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ALTERNATIVE FEED RESOURCES FOR FORMULATING CONCENTRATE DIETS OF RABBITS.

1. UNTHRESHED GRAIN AMARANTH SEEDHEAD.

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ABSTRACT : The acceptable level of inclusion of unthreshed inflorescence or seedheads of mature grain amaranth plants (GASH) as feed ingredient of concentrate diets of rabbits was examined. Four diets were formulated with GASH inclusion levels of 0 (control), 10, 20 and 30%, respectively, by partially replacing the levels of oil cakes in the diets. These were fed to rabbits in an eight-week long feeding trial (8 rabbits/treatment) and a digestibility trials (4 rabbits per treatment). The initial weight of the 7-8 week old rabbits was 710 g (adult weight of this population is 1.8 to 2.4 kg). The proximate composition (g/kg DM) of GASH was : 151 crude protein ; 43 crude fibre ; 572 nitrogen free extract. Intake and weight gain were reduced with diets containing 20 and 30% GASH but values of the control diet, which were highest, were not significantly higher than those of the 10% GASH diet (daily intake 44 and 37.4 g DM, and weight gain 10.0 and 8.2 g for 0 and 10 % GASH). Feed efficiency was similar for the 4 diets : 0.22 weight gain/g DM feed intake. Dry matter and nutrient digestibility and feed conversion efficiency of the GASH diets were generally high with minor differences among the diets. Haematological parameters and serum metabolites were generally better with the 10 and 20% GASH diets than with the control diet but poorer with the 30% GASH diet. Higher white blood cell counts were recorded in the GASH diets than the control. Thus, unthreshed mature grain amaranth seedhead can be used as a component of the concentrate feeds of rabbits, up to 10% dietary level, to partially replace expensive oil cakes in the diets.

RÉSUMÉ : Matières premières alternatives pour la formulation des aliments concentrés pour lapins. 1 – Sommités florales mûres mais non battues d'amarante à grain.
Cette étude a pour but de déterminer le niveau optimal d'inclusion dans un aliment concentré pour lapins, des sommités florales mûres mais non battues d'amarante à grain (GASH), c'est à dire de l'ensemble brut de la partie portant les graines. Quatre aliments ont été formulés comme suit : addition de GASH à 0% (témoin), 10%, 20% et 30% respectivement, par remplacement partiel des tourteaux (palmiste principalement). Ces aliments ont été distribués aux lapins dans un essai de croissance ayant duré 8 semaines (8 lapins par lot) et dans un essai de digestibilité (4 lapins par lot). Les lapins âgés de 7-8 semaines en début d'essai avaient un poids initial de 710g (poids adulte dans cette population : 1,8 à 2,4 kg). La composition approximative du GASH (g/kg MS) était : protéines brutes 151 ; cellulose brute 43 ; extractif non azoté 572. La consommation alimentaire et le gain de poids ont été réduits avec les aliments contenant 20 et 30 % GASH ; mais les valeurs pour l'aliment témoin, nettement plus élevées, ne sont pas significativement différentes de celles obtenues avec 10 % de GASH (consommation journalière 44 et 37,4g MS et gain de poids 10,0 et 8,2g/j. pour 0 et 10 % de GASH). L'efficacité alimentaire a été identique pour les 4 aliments : gain de poids 0,22/g MS ingérée. La digestibilité de la matière sèche et des différents nutriments et l'efficacité alimentaire des aliments contenant du GASH étaient élevés. Les meilleurs résultats par rapport à l'aliment témoin ont été obtenus avec les aliments contenant 10 et 20 % de GASH, les plus mauvais concernant l'aliment avec 30 % de GASH. Par rapport au lot témoin, une quantité plus élevée de globules blancs a été trouvée dans le sang des lapins des lots recevant du GASH. En conclusion, les inflorescences non battues, portant des graines matures d'amarante à grain peuvent être utilisées à hauteur de 10 % dans les aliments concentrés pour lapin, pour remplacer partiellement les tourteaux de graines oléagineuses.

