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National Animal Production Research Institute
Ahmadu Bello University
P.M.B 1096, Shika-Zaria,
Kaduna State, Nigeria.
Email:japr@napri.gov.ng Url:journal.napri.gov.ng

EFFECT OF TURMERIC (*Curcuma longa*) FEED ADDITIVE ON GROWTH PERFORMANCE, HAEMATOLOGICAL AND SERUM BIOCHEMICAL CONSTITUENTS OF WEST AFRICAN DWARF GOATS

***Aderinboye, R. Y., Ojediran, T. O. and Agunloko, O. O.**
Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
**Author's Corresponding E-mail: aderinboyery@funaab.edu.ng*

ABSTRACT

This study was conducted to evaluate the effect of turmeric feed additive on growth performance, haematological and serum biochemical indices of West African Dwarf goats. Twenty-four West African Dwarf goats with initial live weight of 8 - 10 kg were used for the study. Animals were divided into three groups of eight animals each, with comparable mean weights across groups. Each group of animals was fed diets of *Panicum maximum* and concentrate in ratio 6:4 (dry matter basis). One of three dietary doses of turmeric additive at 0, 2.5 and 5.0 g/animal/day were randomly administered to each animal group in a completely randomized design. Treatments were replicated twice with four animals per replicate. Animals were fed for a period of 90 days during which dry matter intake, nutrients intake, weight gain, feed conversion ratio, nutrient digestibility, haematological and serum biochemical constituents of goats were determined. Results showed that animals offered turmeric feed additive had a linear reduction ($P < 0.05$) in dry matter, crude protein and organic matter intake with no change ($P > 0.05$) in weight gain. Feed conversion ratio was improved linearly ($P < 0.05$) when goats were administered 2.5 and 5.0 g of turmeric/animal/day relative to the control group. Crude protein, neutral detergent fibre, ether extract and ash digestibility increased linearly ($P < 0.05$) with turmeric feed additive. Turmeric additive had no significant effect ($P > 0.05$) on blood parameters measured. Turmeric can be safely administered to West African Dwarf goats at 2.5 g/animal/day for improved conversion of feed to weight gain, and enhanced nutrient absorption without threat to animals' haematological and serum biochemical status.

Keywords: Tumeric, Feed intake, Weight, Blood profile, Goats

INTRODUCTION

Growth promoters have been used as a nutritional strategy for improving animal productivity, and antibiotics were the first class of feed additives to be discovered in 1940 as growth promoters, when used at sub-therapeutic levels in livestock diet (Chattopadhyay, 2014). However, the use of antibiotics in livestock feeds at sub-therapeutic levels has been banned due to concerns of antibiotic residue in animal tissues, and the development of antibiotic resistance which poses risk to the health of animals and consumers (Kholif *et al*., 2017; Reiss *et al*., 2018). In recent times, plant-based feed additives have gained tremendous interest in ruminant nutrition as a replacement for antibiotic growth promoters. The major essence for their use, is the presence of naturally occurring substances which are referred to as secondary metabolites, or phytogenic compounds that mediate various biological effects in livestock (Bodas *et al*., 2012; Hussein and El-Anssary, 2018; Coelho *et al*., 2020; Reddy *et al*., 2020).

Herbs and spices are well recognized sources of phytogenic compounds (Kumar *et al*., 2014; Chowdhury *et al*., 2018; Reiss *et al*., 2018; Aderinboye *et al*., 2020; Rossow *et al*., 2020). *Curcuma longa* commonly referred to as turmeric, is one of such plants containing biologically active compounds and it is widely used as herb or spice (Nasri *et al*., 2014). Several positive biological responses in ruminants have been reported with the use of turmeric (Chaudhry and Khan, 2012; Hodjatpanah-montazeri *et al*., 2014**;** Chowdhury *et al*., 2018; Oderinwale *et al*., 2020; Aderinboye and Olanipekun, 2021). However, majority of these studies were done *in vitro* with very few studies available *in vivo* to ascertain animal responses in terms of growth and animal health.

