Comparative Efficiency of Milo and Some Millets with and without Dietary Enzyme as Replacer of Corn in Broiler Ration

THESIS

SUBMITTED TO THE

RAJENDRA AGRICULTURAL UNIVERSITY

(BIHAR)

(FACULTY OF VETERINARY SCIENCE)

PUSA (SAMASTIPUR)

In partial fulfilment of the requirements

FOR THE DEGREE OF

Master of Veterinary Science

IN

ANIMAL NUTRITION

By

Kanchana

(Registration No.- M/AN/ /1998-99)

DEPARTMENT OF ANIMAL NUTRITION

BIHAR VETERINARY COLLEGE

PATNA

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Dedicated

to my

Adorable

Parents

Sometimes farm animals compete directly with man for food, but more often they are the most practical sometimes the only way of providing essential protein. In the future more animals, husbanded more efficiently, will be needed to improve the quality of human diets through out the world.

- Blaxter

CERTIFICATE - II

*We, the undersigned members of the Advisory Committee of "**Dr. Kanchana**", a candidate for the Degree of Master of Veterinary Science with major in Animal Nutrition, have gone through the manuscript of the thesis and agree that the thesis entitled "**Comparative efficiency of milo and some millets with and without dietary enzyme as replacer of corn in broiler ration**" may be submitted by "**Dr. Kanchana**" in partial fulfilment of the requirements for the degree.*

29/5/2001

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CERTIFICATE - I

This is to certify that the thesis entitled "**Comparative efficiency of milo and some millets with and without dietary enzyme as replacer of corn in broiler ration**" submitted in partial fulfilment of the requirements for the degree of Master of Veterinary Science (Animal Nutrition) of the faculty of Post Graduate studies, Rajendra Agricultural University, Bihar, Pusa is the record of bonafide research carried out by "**Dr. Kanchana**" under my supervision and guidance. No part of the thesis has been submitted for any other Degree or Diploma.

It is further certified that such help or information received during the course of this investigation and preparation of the thesis have been duly acknowledged.

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And finally I shall never forget to acknowledge the super power "GOD" without whom no work is possible.

Kanchana

Kanchana

List of Abbreviations

%	:	Percentage
Ad - lib	:	*Ad libitum*
AOAC	:	Association of Official Analytical Chemists
ARC	:	Agricultural Research Council
Ca	:	Calcium
CD	:	Critical difference
CF	:	Crude Fibre
CP	:	Crude Protein
DM	:	Dry matter
EE	:	Ether Extract
FCR	:	Feed conversion ratio
G	:	Gram
IU	:	International Unit
Kcal	:	Kilocalories
Kcal/kg	:	Kilocalories per kilogram
Kg	:	Kilogram
ME	:	Metabolizable energy
NFE	:	Nitrogen Free Extract
NRC	:	National Research Council
NSP	:	Non starch polysaccharide
P	:	Phosphorus
PI	:	Performance Index
U/gm	:	Units per gram
Vit.	:	Vitamin

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Chapter 1

Introduction

Introduction

Indian poultry industry has made a commendable stride during last three decades emanating from backyard venture into a full-fledged agri-based, self-sufficient industry. The strides of development have not only been made in number but also in size, productivity, sophistication image, versatility and self-sufficiency. Planned systematic institutional research, developmental strategies, application of modern technologies in poultry breeding, improved management practices, provision of balanced nutrition and feeds, proper health cover contributed significantly for present development. There is now growing awareness and an increasing appreciation of the social role of poultry farming in rural development due to its multiple benefits like self employment, low input and quicker returns and also a source of economic upliftment through supplemental income. Meat from chicken is considered as a cheaper animal protein source that a low-income group can afford it than goat and other animals meat. Among meat producing strain of chicken broiler today occupy a pride place is widely accepted by common people. Broiler has registered a record production of 450 million in the year 1998 (Anonymous, 1998) from a meagre figure of 4 million in 1971 and is projected to achieve 6000 million during 2015 A.D. (Anonymous, 1986). At present poultry meat production is around 6.2 million tones which contributes 13% of total meat production in Indian (FAO, 1998). Despite this gigantic achievements the per capita availability of poultry meat stands about 900 g/year (Anonymous, 1998) a wide gap between availability and requirement.

The enormous growth of the poultry industry in recent times calls for a large quantity of feed with right proportion of nutrients to enable the hybrid variety of chicken to perform to its full genetic potential. The projected annual feed requirement of poultry industry is 13 million tones for 2000 A.D. (Arun Babu and Devegowda, 1997).

The major constraint today is availability of quality feed at economic prices which is the most important pre - requisite for profitable broiler production, since the feed cost alone accounts for 65 - 70% of total cost of production.

Broiler rations are usually formulated with energy and protein sources alongwith minerals and other feed additives.Out of these energy source constitute more than 50% of rations. Maize is the golden grain that has enjoyed greater acceptance in poultry ration in India (Reddy and Reddy, 1970; Yaqoob and Netke, 1975) and also elsewhere (Wilson and McNab, 1975) is the choice energy source in poultry ration. In recent years, the poultry growers had to face several constraints in using the maize as major ingredients for feed for livestock and poultry. The reasons may be attributed due to its high dependence for livestock and poultry, human consumption and preferential cultivation of rice and wheat than maize. In order to combat the high demand in various sectors that the government has recently started importing maize. All these factors led to its limited availability with the consequential high price.

