Turmeric (*Curcuma longa*) Root Powder and Mannanoligosaccharides as Alternatives to Antibiotics in Broiler Chicken Diets

K. Samarasinghe*, C. Wenk[1], K. F. S. T. Silva and J. M. D. M. Gunasekera

Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka

ABSTRACT : Two bio-assays were conducted to evaluate turmeric root powder and mannan-oligosaccharides (MOS) as alternatives to feed antibiotics for broilers. In one trial, one hundred and eighty 19-days old broilers assigned to 18 groups of 10 were fed on one of six experimental diets with three replicates during four weeks. The diets included a basal feed without additives and with either virginiamycin, MOS, or turmeric at 1, 2 and 3 g/kg, respectively. In the second trial, one hundred and forty four 21-days old broilers arranged in 16 groups of nine were fed on the first four diets with four replicates for a similar period. Virginiamycin, MOS and turmeric (1 g/kg) in the first trial generally improved the weight gain of broilers by 3.4, 6.2 and 5.3%, respectively. In the second trial they increased the weight gain significantly ($p<0.05$) by 8.8, 8.0 and 15.1%, respectively. Additives improved the feed efficiency up to 15.1% and carcass recovery up to 3.1% ($p<0.05$). Virginiamycin, MOS and turmeric (1 g/kg) markedly reduced the abdominal fat content from 1.91% BW in the control to 1.44, 0.97 and 1.2% BW, respectively, in the first trial. The corresponding values obtained in the second trial were 1.01, 0.55 and 0.6%, respectively as compared to 1.22% in the control group. All additives showed a remarkable inhibition of duodenal coliform bacteria, yeast and mould in the caecum, and all viable microbes in the ileum. A significant ($p<0.05$) improvement in energy and protein utilization could be recorded with supplemented diets except for high turmeric diets. Dietary 2 and 3 g/kg addition of turmeric reduced energy and protein utilization as well as fat deposition. Present results reveal that turmeric and MOS are satisfactory alternatives to antibiotics in broiler feeds. Both MOS and turmeric possess an antimicrobial effect *in vivo*. Turmeric may also depress fat deposition in broilers. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 10 : 1495-1500)***

Key Words : Turmeric, Mannanoligosaccharides (MOS), Antibiotics, Broiler Chicken

INTRODUCTION

Feed additives have become essential components of feeds especially for monogastric animals. Until late 1980's, various antibiotics were heavily used world wide as growth promoting feed additives. Complete or partial prohibition of feed antibiotics has created a need to look for alternatives and today various potential substances are under investigation. The potential use of prebiotics like mannanoligosaccharides (MOS) (Cumming, 1995; Olsen, 1996; Jamroz et al., 1997; Kumprecht and Zobac, 1997; Savage and Zakrzewska, 1997; Parks et al., 2000; Spring et al., 2000) and various herbs (Dobretsberger et al., 1997; Bourne, 1998; Wenk and Messikommer, 1999; Wenk, 2002) in poultry diets have been recently discussed.

Rhizome and roots of turmeric (*Curcuma longa*), a tropical herb of *Zingiberaceae* family, is an essential component of curry powder used in the Asian kitchen, especially in South and South-East Asia. It is also widely used in indigenous medicine in Asia as an antimicrobial, endogenous stimulant, antiflatulent and anti-inflammatory agent. Reports on its phytochemistry and pharmacological uses are readily available but not necessarily based on scientific work. The main active substance of turmeric extract is identified as curcumin, a strong anti-oxidant (He, 1998; Torres et al., 1998; Unchern, 1998; Asai et al., 1999; Murray and Pizzorno, 1999; Dang et al., 2000). Another antioxidant peptide named as Turmerin has also been isolated from turmeric extract (Srinivas et al., 1992). Several *in vitro* studies reveal that turmeric extracts have antimicrobial effects too (Allievi and Gualandris 1984; Apisariyakul and Niyomka, 1986; Niaz et al., 1994; Torres et al., 1995). However, the possibility of using turmeric as a growth promoting feed additive for farm animals *in vivo* is so far not reported. Owing to its pharmacological properties partly proved by scientific work, the present study was conducted to investigate the possibility of using turmeric root powder and also MOS as alternatives to antibiotic growth promoters in broiler feeds.

