STUDIES ON FATTY ACID COMPOSITION AND COMPARATIVE RESPONSE OF BROILER CHICKS TO DIETARY NEEM (*AZADIRACHTA INDICA*) SEED AND PALM OILS

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SUMMARY

Studies were conducted to evaluate fatty acid composition of neem (*Azadirachta indica*) oil, and the response of broiler chicks fed on diets supplemented with two levels (30, 60 g/kg) of neem oil. Palm oil was used as control. Neem oil is rich in low molecular fatty acids and its oleic and linoleic acids represent 58% of the total acids. The oil significantly ($P<0.05$) depressed appetite and slowed growth rate of the birds but food and protein efficiencies did not differ ($P>0.05$) among the groups. Apparent nutrient digestibility was not affected ($P>0.05$) by oil types except phosphorus availability, which was decreased ($P<0.05$) by neem oil. It was concluded that the potentially valuable fatty acids of neem oil could be used as dietary supplement for broiler chicks only following removal of the neem bitters.

KEY WORDS: Broiler chicks, Growth performance, Digestibility, Neem oil

INTRODUCTION

Most diets for farm animals do not contain supplementary fat/oil or they are added at low levels of about 3-6 % to boost energy density of diets. The oils are more energetically convertible feed with a lower heat increment (Freeman, 1983). Additionally, fat and oil improve the general appearance and palatability of diets (Dale and Fuller, 1978; Moran, 1982), facilitate greater dietary nutrient utilization (Majorino *et al.*, 1986; Nomani *et al.*, 2000), enhance body weight gains and feed utilization efficiency (Fajinmi *et al.*, 1993), and are sources of essential fatty acids and vitamins (McDonald *et al.*, 1995). They are particularly useful in hot tropics to minimize the growth depressing effects of heat stress (Miller, 1979; Fuller, 1981). Whitehead (1981) also reported a marked increase in production rate and weight of eggs when different sources of oils were used in diets for layers. Aside from the economic benefits of oil, many vegetable oils widely consumed in the tropics have been reported to lower plasma cholesterol and other lipid concentrations (Ahrens *et al.*, 1959; Stroev, 1989).

In the past, dietary oil supplementation in Nigeria depended largely on palm oil because of its relatively high availability and low price compared to other plant oils. Currently, however, competing demands from other sectors of the economy have made palm oil uneconomical for use in livestock feed formulation. Therefore, alternative non-conventional oil sources have been vigorously evaluated (Babatunde and Pond, 1987; Adeyemi, 1998; Odunsi and Gbadamosi, 2001) as animal feeds in order to save more edible oils for human consumption; and to make livestock products cheaper. Of all neem products, the oil is perhaps the most important commercially and finds a ready market for a variety of purposes in the Indian subcontinent (Verma *et al.*, 1998). No such role, on the other hand, has yet been found for neem in Nigeria. The oil content of neem seed kernel is quite high (40-45 %) (Ketkar, 1976). It is much like other vegetable oils and composed principally of triglycerides (Ketkar, 1976; NRC, 1992).

The high oil content of neem kernel could be used as feed supplement in Nigeria and other countries with high neem population. The studies were, therefore, designed to characterize manually extracted neem (*Azadiracta indica*) oil, and to compare its nutritive value with that of palm oil.

MATERIALS AND METHODS

Preparation of oils

Neem seeds were collected within Sokoto metropolis, sun-dried and decorticated. The obtained neem kernels were toasted for 10 min, finely ground with hammer mill, and the oil manually squeezed out as the kernel meal was rolled on a flat surfaced millstone. Red palm oil purchased from Sokoto Central market and the neem oil were separately heated for 2 hours until completely bleached. The bleached oils were stored in a refrigerator (4 ^{0}C) for 2 weeks to prevent rancidity before use.

