Replacement of Yellow Maize with Pearl Millet (*Pennisetum typhoides*), Foxtail Millet (*Setaria italica*) or Finger Millet (*Eleusine coracana*) in Broiler Chicken Diets Containing Supplemental Enzymes

S. V. Rama Rao*, M. V. L. N. Raju, M. R. Reddy and A. K. Panda
Project Directorate on Poultry, Rajendranagar, Hyderabad, 500 030, India

ABSTRACT : An experiment was conducted to study the performance of broilers chicks (2 to 42 d of age) fed diets containing pearl millet (PM, *Pennisetum typhoides*), foxtail millet (FOM, *Setaria italica*) or finger millet (FIM, *Elusine coracana*) totally replacing (w/w) yellow maize (YM) with and with out supplementing non-starch polysaccharide (NSP) hydrolysing enzymes at the rate of 0.5 g/kg diet. Enzyme preparation contained amylase 2,400 units, hemi-cellulase 5,400 units, cellulase 12,000 units, protease 2,400 units and beta-glucanase 106 units/g. Each diet was fed to eight replicates (five female *Vencob* broilers/replicate) housed in stainless steel battery brooders. The estimated metabolizable energy (ME) contents of YM, PM, FOM and FIM were FM (PM) were about 3,389, 2,736, 3,303 and 2,846 kcal/kg, respectively. Total replacement of YM with FOM did not influence the body weight gain, ready to cook yield, relative weights of giblet, liver, intestine, lymphoid organs (bursa and spleen) and length of intestine, antibody titers and livability at 42 d of age. But the food efficiency decreased significantly in FOM fed broilers compared those fed YM. Further, the fat content in thigh muscle reduced with FOM fed groups compared to those fed YM. The performance of broilers decreased significantly in PM and FIM fed broilers compared to those fed YM. The relative weights of giblet, gizzard and liver increased in FIM fed groups compared to those fed YM as the principal source of energy in broilers. Incorporation of NSP hydrolysing enzymes in commercial broiler diets improved the efficiency of feed utilization during starter phase but not at 42 d of age. The results thus indicate that yellow maize can be replaced *in toto* on weight basis in commercial broiler diets without affecting the performance. Supplementation of NSP hydrolysing enzymes was beneficial in enhancing feed utilization during the starter phase. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 6 : 836-842)***

Key Words : Yellow Maize (YM), Pearl Millet (PM), Foxtail Millet (FOM), Finger Millet (FIM), Non-starch Polysaccharides (NSP), Ready to Cook (RTC), Sheep Red Blood Cells (SRBC), Post Inoculation (PI), Metabolizable Energy (ME), Newcastle Disease (ND)

INTRODUCTION

The ever increase in price and non-availability of maize as energy source in poultry diets forces the poultry nutritionists to search for alternate energy sources for maize. Numerous studies were conducted in the past to test the feasibility of incorporation of certain coarse cereals as energy sources in poultry diets (Kumar et al., 1991; Thakur and Prasad, 1992; Reddy and Narahari, 1997; Rama Rao et al., 2000,2001). Among various cereals, foxtail millet (FOM), finger millet (FIM) and pearl millet (PM) are being cultivated in major parts of India and their production is considerably higher. The annual production of FOM, FIM and PM was about 8.16, 2.70 and 5.42 million metric tons, respectively (Annon, 1995). FOM is also known as *korra*, Italian millet and German millet, FIM known as *ragi*, African millet or Indian millet. Similarly, PM is known as *bajra*. These cereals were utilized as staple food for humans in the areas of their cultivation. With change in food habits, now these millet are available in surplus, which can be used as energy source in poultry diets. Further, the cost of these coarse cereals is relatively less compared to maize in the areas of their cultivation. Incorporation of these cereals in poultry diets can reduce the dependency on maize and also the cost of poultry production. Majority of coarse cereals contains high fibre and low energy compared to maize. Therefore, incorporation of these cereals resulted in poor performance especially at higher levels of their incorporation in poultry diets.

Utilization of non-starch polysaccharide (NSP) hydrolysing enzymes in poultry diets to enhance the energy utilization is gaining more importance in the recent times (Bedford and Partridge, 2001). Majority of such studies utilized maize, barley, wheat or oats as the principal source of energy (Newman and Newman, 1987; Choct et al., 1995; Hanumantha Rao, 1999). Information on the effect of enzyme supplementation in diets based on foxtail millet, finger millet and pearl millet as the principal source of energy is not available in the literature. In this study an attempt has been made to find out the performance, carcass traits, serum lipid profile and immunecompetence in broilers fed diets based on different coarse cereals viz. pearl millet (*Pennisetum typhoides*), foxtail millet (*Setaria italica*) and finger millet (*Eleusine coracana*) in place of yellow maize (YM) with or without supplemental enzymes.

