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EFFECT OF FEEDING GRADED LEVELS OF ROASTED SUNFLOWER MEAL ON THE PERFORMANCE, NUTRIENT DIGESTIBILITY AND CARCASS CHARACTERISTICS OF RABBITS

K.E. Akande, M.M. Abubakar, T.A. Adegbola, S.E. Bogoro and U.D. Doma
Animal Production Programme , School of Agriculture, Abubakar Tafawa Balewa University, Bauchi, P.M.B 0248, Bauchi State, Nigeria

ABSTRACT
An experiment was carried out in a five-week feeding trial to determine the effect of feeding graded levels of roasted sunflower seed meal (SFM) on the performance, nutrient digestibility and carcass characteristics of rabbits. Forty male and female New Zealand White x California rabbits were randomly assigned to four dietary treatments in five replications. The inclusion levels of SFM in diets were 0 (control), 10, 20, and 30% levels in a completely randomized design. There was significant (P<0.001) reduction in daily feed intake (DFI) of rabbits on 30% SFM based diet. The DFI of 56.81g was obtained for rabbits fed 30% SFM based diet against 65.73, 67.17 and 71.98g for those fed 0, 10 and 20% dietary levels of SFM, respectively. The daily weight gain (DWG) (15.65 - 18.09g), feed conversion ratio (FCR) (3.72 - 4.28), final live weight (1512.50 - 1662.50g), carcass weight (712.50 - 837.50g), relative organ weights and dressing percentage (46.92 - 50.34%) were not significantly influenced by dietary treatments. The dry matter intake (DMI), organic matter intake (OMI), acid detergent fibre intake (ADFI) increased with increasing dietary levels of SFM up to 20%, but there was a significant (P<0.01) reduction in the intake of these nutrients at 30% dietary level of SFM. The crude protein intake (CPI) and neutral detergent fibre intake (NDFI) also followed the same trend but with a higher level of significance (P<0.001). There were significant differences in the digestibilities of some nutrients (DMD, P<0.001; OMD, P<0.001; and NDFD, P<0.01). However, crude protein digestibility (CPD) and acid detergent fibre digestibility (ADFD) were not significantly affected by dietary treatments. The results showed that SFM could be incorporated in rabbit diets up to 30% level of inclusion without adversely affecting the animal.

KEY WORDS: Sunflower, performance, nutrient digestibility, carcass characteristics, rabbits

INTRODUCTION
Sunflower (*Helianthus annuus* L.) is one the few cultivated plant native to North America. It is believed that wild sunflower covered thousands of square miles of land that is now the Western United State (Putt, 1978; Skoric, 1992). Sunflower remains have been found in North America archaeological sites dating from as early as 3,000 B.C. (Putt, 1978). The centre of origin for wild sunflowers is considered to be the Western plains of North America, but the ancestors of the cultivated type have been traced to the Missouri – Mississippi River valley areas (Relf, 1997). Sunflower is tolerant of both low and high temperatures but more tolerant to low temperatures (Putnam *et al*., 1990).

NRC (1984) quoted sunflower seed meal (after oil extraction) figures as 23.3% protein, 31.6% crude fibre, 1% lysine, 0.5% methionine and 1543kcal/kg ME. Putnam *et al*. (1990) reported that sunflower oil accounts for 80% of the value of the sunflower crop. The primary fatty acids in the oil are oleic and linoleic (typically 90% unsaturated fatty acids) with the remainder consisting of palmitic and stearic saturated fatty acids. The major nutrients in sunflower seeds include protein, thiamine, vitamin E, iron, phosphorus, potassium, calcium and the essential fatty acids such as linoleic acid and oleic acid (Relf, 1997). According to the reports of the USDA Nutrient Database (2002), sunflower seeds are the best natural, whole food source of vitamin E, almost all of which is alpha-tocopherol, the most biologically active form. In the United States sunflower seed is used for birdseed, most typically mixed with millet and other grains. The black oilseed varieties are also sold separately, and usually are favoured by birds over the striped confectionary seeds. The high oil content of sunflower seeds provides an excellent source of energy for birds. Sunflowers are sometimes used as livestock feed. Non-dehulled or partly dehulled sunflower meal has been substituted successfully for soybean meal in isonitrogenous (equal protein) diets for ruminant animals, as well as for swine and poultry feeding (Adeniji and Ogunmodede, 2006). Sunflower can also be used as a silage crop the chopped stalks have been shown to be a reasonable silage crop (Putnam *et al*., 1990).