The high cost of production and hence increasing prices of cereals such as maize and wheat have necessitated the search for other ingredients to replace these cereals partly or wholly in poultry feed. Researches were conducted in this direction to search alternate sources and devise methods for its optimum utilization in poultry rations. Among various alternate sources of energy, milo and millets have been used as promising source of energy for this purpose. Screening of agricultural product data indicates that sorghum and small millets are produced in sizeable quantities in this country. India produced 31.15 million tones of coarse cereal out of which Bihar contributed 7.31 million tones (Singhal, 1999). An all India estimates indicated that milo and small millets such as jowar (*Sorghum vulgare*), pearl millet (*Pennisetum typhoides*), finger millet (*Eleusine coracana*) and foxtail millet (*Setaria italica*) are produced abundantly with a figure of 9.32, 7.7, 2.76 and 0.82 million tones, respectively (Singhal, 1999). At present, though these millets are available in Bihar but its incorporation in poultry rations is negligible or in a very limited amount due to lack of knowledge in its use and also due to presence of some anti-nutritional factors in different varieties of these grains. Being cheaper than maize, their inclusion in the diet of broiler will make the ration more economic.

Chemical composition of sorghum and small millets revealed that these millets were found to be higher in protein, high in fibre except sorghum but low in metabolizable energy due to some anti-nutritive factors including fibre.

The invariable responses by feeding of these feed ingredients, found by different workers were due to some anti-nutritive factors such as NSPs, tannins and high fibre which is detrimental to growth and inefficient utilization of feed (Ramchandra *et al.* 1977; Alagianagalingam *et al.*, 1978; Reddy *et al.*, 1995; Bhaskara *et al.*, 1997; Chang and Fuller, 1964). Reports are also available showing even better weight gain and feed intake by complete replacement of maize with some of these millets in broiler diets (Asha Rajini *et al.*, 1986 and Reddy *et al.*, 1989).

Anti-nutritive factors present in these cereals are attributed to the heavy and strongly adhesive outer seed coat. The ANFs are substances that cannot be degraded/destroyed in the digestive tract of monogastrics and are of two types. The first variety will by themselves make unavailable and hinder the absorption of other nutrients whilst the other will directly inhibit the host enzyme responsible for digestion.

Poultry do not produce enzymes like cellulase, hemi-cellulase and β - glucanase which are required for digestion of cell wall (fibre) of plant material. Thus supplementation of multienzyme preparation will be of practical importance in improving the feeding value of high fibre and other anti-nutritional factors containing poultry feed ingredients. The area of enzymatic action include :

(a) Removal of deleterious incriminating factors.

(b) Increasing crude fibre digestion.

(c) Rendering the nutrients more available for digestion.

(d) Supplementing host endogenous enzyme production during adverse condition.

Information on complete substitution of maize by the milo & millets and also the beneficial effect of supplementation of multienzyme on milo and millets based rations in broiler are meagre and limited. With this view the present study was planned to study the effect of complete replacement of maize by sorghum (milo) and some locally available millets with and without enzyme supplementation in broiler ration with the following objectives :

1. To determine the quality of locally available milo and small millets by analyzing their proximate principles and inorganic constituents.

2. To explore the possibility of replacing maize by milo and small millets in broiler ration.
3. To observe the effect of dietary enzyme supplementation in milo and small millets based diets on the performance of broilers.
4. To develop nutritionally balanced and economic ration based on milo and small millets for broiler.
5. To determine the extent of reduction in feed cost by substitution of maize with milo and small millets in broiler ration.
6. To study the effect of different dietary treatment on carcass trait of experimental chicks.

Chapter 2

Review of Literature

Review of Literature

Balanced feed available at economic price is by far the most important prerequisite to accomplish economic broiler production. Cereal grains form the major component of poultry ration among which maize is traditionally used as principal energy source in broiler rations. However, the increased demand of maize due to its varied use in starch industry and for human consumption led to shortage and steep rise in price. So in order to reduce the cost of ration and relieve pressure on the availability of the commodity, researches are being conducted in this direction to include alternate energy sources in the rations of poultry. Since the feed accounts for approximately about 60 - 70% of total cost of productions, it is imperative for the nutritionists to explore the possibility for utilizing alternate energy sources in poultry ration which should be economical and do not produce any adverse effect on the performance through meeting the nutritional requirement of broiler. Among various alternate sources of energy, milo and millets are being explored as potential replacer of maize in broiler ration though with conflicting reports. Screening of agricultural products reports indicate that sorghum and millets are produced in sizeable quantity in India and Bihar also. If these cereals utilised as poultry feed, they would subsequently expand the stock of available energy sources for use in poultry feed. But their usage in poultry ration is not too common because of lack of knowledge for its proper utilization. The presence of some antinutritional factors like tannin, high fibre content, improper balance of amino acids are a few factors which hinders their potentiality as complete replacer of maize in poultry rations. Therefore, researches have been conducted in this direction to utilize as much as milo and various millets such as pearl millet, finger millet and foxtail millet in poultry ration. An attempt has, therefore, been made here to review the relevant literature under following subheadings.