INTRODUCTION

Rabbits are herbivores with post-gastric digestion and can utilize a wide variety of feed resources. This versatility in the feeding habits of rabbits, their ease of handling and limited space requirements, among other attributes, are the reasons why they are becoming a very popular source of meat among city dwellers in Nigeria (ONIFADE *et al.*, 1999). However, for rabbits to grow rapidly and perform optimally, they require good quality feeds. Our previous study (BAMIKOLE and EZENWA, 1999) and others (e.g. ADEGBOLA *et al.*, 1985) showed that concentrate feeding is essential for rabbits. The expensive nature of concentrate feeds and the cost and erratic supply of the ingredients used in their formulation, especially oil cakes that are the major sources of protein in the diets, can potentially limit the spread of rabbit keeping. Against these scenarios, we examined the possibility of reducing the level of oil seed cakes in the diets by using raw materials that can be grown easily by the rabbit keepers. The use of unthreshed grain amaranth inflorescence or seedhead is reported in this paper.

Grain amaranth is an underutilized plant whose many attributes for food and feed are increasingly being recognized. The crop is exotic to Nigeria. Unlike indigenous amaranths with small inflorescence and low seed yields, and whose leaves and succulent stems are consumed as vegetables, grain amaranths have large seedheads with seed yields of 1.5 – 2.0 t/ha. The nutritive value of grain amaranth is comparable to or better that those of maize and wheat (BRESSANI, 1984; TILMAN and WALDROUP, 1988; OLOGUNDE *et al.*, 1992; FANIMO *et al.*, 1999; JALC *et al.*, 1999). The grains, however, contain antinutritional factors including alkaloids, saponins, phytates and tannins (AFOLABI and OKE, 1981, OLOGUNDE *et al.*, 1992), requiring some form of treatment or detoxification to maximize the utilization of the grains as feed for non-ruminants. There are, however, some indications that the levels of the antinutritional factors in amaranth grains may not always be present at levels that would inhibit protein and mineral utilization in animals (OLOGUNDE *et al.*, 1992).

Most of the information on the use of grain amaranth in animal feeding has been obtained with avian species for which the raw grains cannot be used without treatment (TILMAN and WALDROUP, 1988). JALC *et al.* (1999) showed that the untreated grains could be incorporated into sheep diets without an adverse effect. In rabbits, the composition of feed strongly influences the haematological characteristics of the animals and some of these characteristics, such as packed cell volume (PCV) and haemoglobin (Hb) levels, can indicate the nutritional adequacy of the feeds (HACKBARTH *et al.*, 1983; BABATUNDE and POND, 1987; ONIFADE and TEWE, 1993).

The use of amaranth grain as a component of livestock feed requires that the seedhead be processed to extract the very small grains. Under the current level of production in Nigeria and with the drudgery associated with manual processing methods, threshing of amaranth seedhead is a constraint to the use of the grains in routine feed formulation. Thus, we set out to determine the nutritional quality of the unthreshed grain amaranth seedhead (inflorescence with intact grains) and its replacement value for oil cakes in concentrate feeds based on the performance of rabbits fed diets containing different levels of inclusion of grain amaranth seedhead (GASH).

MATERIALS AND METHODS

The experiment was carried out in the Teaching and Research Farm of the University of Ibadan (7° 20' N, 3° 5' E; 200 m above sea level; average daytime temperature, 28 – 34° C). Mature GASHs were harvested from the evaluation plots of the Agronomy Department of the University. The only processing done on the materials involved air-drying and removal of the main stalks or peduncles. They were then transferred to the Feed Mill and ground with the other feed materials used in formulating the experimental diets.

Table 1 : Ingredient composition (g/kg) of the experimental diets containing different levels of unthreshed grain amaranth seedhead (GASH).

	Inclusion level of GASH (g/kg)			
Ingredients	**0**	**100**	**200**	**300**
Maize	200.0	200.0	200.0	200.0
GASH	0	100.0	200.0	300.0
Dried brewer's grain	227.5	227.5	227.5	227.5
Palm kernel cake	440.0	360.0	260.0	160.0
Groundnut cake	100.0	80.0	80.0	80.0
Oyster shell	10.0	10.0	10.0	10.0
Bone meal	15.0	15.0	15.0	15.0
Mineral and vitamin mix[1]	2.5	2.5	2.5	2.5
Salt	5.0	5.0	5.0	5.0

[1] Supplied per kg of diet: Vitamin A, 7,000 IU; Vitamin D3, 1,400 IU; Vitamin E, 5 IU; Vitamin K, 2.0 mg; Vitamin B1, 1.5 mg: Vitamin B2, 4.0 mg; Vitamin B6, 1.5 mg; Vitamin B12, 0.1 mg; Niacin, 15 mg; Pantothemic acid, 5.0 mg; Folic acid, 0.5 mg; Mn, 75 mg; Zn, 45 mg; Fe, 20 mg; Cu, 5 mg; I, 1 mg; Se, 0.1 mg; Co, 0.2 mg; Choline Chloride, 100 mg.