Physicochemical properties and fatty acid composition of neem oil

Determination of specific gravity, saponification and iodine values of neem oil were all carried out following the standard AOAC (1990) procedures. The oil was saponified (Utrilla *et al.*, 1976) and the methyl ester extracted with diethyl ether. The ester was analyzed for fatty acid composition by gas chromatography on a Perkin-Elmer Sigma 3B series chromatograph using a stainless steel DEGS Column. Nitrogen was used as carrier gas. Detection was made by a flame ionization detector.

Experimental diets

The experiment comprised four iso-nitrogenous (230 g crude protein/kg) diets with similar metabolisable energy contents (12.8 - 13.2 MJ/kg) and formulated mainly from maize-groundnut cake basal diet. Neem and palm oils were used at two levels (30, 60 g/kg) and each level incorporated into the basal diet largely at the expense of maize grains. Each diet was supplemented with fishmeal (85 g/kg) to improve its protein quality while groundnut-cake levels were slightly adjusted to provide similar crude protein concentrations. The diets are presented in Table I.

TABLE I: Composition of the diets (g/kg) containing palm and neem oils.

Feed ingredients	Diets			
	Palm oil		Neem oil	
Palm oil	30.0	60.0	-	-
Neem oil	-	-	30.0	60.0
Maize	500.0	463.0	500.0	463.0
Groundnut cake	290.5	297.5	290.5	297.5
Fish meal	85.0	85.0	85.0	85.0
Wheat bran	57.0	57.0	57.0	57.0
Bone meal	20.0	20.0	20.0	20.0
Limestone	10.0	10.0	10.0	10.0
Sodium chloride	5.0	5.0	5.0	5.0
Vitamin/mineral premix*	2.5	2.5	2.5	2.5
Determined analysis				
Dry matter	935.7	935.2	933.8	935.5
Protein (Nx6.25)	230.6	229.8	231.1	231.0
Etner extracts	136.4	164.0	136.7	163.0
Calcium	11.4	12.0	11.4	11.1
Phosphorus	6.8	6.4	6.9	6.8
ME (MJ/kg diet) +	12.9	13.2	12.8	13.0
Lysine[1]	1.042	1.101	1.042	1.101
Methionine[1]	0.511	0.512	0.511	0.512

*(Univit, Roche) supplied vitamins and minerals per kg diet: Vitamins: A, 10,000IU; D_3 3,000 IU; E, 8.0 IU; K, 2.0 mg; B_3, 1.2 mg; B_1, 0.12 mg; Niacin, 1.0mg; Pantothenic acid, 7.0 mg; Folic acid, 0.6 mg; Choline chloride, 500 mg; Minerals:Fe, 60 mg; Mn, 80 mg, Mg, 100 mg; Cu, 8.0 mg; Zn, 50 mg; Co, 0.45 mg; 1,2.0 mg; Se, 0.1mg. + Calculated according to Carpenter and Clegg (1956)[1] Calculated

Broiler chicks

One hundred and eighty (180), 1-day-old, unsexed Cobb broiler chicks of initial weight of 46.75 ± 3.60 g (mean ± s.d.) were divided into 20 sub-groups of 9 chicks each on weight equalization basis. Each diet was offered to 5 sub-groups of chicks ad *libitum* as mash for 49 days in a fully randomized manner. The chicks were kept in electrically heated wooden cages (9 chicks/cage of 1.2 x 1.2 m^2) with raised wire floors to separate faecal droppings from birds. The droppings were evacuated once in 2 days. Other routine management including vaccination against Newcastle and infectious bursal diseases and prophylactic treatment against coccidiosis were carried out. Lighting was continuous until birds were 42 days of age; then 12 hours/day of natural light afterwards to reduce room temperatures. Body weights and feed consumption data were collected on a weekly basis, and efficiency of food and nutrient utilization (gain: intake) calculated.