* Corresponding Author: K. Samarasinghe. Tel: +94-08-38-71-79, Fax: +94-08-38 64 92 (Sri Lanka), E-mail: ksam@pdn.ac.lk

[1] Institute of Animal Science, ETH-Z, 8092-Zurich, Swizerland.

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MATERIALS AND METHODS

Two feeding trials were conducted with unsexed broilers (Arbor Acres) for 4 weeks each.

Experiment 1

One hundred and eighty, 19-days old broilers were divided into 18 groups of 10 birds having approximately similar group body weights, housed in 18 wire meshed battery cages (60×72 cm) equipped with separate feed troughs, dropping trays and a common drinking line. A basal feed was formulated without any feed additive (Table 1) to contain all the nutrients required by broiler finishers

Table 1. Ingredient composition (%) and the analyzed nutrients (% on dry matter) of the basal diet used in experiments 1 and 2

Ingredients	Amount	Ingredients	Amount
Maize meal	38	Calcium carbonate	1.5
Rice polish	20.7	Dicalcium phosphate	1
Soybean meal	20	Salt	0.25
Coconut meal	10	Lysine HCl	0.1
Fish meal	5	DL-Methionine	0.2
Coconut oil	3	Vitamin & mineral premix[1]	0.25
Analyzed nutrient composition			
Crude protein	24.11	Crude fat	9.34
Crude fiber	5.38	Total ash	7.93

[1] Contained 150,000 IU vit. A, 300,000 IU vit. D_3, 0.3 g vit. B_1, 0.6 g vit. B_2, 0.5 g vit. B_6, 1.5 g vit. B_{12}, 2.5 g vit. E, 1.5 g vit. K, 0.3 g calcium pantothenate, 0.15 g folic acid, 3 g nicotinic acid, 15 g choline chloride, 0.1 g cobolt, 5 g selenium, 4 g iron, 8 g manganese, 1 g copper, 5 g zinc, 0.1 g iodine, 5 g antioxidants and 50 g DL-methionine per kg.

(NRC, 1994). Total amount of the basal feed required for the trial was mixed as one batch using a horizontal feed mixer. The basal feed was then divided into six equal portions and one portion was taken as the control diet, while the other five portions were supplemented with either virginiamycin premix (500 ppm), MOS (200 ppm) or three levels of dried turmeric root powder (1, 2 and 3 g/kg) to produce five test diets. The six experimental diets were then randomly assigned to eighteen groups of broilers with three replicates. Feed in mash form and water were provided to birds *ad libitum* during four weeks. During initial nineteen days, birds had been fed on a commercial broiler starter feed.

Group feed intake and body weight were recorded weekly. Samples of excreta were collected for three consecutive days during 2nd and 4th week of the trial and stored in a deep freezer for subsequent analysis. At the termination of the experiment, three birds from each group were randomly taken and starved for sixteen hours for a slaughter study. Birds were then weighed, stunted by dislocating the head and killed by cutting the neck. After bleeding for few minutes, scalding, defeathering and evisceration was performed manually. The weights of liver, abdominal fat (fat pad surrounding gizzard and abdominal cavity) and the dressed carcass were recorded for each bird. Samples of abdominal fat were stored in a deep freezer for subsequent fat analysis.

Samples of feed and excreta were subjected to proximate analysis according to standard procedures (AOAC, 1992). The samples of abdominal fat tissues were homogenized and subjected to crude fat determination (AOAC, 1992). The gross energy content of feed and excreta was estimated using a bomb calorimeter (Gallenkamp Ballistic bomb calorimeter) and the acid insoluble ash content was determined (AOAC, 1992) to calculate the metabolizability values according to an indicator method. Data were analyzed according to analysis of variance (ANOVA) procedure and means were compared using Duncan's new multiple range test (SAS, 1992).