* Corresponding Author: S. V. Rama Rao. Tel: +91-40-24015651/24017000, Fax: +91-40-24017002, E-mail: svramarao1@rediffmail.com
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Table 1. Ingredient and nutrient composition (g/kg) of the maize reference diet

Ingredient	Starter (2 to 21d)	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[3]	1.50	1.50
Antimicrobial[4]	0.50	0.50
Coccidiostat[5]	0.50	0.50
Nutrient composition (g/kg)		
Metabolizable energy, kcal/kg*	2,830	2,967
Crude protein**	225.6	191.0
Calcium**	8.62	8.63
Non-phytate phosphorus*	4.16	4.00
Lysine*	14.7	12.1
Methionine*	5.30	4.75

[1] Trace minerals contained (mg/kg) manganese, 60 mg; zinc, 35 mg; iron, 30 mg and copper, 5 mg.
[2] 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.
[3] Toxinbinder (hydrated sodium calcium alumino silicate 80%).
[4] Antimicrobial (furazolidone 20% w/w).
[5] Coccidiostat (monensin sodium 10%).
* Calculated, ** Analysed.

MATERIALS AND METHODS

Analysis of feed ingredients

All the feed ingredients were analysed for their proximate principles (AOAC, 1990) calcium, total phosphorus and soluble carbohydrates (Anthrone reagent method). The metabolozable energy (ME) contents in yellow maize (YM), foxtail millet (FOM), finger millet (FIM) and pearl millet (PM) were estimated following the European Reference method (Bourdillon et al., 1990) by feeding each energy source to six, 26 week old White Leghorn cockerels.

Birds and management

Three hundred and twenty commercial d-old *Vencobb* female broiler chicks having uniform body weight (49.4±0.43 g) were wing banded on day one and randomly distributed into 64 stainless steel battery brooders at the rate of 5 chicks in each. The brooder temperature was maintained at about 34°C up to 7 d of age, gradually decreased to 26°C by 21st d of age, after which the chicks were at room temperature. Ground YM on day one and the respective experimental diets from 2 to 42 d of age were fed *ad libitum*. Uniform vaccination and management were adopted for all the birds.

Diets

A starter and a finisher broiler diets were prepared using YM as the principal source of energy (570 and 683.6 g/kg diet respectively). These diets contain 2,830 and 2,967 kcal ME and 225.6 and 191.0 g crude protein/kg diet, respectively in starter and finisher phases (Table 1). The YM was totally replaced with FIM, PM and FOM on weight basis. Another four diets (diet 5 to 8) were prepared by supplementing a cock-tail enzyme preparation (Syner Zyme-FS, Neospark, Hyderabad, India) containing predominantly NSP hydrolysing enzymes at the rate of 0.50 g/kg to the diets based on different energy sources. Each g of the cocktail enzyme preparation contained amylase 2,400 units, hemi-cellulase 5,400 units, cellulase 12,000 units, protease 2,400 units and beta-glucanase 106 units. Each experimental diet was fed to 8 battery brooder pens containing 5 birds in each (a replicate). The experimental diets were allotted to the battery brooders following the completely randomised design.

Traits measured

Body weight gain and feed intake per pen were recorded at weekly intervals. The efficiency of feed utilization was calculated as feed intake per unit body weight gain. One bird from each replicate was selected at random and sacrificed by cervical dislocation at 43rd d of age. The carcass parameter studied include ready to cook yield (RTC) and relative weights of abdominal fat, liver, gizzard, giblet, intestine and lymphoid organ (bursa and spleen). Muscle samples from thigh and breast areas were collected to analyse their fat and protein contents (AOAC, 1990). At 43 d of age, eight birds from each treatment were inoculated intravenously with 0.1ml of 0.5% suspension of sheep red blood cells (SRBC) in normal saline, on 48 and 53 d of age (i.e. 5 and 10 d post inoculation, PI) 0.5 ml of blood was collected in EDTA from the brachial vein of the each chick injected with SRBC and the antibody titers (log2) were measured employing the micro titer haemogglutination procedure (Wegmann and Smithies, 1966).