Digestibility study

Apparent nutrient digestibility was carried out using ten, 42-day old, broilers per treatment (2 per replicate). The broilers were housed individually in metabolism cages; 4 days was allowed for adaptation and 3 days for collection (at 07.00 h) of fecal droppings. Food allocation for the last 4 days was restricted to 90 % *ad libitum* quantity to minimize food refusal and allow adequate digestion in accordance with the method employed by Fetuga *et al.* (1977); but birds had free access to water. The daily faecal output was dried in an oven (60 °C for 48 h), weighed and ground. Samples of the faeces and diets were analyzed for proximate constituents and phosphorus in form of vanadium phosphomolybdate (AOAC, 1990). Determination of calcium level was by absorption using a Perking-Elmer 703 atomic absorption spectrophotometer.

Statistical analysis

The results were reported as means ± standard error of means (SEM). Analysis of data generated from the study was performed with analysis of variance using the procedures of the Statistical Analysis System Institute Inc. (SAS, 1988). Differences among the means were compared using Duncan's multiple range tests (Bradford and Hill, 1991).

RESULTS

Properties and fatty acid content of neem oil

The extraction process yielded 226.3 g golden yellow oil/kg neem kernels, which still remained in oil form at low temperature (10°C). The oil has specific gravity, saponification and iodine values (mg/g) of 0.91, 191.32 and 80.19, respectively. Neem oil is richer in unsaturated (with oleic and linoleic acids representing about 58 % of total acids) than saturated acids. Palmitic acid accounted for 47.2 % of the saturated acids. The fatty acid composition of neem and palm oils is given in Table II.

TABLE II: Physicochemical properties and fatty acid composition (%) of neem seed oil* and palm oil[1].

Properties/fatty acids (g/100g)	Neem oil	Palm oil
Specific gravity	0.910±0.03	-
Saponification value (mg/g KOH)	190.0±3.8	-
Iodine value (mg/g I)	80.3±1.4	-
Palmitic acid	19.28±0.57	40.60
Stearic acid	13.35±0.66	5.10
Oleic acid	48.08±1.44	42.60
Linoleic acid	10.01±0.20	8.80
Arachidic acid	8.26±0.16	-
Total unsaturated acids	58.09	51.40
Total saturated acids	40.89	48.40

* Mean of two determinations. [1](Oyenuga, 1968); - not determined.

Growth performance

Table III shows body weight gains and food utilization efficiency. The levels of oils used did not significantly affect daily weight gains although, when the data from the two levels of each oil were pooled together, palm oil supported more ($P<0.05$) gains than neem oil (21.3 versus 17.8 g/bird/day, respectively). Broilers fed palm oil consumed significantly ($P<0.05$) more feed, protein and energy than those fed neem oil diets but food and nutrient efficiency ratios (gain: food or nutrients) were similar among the dietary groups.

Nutrient digestibility

There were no differences ($P>0.05$) in treatment means for dry matter, crude protein, ether extracts, crude fibre, ash, calcium and nitrogen-free extract digestibility. However, neem oil tended to decrease protein and ash absorption. Neem oil also markedly ($P<0.05$) retarded phosphorus availability and the rate of retardation increased with higher level of its dietary incorporation. Data on apparent nutrient digestibility study are contained in Table IV.

TABLE III: Body weight gain and food utilization efficiency of broiler chicks fed on diets containing palm or neem oils

Performance traits	Diets: Palm oil 30	Palm oil 60	Neem oil 30	Neem oil 60	SEM
Initial weight (g/bird)	45.2	47.3	47.0	45.8	2.1
Weight gain (g/bird/day)	20.0	22.6	18.0	17.6	1.9
Food consumption (g/bird/day)	42.7^a	42.9^a	38.3^b	37.8^b	9.2
Protein consumption (g/bird/day)	9.9^a	9.8^a	8.9^b	8.7^b	1.5
Food efficiency (gain: food)	0.46	0.52	0.47	0.47	0.03
Protein efficiency (gain: protein)	2.02	2.23	2.03	2.01	0.07
ME consumption (KJ/bird/d)	551.0^a	565.6^a	490.7^b	490.7^b	49.2
Energy efficiency (g gain/MJ)	36.3	40.0	36.7	35.8	0.8
Mortality of chicks (No./45)	1	1	0	0	-
Mortality (%)	0.02	0.02	0	0	-

^{a,b}Means in a row with different superscripts differ ($P<0.05$)

TABLE IV: Apparent nutrient digestibility coefficients of broiler chickens fed palm or neem oil diets.