A. Chemical composition and nutritive value of sorghum (milo), pearl millet, finger millet and foxtail millet and their replacement effect on maize based rations in poultry.

B. Importance of exogenous digestive enzymes in improving the productive value of feed ingredients and compound feed.

C. Effect of enzyme supplementation ~~of~~ on the performance and nutrient utilization in broilers.

D. Carcass quality affected by nutritional factors.

A. Chemical composition and nutritive value of sorghum (milo), pearl millet, fingermillet and foxtail millet and their replacement effect of maize based ration in poultry.

The chemical composition and nutritive value of all the above-mentioned cereals, estimated by various workers, are being presented in table 1, 2, 3 and 4.

i) Sorghum as Energy Source

Sorghum (milo) also known, as jowar (*Sorghum vulgare*) is the third important cereal crop cultivated widely in India after wheat and rice (Thakur *et al.*, 1985). It is a popular crop in the arid and semiarid topics, with an important feature of its ability to grow and produce under conditions of drought in low rainfall area due to its special physiological mechanism (vegetative stasis). Data indicated that India alone produced 11.88 million tonnes of sorghum annually in a 14.50 million hectare area with a yield of 819 kg/hectare (Singhal, 1999).

Sorghum is a cereal of remarkable genetic diversity. The inflorescence or head of sorghum consist of a panicle ranging from 75 to 500 mm in length and 40 to 200 mm in width. Each panicle contains between 800 to 3000 kernels enclosed in floral tracts (lemma and palea) which usually thresh free of the kernel during harvesting. The kernel, lemma and palea are located inside the glumes (Rooney, 1973). The glumes are black, brown, red or tan coloured (Arnon, 1972). The seed themselves are red, white, yellow or brown, the pigment being located in the pericarp and/or the testa. There appears to be general agreement that the sorghum kernel or caryopsis in roughly spherical in shape and composed of three main components :-

1. The seed coat - the outer covering;
2. The embryo or germ and
3. The endosperm - the storage tissue depending upon the variety the chemical composition of sorghum is quite variable (Table - 1).

Sorghum grain (red, yellow or white) has about 95% of the feed value of maize. In the most widely grown commercial hybrids protein content may range from 10 - 13% depending on the cultivators and on the soil and climatic condition. The protein of sorghum has much uniform essential amino acid composition. Compared to maize sorghum is reported to have higher levels of crude protein, lysine, methionine, fibre, ether extract, ash and phosphorus and almost twice as much calcium (Gualtieri and Rappaccini, 1990). However, due to presence of antinutritional factor tannin a polyphenol, which lowers its nutritive value and reduces palatibility due to its astringent effect. Tannin form complexes with protein and some other nutrients, which are not utilized in sorghum based diets of poultry. The ME content of sorghum ranges from 2617 to 3886 Kcal/Kg depending upon tannin concentration (Lucbert and Casting, 1986; Douglas *et al.*, 1988). They further suggested that sorghum having less than 1% tannin can be satisfactorily used in broiler diets. According to some workers (Bornstein and Lipstein, 1971; Stephenson *et al.*, 1971; Rostango *et al.*, 1973) sorghum amino acids availability is strictly related to its tannin content. Rostango *et al*,. (1973), compared the apparent amino acid digestibility of sorghum with low, intermediate and high tannin content with that of maize, and digestibility was found to be 73, 41 and 22% respectively. The differences in ME value of sorghum as estimated by a large number of researchers (Table - 1) was attributed due to differences in concentration of tannin in different varieties of sorghum.

Tannins, are polyphenols found in testa of grain. In the gastrointestinal tract tannins are hydrolysed to gallic acid and partially excreted in the form of 4 - 0 - methyl - gallic, utilizing methionine and choline of feed as a source of methyl groups for the 0 - methylation (Potter and Fuller, 1968). Tannins act as anti - nutritional factors and high concentration of it shows reduced feed intake (Rostango, *et al.*, 1973), lower nutrient digestibility and nitrogen retention (Vohra *et al.*, 1966; Nelson *et al.*, 1975). Such effects may explain the growth depression observed in broilers fed on bird resistant sorghum (Chang and Fuller, 1964; Rostango *et al.*, 1973; Armstrong *et al.*, 1974). The quality and test of meat could be altered by tannin was also reported (Petersen, 1969). Armstrong *et al.* (1973) studied the influence of the dietary addition of methionine, lysine, carminative and minerals such as calcium, manganese and zinc on leg abnormality of broilers fed on BR (bird resistant) sorghum, but could not alleviate the problem.