Statistical analysis

Two factorial analysis was carried out following the Completely Randomized Design (Snedecor and Cochran, 1980) with energy source and level of enzyme as factors. When the interaction was not found significant, the effect of individual factors were considered. When interactions were significant, separate analyses were conducted within each main effect. Comparisons among means were made by Duncan's multiple range test (Duncan, 1955).

Table 2. Nutrient composition (%) of feed ingredients used

Ingredient	ME, kcal/kg	CP	CF	EE	Sol. CHO	AIA	Ca	P
YM	3,389	9.05	2.24	3.55	1.80	2.31	0.15	0.33
FIM	2,846	8.69	6.48	1.32	1.07	2.75	0.61	0.40
FOM	3,304	10.4	9.52	3.86	3.10	3.19	0.28	0.38
PM	2,736	8.60	3.85	4.36	0.73	2.98	0.20	0.31
Soyabean meal		42.71	10.2	1.15	4.90	6.11	0.94	1.68
Deoiled rice bran		13.4	12.5	0.33	1.60	6.19	0.48	1.11

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

Table 3. Weight gain and feed efficiency in commercial broilers (1-42 d of age) fed diets fortified with enzyme mixture and containing different millets in place of maize

Energy source*	Body weight gain, g		Feed/gain	
	21 d	42 d	21 d	42 d
YM	436[a]	1,635[a]	1.624[d]	1.858[c]
FIM	319[c]	1,407[c]	1.964[a]	2.069[a]
FOM	369[b]	1,589[a]	1.769[b]	2.039[a]
PM	374[b]	1,473[b]	1.706[c]	1.942[b]
p≤	0.01	0.01	0.01	0.01
Enzyme**				
-	378[a]	1,542[a]	1.787[a]	1.964[a]
+	371[a]	1,508[b]	1.744[b]	1.990[a]
p≤	NS	0.05	0.05	NS
SEM±	6.14	13.87	0.018	0.018

* n=16, ** n=32, ++

Means with in a sub-column having no common superscript in a column differ significantly.

RESULTS AND DISCUSSION

The proximate composition, soluble carbohydrates, calcium and total phosphorus of feed ingredients used in this study are given in Table 2. In general the ME and protein contents were lower and fibre content was higher in coarse cereals compared to that of YM, however, the FOM contained higher protein and slightly lower ME compared to that of YM. The estimated ME content in YM was similar to that of reported value (NRC, 1994). Similarly, the ME values of FOM and PM were almost similar (3,250 and 2,675 kcal, respectively/kg) to the value reported by Baghel and Netke (1982), Rao (1991) and Rama Rao et al. (2000). But, the ME value of FIM was lower than the reported value from this laboratory (Rama Rao et al., 2000). The lower energy value in FIM and PM may be due to lower concentrations of protein, soluble carbohydrates and also higher levels of crude fibre and or acid insoluble ash (Table 2). Age of the birds used in estimating the ME content of the feed ingredients might also be responsible for variation in energy content of a particular feed ingredient (Leeson and Summers, 2001) due to better digestibility of certain nutrients with increase in age of the birds.

The interaction between the source of energy and the enzyme supplementation on body weight gain and efficiency of feed utilization was not significant (p>0.05) both at 21 and 42 d of age. However, source of energy and enzyme supplementation independently influenced these parameters (Table 3). The body weight gain and feed utilization were significantly decreased (p<0.01) at 21 d of age by replacing YM with different millets tested. Similarly, the feed efficiency at 42 d of age was also depressed by replacing maize with the alternate energy sources tested. However, the body weight gain at 42 d of age in FOM fed group was similar (p<0.01) to those fed the maize reference diet, indicating that the maize can totally be replaced with FOM on weight basis in broiler diet without affecting the growth. Among the different energy sources, the rank orders for body weight gain and feed efficiency at 42 d of age were YM=FOM > PM > FIM and YM > PM > FOM=FIM, respectively. The growth depression observed at 21 d of age when YM was replaced with FOM may be due to higher levels of fibre in FOM. Similarly, growth depression during the early age and subsequent compensation in growth at 42/49 d of age due to feeding coarse cereals in broilers was also reported in the literature (Rao, 1991; Srilatha Rani, 1995; Rama Rao et al., 2002). Depression in performance of broilers when fed PM or FIM as the principal source of energy compared to YM contradicts with many reports (Sharma et al., 1979; Asha Rajini et al., 1986; Thakur and Prasad, 1992; Prasad et al., 1997; Rama Rao et al., 2002). These authors reported either similar or superior performance in broilers fed PM or FIM as the principal source of energy compared to those fed YM. The growth depression observed in the present study may be due to lower ME and protein contents in the millets compared to YM. Lack of depression in performance in broilers when fed PM or FIM as the principal source of energy as reported may also be due to variation in duration of the experiment conducted and growth potential of the birds besides the high ME content compared to the energy contents of the millets used in the present study. Majority of the authors (Asha Rajini et al., 1986; Thakur and Prasad, 1992; Rama Rao et al., 2002) studied the performance up to 49/56 d of age against 42 d in the present study. The growth depression observed at an early age due to cereal feeding may be compensated at the latter age when the experiment continued longer duration.