Nutrients	Diets: Palm oil 30 (1)	Palm oil 60 (2)	Neem oil 30 (3)	Neem oil 60 (4)	SEM
Dry matter	771.8	778.3	766.5	758.9	1.1
Crude protein	656.2	666.1	644.3	644.1	2.6
Ether extract	915.3	932.8	902.9	927.1	1.2
Crude fibre	485.1	485.9	474.4	479.0	6.3
Ash	413.8	404.1	416.1	402.4	1.2
Available carbohydrate	898.6	882.3	891.6	873.8	1.3
Calcium	469.0	450.0	490.0	464.0	10.1
Phosphorus	485.0^a	531.0^a	383.0^b	248.0^c	38.0

^{a,b} Means in a row with different superscripts differ ($P<.0.01$)

DISCUSSION

The saponification value of 191.32 mg/g KOH indicates that the neem oil contains high proportion of low molecular (weight) fatty acids and could be useful in soap manufacture. Similarly the neem oil is dry and may be a valuable material in the paint industry. The moderate concentration of linoleic acid in neem oil suggests that the oil may be of high nutritional value as linoleic acid is one of the essential fatty acids. It is also potentially valuable as dietary component to reduce blood lipid levels as reported for some vegetable oils (Ahrens *et al.*, 1959; Stroev, 1989).

Broilers fed on neem oil were expected to have grown faster than those fed on palm oil diets. This is because neem oil is essentially higher in linoleic acid (10.0 %) than palm oil (8.8 %) (Oyenuga, 1968). The poorer weight of broilers on neem diet was ascribed to the smaller quantity of neem oil feeds consumed. Neem oil contains toxic triterpenoids and other bitters reported to be deleterious to the growth of food animals (NRC, 1992; Uko and Kamalu, 2001). Therefore, improved consumption may be observed if these toxic and anti-nutritive factors are removed. The similarity in food, protein and energy efficiencies among the groups lends credence to the low feed intake as major limiting factors to weight gain of birds. Velu and Baker (1974) as well as Adeyemi (1998) showed an inverse relationship between dietary fat content and quantity of food consumed. This was not obvious in the present study, probably, due to low levels of oils used. However the higher metabolizable energy intake by birds on 60 g/kg palm oil diet consistently, although non-significantly, enhanced growth rate and efficiency of nutrient utilization better than all other groups, which agrees with the reports of Miller (1979) and Fuller (1981). During the course of feeding trial birds fed neem oil diets were more active than those fed palm oil diets. This was attributed to the assumed medicinal value of neem products.

Neither neem nor palm oils had any significant effect on the nutrient digestibility in this study. The results suggest that neem oil only depressed the appetite of birds but did not significantly interfere with digestion and/or absorption of most nutrients. Further intake of neem oil produced an apparent increase in calcium availability when compared with the effect of the same level of palm oil consumed. This concurs with the observations that polyunsaturated fats and oils favour calcium utilization more than the saturated ones (Kies, 1988; Perez-Granados *et al.,* 2000). In contrast, neem oil dose-dependently facilitated fecal excretion of phosphorus, thus leading to poor availability of same. However the negative effect of phosphorus excretion did not clinically manifest in leg weakness. It is probable that birds had sufficiently absorbed large amount of the mineral to meet their physiological needs.

CONCLUSION

The investigations revealed that neem oil contains more unsaturated fatty acids than palm oil. However, its feeding value is inferior to that of palm oil because of the heat-stable toxic bitters present therein. The oil has nutritive potentials but before it could be fully exploited for broiler production, it must undergo further processing to remove the neem bitters.

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