The major objective of the study was to determine the nutritional potentials of roasted meal of sunflower as alternative source of dietary protein for rabbits.

MATERIALS AND METHODS

Experimental site:

The experiment was carried out at the Rabbit Research House of the Abubakar Tafawa Balewa University, Bauchi. Bauchi town is located at latitude 13º 30'N and longitude 11º 50'E. Bauchi State is located in the Northern Guinea and Sudan Savanna zones of Nigeria. The wet season is usually about five months (May to September) and seven months of dry season (October to April). The annual rainfall ranges from 600mm in the extreme northern parts to 1300mm in the southwestern part of the state (BSADP, 2002).

Management and feeding trial of experimental animals:

The experiment was conducted using weaner rabbits of cross breeds between New Zealand White and California, obtained from the National Veterinary Research Institute (NVRI) Vom, Plateau State, Nigeria. Forty New Zealand White x California male and female rabbits aged between 6 to 8 weeks with average initial weight of 900g were randomly assigned to four dietary treatments. Each treatment had five replicates of two rabbits each in a completely randomized design (CRD). The sunflower seed was roasted and coarsely milled to form the sunflower seed meal (SFM) and incorporated into the experimental diets at graded levels of 0, 10, 20 and 30% SFM. The compositions of the experimental diets are shown in Table 1.

Treatment 1 (control) was maize-soybean based diet with 0% SFM while treatments 2, 3 and 4 contained 10, 20 and 30% SFM in the diets respectively. The rabbits were housed in a single tier rabbit cage located inside the Rabbit House which was equipped with vents and windows for proper ventilation. Before the commencement of each experiment, the rabbits were weighed and allocated to the metabolic cages. Animals were provided with feed and water *ad libitum*. Left-over feed was collected and weighed before the next morning feeding. Animals were weighed on weekly basis and feed intake was measured daily. In the fourth week of the feeding trial, faecal collection was done for seven days. The faeces were dried, bulked and weighed for nutrient digestibility determination. The feeding trial lasted for five weeks during which data were recorded for feed intake and body weight. At the end of the five-week feeding trial, four out of ten rabbits (40 percent) were randomly selected for carcass and organ measurements. Data obtained from performance parameters, nutrient digestibility, carcass and organ measurements were subjected to the analysis of variance (Steel and Torrie, 1980). When analysis of variance indicated a significant treatment effect, means were separated using the Duncan multiple range test (Duncan, 1955).

Chemical Analysis:

Proximate analyses of sunflower seeds (both raw and processed seeds), experimental diets and faecal samples were carried out using the methods outlined by the Association of Official Analytical Chemists (AOAC, 1990). The acid detergent fibre (ADF) and neutral detergent fibre (NDF) of the samples were determined by the method of Goering and Van Soest (1970). The proximate compositions of sunflower seeds are presented in Table 2

Table 1: Ingredient and chemical composition (%) of roasted sunflower meal based diets