Table 4. Ready to cook yield, relative weights of different visceral organs (g/kg preslaughter weight), length (cm/kg preslaughter weight) of intestine and protein content in liver (g/kg) of broilers fed different energy sources with or without enzyme supplementation

Energy source	RTC yield	Giblet	Gizzard	Liver		Abdominal fat	Intestine	
				Weight	Protein		Weight	Length
YM	731[ab]	43.0[b]	18.10[bc]	20.1[b]	63.7[b]	13.5[ab]	21.0[a]	10.8[a]
FIM	727[b]	48.0[a]	20.79[a]	22.6[a]	64.0[b]	11.5[b]	23.4[a]	11.6[a]
FOM	744[a]	44.8[ab]	20.15[ab]	20.1[b]	65.5[a]	10.4[b]	22.1[a]	10.7[a]
PM	724[b]	43.7[b]	16.32[c]	22.4[a]	64.0[b]	14.9[a]	23.4[a]	11.3[a]
n	16	16	16	16	16	16	16	16
Enzyme								
-	732[a]	44.9[a]	19.15[a]	21.2[a]	64.8[a]	12.4[a]	22.5[a]	11.1[a]
+	731[a]	44.8[a]	18.53[a]	21.5[a]	63.8[b]	12.7[a]	22.4[a]	11.1[a]
n	32	32	32	32	32	32	32	32
p≤	0.05	0.01	0.01	0.01	0.01	0.05	NS	NS
SEM±	2.72	0.53	0.34	0.35		0.57	0.42	0.14

Means with in a sub-column having common superscript(s) did not differ significantly.

Enzyme supplementation in broiler diet did not influence (p>0.05) the weight gain at 21 d of age, but at 42 d of age, weight gain depressed significantly with enzyme supplementation. The feed efficiency was significantly improved at 21 d of age with enzyme supplementation, but such beneficial effects were not seen at 42 d of age. These results indicate that commercial broilers may need supplemental enzyme for better feed utilization during the initial growth period. The lack of response as the bird grows to 42 d of age due to enzyme supplementation suggests the adequacy of endogenous enzyme secretion in the gut at later phase of growth to utilize the nutrients in corn-soya diet. Similar to these findings, Noy and Sklan (1995) reported that the concentrations of certain digestive enzymes in chicken were inadequate to hydrolyze protein and fat in the juvenile stage (4 days of age) and the enzyme production increases with increase in age of the bird. Similar to these findings, several authors reported no improvement in growth in broilers fed maize-soyabean meal based diets supplemented with NSP hydrolyzing enzymes (Zataria and Ferket, 1990; Irish and Balnave, 1993; Irish et al., 1995; Marsman et al., 1997; Rebole et al., 1998). Contrary to this, Ghazi et al. (1996,1997) and Hanumantha Rao (1999) reported significant improvement in growth in broilers fed maize soyabean meal diets supplemented enzyme preparations. However, in these latter studies no improvement in feed efficiency was reported. The lack of response in growth in the present and other reports may be due to very low concentration of NSP in the maize and other cereals used. The NSP content in maize ranges between 4.2 to 8.1% on dry matter basis (Ward, 1995; Classen, 1996), no information is available in the literature regarding the concentration of NSP in the cereal grains used in the present study. The wide variation existing in NSP content and their digestibility among different cultivars of maize (Summers, 2001), may be responsible for conflicting reports on beneficial effects of NSP hydrolyzing enzymes in broilers fed corn-soya diets.