Table 1 : Chemical Composition of Sorghum(*Jowar*)

Sl. No.	ME (Kcal/kg)	DM	CP(%)	EE(%)	CF(%)	NFE(%)	Total ash(%)	Available Carbohydrate	Ca%	P%	Reference
1.	3100	–	11.00	2.80	2.00	-	-	-	0.03	0.10	Singh, 1975
2.	3398	88.80	9.30	2.71	2.42	-	-	-	-	-	Baghel and Netke, 1987
3.	2645	87.30	10.30	3.60	3.60	78.10	3.40	-	0.18	0.32	Reddy and Reddy,1981
4.	2593	90.20	10.00	5.70	-	-	2.79	56.0	0.12	0.69	Sinha *et al*, 1980
5.	-	–	10.46	3.35	2.49	82.05	1.65	-	-	-	Purushothaman and Thirumalai,1995
6.	2645	–	10.30	4.60	3.60	-	-	-	-	-	Rakshit and Rao, 1994
7.	2645	87.30	10.30	4.60	3.60	78.10	3.40	-	0.18	0.32	Panda *et al*, 1990
8.	-	–	15.20	2.50	-	79.50	2.80	-	-	-	Ranjan, 1998
9.	3256	–	8.50	2.00	2.10	-	-	-	0.04	0.29	Saxena and Ketelaars,1993.
10.	3400	–	11.00	3.00	3.00	81.00	2.00	-	0.03	0.35	Devendra, 1988; Gohl, 1981 and Harris *et al*, 1982
11.	3261	88.50	10.50	3.00	2.50	70.50	2.00	-	-	-	Ozement *et al*, 1962
12.	2823	89.80	12.00	2.90	-	-	1.93	59.80	0.35	0.32	Sharma *et al*,1979

To minimize the negative effects of tannins and to improve the nutritive value of BR (bird resistant) sorghum several methods have been proposed :

(a) Physical and/or chemical treatments; (b) amino acid addition (c) other chemical and enzymatic addition. Of the three above mechanism addition of enzyme has been found effective. Pillai *et al.* (1995) have added fungal protease to various tannin level diets and reported that feed can be detoxified by fungal protease.

Feeding value of sorghum in Broiler

Sorghum grain has become increasingly important as a feed ingredient in recent years. Various investigators have reported differences in feeding value of this grain. Possible causes for this variation have been attributed to the type and texture of starch and to the tannin content which is usually higher in grains with dark seed coats. Thayer *et al.*, (1957), reported that seed coat colour alone was not a reliable indication of the feeding value of given variety. Chang and Fuller (1964), reported that feeding sorghum grains with high tannin content resulted in growth retardation of chicks similar to that caused by feeding equivalent levels of tannic acid. Fuller *et al*, (1966), found that milo containing 1.6% or more of tannin depressed chick growth when fed as 50% of diet. Vohra *et al.*, (1966) reported that as little as 0.5% tannic acid caused a depression in the growth of chicks by reduction in feed intake and nitrogen retention. Petersen (1969) achieved the highest gains in a feeding trial with broilers in corn based diet ~~died~~ than sorghum and wheat diets which had similar weight gain but 2% - 3% less than corn fed birds;lower feed consumption for sorghum fed birds were also recorded. Damron *et al*. (1968) fed chicks a diet containing approximately 32% bird resistant grain without affecting performance with non-significant difference in weight gain. Stephenson *et al*, (1971) reported that amino acid availability in sorghum hybrids varied markedly. Nelson *et al*, (1975) conducted feeding trial with hybrid sorghum to study the effect of tannin content and dry matter digestion on the energy utilization and biological availability of amino acids and concluded that dry matter digested influenced amino acid availability and energy utilization more than did the tannin content. Tannin content has a greater effect on amino acid availability and varies with brown seed coat colour than non-brown seed coat colour.

Naphade and Tripathi (1974) attempted to evaluate the performance of starter chicks, grower and layer when fed maize, sorghum, wheat and rice. The test diet contained 100% maize and the rest feeds contained 50% maize and 50% basal diet containing sorghum, wheat and rice. No significant differences observed in between various treatments for feed consumption, feed conversion, egg production and performance indices, indicating that any one of the grains could be substituted with the other.

Thakur and Sharda (1974) replaced maize to the extent of upto 100 percent by sorghum as sole source of energy in broiler rations. Their result showed better body weight gain than those fed sole maize or various combinations of sorghum and maize. However, the best combination reported was 25 percent maize and 75 percent sorghum.

Sharma and Singh (1979), conducted four week trials with sorghum lines CSV-4. CSV-5 and CSH with GNC and fishmeal as dietary protein in separate experiment. With all vegetable from the diet the average weight gains of 66.3 g, 54.3 g, 61.3 g, 53.6 g and 56.3 g (Sem ± 17.6 g) were noted on ground nut cake based diet with maize, CSV - 4, CSV - 5, CSH - 5 and CSH - 6 grains, respectively. Differences in weight gain and feed intake were not significant. Respective mean weight gains on fish meal based diets were 157.1 g, 164.6 g, 162.5 g, 168.2 g and 152 g (Sem ± 18.75), the difference being non - significant. Feed intake and weight gain on practical starter diets containing the maize and sorghum lines also did not differ significantly. They concluded that sorghum lines of commonly cultivar could completely replace maize without ill effect.

In a similar trial of tannin free sorghum varieties CSH - 5 and CSH - 6, Thakur *et al.*, (1984) reported that performance of broiler fed variety CSH - 6 of sorghum was superior to that of CSH -5 in terms of the better essential amino acids makeup as compared to variety CSH - 5. They also reports that 50% maize could be replaced with CSH - 6 variety of sorghum without affecting the body weight gains of the birds.