Thirty-two (20 females and 12 males) rabbits of mixed breeds (characteristic of the rabbits commonly kept by most keepers in the area) were purchased from locations around the Ibadan metropolis. The ages of the rabbits were between 7 and 8 weeks while the average initial body weight was 710 g (range 640 – 850 g). On arrival at the Rabbit Unit, they were given prophylactic treatment that involved administration of antibiotic (Neo-terramycin), anti-stress (Aminovit) as well as dewormer (Coopane, a brand of piperazine). The animals were housed individually in raised hutches in a house which had a concrete floor with metallic sheet roofing. The house was designed to ensure cross ventilation and to exclude rodent and other pests. Each cage was provided with a metallic feeder, hung at a reasonable height in the cage to prevent wastage of feed and weighted clay bowls for water.

Four experimental diets (Table 1) were formulated to achieve GASH inclusion levels of 0, 10, 20 and 30%, i.e. 0, 100, 200 and 300 g/kg, respectively, at the expense of the levels of palm kernel and groundnut cakes, the major protein sources in the diets. The diets were not pelleted. The levels of crude protein, energy and fibre in the diets were maintained at similar levels as much as possible and adequate to meet their recommended levels according to NRC (1977). After balancing for weight differences, the rabbits were randomly allocated to the four experimental diets at eight animals per diet in a randomized complete block design with each rabbit serving as a replicate.

The feeding trial lasted for eight weeks, but was preceded by a two-week period of adaptation during

Table 2 : Proximate composition (g/kg DM) of unthreshed grain amaranth seedhead (GASH) and the experimental diets containing different levels of it.

		Inclusion level of GASH (g/kg)			
Variable	GASH	0	100	200	300
Dry matter	918.5	911.0	918.5	923.4	923.8
Crude protein	151.3	195.2	197.8	200.8	205.6
Crude fibre	43.0	106.8	105.1	111.3	120.7
Ether extract	157.9	61.0	52.4	50.7	49.0
Ash	75.6	54.3	56.4	58.6	60.7
Nitrogen Free Extract	572.2	582.7	588.3	578.6	564.0

which the animals were accustomed to the experimental diets and the cages. Each rabbit was offered feed at the rate of 50 g DM/kg liveweight (LW)/day. At this level of feeding, the animals received at least 5% above the previous day's consumption. Leftover feed (before the next morning feeding) was weighed daily for the computation of intake. The animals were individually weighed weekly.

In the last seven days of the feeding/growth trial, a digestibility study was carried out. Four rabbits were randomly selected and their cages were equipped with facilities that could permit separate collection of their faeces and urine. Feed intake and the quantity of faeces and urine voided were determined daily and 10% aliquots were taken and later bulked over the whole period per rabbit for DM and chemical analysis.

On the last day of the trial, blood samples were collected through the veins of three randomly selected rabbits in each treatment. Blood was collected in bottles containing ethylene diamine tetra-acetic acid (EDTA) salts for haematological analysis and in ice-cooled centrifuge tubes for the analysis of the serum metabolites and enzymes.

The chemical analysis of the feeds, faeces and GASH was done using the standard methods of AOAC (1990). The haematological parameters (red blood cell (RBC), white blood cell (WBC), haemoglobin (Hb) and packed cell volume (PCV) were determined by the method of DACIE and LEWIS (1977). Serum total protein determination was by the method of WOOTTON (1964) while serum albumin was assayed by DOUMAS and BIGGS (1972) method. The standard procedure described by SCHALM (1965) was used for other blood parameters. All data were analyzed by the analysis of variance procedure (SAS, 1995) as randomized complete block design. Mean separation was done where there were indications of significance using DUNCAN'S multiple range test.

RESULTS

The gross compositions of the experimental diets are shown in Table 1. Decreasing the levels of palm kernel cake and/or groundnut cake in the diets accommodated increasing levels of GASH in the diets. The chemical composition of the diets (Table 2) shows that they are able to adequately meet the nutrient requirements of growing rabbits. The composition of GASH indicates good levels (g/kg) of crude protein (CP), 151.3; crude fibre (CF), 43.0; and nitrogen free extract (NFE), 572.2.