Ingredients	SFM 0%	SFM 10%	SFM 20%	SFM 30%
Maize	32	22	14	5
Soyabean (full-fat)	19	16	12	9
Sunflower meal	0	10	20	30
Groundnut haulms	15	18	20	22
Maize offal	30	30	30	30
Bone meal	3	3	3	3
Salt	0.5	0.5	0.5	0.5
Min/vit/premix*	0.5	0.5	0.5	0.5
Total	100	100	100	100
Calculated analyses:				
Crude protein	16	16	16	16
Energy (Kcal/kg)	2689	2752	2830	2908
Lysine (%)	0.66	0.65	0.61	0.60
Methionine + cystine (%)	0.50	0.53	0.55	0.58
Calcium (%)	1.20	1.22	1.23	1.24
Phosphorus (%)	0.77	0.79	0.80	0.82
Chemical analyses:				
Dry matter	95.43	95.91	95.29	96.13
Crude protein	16.12	16.12	16.10	15.68
Crude fibre	8.73	8.96	9.25	10.34
Crude fat	5.09	6.73	7.59	8.82
Ash	7.54	8.79	8.63	9.01

*Premix (Agricare-mix®) supplied per kg of diet; Vitamin A 20,000IU; Vitamin D 4,000IU; Vitamin E 39.96 IU; Vitamin K 5.99mg; Riboflavin 12mg; Vitamin B_{12} 0.1mg; Pyridoxine Hcl 7mg; Cal-D-Panthothenate 30mg Nicotinic acid 70mg; Folic acid 2mg; Biotin 0.2mg; Potassium 0.41%; Sodium 0.30%; Copper 24mg; Manganese 110mg; Zinc 100mg; Iron 110mg; Selenium 0.3mg; Calcium 0.22mg; Iodine 3mg; Choline 1000mg; Butylated hydroxytoluene (BHT) 140mg and Zeolex 50mg.

Table 2: Proximate composition (%) of raw and roasted sunflower seeds

Content	Raw seed	Roasted seed
Dry matter	96.64	98.43
Crude protein	18.70	20.07
Crude fat	23.98	24.86
Crude fibre	12.92	11.81
Ash	3.36	4.98
Nitrogen free extract	37.68	36.71

Table 3: Effect of graded dietary levels of sunflower meal on performance parameters of rabbits

	Dietary levels of sunflower meal (%)				
Parameters	0	10	20	30	SEM
Initial live weight (g)	940.00	957.50	900.00	905.00	25.28^{NS}
Final live weight (g)	1612.50	1662.50	1525.00	1512.50	56.55^{NS}
Daily feed intake (g)	65.73^{a}	67.17^{a}	71.98^{a}	56.81^{b}	1.53***
Daily weight gain (g)	15.65	17.14	18.09	15.71	1.17^{NS}
Feed conversion ratio	4.28	3.97	4.08	3.72	0.31^{NS}

Note: Means bearing different superscripts within the same row differ significantly, (***=P<0.001; NS=Not significant), SEM = Standard error of mean

Table 4: Effect of graded dietary levels of roasted sunflower meal on carcass characteristics of rabbits

	Dietary levels of sunflower meal (%)				
Parameters	0	10	20	30	SEM
Carcass weight (g)	800.00	837.50	737.50	712.50	39.13 NS
Dressing %	49.49	50.34	48.36	46.92	0.96 NS
Organ weights (% LW):					
Small intestine	4.72	4.83	5.56	5.37	0.22 NS
Large intestine	1.46	1.22	1.79	1.31	0.03 NS
Caecum	5.76	5.42	6.54	5.28	0.17 NS
Stomach	5.10	5.28	6.13	5.84	0.59 NS
Liver	2.91	2.97	3.30	3.12	0.02 NS
Kidney	0.65	0.68	0.75	0.77	0.09 NS
Heart	0.33	0.35	0.33	0.36	0.04 NS
Head	10.81	10.48	10.98	11.07	0.22 NS
Pelt	11.71	10.58	10.97	11.31	0.45 NS

SEM = Standard error of mean, NS = Not significant, LW = Live weight

Table 5: Nutrient intake and digestibility (%) of rabbits fed diets containing graded levels of roasted sunflower meal