Experiment 2

One hundred and forty four, 21 days old broilers were divided into sixteen groups of nine birds having approximately similar group body weights, housed in sixteen battery cages as described under experiment 1. During initial three weeks, they had been fed on the same commercial broiler starter feed. The same basal diet as in experiment 1 was used as the control feed. Three test diets were derived from the basal diet by supplementing it with either virginiamycin premix (500 ppm), MOS (200 ppm) or dried turmeric root powder (1 g/kg). The four experimental diets were then randomly assigned to sixteen groups of broilers with four replicates and feeding continued for four weeks as in experiment 1.

The growth and carcass parameters studied, sample collection and analyses were similar to those in the experiment 1. In addition to the slaughter study, another three birds from each group, which were fed continuously were randomly taken for a microbiological study in the second experiment. Birds were stunted and killed as already described and then skinned off without scalding. The abdominal cavity was opened by making a cut ventrally below the keel bone and the viscera was taken out manually. Gut contents were carefully collected aseptically from duodenum, ileum and caecum and subjected to a microbiological study to estimate coccidia in caecum, coliform bacteria in duodenum, yeast and mould in caecum and all viable micro-organisms (AVM) in ileum of the GI tract. McMaster worm egg counting chamber (Weber Scientific International Ltd.) was used to count coccidia oocytes. MacConkey Agar, Potato Dextrose Agar and Total Plate Count Agar were used to culture coliform bacteria, yeast and mould and AVM, respectively. Data were analyzed according to analysis of variance (ANOVA) procedure and means were compared using Duncan's new multiple range test (SAS, 1992).

RESULTS

As shown in Table 1, the basal feed contained adequate levels of nutrients to meet the requirements of birds (NRC 1994) and the analyzed values compared well with estimated values. The effect of turmeric, MOS and virginiamycin on the performance of broilers was somewhat similar in both experiments though more clear effects were observed in the second experiment (Tables 2 and 3). In the second experiment, MOS reduced the feed intake of broilers ($p<0.05$) by 4.7% but this effect could not be seen in the first experiment. In both experiments neither virginiamycin nor turmeric showed a significant influence on feed intake.

Table 2. Performance of broilers as affected by virginiamycin (AB), MOS and different levels of turmeric in experiment 1

	Control	AB	MOS	Turmeric 1 g/kg	Turmeric 2 g/kg	Turmeric 3 g/kg
Initial body weight, g	319	316	318	316	317	319
Daily feed intake, g	110.7	112.2	111.3	112.4	110.5	112.4
Daily weight gain, g	51.46	54.20	54.65	53.20	51.78	52.45
Feed conversion ratio	2.15	2.07	2.05	2.11	2.13	2.18
Energy metabolizability	0.736^{ab}	0.826^{b}	0.837^{b}	0.844^{b}	0.605^{a}	0.690^{a}
Net protein utilization	0.589^{b}	0.739^{c}	0.770^{c}	0.741^{c}	0.403^{a}	0.445^{a}
Weight of carcass, % LW	74.4 ^{a}	76.7^{b}	75.7^{ab}	76.4^{b}	75.2^{ab}	75.5^{ab}
Weight of liver, % LW	2.05	1.84	2.01	2.00	2.16	1.83
Abdominal fat wt[1]. % LW	1.91	1.44	0.97	1.20	1.41	1.00

$^{a, b, c}$ Means with different superscripts within the same row are significantly different ($p<0.05$).

[1] Corrected for the analysed fat content of the abdominal fat pad.

Table 3. Performance of broilers as affected by virginiamycin (AB), MOS and turmeric in experiment 2

	Control	AB	MOS	Turmeric 1 g/kg
Initial body weight, g	380	381	380	379
Daily feed intake, g	109.7^{b}	107.6^{ab}	104.5^{a}	108.4^{ab}
Daily weight gain, g	52.85^{a}	57.48^{b}	57.08^{b}	60.81^{b}
Feed conversion ratio	2.07^{b}	1.86^{a}	1.81^{a}	1.76^{a}
Energy metabolizability	0.787^{a}	0.796^{b}	0.837^{d}	0.803^{c}
Net protein utilization	0.744^{a}	0.775^{b}	0.780^{c}	0.790^{d}
Weight of carcass, % LW	75.5^{a}	76.7^{b}	77.1^{b}	77.2^{b}
Weight of liver, % LW	1.93^{a}	2.52^{bc}	2.42^{bc}	2.69^{c}
Abdominal fat wt[1] % LW	1.22^{c}	1.01^{b}	0.55^{a}	0.60^{a}

$^{a, b, c, d}$ Means with different superscripts within the same row are significantly different ($p<0.05$).