Thakur *et al.* (1985) compared the feeding value of different tannin free sorghum varieties (SPV - 346 and Local white) replacing maize at 50 and 100% levels in broiler diet. Body weight gain, feed intake and feed conversion ratio were non - significantly different ($P < 0.05$) indicating their equal feed value. The overall data indicate that both the varieties i.e. SPV - 346 and LW could replace maize completely in broiler diets. Kaduskar and Khira (1982) also reported that feed consumption on diet containing 75% sorghum and all sorghum diets was significantly higher than other.

Hulan and Proudfoot (1982) reported that the inclusion of sorghum grain upto 45 percent in starter diet and 58 percent in the finisher diet at the expense of maize, had no significant effect on mortality, live body weight, feed conversion or percentage of grade A carcasses. Furthermore, there was not any significant effect on weight gain and feed conversion efficiency when the sorghum containing diets were made iso-energetic to maize diet.

In another experiment Eshwaraiah *et. al*,. (1994) used two sorghum genotype CSV - 8R with 117 g/protein and 19.3 g lysine and its shrivel high lysine mutant with 182 g protein and 28.7 g lysine per kg were included in broiler diets at 250 and 500 g/kg diet at the expense of maize of reference diet part per part. The body weight of broilers (1 day to 6 weeks) was numerically better on sorghum diets than on maize reference diet.

Nagra *et. al*,. (1990) evaluated the purebred (0.72% tannin) and hybrid (0.62%) sorghum grains in diet for starter broilers. Sorghum replaced maize at 25, 50, 75 and 100% levels. Significant ($P < 0.05$) growth depression was recorded only with complete replacement of maize by sorghum. Feed efficiency and the efficiency of protein utilization was not significantly ($P < 0.05$) affected at 75% replacement. In a second experiment, however, addition of groundnut oil significantly ($P < 0.05$) improved the body weight gain, feed efficiency and protein efficiency, particularly at highest level of sorghum in the diet.

Eshwaraiah *et. al*,. (1990) incorporated high lysine sorghum in poultry feeding which contained 14.1, 2.96 and 3.13% crude protein, available lysine and total tannin, respectively as compared to 10.2, 1.68 and 1.81% in normal sorghum, respectively. Inclusion of high lysine sorghum at 20% in place of maize resulted in significantly ($P < 0.05$) higher weight gain (361 g) over the other dietary treatment. Despite higher crude protein and available lysine, sorghum inclusion at 40% was found to be detrimental for growth, however, 20% high lysine sorghum gave the best feed efficiency. A similar depression in growth was also observed on account of feeding high lysine sorghum at 50% level.

Dixit and Baghel (1997), in a feeding trial replaced maize with sorghum at 40, 60, 80 and 100% level. Weight gain was higher in control group (maize), however, FER and PER were higher ($P < 0.05$) in broiler fed the diet containing 40% sorghum. Performance index was maximum in control group, while most economical weight gain was attained in the diet containing 40% sorghum. They concluded that sorghum could replace maize upto 40%.

Jacob *et. al*. (1996a) explored the possibility of over coming any detrimental effect of sorghum tannin on the growth rate and feed efficiency of broiler chicks by supplementing the diet with intact CP or D, L - methionine in two, 4 - week feeding trials of 280 chicks each. In each trial the effects of feeding maize or brown sorghum were compared under 3 dietary specifications similar to the control diets. In trial 1 control diet containing maize was compared with diets containing combination of white and brown (W/b) sorghum (50/50, w/w) and white sorghum alone. No significant differences in final body weight among the 3 diets (770.2, 759.0 and 753.0 g for the broiler on the maize, brown sorghum and W/b sorghum diets was noted. In trial 2 the weight gain was 822.7, 764.8 and 827.2 g for the broiler on the maize, brown sorghum and white sorghum diets. In addition, there were no significant differences in feed conversion ratio (FCR) between the maize and brown sorghum fed broilers (2.01 Vs 2.03 in trial 1; and

1.82 Vs 1.94 in trial 2). In trial 2, however, the FCR for the broilers receiving the white sorghum diet (1.73) was significantly lower than for those receiving the brown sorghum diet (1.94), but not significantly different from those receiving the maize control diet (1.82). No beneficial effect of methionine supplementation on final body weight or FCR in either trial was obtained. In trial 1, increasing the dietary CP content resulted in significantly lower final body weights (708.2 Vs 822.7 g) and higher FCR (2.06 Vs 1.82) for the maize fed broilers. The result of this study suggests that high tannin sorghum can be substituted for white maize in broiler starter diets with no significant adverse effects on growth and feed efficiency. The dietary treatments with increased CP or methionine levels, could not be successful to overcome the detrimental effects of sorghum tannins.

In another trial Jacob *et al.* (1996b) determined the feeding value of Kenyan Sorghum, in an 8 weeks broiler trial. The diet used either contained white maize (Hb25) or brown sorghum (serena) based contained imported soyabean meal (SBM), a combination of SFC and SBM or SSC as the main protein source. In the broiler trial, mean weekly body weights were significantly higher for chicks fed on the maize based diets, but at the end of the 8 weeks, however, the difference between the mean body weights for the 2 groups of broilers was not significantly different (2136 Vs 2023 g) for broiler on the maize and sorghum diets, respectively. Feed conversion ratio (FCR) was not significantly affected by grain type (2.72 Vs 2.76) for broilers on maize and sorghum diets, respectively.