Parameters	Dietary levels of sunflower meal (%)				SEM
	0	10	20	30	
DMI (g)	58.87^{bc}	63.05^{ab}	66.87^{a}	52.85^{c}	1.52**
OMI (g)	54.43^{abc}	57.51^{ab}	61.11^{a}	48.09^{c}	1.40**
CPI (g)	9.49^{ab}	10.16^{a}	10.77^{a}	8.27^{b}	0.24***
ADFI (g)	7.85^{bc}	8.48^{ab}	9.03^{a}	7.18^{c}	0.20**
NDFI (g)	13.66^{ab}	14.11^{ab}	16.01^{a}	11.92^{b}	0.35***
DMD	76.67^{a}	66.74^{b}	66.87^{b}	70.70^{b}	0.98***
OMD	83.47^{a}	71.21^{b}	69.92^{b}	75.87^{b}	1.38***
CPD	83.29	86.46	85.75	83.51	0.85^{NS}
ADFD	32.05	31.21	33.24	30.64	0.92^{NS}
NDFD	43.79^{b}	48.16^{a}	48.00^{a}	47.88^{a}	0.74**

Note: Means bearing different superscripts within the same row differ significantly (*** = P<0.001; **= P<0.01 NS = Not significant), DMI = Dry matter intake, DMD = Dry matter digestibility OMI = Organic matter intake, OMD = Organic matter digestibility CPI = Crude protein intake, CPD = Crude protein digestibility, ADFI = Acid detergent fibre intake, ADFD = Acid detergent fibre digestibility, NDFI = Neutral detergent fibre intake NDFD = Neutral detergent fibre digestibility, SEM = Standard error of mean

RESULTS AND DISCUSSION

The performance parameters of rabbits fed varying dietary levels of sunflower meal are presented in Table 3. There was a significant (P<0.001) reduction in daily feed intake at 30% inclusion level of SFM in the diet. Daily feed intake of 56.81g was obtained for rabbits fed 30% SFM based diet which was significantly lower than the values of 65.73, 67.17 and 71.98g for those fed 0, 10 and 20% SFM based diets, respectively. Daily feed intake (DFI) increased with increasing levels of SFM up to 20% in the diet, but at 30% dietary level of SFM there was a drastic reduction in DFI. Similar report was made by Gbadamosi and Atteh (2004). This may be due to high energy density of the diet, since sunflower seed is rich in oil and the sunflower meal used in this study was full-fat. Rabbits consume feeds to satisfy their energy requirements (Schlolaut, 1987). The reason for the drastic reduction in feed intake at 30% dietary level of SFM may be associated with the fact that the rabbits were able to satisfy their energy requirements with less feed due to the high energy density of the diet. The higher energy content of the diet enabled the rabbits meet their energy needs with reduced feed intake and yet their final live weight was not significantly affected, even at 30% dietary level of SFM where feed intake was significantly reduced. Researchers have reported that high energy diets lead to reduced feed intake because the energy need of the animal will be satisfied with less feed intake (Richard *et al.,* 1982; Beyen, 1988; Joseph *et al*., 2000; Egbo, 2001). Results on daily weight gain, feed conversion ratio and final live weight of rabbits showed no significant variation among treatment means. Similar observations were made by Adeniji and Ogunmodede (2006) at the finisher phase, when they fed sunflower seed cake to broiler chickens.

