Utilization of Graded Levels of Finger Millet *(Eleusine coracana*) in Place of Yellow Maize in Commercial Broiler Chicken Diets

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ABSTRACT : An experiment was conducted to study the performance, carcass traits, serum lipid profile and immune competence in commercial broilers (2 to 42 d of age) fed graded levels (25, 50, 75 and 100%) of finger millet (FM) *(Elusine coracana*) in place (w/w) of yellow maize (YM). Each diet was fed to eight replicates (five female *Vencobb* broilers/replicate) housed in stainless steel battery brooders. The estimated metabolizable energy content of FM was about 540 kcal less than the YM. FM contained more protein (10.42 vs. 9.05%) and fibre (9.52 vs. 2.24%) compared to YM. Body weight gain, ready to cook yield, relative weights of giblet, liver, intestine and length of intestine at 42 d of age was not affected due to replacing YM with FM. But, the feed efficiency decreased in broilers fed diets containing 75 and 100% FM in place of YM at both 21 and 42 d of age. The amount of fat deposited in abdominal area decreased and the relative weight of gizzard increased with increase in level of FM in the diet. The serum HDL cholesterol at 21 and 42 d of age and serum triglycerides at 42 d of age decreased with increase in level of FM in diet. The relative weight of spleen and antibody titers against sheep red blood cells (SRBC) at 5 d post inoculation (PI) decreased in broilers fed FM at 100% of YM. However, the relative weight of bursa, SRBC titers at 10 d PI, antibody titers against ND virus and mortality were not affected due to incorporation of FM in place of YM in diet. The fat content in thigh muscle and liver decreased, while the protein content in these tissues increased with increase in the level of FM in broiler diet. Based on the results, it may be concluded that YM can be replaced with FM up to 25% on weight basis without affecting weight gain, carcass yields and immunity in commercial broiler diet (up to 42 d of age). Further, inclusion of finger millet reduced the fat deposition in thigh muscle, liver and in abdominal area compared to those fed maize as the principal source of energy. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 1 : 80-84)***

Key Words : Finger Millet, Broiler Chicken, Growth, Carcass Traits, Immunity, Serum Cholesterol, Triglycerides

INTRODUCTION

The ever increase in demand for maize as energy source in poultry and other livestock species diet leads to sharp increase in its price and at times non-availability of maize for poultry feeding. Maize is also being diverted for starch production. This situation forces to search for alternate energy sources for maize. In this context, certain coarse cereals have been tried as alternatives to maize with varied degree of response (Kumar et al., 1991; Reddy and Narahari, 1997; Rama Rao et al., 2000,2004). Majority of coarse cereals contain high fibre and low energy compared to maize. Therefore, incorporation of these cereals resulted in poor performance especially at higher levels of incorporation in poultry diets.

Finger millet (*Elusine coracana*) is known as *ragi* in India and as African millet and Indian millet in other countries. Finger millet (FM) is a minor millet cultivated in many parts in South India, with an annual production of 2.7 million metric tons (Annon, 1995). It was the staple food for humans in some areas. Due to change in food habits, now this millet is available to feed livestock and poultry as an alternative to maize. The cost of FM is relatively less compared to maize in the areas of its cultivation. Therefore, incorporation of FM in place of maize can reduce the dependency on maize and also the cost of poultry production. The FM contains slightly less protein and fat and high levels of crude fibre. The metabolizable energy of FM reported in the literature (3,024 kcal/kg) was lower than that of maize (Venkateswara Rao, 1995). The protein is well balanced in limiting amino acids in practical poultry diets. Lysine, methionine and cystine contents in FM were about 2.86%, 2.86% and 1.51% of the crude protein (Rachie and Peters, 1977). However, literature on utilization of FM in poultry diet is scanty (Srilatha Rani, 1995; Vankateswara Rao, 1995; Rama Rao et al., 2000,2004). Therefore, an experiment was conducted to study the performance, carcass traits, serum lipid profile and immune competence in commercial broilers fed graded levels (w/w) of FM in place of maize.

MATERIALS AND METHODS

Analysis of feed ingredients

All the feed ingredients were analysed for their proximate principles (AOAC, 1990), calcium, total phosphorus, soluble carbohydrates (Anthrone reagent method). The metabolizable energy contents of maize and FM were estimated following the European Reference method (Bourdillon et al., 1990) by feeding each energy source to six, 26-week old White Leghorn cockerels.