In the last 4 weeks of the broiler trial, mean weekly body weights were significantly higher for chicks fed on SSC diets than for those receiving SBM diets. By the end of 8 week trial the mean body weight of the broilers receiving the SSC diets was 12.1% higher (2212 Vs 1972 g) for broilers than receiving the SSC and SBM diets, and receiving SBM diets. FCR was significantly lower for chicks receiving SSC diets (2.52) as compared to those receiving the SBM or SFC/SBM diet (2.86 and 2.88), respectively.

Ozement *et al.* (1962), in a trial of two nutrient intake levels, studied that there were no statistically significant differences in feed consumption per broiler, in average weight, or in average body weight gain among the broilers fed the five experimental diets. Feed per unit gain were also not statistically different among the broilers fed five experimental diets within high nutrient intake basis. A comparison between the two nutrient intake levels shows that significant differences ($P < 0.01$) exist for feed consumption per broiler, average body weight gain and units of feed per unit gain. The interpretation of data revealed that broilers fed the low nutrient - intake diets consumed more feed than did the broilers fed the high nutrient - intake diets.

Rostango *et al.* (1973), fed corn and three varieties of sorghum RS 610, BR64 and NK300 on an equal weight basis in an experiment and found poor weight gains and feed conversion and were statistically ($P > 0.05$) significant to that of corn.

Sadagopan *et al.* (1994), evaluated sorghum varieties as sole source of energy and in combination with maize. The results of which indicated that performance in terms of body weight gain in broilers fed 50% sorghum + 50% maize combination was comparable to reference group. Body weight gain at this level was marginally superior to reference diet, while total replacement resulted in significantly poor growth, cumulative feed intake and feed/gain ratio varies marginally but insignificantly.

Shafique (1973) compared the feeding value of corn, sorghum, wheat and barley in broilers. The body weight gain, after 6 weeks ~~were~~ did not differed significantly; Similarly feed intake were also not different from each other. The feed conversion reflected a non-significant lower value.

ii) Pearl millet as Energy Source

Pearl millet, also known as *bajra,* ranks sixth in the world's cereal production (Hulse *et al.*, 1980) and fourth in India with a production of 6.91 MT. In 1990 - 91 under an area of 10.45 million hectare with a yield of 661 kg/ha. Pearl millet is one of the most drough tolerant of all cereals. It can survive in lower total rainfall than sorghum. It grows well on light soil under semi arid condition. Pearl millet can be divided into two broad classes : (a) early millet, matures within 60 - 95 days and (b) Late season millet which matures within 130 - 150 days. The pearl millet seed is white, pale yellow, brown, grey, slate blue or purple. Kernels are about one - third the size of the sorghum kernels. The pericrap of pearl millet appeared similar to sorghum except that no starch granules were found in the millet mesocrap.

The pearl millet contains more protein ranging from 10.5 to 14.0 which is high for non - leguminous seed, a note worthy feature. Bolton *et al,* (1963) reported that pearl millet was equal or superior to the grain of maize in protein and high in its mineral content.

Several workers studied the effect of replacing maize grain by pearl millet on the performance of broilers. Sharma *et al.*, (1979) observed better efficiency of energy deposition in broilers on inclusion of pearl millet in diet at the expense of maize. Incorporation of pearl millet at the expense of maize part per part, resulted in lowering metabolizable energy content in pearl millet than maize diet; yet the growth of chicks was better on pearl millet than on maize diet. They reported that the better growth might be due to higher energy utilization with pearl millet than with maize.

Reddy *et al.* (1989) conducted three experiments, including *bajra* as only source of grain at the expense of maize. In experiment 1 and 2 pearl millet replaced maize part per part while in experiment 3, *bajra* replace isocalorically and isonitrogenously. In all the three experiments the weight gains (Maize Vs *bajra*, were 846 Vs 1031, 1128 Vs 1330, 900 Vs 1267 g in experiment 1, 2 and 3, respectively) and feed intake (Maize Vs *bajra* : 2061 Vs 2411, 2299 Vs 2674, 2083 Vs 2862 g in experiment 1, 2 and 3, respectively) were significantly ($P < 0.05$) higher on *bajra* diets than on maize diets. Feed/gain values were (2.38 Vs 2.36, 2.00 Vs 2.01, 2.16 Vs 2.12 respectively in experiment 1, 2 and 3 ~~respectively~~) were similar on both the diets. Inclusion of pearl millet at the expense of maize isocalorically and isonitrogenously resulted in better growth of chicks in experiment 3. Incorporation of *bajra* at the expenses of maize part per part (in experiment 1 and 2) resulted in lowering of ME in *bajra* than in maize diets. Yet the growth of chicks was better on pearl millet than on maize in diet. They opined that this might be due to higher efficiency of energy utilization with *bajra* than maize. It was thus inferred that *bajra* can be included in broiler diets even upto 600 g/kg (60% level).