The effect of graded dietary levels of sunflower meal on the carcass characteristics of rabbits are presented in Table 4. Rabbits on 10% SFM based diet had the highest carcass weight of 837.50g as against those on 30% SFM based diet that had the lowest carcass weight of 712.50g. The dressing percentage followed a similar trend as that of the carcass weight. Rabbits fed 10% SFM based diet had the highest dressing percentage of 50.34% and those on 30% SFM based diet had the lowest dressing percentage of 46.92%, but the difference was not significant. Dietary treatments also had no significant effect on organ weights. The following range of values were obtained: caecum (5.28 - 6.54%), stomach (5.10 - 6.13%), liver (2.91- 3.30%), kidney (0.65 - 0.77%), heart (0.33 - 0.36%), head (10.48 - 11.07%) and pelt (10.58 - 11.71%)

The intake of nutrients and nutrient digestibilities of rabbits fed graded dietary levels of sunflower meal are presented in Table 5. The intakes of all nutrients (DMI, OMI, CPI, ADFI and NDFI) were significantly influenced by dietary treatments. The level of significance of (P<0.01) was obtained for DMI, OMI and ADFI and (P<0.001) for CPI and NDFI respectively. Nutrient intakes had the following range of values: DMI (52.85 - 66.87g); OMI (48.09 - 61.11g); CPI (8.27 - 10.77g); ADFI (7.18 - 9.03g) and NDFI (11.92 - 16.01g). It was observed that intakes for all nutrients followed a similar trend. Intake of nutrients (DMI, OMI, CPI, ADFI and NDFI) increased with increasing dietary levels of SFM up to 20%, but at 30% dietary level of SFM, decreased significantly. This may be attributed to the fact that the rabbits ate to satisfy their energy need. The energy content of full-fat sunflower meal at 30% inclusion level in the diet became excessive. The dry matter intake (DMI) obtained in this study fell within the range of 52.85 - 66.87g and the CPI ranged from 8.27 to 10.77g. These values were much lower than the mean value of 75.20g for DMI and the mean value of 14.10g for CPI reported by Gutierrez *et al.* (2003) who fed sunflower meal based diets to early-weaned rabbits.

Dietary treatments had significant effect on the digestibility of some nutrients; DMD (P<0.001), OMD (P<0.001) and NDFD (P<0.01). Dry matter digestibility (DMD) was in the range of 66.74 - 76.67%. The DMD of 65.30% reported by Gutierrez *et al.* (2003) falls within the range obtained in this study. The organic matter digestibility (OMD) varied from 69.92 to 83.47%. The control diet (0% SFM based diet) for both DMD and OMD resulted in significantly (P<0.001) higher values than the other dietary treatments. For DMD and OMD, rabbits on the control diet had significantly (P<0.001) higher values than those on other dietary treatments. Despite the reduction in the crude protein intake, the crude protein digestibility was not significantly affected. This revealed that rabbits were able to utilize the quantity of crude protein ingested from SFM based diets efficiently. The CPD values ranged from 83.29% for rabbits on 0% SFM based diet to 86.46% for those on 10% SFM based diet, which is higher than the mean value of 76.90% for CPD reported by Gutierrez *et al.* (2003). The difference in CPD values of this study and that of Gutierrez *et al*. (2003) may be due to the younger age of rabbits (early-weaned rabbits) used by these workers. It has been reported that gastric and pancreatic protease activities are lower in young animals than in the older ones and this could decrease protein digestibility (Dojana *et al*., 1998). The ADFD was in the range of 30.64 - 33.24% for rabbits on 30 and 20% SFM based diets respectively. The ADFD was not significantly influenced by dietary treatments. The digestibility of neutral detergent fibre NDFD was significantly influenced by dietary treatments (P<0.01), rabbits fed the control diet (0% SFM based diet) had the value of 43.79% which was significantly lower than other dietary treatments.

CONCLUSION

The results obtained in this study revealed the nutritional potentials of sunflower seed for rabbit feeding. It was concluded that sunflower meal is capable of supporting growth of rabbits. The results obtained from the study indicates that SFM could be included up to 30% in the diets of rabbits without negatively influencing performance, nutrient digestibility and carcass characteristics of rabbits.

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Corresponding Author:
K.E. Akande,
Animal Production Programme , School of Agriculture, Abubakar Tafawa Balewa University, Bauchi, P.M.B0248,Bauchi State, Nigeria