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Table 1. Composition (g/kg) of maize reference diets

Ingredient	Starter (up to 21 d)	Finisher (22-42 d)
Yellow maize	570.0	683.6
Deoiled rice bran	28.1	0.0
Soyabean meal	360.0	275.0
Oyster shell grit	9.0	9.0
Dicalcium phosphate	19.0	19.0
Lysine HCl	2.50	2.20
DL-methionine	1.90	1.70
Trace minerals[1]	1.50	1.50
Vitamin Premix[2]	0.50	0.50
Choline chloride, 50%	1.00	1.00
Common salt	4.00	4.00
Toxin binder	1.50	1.50
Antimicrobial[3]	0.50	0.50
Coccidiostat[4]	0.50	0.50
Nutrient composition (g/kg)		
Metabolizable energy* (kcal/kg)	2,847	2,980
Crude protein**	220.2	191.3
Calcium**	8.62	8.63
NPP*	4.16	4.00
Lysine*	12.7	11.1
Methionine*	5.30	4.75

Trace minerals contained (mg/kg) manganese, 60 mg; zinc, 35 mg; iron, 30 mg and copper, 5 mg.
Vitamin premix contained (units/kg): Vitamin A, 12,375 IU; Ribiflavin, 7.5 mg; Cholecalciferol, 1,800 ICU; Vitamin K, 1.5 mg; Thiamin, 1.2 mg; Pyridoxine, 2.4 mg; Cyanocobalamine, 12 mcg; Vitamin E, 12 mg; Pantothenic acid, 12 mg; Niacin, 18 mg.
Antimicrobial (Furazolidone 20% w/w), Coccidiostat (monensin sodium 10%). * calculated; ** analysed.

Birds and management

Day old *Vencobb* female broiler chicks were wing-banded on day one and randomly distributed in to 40 stainless steel battery brooders at the rate of 5 chicks in each brooder. The brooder temperature was maintained at about 34°C up to 7 d of age, gradually decreased to 26°C by 21 d of age, after which the chicks were at room temperature. On day one ground yellow maize (YM) was provided *ad libitum* and experimental diets were fed *ad libitum* from day two to 42 d of age. Uniform vaccination and management were adopted for all the birds.

Diets

Maize-soyabean based starter and finisher reference diets were prepared (Table 1) with 2,847 and 2,980 kcal ME/kg and 220.2 and 191.3 g crude protein/kg, respectively. The YM in starter (570 g/kg) and finisher (684 g/kg) diets was replaced with the FM at 25, 50, 75 and 100% on weight basis. Each experimental diet was fed to 8 replicates (battery brooder pens). The experimental diets were allotted to the battery brooders following the completely randomized design.

Traits measured

Body weight gain and feed intake per replicate at weekly intervals were recorded. The efficiency of feed utilization was calculated as weight gain per unit feed intake. About 3-5 ml of blood per bird was collected from jugular vein of a bird from each replicate at 21 and 42 d of age. The serum was analysed for tri-glycerides (glycerol phosphate oxidase method), total cholesterol (enzymatic method) and HDL cholesterol (PTA precipitation enzymatic method), using diagnostic kits of M/s. Qualigens Fine Chemicals, Mumbai, India. One bird from each replicate was selected at random and sacrificed by cervical dislocation at 43 d of age. The carcass parameters studied include ready to cook yield (RTC) and relative weights of abdominal fat, liver, gizzard, giblet, intestine, bursa and spleen. The length of intestine was measured from duodenum to the caecal tonsils. These parameters were expressed in relation to the pre-slaughter weight of the respective bird. Muscle samples from thigh and breast areas and whole liver were collected to analyse fat and protein contents. At 43 d of age, eight birds from each treatment were inoculated intravenously with 0.1 ml of 0.5% suspension of sheep red blood cells (SRBC) in normal saline. On d 48 and 53 of age (5 and 10 d post inoculation, PI), 0.5 ml of blood was collected in EDTA from the brachial vein of each chick injected with SRBC and the antibody titers (log2) were measured employing the micro titer haemagglutination procedure (Wegmann and Smithies, 1966).

Statistical analysis

The data was subjected to analysis of variance (Snedecor and Cochran, 1980) and the differences among the means were compared by multiple range test (Duncan, 1955) at the respective probability value for each parameter, which were significantly influenced by the treatments employed.