The interaction between dietary energy source and enzyme supplementation was not significant (p>0.05) on the slaughter traits studied. However, the dietary energy source significantly influenced these slaughter parameters (Table 4). The RTC yield was significantly higher (p≤0.01) in FOM based diet compared to those fed FIM or PM based diets, while the maize reference group was intermediate. The higher proportion of RTC yields in FOM group may be due to significantly lower weights of abdominal fat and liver in FOM group compared to those fed FIM or PM based diets. The relative weights of giblet and gizzard were significantly (p≤0.01) higher in FIM fed birds compared to those fed maize or PM based diets. The weight of these organs in FOM group was intermediate. The higher weights of these organs in FIM and FOM fed groups may be due to higher fibre contents in these energy sources (6.48 and 9.52%, respectively). The higher levels of fibre might have increased the physical activity of these organs in an effort to grind and digest them resulting in hypertrophy or hyperplacia of these organs. Similar changes in structure and function of different visceral organs due to feeding various high fibrous diets in broilers were reported (Dibner et al., 1996; Nyachoti et al., 1996; Rama Rao et al., 2000). The relative weight and length of intestine were not influenced (p≥0.05) by the variation in dietary energy source. The weight of liver in FIM and PM groups were significantly (p≤0.01) higher compared to maize or FOM groups. The protein content in liver was significantly (p≤0.01) higher in PM group compared to those fed other energy sources. The abdominal fat content was also significantly (p≤0.01) higher in PM fed group compared to those fed FIM or FOM as the principal source of energy. Similar to these findings, the previous reports also indicated increased abdominal fat content/fat retention in birds fed PM as the principal source of energy (Sharma et al., 1979; Rama Rao et al., 2000, 2002).

Table 5. Relative weight of lymphoid organs (g/kg pre slaughter weight), antibody titers (log 2) to SRBC and ND virus inoculation and serum cholesterol (mg/dl) at 42 d and HDL cholesterol (mg/dl) at 21 d of age in broiler fed different energy sources with or without enzyme supplementation

Energy source	Relative weight		SRBC titers		ND titers 42 d	Livability
	Spleen	Bursa	5 d	10 d		
YM	1.55^{ab}	1.72^{a}	6.88^{ab}	6.81^{a}	4.50^{a}	79/80
FIM	1.66^{a}	2.04^{a}	6.06^{b}	5.81^{a}	4.50^{a}	80/80
FOM	1.30^{b}	2.39^{a}	6.19^{b}	5.63^{a}	4.69^{a}	80/80
PM	1.75^{a}	2.21^{a}	7.69^{a}	7.25^{a}	4.63^{a}	80/80
n	16	16	16	16	16	
Enzyme						
-	1.52^{a}	2.16	6.88^{a}	6.16^{a}	4.47^{a}	159/160
+	1.61^{a}	2.02	6.53^{a}	6.59^{a}	4.69^{a}	160/160
n	32	32	32	32	32	
p≤	0.05	NS	0.01	NS	NS	
SEM±	0.06	0.12	0.20	0.30	0.10	

Means with in a sub-column having common superscript(s) did not differ significantly.

Table 6. Protein and fat content (g/kg dry matter) in breast muscle and thigh muscle and liver in broiler fed different energy sources with or without enzyme supplementation

Energy source	Thigh muscle				Breast muscle				Liver	
Enzyme	Protein		Fat		Protein		Fat		Fat	
	-	+	-	+	-	+	-	+	-	+
YM	773.3^{bx}	787.2^{bx}	110.1^{ax}	94.7^{dx}	825.3^{by}	806.2^{bx}	23.47^{bx}	56.99^{ay}	137.4^{ax}	139.3^{bx}
FIM	787.2^{bx}	814.4^{ay}	96.5^{bx}	156.2^{ay}	822.8^{bx}	842.6^{ax}	44.78^{ay}	27.29^{dx}	130.1^{ax}	164.3^{ay}
FOM	815.8^{ay}	759.0^{cx}	87.1^{cx}	110.3^{cy}	829.1^{abx}	829.1^{ax}	26.82^{bx}	33.81^{cx}	146.6^{ax}	133.5^{bx}
PM	793.0^{bx}	785.1^{bx}	95.1^{bx}	119.3^{bx}	835.9^{ax}	824.2^{ax}	23.25^{bx}	45.94^{by}	149.7^{ax}	148.4^{aby}
n	8		8		8		8		8	
p≤	0.01		0.01		0.01		0.01		0.01	
SEM	2.88		2.15		2.65		1.52			

$^{a, b, c}$ Means with in a column having no common superscript differ significantly (p<0.01).

$^{x, y}$ Means with in a row having no common superscript differ significantly (p<0.01).