Growth is a desirable biological response in ruminant production and substances used as growth promoters in livestock feeds must not pose a threat to animal health. Although, phytogenic substances are generally recognized as safe for use in feeds, they may also induce toxic effects, regulatory obstacles or other potential side effects, particularly when consumed in excess (Olafadehan *et al*., 2014; Yang *et al*., 2015; Valenzuela-Grijalva *et al*., 2017). Therefore, to effectively adopt turmeric as growth promoters for ruminants, a safe level for use in the diet, at which growth performance can be enhanced without jeopardizing animal health, must be established. These recommended levels for goats are scarce in literature. An understanding of the influence of turmeric on growth performance and physiological status of animals can serve as significant factors to determine safe levels for use in ruminant diets. Blood assessment mostly provides a rapid means of discovering feed toxicity in animals, and the haematological and serum biochemical assay of livestock indicates the physiological, pathological and nutritional status of the animals (Olafadehan, 2011; Etim *et al*., 2013; Molefe and Mwanza, 2019). Thus, this study examined the effect of turmeric as feed additive on growth performance and some blood parameters in West African Dwarf goats to ascertain a safe level for use in their diet.

MATERIALS AND METHODS

Location of Experimental Site

The experiment was conducted at the Small Ruminant Experimental Unit of the Teaching and Research Farm of the Directorate of University Farms, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The geographical coordinate of the area falls within latitude 7°13'23.8" N and longitude 3°26'25.4" E (Google Earth, 2019). It is located in the rainforest vegetation..

Preparation of Tumeric

Fresh turmeric rhizomes were purchased from a local spice market in Abeokuta, Ogun State, Nigeria. The rhizomes were briskly washed in water to remove soil particles. Thereafter, the rhizomes were sliced into small pieces and were spread in a clean tray to air-dry until suitable for milling. The air-dried samples were then used as feed additive. Sub-samples (n=3) of the fresh turmeric slices were weighed before and after air-drying to determine dry matter percentage. The air-dried sub-samples were then milled into fine particles and used for phytochemical analysis.

Experimental Animals, Feed and Dietary Treatments

Twenty-four (24) West African Dwarf goats with initial weights of 8 -10 kg were used for the experiment. The experimental animals were allowed an adaptation period of four weeks prior to the commencement of the experiment. After the adaptation period, the animals were divided into three groups of eight (8) animals each, based on weight equalization across groups. Animals were offered feed on dry matter basis at 5% body weight. Animals in all groups were fed basal diet of *Panicum maximum* and concentrate supplement in ratio 6: 4 of each animal's daily dry matter (DM)

requirement. *Panicum maximum* and concentrate samples (n=3) of known weights were taken for dry matter determination and chemical analysis. The composition of the basal and supplemental diet is shown in Table 1. Turmeric was included at varying rates of 0, 2.5 and 5.0 g/animal/day. Each of the three animal groups were randomly assigned to one of the three rates of turmeric. Turmeric was included in the daily portion of the concentrate diet for each animal. Water was supplied *ad libitum* and feeding was done over a period of 90 days. The experiment was arranged in a completely randomized design with three treatments, two replicates per treatment and four animals per replicate.

Table 1: Composition (%) of Experimental *Panicum maximum* and Concentrate

Ingredient	**Concentrate**	***P. maximum***
Wheat offal	48.00	-
Maize	17.00	-
Brewers' dried grain	32.00	-
Bonemeal	2.00	-
Common salt	1.00	-
Total	**100**	**-**
Nutrient Composition[1](%DM)		
Dry matter[2]	91.64	31.43
Crude protein	18.13	10.68
Ether extract	6.86	6.18
Organic matter	93.88	89.80
Neutral detergent fibre	53.95	68.38
Acid detergent fibre	22.51	30.63
Acid detergent lignin	10.68	18.11
Metabolizable energy (MJ/kg DM)[3]	12.55	12.24