RESULTS AND DISCUSSION

The composition of proximate principles, soluble carbohydrates, calcium, phosphorus and metabolizable

Table 2. Metabolizable energy (kcal/kg) and concentrations (%) of other nutrients in feed ingredients used in the study

Ingredient	ME	CP	CF	EE	Sol. CHO	AIA	Ca	P
Yellow maize	3,389	10.4	2.24	3.55	1.80	2.31	0.25	0.33
Finger millet	2,846	8.70	6.48	1.32	1.07	2.75	0.61	0.40
Soyabean meal		39.7	12.2	1.15	4.90	6.11	0.94	1.68
Deoiled rice bran		13.4	14.5	0.33	1.60	6.19	0.48	1.11

CP: crude protein; CF: crude fibre; EE: ether extract, Sol.CHO: soluble carbohydrates; AIA: acid insoluble ash; Ca: calcium; P: phosphorus.

Table 3. Body weight gain and feed/gain in commercial broilers fed different levels of finger millet (FM) replacing yellow maize (YM) on weight basis

Energy source (%)	Weight gain (g)		Feed/gain	
	21 d	42 d	21 d	42 d
YM 100	441[a]	1,661[a]	1.651[c]	1.873[c]
FM 25	390[b]	1,560[ab]	1.722[bc]	1.902[bc]
FM 50	367[bc]	1,487[bc]	1.824[b]	1.970[abc]
FM 75	305[d]	1,382[c]	1.983[a]	2.010[ab]
FM 100	327[cd]	1,481[bc]	1.981[a]	2.026[a]
SEM±	8.97	21.66	0.03	0.02
n	8	8	8	8
p≤	0.01	0.01	0.01	0.01

Means with common superscript in a column differ significantly.

energy (ME) in FM and YM (YM) are given in Table 2. The ME content in FM was less by about 540 kcal/kg compared to YM. The estimated ME content in YM was similar to the reported value (NRC, 1994). But, the ME value of FM was lower than the reported value from this lab (Rama Rao et al., 2000). The lower energy content in FM may be due to lower concentration of protein, ether extract, soluble carbohydrates and also higher levels of fibre and acid insoluble ash (Table 2) in the millet compared to YM.

Body weight gain and feed efficiency of commercial broilers fed diet containing different levels of FM at the expense of YM are given in Table 3. At 21 d of age, the body weight gain was significantly depressed with inclusion of FM at the lowest level of inclusion in diet (25% of maize). Growth depression was more severe at higher levels of FM in the diet. However, the body weight gain in broilers fed 25% FM at 42 d of age was similar to that of the maize reference group, while the broilers fed 50% or above levels of FM weighed significantly ($p \leq 0.01$) lower than the maize reference group. These findings are contradicting to the reports of Venkateswara Rao (1995), who found similar growth in broilers fed FM and maize as the principal sources of energy in the diet. Growth depression observed with incorporation of FM at 25 and 50% of YM at 21 and 42 d of age, respectively compared to those fed the maize reference diet may be due to low ME content in FM. Increased feed intake with increase in level of FM in diet also support this hypothesis. Contrary to these observations, Asha Rajini et al. (1986) and our earlier findings (Rama Rao et al., 2002) suggest similar growth performance in broilers fed FM and YM as the principal source of energy. The reasons for lack of difference observed between YM and FM in broilers may be due to poor growth rate of the birds used in their studies compared to the growth observed in the present study. The feed efficiency data during the starter phase indicate that FM can be used up to 25% of maize without significantly affecting the feed utilization. The feed efficiency was significantly depressed at 50% and above levels of FM in the diet, while at 42 d of age, the feed efficiency was not significantly affected by incorporating the FM even up to 50% of the maize in broiler diet. Increased feed intake and reduced growth with increase in the level of FM in diet are responsible for poor feed efficiency (Table 3). Reduced feed efficiency was also observed in our previous study (Rama Rao et al., 2002), when maize was totally replaced with FM (58%) on weight basis in broiler diet.