Supplementation of enzyme to different energy sources failed (p≥0.05) to elicit any response on RTC yield and relative weights of giblet, gizzard, liver, abdominal fat and intestine and the length of intestine. The protein content in liver was significantly (p≤0.01) depressed with enzyme supplementation. Decreased protein accretion in liver of boilers fed diets supplemented with enzymes compared those fed non-supplemented diets might be due to significant increase in fat deposition in liver of broilers fed FIM compared to those fed FIM based diets containing no supplemental enzymes.

The interaction between energy source and enzyme supplementation did not influence (p≥0.05) the relative weights of lymphoid organs (spleen and bursa) and the antibody titers against SRBC and Newcastle disease virus inoculation However, the dietary variation in energy source significantly influenced the relative weight of spleen (p≤ 0.05) and antibody titers against SRBC at 5 d PI (p≤0.01) (Table 5). The relative weight of spleen was significantly lower in FOM fed birds compared to those fed FIM or PM, while the broilers fed maize was ranking intermediate. The relative weight of bursa, antibody titers against SRBC at 10 d PI and Newcastle disease virus at 42 d of age were not affected due to the variation in energy source. Enzyme supplementation to broiler diet also failed to influence the relative weight of lymphoid organs (bursa and spleen), antibody titers to SRBC and ND-virus inoculation. Majority of immunilogical traits were not affected due to variation in energy source in the diet. Though the relative weight of spleen and antibody titers against SRBC on 5 d PI significantly more influenced, the livability of chicks among different energy sources was similar (Table 5), indicating that the immunity and mortality were not affected by replacing the YM with different coarse cereals in broilers (Table 5).

The interactions between dietary energy source and enzyme supplementation on the protein and fat content in both thigh and breast muscles and liver content are presented in Table 6. The protein content increased and fat content decreased in thigh muscle of broilers fed FOM compared to other energy sources. The reduction in fat deposition in thigh muscle may be due to higher levels of protein in FOM based diets. Increased protein (Sterling et al., 2002) or sulfur amino acids (Huyghebaert and Pack, 1996) were known to decrease fat deposition in chicken due to their inhibitory effects on hepatic lipogenesis (Yeh and Levelle, 1969). Further, higher levels of protein in liver and thigh muscle may be due to accretion of more protein in these organs with higher amino acid levels in FOM compared to YM (Baghel and Netke, 1982). Similarly, increased protein deposition rate with additional amino acid intake was also reported by Eits et al. (2002). With enzyme supplementation the thigh muscle protein content significantly increased in FIM fed group and decreased in FOM fed birds. The fat content in thigh muscle of broilers fed alternative energy sources was significantly lower compared to those fed the maize reference diet. This may be lower energy contents in alternate energy sources compared to YM (Table 2). Contrary to this, among enzyme supplemented groups the fat content in thigh muscle was significantly higher in broilers fed alternate energy sources as compared to the maize reference diet. The protein concentration in breast muscle was significantly higher in PM fed birds compared to those fed YM or FIM as the principal source of energy. The protein content in breast muscle of enzyme supplemented groups was significantly higher in broilers fed alternative energy sources as compared to those fed the maize reference group. The fat content in breast muscle was significantly ($p \leq 0.01$) higher in FIM based diets compared to those fed other cereal grains. Among enzyme supplemented groups, the fat content was higher in the maize group followed by PM, FOM and FIM in order. The liver fat content was not affected ($p>0.05$) by the source of energy when no supplemental enzyme was added. Among enzyme supplemented groups, the liver fat content was significantly higher in FIM fed group compared to other energy sources. Enzyme supplementation increased the liver fat content in FIM fed groups, but not in other energy sources. Though the enzyme supplementation altered the deposition of fat and protein contents in liver, thigh and beast muscles of broilers fed different energy sources, no specific trend was observed to attribute the changes to the treatment effects.

Based on the results, it can be concluded that, yellow maize can be totally replaced with foxtail millet on weight basis without affecting the body weight gain and other economic traits. Further, the fat content in thigh muscle reduced with foxtail millet compared to yellow maize. Total replacement of maize with either finger millet or pearl millet reduced the broiler performance. Lower ME content in finger millet and pearl millet may be responsible for the poor performance reported in these groups. Incorporation of non-starch polysaccharides hydrolyzing enzymes in commercial broiler diet improved the efficiency of feed utilization only during starter phase and failed to do so at the end of 42 d of age.

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