There were significant differences among the diets in their effects on feed intake and performance of the rabbits (Table 3). The dry matter intakes (DMIs) of the GASH diets by the rabbits were not significantly different. Rabbits on the control diet had the highest DMI value but this was not significantly different from that of the 10% GASH diet. DMI value of the control diet was, however, significantly higher than those of the 20 and 30% GASH diets. The intakes of organic matter (OM), CP and CF followed a similar pattern as that for DMI. The weight gains of the rabbits showed progressive but non-significant decrease from the control to the 20% GASH diet. At 30% inclusion level of GASH, weight gain significantly dropped to 64% of the average of the weights of rabbits on the control and 10%

Table 3 : Feed intake, growth performance and nutrient digestibility of rabbits fed diets containing different levels of unthreshed grain amaranth seedhead (GASH).

	Inclusion level of GASH (g/kg)				
Variable	0	100	200	300	SEm[1]
Daily intake(g/day)					
Dry matter	44.0a[2]	37.4ab	35.2b	31.6b	2.8
Organic matter	41.6a	35.3ab	33.1b	29.7b	2.6
Crude protein	8.6a	7.4ab	7.1b	6.5b	0.9
Crude fibre	4.7a	3.9ab	3.9ab	3.8b	0.3
Weight gain (g/day)	10.0a	8.2a	7.9ab	5.8b	1.8
Feed conversion efficiency	0.22a	0.22a	0.23a	0.19a	0.04
Digestibility coefficients					
Dry matter	0.89a[2]	0.87a	0.90a	0.86a	0.023
Crude protein	0.87a	0.87a	0.92a	0.87a	0.024
Crude fibre	0.84a	0.82a	0.75a	0.72a	0.083
Organic matter	0.89a	0.88a	0.91a	0.86a	0.024
Ether extract	0.77b	0.61c	0.79b	0.91a	0.017
Nitrogen free extract	0.92a	0.92a	0.92a	0.90a	0.014

[1]Standard error of the mean
[2]Means in a row followed by the same letters are not significantly different at P = 0.05.

Table 4 : Haematological parameters of rabbits fed diets containing different levels of unthreshed grain amaranth seedhead (GASH).

Parameter	Inclusion level of GASH (g/kg) 0	100	200	300	SEm[1]
Blood					
Packed cell volume (%)	32.0b[2]	35.00ab	39.5a	32.5b	2.0
Haemoglobin (g/dl)	8.50b	9.70ab	10.80a	9.30ab	0.72
Red blood cell ($x10^{12}$/l)	8.46a	6.54a	7.06a	5.96a	0.96
White blood cell ($x10^{9}$/l)	6.4a	11.11a	7.7a	11.8a	2.3
Lymphocyte (%)	70.5a	57.50b	57.5b	75.0a	4.2
Neutrophil (%)	26.5b	42.50a	41.5a	23.0b	3.8
Monocyte (%)	1.67ab	0.00b	1.00ab	2.00a	0.76
Serum					
Total protein (g/dl)	9.68a	10.50a	7.47ab	5.46b	1.30
Albumin (g/dl)	3.54ab	3.96a	2.74ab	2.05b	0.51
Globulin (g/dl)	6.14a	6.57a	4.73ab	3.41b	0.79
GPT[3] (IU/l)	61.5c	100.0a	75.0bc	92.5ab	7.1
GOT[4] (IU/l)	25.0a	35.0a	30.0a	22.5a	3.8

[1]Standard error of the mean
[2]Means in a row followed by the same letters are not significantly different at P = 0.05
[3]GPT = Glutamic pyruvic transaminase
[4]GOP = Glutamic oxaloacetic transaminase

GASH diets. There was no significant difference between the weight gains of the rabbits on 20 and 30% GASH diets. Variations among the feed conversion efficiency (FCE) values of the diets were minor and not significantly different.

In general, the DM and nutrient digestibilities of the diets did not vary significantly and were relatively high (Table 3). The DM digestibility values ranged from 86% at 30% inclusion level of GASH to 90% at 20% GASH level. Crude protein and organic matter digestibility values were also highest with 20% GASH diet while the crude fibre digestibility was highest with the 10% GASH diet. The digestibility of ether extract (EE) was highest with the 30% GASH diet and least with the 10% GASH diet while the values for the control and 20% GASH diets were intermediate.