The ready to cook (RTC) yield and the relative weights of giblet, gizzard, liver, abdominal fat and intestine and the length of intestine of broilers fed diets containing different levels of FM in place of maize are given in Table 4. The RTC yield and the relative weights of giblet, liver and abdominal fat were not affected ($p > 0.05$) due to incorporation of FM in broiler diet. The gizzard weight was significantly ($p \leq 0.05$) increased with level of the millet in diet. Incorporation of FM at 75 and 100% showed significant increase in the weight of gizzard. Similarly, the weight of intestine also increased with inclusion of FM in the diet even at 25% of the maize. The intestine length also increased ($p \leq 0.05$) with the increase in the level of FM in the diet and reached to significance at 75 and 100% replacement of maize. The increase in weights of gizzard and intestine and length of intestine in FM based diets may be due to their higher fibre content (5.17 to 8.99% in starter and 4.77 to 9.29% in finisher diets) compared to the maize reference diets (3.90 and 3.25%, respectively). The increase in weight of different organs and length of intestine may be due to increased activity of these organs in an effort to

Table 4. Carcass parameters (g/kg pre-slaughter weight) and the length of intestine (cm/kg pre-slaughter weight) in commercial broilers fed different levels of finger millet (FM) replacing yellow maize (YM) on weight basis

Energy source (%)	RTC	Giblet	Gizzard	Liver	Abdo. fat	Intestine	
						Weight	Length
YM 100	727.5	43.8	18.4[c]	20.5	13.2	20.6[b]	10.4[b]
FM 25	734.4	45.7	18.9[bc]	21.9	11.7	23.9[a]	11.2[ab]
FM 50	725.2	46.0	19.2[abc]	21.9	12.3	23.3[ab]	11.4[ab]
FM 75	730.5	48.5	20.6[ab]	23.4	11.1	23.0[ab]	11.8[a]
FM 100	731.5	47.0	21.1[a]	21.7	10.9	24.7[a]	11.7[a]
SEM±	3.01	0.58	0.33	0.39	0.65	0.46	0.16
n	8	8	8	8	8	8	8
p≤	NS	NS	0.05	NS	NS	0.05	0.05

Means with common superscript in a column differ significantly.

Table 5. The serum biochemical profile (mg/dl) in commercial broilers fed different levels of finger millet (FM) replacing yellow maize (YM) on weight basis

Energy source (%)	Serum cholesterol		HDL cholesterol		Serum triglycerides	
	21 d	42 d	21 d	42 d	21 d	42 d
YM 100	129^{b}	131	109^{a}	85^{a}	102.8^{a}	48.0^{a}
FM 25	164^{a}	126	98^{ab}	76^{a}	81.5^{ab}	39.1^{b}
FM 50	147^{ab}	124	92^{b}	58^{b}	74.3^{b}	34.9^{b}
FM 75	146^{ab}	129	88^{b}	65^{b}	59.0^{bc}	33.7^{b}
FM 100	124^{b}	114	93^{b}	66^{b}	45.4^{c}	36.4^{b}
SEM±	3.67	2.07	2.15	1.94	4.32	1.33
n	6	6	6	6	6	6
p≤	0.01	NS	0.05	0.01	0.01	0.01

Means with common superscript in a column differ significantly.

Table 6. Relative weights of lymphoid organs (g/kg) and antibody titers (log 2) against SRBC and ND virus inoculation in broilers fed different levels of finger millet (FM) replacing yellow maize (YM) on weight basis

Energy source (%)	Bursa	Spleen	SRBC titers		ND titer
			5 d PI	10 d PI	5 d PI
Maize 100	1.88	1.58	7.13^{a}	6.75	4.25
FM 25	1.85	2.06	6.75^{ab}	4.50	4.25
FM 50	2.19	1.80	5.88^{b}	6.88	4.63
FM 75	1.98	1.64	4.75^{c}	6.00	4.50
FM 100	2.06	1.54	2.25^{d}	6.38	4.38
SEM±	0.10	0.10	0.30	0.34	0.09
n	8	8	8	8	8
p≤	NS	NS	0.01	NS	NS

Means with common superscript in a column differ significantly.

decrease the fibre length and thereby increase its digestion. This might have resulted in hypertrophy and/or hyperplasia of these organs in broilers fed higher levels of FM. Similar adoptive changes in structure and function of the gut and other organs due to feeding of various feed ingredients in broilers (Dibner et al., 1996; Nyachoti et al., 1996; Rama Rao et al., 2002) were reported earlier.