Reddy *et al.* (1991) conducted two experiments to incorporate *bajra* (*Pennisetum typhoides*) replacing maize in ground Vs unground form and in iso-caloric and iso-nitrogenous diets in broilers. In the first experiment, *bajra* replaced maize at 0, 50 and 100% levels either in ground or unground form. In the second experiment, *bajra* replaced maize at 0, 25, 50, 75 and 100% levels in iso-caloric and iso-nitrogenous diet. In the first experiment the body weight, feed intake, feed efficiency were not significantly influenced by the incorporation of *bajra* either in ground or unground form in place of maize. In the second experiment, maximum weight gain (1344 g) and minimum feed intake (3145.49 g) was observed on the groups of broilers receiving 100% *bajra* grain, however, the feed conversion was not significantly influenced by source of the grain fed.

In a feeding trial Thakur and Prasad (1992) replaced maize part per part with rice wheat and pearl millet and also replaced 100% of these grains in the diet of broilers. No significant difference was obtained in replaced diet with that of control diet. Body weight gain at 50% and 75% replacement of pearl millet with maize found intermediate place between broiler receiving rice and wheat. When FCR was considered pearl millet (2.80 ± 0.01) followed the maize (2.56 ± 0.02). Considering 0 - 8 week period collectively, body weight gain was highest with 100% pearl millet ($P < 0.05$), however, best FCR was obtained in maize ration which was similar to 50% pearl millet ration.

Prasad *et al.* (1997) conducted a feeding experiment where pearl millet was included in broiler diets replacing ground maize in grain or ground forms. Analysis of eight weeks data revealed significantly higher ($P < 0.05$) weight gain by broiler fed pearl millet flour diet as compared to pearl millet grain. However, both

Table 2 : Chemical composition of Pearl millet (*bajra*)

Sl. No.	ME (Kcal/kg)	DM	CP(%)	EE(%)	CF(%)	NFE(%)	Total ash(%)	Available Carbohydrate	Ca%	P%	Reference
1.	2640	–	11.70	4.20	1.80	-	-	-	0.15	0.20	Singh, 1982
2.	2642	89.20	12.70	4.90	2.20	78.20	2.00	-	0.13	0.72	Reddy and Reddy, 1981
3.	2693	–	11.90	4.50	-	-	2.70	59.20	0.13	0.56	Shrivastav *et al*, 1990
4.	2655	90.10	10.50	5.40	-	-	6.90	59.80	0.13	0.75	Sinha *et al*, 1980
5.	2642	89.60	12.70	4.90	2.20	78.20	2.00	-	0.13	0.32	Panda *et al*, 1990
6.	-	–	11.70	5.50	1.10	78.90	2.80	-	-	-	Ranjan, 1998
7.	2642	–	12.70	4.90	2.20	-	-	-	0.13	0.72	Saxena and Ketelaars, 1993
8.	-	–	12.96	4.98	2.32	77.11	2.63	-	-	-	Purushothaman and Thirumalai, 1995
9.	3445	–	10.60	6.90	1.80	74.70	6.00	-	-	-	Prasad *et al*, 1997
10.	2723	88.00	11.40	4.30	-	-	2.75	60.80	0.31	0.39	Sharma *et al*, 1979
11.	3300	–	14.00	3.50	2.00	78.50	2.01	-	0.05	0.30	Devendra, 1988; Gohl, 1981 and Harris *et al*, 1982

forms in all age group (1st, 2nd, 3rd and 4th week) produced higher ($P < 0.05$) weight gain as compared to ground maize diet. On the other hand, late feeding of grains (4th week) produced as good weight gain as flour fed group. Feed conversion ratio was favourable ($P < 0.05$) with grain feeding to early ages of broiler chicks than the late grain fed and ground maize/pearl millet fed groups. It may be inferred from above results that pear millet in both forms (grain/flour) was considered as a better energy source for broilers than maize.

Qureshi (1967), conducted feeding trials with broiler chicks for 18 weeks, on starting and growing ration containing maize and pearl millet separately or in combination. No statistically significant differences in body weight gain and feed/gain quotient were found among rations. He concluded that rations containing maize alone or maize and pearl millet are better than pearl millet alone for chicks. Simhaee *et. al.* (1971), observed a poor feed conversion ratio of the chicks on diet with pearl millet only than diets with maize alone or in combination with pearl millet.

iii) Finger millet as Energy Source

Finger millet (*Elensine coracana*) is also termed as *ragi, marua* is an important staple food in India. It is widely grown in hilly lateritic soils in 500 - 1000 mm rainfall belt of tropics and sub tropics (Rachie, 1975). In certain part of India, two crops per year are grown. The height of plant may range from 40 cm - 100 cm. The type of inflorescence is straight and open spikes, incurred or close spikes and branched spikes resembling a cock's comb, length of the spikes ranges from 3 - 13 cm: colour of grain may vary from white, through orange red, deep brown, purple to almost black. The time of maturity varies from 3.5 to 6 months. It was grown in 21.5 lakh hectare and produced 2.676 MT having a yield of 1242 kg/h. The grain is fibrous and contains tannin from 7.52 g/kg - 7.6 g/kg that makes its limited use in poultry diet.