[1]Estimate of three replicates
[2]Determined on as-fed basis,
[3]Metabolizable energy calculated according to De Boever *et al*. (1997)

Feed Intake and Weight Gain Measurement

During the 90 days feeding period, experimental diets were offered individually to animals from 8.00 a.m. daily with the concentrate diet offered first. Quantities of *P. maximum* and concentrate diet offered daily to animals, and quantities of feed refusals after 24 hours were measured, to determine daily dry matter intake. At the commencement of the feeding trial, the initial weight of each experimental animal was taken. Thereafter, weights of the animals were taken individually on weekly basis, to determine weekly weight changes. Feed conversion ratio was estimated by dividing the quantity of feed consumed (in grams per day) of animals with the corresponding weight gain (in grams per day).

Nutrient Digestibility Measurement

At the end of the feeding trial, animals were transferred into metabolic cages with provision for separate collection of faeces and urine. Animals were allowed an adjustment period of seven days and a collection period of five days. During the collection period, total faeces voided were collected from individual animal and weighed daily. Aliquots (about 10%) of the faeces were sub-sampled, dried at 60°C, bulked per animal and stored for proximate and fibre analysis. Digestibility of nutrients was calculated according to Khan *et al*. (2003).

Blood Sampling and Analyses

Blood samples (about 15 ml) were drawn from each animal at the end of the experiment. The blood sampling was done before feeding via the jugular vein using hypodermic syringes. About 5 ml of the blood samples were collected into sample tubes containing Ethylene diamine tetra acetate (EDTA) for haematological analysis. The remaining portion were collected into plain tubes. The tubes were allowed to stand for 30 minutes at room temperature for blood to clot. Tubes were then centrifuged for 15 minutes at 2500 rpm to harvest serum for serum biochemical analysis. For haematological indices, packed cell volume was determined by capillary microhaematocrit method while haemoglobin concentration was determined by acid haematin method according to Benjamin (1978). Red blood cells and white blood cells were determined using the haemocytometer method as described by Chirkena *et al*. (2016). Mean corpuscular volume, mean corpuscular height and mean corpuscular haemoglobin concentration values were estimated from packed cell volume, red blood cell and haemoglobin values according to Jain (1986). For serum biochemical indices, serum glucose was determined by the glucose oxidase method as described by Bauer *et al*. (1974), total serum protein, albumin and globulin were analyzed using the biuret method (Reinhold, 1953). Serum urea was determined by the method of Marsh *et al*. (1965) and serum calcium was determined following the method of Gingler and King (1972). Alanine transaminase and aspartate transaminase were measured according to Reitman and Frankel (1957) while alkaline phosphatase was determined according to Roy (1970).

Chemical Analyses of Diets and Turmeric Fed to Experimental Animals

The proximate composition of the experimental diets were determined following the method of AOAC (2000) while the fibre fractions were analyzed according to the method of Van Soest *et al*. (1991). The phytochemical constituents of turmeric which include curcumin (Pawar *et al*., 2014), tannin (Makkar 2003), saponin (Mir *et al*., 2016), total phenol (Do *et al*., 2014), flavonoids (Nasseri *et al*., 2019) and oxalate (Mishra *et al*., 2017) were determined following standard methods.

Statistical Analyses

Data obtained from this study were analyzed using one-way analysis of variance procedure (SAS, 2002) in a completely randomized design. Orthogonal polynomial contrasts for equally spaced treatments, were used to determine the linear and quadratic effects of the doses of turmeric feed additive. Significant differences between means were stated at $P \leq 0.05$. The statistical model used was:

$$\Upsilon_{ij} = \mu + Ti + \Sigma_{ij}$$

Where:

Υ_{ij} = the dependent variable,

μ = population mean,

T_i = effect of the i^{th} dose of turmeric additive (i = 1, 2, 3) on variables measured and

Σ_{ij} = residual error.

