of the concentrate, having higher content of CP and CF, but lower contents of EE than the concentrate. However, both have more than adequate levels of the nutrients and total digestible nutrients (TDN) to meet requirements of a growing rabbit (NRC, 1984).

The intake, weight gain and feed conversion efficiency (FCE) of the rabbits on the different diets are given in Table 3. There were no significant differences among the diets when the percentage of concentrate was 50% or more. DM intake declined significantly when the

Table 2: Proximate composition (g/kg DM) of the mulberry leaves and concentrate fed to the rabbits

Composition	Concentrate	Mulberry
Dry matter	925.0	262.2
Organic matter	864.8	898.2
Crude protein	190.0	231.9
Crude fibre	120.0	384.2
Ether extract	48.5	31.8
Ash	135.2	101.8
Nitrogen free extract	506.3	250.3
Total digestible nutrients (%)[1]	79.3	76.5

[1]Total digestible nutrients (TDN) was calculated from the digestibility values of nutrients obtained in this experiment with the all-concentrate and mulberry leaves diets:
TDN% = CF% x dc + CP% x dc + 2.25EE% x dc + NFE% x dc, where dc = digestibility coefficient.

percentage of concentrate was 25% and was lowest when an all-mulberry leaves ration was fed. OM intake differed among the treatments, and followed a similar trend as dry matter intake. The intakes of CP and CF significantly increased while those of EE, NFE and ash decreased with increasing level of mulberry leaves in the diets.

Daily weight gains of the rabbits declined as the percentage of concentrate decreased or that of the mulberry leaves increased. The weight gains of rabbits on the 75:25 and 50:50 concentrate: mulberry leaves diets were not significantly less than that of the all-concentrate (100:0) diet. Daily weight gain significantly declined when mulberry leaves was given at >50%. When fed as sole diet (0:100), only 40% of the weight gain on the all-concentrate ration was achieved. FCE followed a similar trend as weight gain. The diets had similar nutrient digestibilities (Table 4). Levels of DM, OM, CP, and CF were not significantly different among the diets, except for EE and NFE. Values of EE and NFE significantly declined as the percentage of concentrate offered decreased. NFE was highest in the all-concentrate ration but the values for the other diets were similar.

Discussion

The high nutrient content and digestibility of mulberry leaves, comparable to those of concentrate make the leaves popular as feed supplements. Mulberry leaves can supply the nutritional requirements of growing rabbits according to the recommendations of Omole (1982) and NRC (1984). The contents of CP, EE, and ash in mulberry leaves used in this study are similar to reported values (Deshmukh *et al*., 1993; ITA, 1998). In temperate countries, lower values of CP and CF, but higher values of EE and ash than in this study were reported (Narayana and Setty, 1977; Singh *et al*., 1984). The higher CF in our study is attributable to high ambient temperatures under which the plants grew (Wilson and Wong, 1982). The high CF contents of mulberry leaves in the current study did not limit intakes of DM, OM, and nutrients since the different diets were consumed to similar levels. Deshmukh *et al*. (1993) using adult rabbits obtained higher DM intake (68.5 g) when mulberry leaves was fed as a sole diet. The use of weaner rabbits in current study is the reason for the different result.

The DM intake of rabbits on sole mulberry leaves was only 3.9% lower than that of the all-concentrate ration. Secondly, there were no significant differences in DM intake when mulberry leaves replaced up to 50% of the concentrate. These are pointers to the highly palatable and nutritive quality of the leaves. High palatability of mulberry leaves to goats has also been demonstrated by their avid consumption of the leaves when it is first introduced to them (Sanchez, 2002). The intake of mulberry leaves in current study (6.9% of body weight) is within recommended levels of 4.6-7% (Prud'hon, 1968). The variations in the intakes of CP, CF, ash, EE, and NFE among the experimental diets followed the trends of the differences in the levels of the nutrients in the concentrate and mulberry leaves. The potential of the mulberry leaves to enhance intake of a critical nutrient like CP is noteworthy.

Mulberry leaves can replace a substantial amount of concentrate needed for reaching potential weight gains in rabbits. Weight gain and FCE were only significantly depressed below the level achieved with an all-concentrate ration when mulberry leaves comprised more than 50% of the ration. As the proportion of mulberry leaves in the rations increased, reduction in weight gain and FCE might have resulted from the combination of lower DM intake of the leaves because of its low DM content (262 g/kg vs. 925 g/kg in the concentrate) and lower intake and digestibility of NFE, and possibly digestible energy. However, the digestibility values obtained with feeding mulberry leaves are higher than many reported values (Deshmukh *et al*., 1993). Evidently, the rabbits were able to digest CF and nutrients in the leaves even to levels similar to the 75 - 85% reported for alfalfa protein (McNitt *et al*., 1996; Irlbeck, 2001). Ezenwa and Kitahara (1999) recorded potential degradability of 91-97% in eleven mulberry varieties. Similarly, ITA (1998) reported a degradability value of 99.7%. In goats, Jegou *et al*. (1994) and Rodrguez *et al*. (1994) reported *in-vitro* digestibility of 78 - 95%.