[1] Corrected for the analysed fat content of the abdominal fat pad.

Table 4. Coccidia oocytes and colony forming units of coliform bacteria, yeast and mould, and all viable micro-organisms in gut contents of broilers in experiment 2 as affected by virginiamycin (AB), MOS and turmeric powder

	Control	AB	MOS	Turmeric
Coccidia oocytes in caecum, cfu/g	83,033	62,867	87,000	7,9217
Coliform bacteria in duodenum ($\times 10^9$)	11.663^{b}	3.950^{a}	4.932^{a}	4.623^{a}
Yeast and mould in caecum ($\times 10^7$)	41.89^{c}	25.63^{b}	6.58^{a}	12.47^{a}
All viable microbes in ileum ($\times 10^{10}$)	11.36^{b}	4.38^{a}	5.60^{a}	3.7^{a}

$^{a, b, c}$ Means with different superscripts within the same row are significantly different ($p<0.05$).

However, all supplemented diets resulted a better growth rate of broilers in both experiments. Turmeric (1 g/kg), MOS and virginiamycin increased the weight gain of broilers in the first experiment by 5.3, 3.4 and 6.2% (Table 2) and in the second experiment by 15.1 and 8.8 and 8.0% (Table 3), respectively. Compared to the control, feed conversion ratio of birds in the second experiment was reduced ($p<0.05$) by 15.1, 12.5 and 10.5%, when they were fed on diets supplemented with turmeric, MOS or virginiamycin, respectively. However in the first experiment, the feed conversion ratio was not significantly influenced by additives. There was no difference ($p<0.05$) observed between virginiamycin and turmeric in respect to feed intake, growth rate or feed conversion ratio.

In both experiments, energy metabolizability and net protein utilization (NPU) were increased ($p<0.05$) by virginiamycin, MOS and turmeric (1 g/kg level). Higher levels (2 and 3 g/kg) of turmeric did not have any effect on feed intake or weight gain but reduced the NPU and energy metabolizability.

All additives significantly improved (up to 3.1%) the carcass recovery (dressing percentage) of birds in both experiments. Significantly heavier livers were observed with birds fed on supplemented diets in the second experiment but not in the first experiment. A lower abdominal fat deposition was observed with all additives though the effect was significant ($p<0.05$) only in the second experiment.

Colony forming units (cfu) of coliform bacteria, yeast and mould as well as total viable microbes in broiler gut contents have been markedly reduced ($p<0.05$) when the diet was supplemented with turmeric, MOS or virginiamycin (Table 4). There was no significant effect of additives on coccidial population in the broiler gut.

DISCUSSION

In general, the two experiments have generated comparable results indicating a good repeatability of present data. The improved growth resulted without

consuming extra feed as observed with all test diets suggests that supplemented diets were utilized by birds more efficiently. Therefore, a better feed conversion ratio could be seen with all the supplements, especially in the second experiment. As shown in Table 2, both NPU and energy metabolizability of broilers were improved by virginiamycin, MOS and low level of turmeric thus explaining the observed growth increases. Values obtained in the second experiment suggest that MOS and turmeric were superior to virginiamycin in improving energy and nutrient utilization by broilers.

The mode of action of antibiotics in improving the growth of animals is a well known fact. It is reported that MOS can alter the gut microbial population in non-ruminants in a desirable manner by selectively binding to the micro-organisms in the gut (Spring et al., 2000, Shane, 2001; Newman et al., 1994). Therefore favorable micro-organisms like lactobacilli will be able to further suppress the growth of harmful micro-organisms in the chicken gut (Vandevoorde et al., 1991; Hinton et al., 1992; Pascual et al., 1999) thus improving the feed digestibility and nutrient utilization (Schneitz et al., 1998) which in turn results a better performance of the animal. In the present study, MOS had significantly reduced the cfu of duodenal coliform bacteria (Table 4) thus avoiding their negative effect on the performance of birds.