RESULTS AND DISCUSSION

The phytochemical composition of turmeric rhizomes used as feed additive in this study is presented in Table 2. Turmeric rhizomes

contained 3.52% curcumin while saponin, total phenol, tannin, flavonoids and oxalate contents in turmeric were below 1%. The presence of curmin and other phytochemicals in turmeric rhizomes, confirms the presence of plant secondary metabolites, which are often the basis for use of most plants as alternative growth promoting agents. Curcumin has been reported as the main bioactive compound in turmeric which confers on it characteristic yellow colour; it is reported to exert different biological and cellular effects (Epstein, 2010; Pawar *et al*., 2014). Curcumin content within the range of 0.68 and 4.32% have been reported for turmeric rhizomes (Pawar *et al*., 2014; Geethanjali *et al*., 2016) and these vary with ecological location. The presence of saponin, tannin, flavonoids, have also been reported in turmeric (Ikpeama *et al*., 2014).

Table 2: Phytochemical Composition of Turmeric

Phytochemical	Concentration
Curcumin (%)	3.52
Saponin (%)	0.82
Total phenol (mg/kg)	3107.83
Tannin (mg/kg)	1455.75
Flavonoids (mg/kg)	465.26
Oxalate (mg/kg)	370.5

For conversion of mg/kg to percentage, divide mg/kg value by10,000.

The feed intake and body weight response of West African dwarf goats to turmeric feed additive is shown in Table 3. There was a linear reduction ($P < 0.05$) in the intake of total dry matter, crude protein and organic matter by goats offered daily doses of 2.5 and 5.0g turmeric feed additive. The observed reduction in total dry matter intake by goats administered turmeric could be a resultant effect of the linear reduction ($P < 0.05$) in the intake of the concentrate diet, which served as carrier for the additive. This reduction was attributed to the effect of phytochemical constituents in turmeric which probably reduced the palatability and acceptability of the diet. Diet palatability is an age-long factor that is known to influence feed consumption, and sensory properties of a feed can either stimulate or depress hedonic feeding behaviour (Baumont, 1996). Spices are reported to have marked flavouring properties which influence sensory properties of the diet and consequently influence gustation and olfaction in animals (Steiner and Syed, 2015). Turmeric inclusion at 2.5 and 5.0 g/animal/day was therefore, assumed to have affected the sensory properties of the diet to the level at which a depressive feeding response was triggered in goats. The observed linear reduction ($P < 0.05$) in nutrients intake by goats offered turmeric was presumed as a direct effect of the reduced dry matter intake. Animals offered 2.50 and 5.0 g of turmeric daily, did not show linear or quadratic variation ($P > 0.05$) in weight gain compared with those fed turmeric-free diet. The feed conversion ratio was improved linearly ($P < 0.05$) when goats were administered turmeric additive relative to the control. The improved feed conversion ratio implied that animals offered turmeric additive utilized less feed to produce a unit weight change.

The effect of turmeric additive in goat diet on nutrient digestibility is presented in Table 4.

Relative to the control diet, there was a linear increase ($P < 0.05$) in crude protein, ether extract, ash, and neutral detergent fibre digestibility, when goats were administered 2.5 g and 5.0 g of turmeric additive/animal/day. This suggested an increased absorption and utilization of nutrients by animals offered turmeric feed additive. The enhanced nutrient digestibility could possibly be due to a stimulatory effect of turmeric bioactive compounds on digestive enzymes activity. Turmeric has been reported to enhance bile acids synthesis, stimulate secretion of pancreatic enzymes and increase the activity of digestive enzymes in the gastrointestinal mucosa (Zotta *et al*., 2016).