The serum lipid profile of commercial broilers (at 21 and 42 d of age) fed different levels of FM in place of maize is shown in Table 5. The concentration of total cholesterol in serum at 42d of age was not significantly (p>0.05) influenced by inclusion of FM in the diet. But, at 21 d of age the serum cholesterol concentration was significantly (p≤0.01) increased at 25% of FM in the diet and further increase in the level of FM in the diet reduced the concentration of serum cholesterol to the level of the maize reference group. The concentration of serum HDL cholesterol was significantly (p≤0.05) higher in the maize reference group and 25% FM fed group. Further, increase in FM level in the diet (50% and above) decreased the concentration of the HDL cholesterol in serum. Similarly, the serum triglyceride concentration also decreased with increase in the level FM in broiler diet both at 21 and 42 d of age. The changes in serum lipid profile due to feeding different levels of FM needs to be verified further to make use of these findings in producing the birds with modified

Table 7. Protein and fat content (g/kg dried sample) in thigh muscle, breast muscle, and liver of broilers fed different levels of finger millet (FM) replacing yellow maize (YM) on weight basis

Energy source (%)	Thigh muscle		Liver		Breast muscle	
	Fat	Protein	Fat	Protein	Fat	Protein
YM 100	124^{a}	773^{c}	153a	622^{c}	23.5	824
FM 25	111^{b}	776^{c}	141^{ab}	636^{b}	26.1	831
FM 50	99^{c}	795^{b}	141^{ab}	637^{bc}	24.8	822
FM 75	100^{c}	807^{ab}	137^{b}	651^{ab}	26.7	823
FM 100	87^{d}	814^{a}	129^{b}	662^{a}	24.7	823
SEM±	2.2	3.1	1.8	2.7	2.3	1.9
n	8	8	8	8	8	8
p≤	0.01	0.01	0.01	0.01	0.01	NS

Means with common superscript in a column differ significantly.

serum lipid profile and their subsequent accretion in various organs.

The data on relative weights of bursa and spleen, and antibody titers to SRBC and Newcastle disease virus inoculation are presented in Table 6. Incorporation of FM at different levels in broiler diet did not influence (p>0.05) these immunological traits except the SRBC titers at 5 d PI. The antibody titers against SRBC at 5 d PI decreased significantly (p≤0.01) with increase in FM level in diets beyond 50%. But, other parameters like relative weight of lymphoid organs, antibody titers against ND virus and SRBC titers on 10 d PI were not affected due to FM level in diet. Further, mortality was not significantly affected due to the treatments employed. Thus, it may be concluded that immunity was not affected in broilers fed different levels of FM in place of YM in diet. The protein and fat contents in breast muscle were not significantly (p>0.05) influenced by substitution of maize with FM at different levels (Table 7). The fat content in liver and thigh muscle decreased, while protein content increased with increase in level of FM in diet. Decreased fat deposition in liver and thigh muscle may be due to low energy content in diets based on FM compared to the maize reference diet. The calculated energy content in FM based diets was about 77 to 305 kcal and 93 to 369 kcal/kg, respectively lower in starter and finisher phases compared to their respective maize reference diets (2,847 and 2,980 kcal/kg). The significant increase in protein content in liver and thigh muscle of broilers fed increased quantities of FM in diet may be due to increase in the concentration of methionine with increase in FM level in diet. The calculated methionine concentration increased from 0.53 to 0.58% in starter and 0.47 to 0.52% in finisher diet. The increase in dietary levels of protein/limiting amino acids were known to reduce fat deposition in chicken (Hill et al., 1960; Weiss et al., 1967) by decreasing the fatty acid synthesis. Similarly, significant reduction in fat deposition in these tissue may also responsible for the relative increase in the protein content with increase in FM content in diet. This assumption can be supported by decreased serum triglyceride concentration with increase in FM content in the diet (Table 5). Another possible reason may be the increased protein synthesis with increase in the level of methionine associated with increase in FM content in the diet. Increased protein deposition rate with additional amino acid intake was also reported in literature (Eits et al., 2002).

Based on the results, it may be concluded that maize can be replaced with finger millet up to 25% on weight basis without affecting growth and feed efficiency. At higher levels, finger millet (≥50%) depressed growth and feed efficiency. The lower concentration of energy and higher levels of fibre in FM may be responsible for poor performance at higher levels of its inclusion in the diet. Incorporation of FM in broiler diet progressively reduced the concentrations of triglycerides and HDL cholesterol in serum and fat content in liver and thigh muscle with graded levels of FM in broiler diet.

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