In the present study, all additives significantly improved the energy metabolizability and NPU indicating that their antimicrobial effect from duodenum to ileum has increased feed digestion and nutrient utilization as observed by Schneitz et al. (1998). In the case of turmeric supplement, it is also possible that turmeric has increased the secretion of digestive juices and improved the gastro-intestinal condition as shown by Ammon and Wahl (1991) which could contribute to the increased nutrient utilization, in addition to its antimicrobial effect. As a result of these effects, a proportionate increase in growth rate could be recorded. Present results also suggest that unlike in other monogastric animals the microbial population in the small intestine (even at duodenum) of poultry birds has a great impact on the feed digestibility and nutrient utilization.

The distribution of gut micro-organisms showed that both MOS and turmeric have almost the same effect as virginiamycin in their anti-microbial effect. The inhibition of yeast and mould was greater with MOS and turmeric than with virginiamycine. *In vitro* studies carried out by Allievi and Gualandris (1984), Apisariyakul and Niyomka (1986), Niaz et al. (1994) and Torres et al. (1995) have clearly demonstrated that turmeric extract has good anti-microbial effect against various harmful bacterial and fungal species. Swanson et al. (2002) observed that in dogs total aerobic microorganisms were inhibited while lactobacilli population was increased when the feed was supplemented with MOS. All these findings support the present observations.

Allen et al. (1998) reported an anticoccidial effect of diets containing turmeric at 10 g/kg feed given to chicken. However in the present study, turmeric did not significantly reduce the coccidia oocytes in the caecum though there was a general reduction (Table 4). Probably the present turmeric concentration (1 g/kg) that we have used was not sufficient enough to produce a significant effect.

Abdominal fat deposition of broilers ranged from 0.5 to 1.9% of live weight which were within levels reported with similar birds earlier (Samarasinghe, 1992). All test diets showed a remarkable reduction of fat deposition (given as a % of BW) which might be partly responsible for higher carcass recovery rates observed with supplemented diets. In view of this observation and the increased daily gain, it appears that birds fed on supplemented diets have utilised nutrients and energy to deposit body protein (growth) rather than body fat. However as shown in Table 2, higher levels of turmeric (2 and 3 g/kg) did not improve the growth of broilers but reduced the fat deposition thus suggesting a fat depressing effect of turmeric. Asai et al. (1999) found a significant inhibition in the deposition of triacylglycerol and total cholesterol in mice liver with turmeric extract showing its involvement in fat metabolism in animals.

The reasons for not improving the performance of broilers at higher levels of turmeric (2 and 3 g/kg) are not very clear. Ahilan and Jeyaseelan (2001) also have observed a growth inhibition of juvenile goldfish fed with diets containing 50 g/kg turmeric powder (an extremely high concentration compared to present dosages). Sittisomwong et al. (1991) have observed a subchronic toxicity of dietary turmeric powder at 0.03 g/kg BW/day or more in Wistar rats. They have further reported that turmeric at 2.5 and 5 g/kg BW/day reduced the growth of rats as compared to 0.03 g level. The 2.5 g/kg BW/day level is obviously a higher dietary concentration than 1 g/kg feed, the lowest level used in the present study. In connection to this regards, a slight *in vitro* alpha-amylase inhibition with turmeric has been reported by Jiaviriyaboonya and Rattanapanon (1989). However, further studies are necessary to explain the effect of turmeric at high doses.

CONCLUSIONS

Present results clearly demonstrate that MOS and turmeric can improve the growth and feed efficiency similar to antibiotics in broiler diets. The positive responses are due to improvements in energy and nutrient utilization. Both MOS and turmeric have an antimicrobial effect *in vivo* which is quantitatively similar to feed antibiotics. All three additives improve the carcass recovery and reduce the fat deposition in broilers due to better protein utilization.

Turmeric seems to possess a fat depressing effect which needs further investigations. It appears that higher levels of turmeric do not support broiler performance.

Present results conclude that both turmeric and MOS are satisfactory alternatives to antibiotic growth promoters in chicken broiler feeds.

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