Table 3: Intake and Weight Gain in West African Dwarf Goats in Response to Turmeric Feed Additive

	Dietary levels of turmeric (g/animal/day)				P value	
Parameters	**0**	**2.5**	**5**	**SEM**	**L**	**Q**
Initial weight, kg	9.47	9.32	9.45	0.28	0.980	0.846
Final weight, kg	12.30	12.68	12.60	0.28	0.880	0.743
Daily weight gain, g/day	33.14	40.01	37.45	1.86	0.057	0.062
Panicum dry matter intake, g/day	315.27	322.43	307.44	2.65	0.141	0.078
Concentrate dry matter intake, g/day	147.67[a]	126.00[b]	130.93[b]	1. 73	0.003	0.001
Total dry matter intake, g/day	462.94[a]	448.13[b]	438.37[c]	3.21	0.024	0.771
Crude protein intake, g/day	60.44[a]	57.23[b]	56.57[b]	2.07	0.042	0.525
Neutral detergent fibre intake, g/day	295.25	288.30	280.86	1.43	0.211	0.163
Organic matter intake, g/day	421.75[a]	407.55[b]	398.99[c]	2.94	0.031	0.988
Feed conversion ratio	13. 98[a]	11.25[b]	11.71[b]	1.70	0.008	0.065

[a,b,c] Means along the same row with different superscript are significantly different ($P < 0.05$)
SEM: Standard error of means
L, Q: Probability levels for linear (L) and quadratic (Q) trends.

Table 4: **Nutrient Digestibility (%) in West African Dwarf Goats in Response to Turmeric Feed Additive**

Parameters	Dietary levels of turmeric (g/animal/day)			SEM	P value	
	0	2.5	5		L	Q
Crude protein digestibility	73.12[c]	77.46[a]	76.61[a]	0.364	0.001	0.301
Ether Extract digestibility	70.91[c]	73.80[b]	75.69[a]	0.727	0.001	0.220
Ash digestibility	77.52[b]	81.49[a]	82.09[a]	0.782	0.004	0.671
Neutral detergent fibre digestibility	71.71[b]	74.76[a]	75.30[a]	0.437	0.006	0.155
Acid detergent fibre digestibility	70.60	71.60	72.86	0.424	0.066	0.830

[a, b, c] Means in the same row with different superscripts differ significantly ($P < 0.05$)
SEM: Standard error of means
L, Q: Probability levels for linear (L) and quadratic (Q) trends.

Table 5: Effect of turmeric additive on hematological profile of West African dwarf goats

Parameters	Normal values[1]	Dietary levels of turmeric (g/kg DM)			SEM	P value[2]	
		0	2.5	5		L	Q
Packed cell volume, %	22-38	31.0	34.0	33.5	1.20	0.50	0.58
Haemoglobin concentration, g/dL	8-12	10.8	11.2	11.6	0.36	0.53	0.98
Red blood cells, $x10^{-6}$/µL	8-18	11.7	12.2	12.3	0.20	0.35	0.66
White blood cells, $x10^{-3}$/µL	4-13	11.8	12.4	11.7	0.34	0.89	0.52
Mean corpuscular volume, fl	16-25	26.5	27.8	27.3	0.70	0.74	0.65
Mean corpuscular height, pg	5.2-8	9.25	9.15	9.40	0.27	0.88	0.82
Mean corpuscular haemoglobin concentration, g/dL	30-36	34.9	32.9	34.6	0.78	0.87	0.40

[1]Fielder (2015a), [2]Probability levels for linear (L) and quadratic (Q) trends.
[a, b, c] Means in the same row with different superscripts differ significantly ($P < 0.05$)
SEM: Standard error of means
L, Q: Probability levels for linear (L) and quadratic (Q) trends.