The high nutritive value of mulberry leaves notwithstanding, some level of concentrate feeding is required for optimum growth to be achieved. This is in line with the results of Adegbola *et al*. (1985) and Bamikole and Ezenwa (1999) where weight losses of rabbits on sole forage diets were reported even though

Table 3: Nutrient intake and weight gain of rabbits fed diets containing different percentages of concentrate and mulberry leaves

Parameter	Diets (% concentrate: mulberry leaves)					
	100:0	75:25	50:50	25:75	0:100	SEM
Intake (g/d)						
Dry matter	37.98ab[1]	38.54a	38.44a	37.38b	36.54c	0.34
Organic matter	33.88a	33.65a	33.26ab	32.84b	32.82b	0.27
Crude protein	7.22d	7.73c	8.10b	8.27b	8.47a	0.07
Crude fibre	4.56e	7.16d	9.64c	11.81b	14.04a	0.10
Ether extract	1.84a	1.70b	1.55c	1.35d	1.16e	0.01
Ash	5.14a	4.89b	4.56c	4.13d	3.72e	0.03
Nitrogen free extract	19.23a	17.07b	14.59c	11.84d	9.15e	0.10
Weight gain (g/d)	5.72a	5.14a	4.72a	3.43b	2.27b	0.40
Feed conversion efficiency	0.15a	0.13a	0.12a	0.09b	0.06c	0.01

[1]Means in a row followed by the same letter are not significantly different at 0.05 level of probability.

Table 4: Dry matter and nutrient digestibility of diets containing different percentages of concentrate and mulberry leaves fed to the rabbits

Parameter	Diets (% concentrate: mulberry leaves)					
	100:0	75:25	50:50	25:75	0:100	SEM
Dry mater	82.33a[1]	75.67a	75.67a	77.00a	79.67a	2.39
Organic matter	8.67a	77.33a	78.33a	78.67a	82.33a	1.89
Crude protein	84.00a	77.67a	76.33a	80.33a	83.67a	2.17
Crude fibre	81.67a	86.67a	79.67a	83.67a	88.67a	2.19
Ether extract	86.00a	68.67b	65.67b	74.33b	55.65c	3.24
Ash	62.67a	58.00a	57.33a	56.33a	52.00a	4.57
Nitrogen free extract	87.33a	76.33b	79.67b	73.33b	76.00b	2.33

[1]Means in a row followed by the same letter are not significantly different at 0.05 level of probability.

adequate levels of DM intakes were obtained. The work of Singh *et al*. (1984) which evaluated the supplementary value of mulberry leaves fed with concentrate diets to Angora rabbits for wool production, indicated that mulberry leaves may be used up to 40% of DM intake. Published reports involving chemical analyses not carried out in current study indicate outstanding chemical composition of mulberry leaves. These reports indicate high levels of total and essential amino acids, Ca, P, and other minerals in the leaves (Narayana and Setty, 1977; Trigueros and Villalta, 1997; Yao *et al*., 2000).

The outstanding nutritive quality of mulberry leaves has also been exploited for other livestock. Daily gain was not affected in female calves (0-4 months) when mulberry leaves were offered *ad libitum* and the commercial concentrate reduced to 25% (Gonzalez and Mejia, 1994). In lactating cows, mulberry leaves effectively replaced grain-based concentrate with no significant effect on milk yield (Esquivel *et al*., 1996). In lambs, improvement in gain up to 100 g/d was reported on supplementing king grass with 1.5 DM of mulberry leaves (Benavides, 1986). Daily weight gains of pigs on commercial concentrate substituted with 15% mulberry leaves increased from 680 to 740 g/d (Trigueros and Villalta, 1997).

Conclusion: The high levels of nutrients, intake and digestibility confirm the high nutritive value of mulberry leaves and their potential as a forage that can support rabbit production. With comparable DM intake, digestibility and weight gain as in all-concentrate ration achieved with up to 50% substitution of concentrate in rations, rapid growth rate of rabbits can be achieved at less cost. Where marketing opportunities does not necessitate rapid weight gains, producers may chose to substitute more concentrate or even feed mulberry leaves as a sole diet to achieve satisfactory gains at even lower costs.

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