Data on the haematological parameters are shown in Table 4. PCV and Hb values tended to increase with inclusion and increasing levels of GASH up to 20%. There was no significant difference between the values of the control and 30% GASH diets. The RBC and WBC values were not significantly different among the experimental diets. Higher levels of lymphocyte and monocyte were recorded with the control and the 30% GASH diets than with the 10 and 20 % GASH diets. On the other hand, the 10 and 20% GASH diets had higher counts of neutrophil than the control and 30% GASH diets. The serum metabolite and enzyme assays (Table 4) indicated significant decline in the values of total protein, albumin and globulin at 30% GASH inclusion relative to the control and the 10 and 20% levels. The values of the glutamic pyruvic transaminase (GPT) tended to increase with inclusion of GASH. Levels of glutamic oxaloacetic transaminase (GOT) were higher at 10 and 20% GASH than for the control and 30% levels but the differences were not significant.

DISCUSSION

The nutrient (proximate) compositions of the diets are adequate according to the levels recommended by NRC (1977). The levels of the nutrients in GASH are slightly less than those reported for the extruded grains (OLOGUNDE *et al.*, 1992; FANIMO *et al.*, 1999; JALC *et al.*, 1999), by 11-16% for CP, 25% for EE, 19% for CF and 12 for NFE. The lower content of nutrients in the present study was probably due to the dilution effect of the other materials in the unthreshed seedhead, besides the grains. However, the content of ash was 84% higher. The proximate compositions of GASH are also within the ranges of the recommendation levels of the nutrients for rabbits, making GASH a potential feed resource for compounding diets and feeding rabbits.

The DMI values recorded in this study were generally lower than the values recorded for concentrate and concentrate-forage diets in a previous study (BAMIKOLE and EZENWA, 1999). This was probably because the initial weights of the rabbits used in the current study were less than those of the rabbits in the other study. The non-significant differences between the intakes of DM, OM and CP of the control and 10% GASH diets indicate that inclusion of GASH up to 10% did not impose any physical limitation on intake. The adverse effects on intake of the inclusion and increasing levels of GASH in the diets was only significant at 30% level, indicating the inability of the rabbits to efficiently utilize the nutrients.

The depressions in the weight gains of the rabbits with increasing levels of GASH cannot be explained by the DM and nutrient digestibilities of the diets since these values were generally adequate. In another replacement trial where extruded grains were used to replace barley contents of sheep diets at 5, 10 and 20% levels (JALC *et al.*, 1999), DM, OM and cellulose digestibilities and other fermentation characteristics were not affected relative to the no-amaranth grain control diet.

The PCV, HB and RBC, which are good indicators of nutrient availability (OLOGHOBO *et al.*, 1986), were also not depressed in the current study. The high levels of WBC and lymphocyte in the blood of the rabbits fed

30% GASH diet signaled the accumulation of foreign or antinutritional factors (COLES, 1997).

The depression in the serum total protein, albumin and globulin at 30% GASH level seems to confirm that the depressed weight gains recorded at that level of inclusion was the result of poor utilization of the protein in the diets. JALC *et al.* (1999) reported lower levels of microbial synthesis in the sheep that received raw grains as replacement of barley up to 10 or 20% level. It can be surmised that antinutritional factors such as phytate and tannins that may occur at relatively low levels in amaranth grains (OLOGUNDE *et al.*, 1992) could hamper nutrient utilization in rabbits when amaranths are included at a high level in the diets.

CONCLUSION

The nutritional composition of unthreshed grain amaranth seedhead makes it a potential feed resource that can be used as a cheap replacement of expensive oil cakes in concentrate diets of rabbits. Our results demonstrate that the level of inclusion of GASH should not exceed 10% in order to forestall adverse effects on the weight gain of the rabbits. Up to 20% level of inclusion of GASH, only intake is adversely affected, but at 30% inclusion level, intake and possibly utilization of protein and other nutrients in the feed are adversely affected due to the antinutritional factors in the raw grains. The overall potential of GASH as a component of rabbit diets may be higher where the grains can easily be extruded from the seedheads and appropriate methods are employed to eliminate the antinutritional factors in the grains. The possibility of including higher levels of treated amaranth grains and the determination of the mechanism of the adverse effect of GASH at high levels of inclusion in diets are suggested for further studies.

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