The haematological parameters of West African Dwarf goats in response to turmeric feed additive is presented in Table 5. Administering turmeric to West African Dwarf goats at 2.5 and 5.0 g/animal/day did not alter (L, Q; P > 0.05) animals' packed cell volume, haemoglobin, red blood cells, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, and white blood cells. Blood assays as indicators of physiological status in animals are well defined in literature (Daramola *et al*., 2005; Etim *et al*., 2013; Kubkomawa, 2015). Packed cell volume below normal range were indicators of anaemia while higher values reflected dehydration (Kundrapu and Noguez, 2018). Haemoglobin is the carrier of oxygen in the blood from the lungs to body tissues for nutrient breakdown to release energy (Etim *et al*., 2013). Normal red blood cells indicate maintained erythropoiesis in animals (Jones and Allison, 2007). Mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration are attributes of red blood cells which signify average cell size, average cell hemoglobin content and average cell hemoglobin concentration (Jones and Allison, 2007). Normal white blood cell levels in goats from this study, provides evidence of no toxicity from doses of turmeric additive used. Abnormal white blood cell values indicate pathophysiological conditions arising from an infection or presence of toxic substances in the blood (Olafadehan *et al*., 2014). Overall, the maintained haematological status of animals in this study, thus, suggested that the doses of turmeric administered did not trigger anaemic conditions, dehydration, restriction in oxygen transport round body tissues, negative immune system, or cell alterations in goats.

Table 6: Effect of Turmeric Additive on Serum Biochemical Indices of West African Dwarf Goats

Parameters	Normal values[1]	Dietary levels of turmeric (g/kg DM)			SEM	P value[2]	
		0	2.5	5		L	Q
Glucose, mg/dL	50-75	56.35	61.2	60.3	1.97	0.53	0.58
Total serum protein, g/dL	6.4-7.0	6.40	7.05	6.75	0.17	0.44	0.26
Albumin, g/dL	2.7-3.9	3.10	3.45	3.25	0.11	0.64	0.35
Globulin, g/dL	2.7-4.1	3.30	3.60	3.50	0.07	0.18	0.14
Albumin: Globulin	-	0.94	0.96	0.93	0.02	0.86	0.64
Urea nitrogen, mg/dL	10-20	14.7	13.6	14.0	0.30	0.38	0.27
Calcium, mg/dL	8.9-11.7	7.0	7.2	8.05	0.37	0.36	0.73
Blood enzymes:							
Alanine aminotransferase, U/L	6-19	9.3	9.85	10.3	0.29	0.26	0.94
Aspartate aminotransferase, U/L	167-513	247	231	235	3.84	0.22	0.21
Alkaline phosphatase, U/L	93-387	131	128	123	3.60	0.50	0.96

[1]Fielder (2015b), [2]Probability levels for linear (L) and quadratic (Q) trends.
[a, b, c] Means in the same row with different superscripts differ significantly (P < 0.05)
SEM: Standard error of means
L, Q: Probability levels for linear (L) and quadratic (Q) trends.

The serum biochemical constituents in goats administered turmeric feed additive is presented in Table 6. Serum glucose, protein and urea nitrogen were unaltered (L, Q; P > 0.05) when goats were given turmeric additive at doses of 2.5 to 5.0 g/animal/day. This similarity in serum values across the treatment groups implied that the doses of turmeric additive administered to goats maintained the nutritional and metabolic condition of the animals. Serum glucose, protein and urea nitrogen had been reported as useful indices in assessing the nutritional and metabolic status of ruminants (Cecchinato *et al*., 2018; Babale *et al*., 2019). Serum calcium levels were similarly normal and unaltered (L, Q; P > 0.05). This signified that the animals were neither hypocalcaemic nor hypercalcaemic. The activity of serum enzymes were not hindered (L, Q; P > 0.05) by turmeric additive. The observed similarity in serum enzymes activity indicated that the levels of turmeric additive used did not affect liver and muscle tissues function. According to Tibbo *et al*. (2008), serum enzymes were good indices that provided information on liver disease and muscle tissue degeneration.

CONCLUSION

The inclusion of 2.5 – 5.0 g/animal/day of turmeric in the diet of West African Dwarf goats reduced feed intake, increased nutrient digestibility with no change in weight gain. Turmeric additive did not cause any alterations in the haematological and serum biochemical indices of animals. For efficient feed conversion efficiency and enhanced nutrient absorption, turmeric could be safely administered as phytogenic feed additive for West African Dwarf goats at a dose of 2.5 g/animal/day.

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