Several workers have tried it in poultry ration. Ayyaluswami and Jaganathan (1967) replaced *ragi* at 20 and 45% in chick's mash. There was not any significant different in body weight gain. The male bird receiving maize and those receiving ragi at 40% in first trial did not differed significantly but in second trial they differed significantly ($P < 0.05$), however, female receiving maize and 45% *ragi* differed significantly ($P < 0.05$) in first trial whereas they do not differed in second trial. Live weight gain of maize Vs 40% ragi was 485 : 488 and feed intake was 1234 Vs 1352. In second trial the results differed. The live weight gain in maize Vs 40% *ragi* was 556 : 514 and feed intake was 1502 g : 1547.g

Rao et al., (1996) conducted feeding trial each for 56 days duration to study the performance of broilers fed with *ragi*. The ground *ragi* was incorporated at 0, 25, 50, 75 and 100 percent levels in place of maize. Non - significant differences were observed for body weight gains among different treatments, except for 75 percent percent unground *ragi* and 100 percent unground and ground *ragi* fed groups, which showed significantly poor growth ($P < 0.01$) in broilers fed with 100% ground/unground *ragi* as compared to other treatments.

Reddy *et al.* (1996) studied the nutritive value of finger millet (*Elensine coracana*) and the effects of its inclusion as unground and ground form in the diet on growth ~~was investigated~~. *Ragi* in unground or ground form at 600 g/kg replaced corn or corn + deoiled rice bran (DORB) part per part. Each of the diets

Table 3 : Chemical composition of Finger millet (*ragi*)

Sl. No.	ME (Kcal/kg)	DM	CP(%)	EE(%)	CF(%)	NFE(%)	Total ash(%)	Available Carbohydrate	Ca%	P%	Reference
1.	-	-	9.38	3.96	2.94	81.79	1.93	-	-	-	Purushothaman and Thirumalai, 1995
2.	-	10.00	10.30	1.20	3.70	81.00	3.90	-	-	-	Ranjan, 1998
3.	3280	88.50	10.46	1.15	4.36	-	-	-	-	-	Baghel and Netke, 1987
4.	3000	-	9.50	2.00	4.00	81.50	3.00	-	0.40	0.30	Devendra 1988; Gohl (1981) and Harris *et al.*, 1982
5.	3025	88.96	9.30	2.16	4.40	81.12	3.02	59.65	0.28	0.27	Reddy *et al.*, 1995; Sri Latha rani 1995 and Rao 1995
6.	-	87.50	9.46	1.15	4.32	69.97	2.60	-	-	-	Netke and Baghel , 1982
7.	-	87.30	6.25	3.96	2.70	83.26	4.10	-	0.42	0.25	Applied Nutrition Unit, 1960
8.	-	88.10	7.50	2.20	3.10	84.70	3.20	-	0.30	0.24	Carr, 1961
9.	3360	88.00	6.00	1.50	3.00	75.00	-	-	0.35	-	Platt , 1962

was fed to 4 groups × 8 WL male chicks from 1 to 28 days, 6 groups × 6 Hubbard broiler female from 1 to 35 days. From the data of chemical composition, *Eleusine coracana* contained slightly lower protein and ether extract but higher crude fibre, calcium and phosphorus than corn. In WL male chicks, weigh gain feed intake and feed/gain, energy intake and liability were similar on all the diets. In broilers, replacement of corn with *Eleusine coracana*, either in unground or ground from at 600 g/kg resulted in lower weight gain and poorer feed efficiency. The cost of feeding for broiler production with *Eleusine coracana* ground diet only was lower than other diets.

Netke and Baghel (1982), in a limited studies conducted with *ragi*, advocated its use as substitute for maize in growing cockerels. The Ragi - GNC diet was the main objective and it was compared with reference diet containing Maize - GNC - fishmeal diet. A third group of cockerels was fed Ragi - soyabean extraction diet. These diets were fed for a 6 - week period from 10th to 14th weeks. The gain in weight of the birds fed Maize - GNC fish meal diet was 10.6 g/day. The birds receiving Ragi - GNC diet did not grow well but when GNC was replaced by soyabean extraction (Ragi - SOBM diet) the growth rate of the birds shot up. The feed consumption of the birds did not differ much. The studies thus indicated that even though the requirement of lysine and methionine in grower diet is less than that for starter diet, Ragi - GNC diet without fish meal would not support proper growth. The fact that growth was improved with Ragi - Soyabean extraction diet indicated the Ragi - GNC diet was deficient in lysine. The methionine deficiency did not appear to be a problem as the growth rate with Ragi - SBM diet was similar to that obtained in reference diet.

It was thus concluded that *Ragi* could be used in grower diet if combined with Soyabean extraction. Yeong and Ali (1976) found no significant differences in feed intake or feed efficiency when maize was replaced by *ragi* at levels 15, 30, 45 or 60 and feed intake was higher for *ragi* based diet.

iv) Foxtail millet as Energy Source

Foxtail millet (*Setaria italica*) also known as *Kauni* or *Kangni* is short plants, the seeds of which are smaller and are enclosed in thin outer hulls. Foxtail millet can be grown at low rainfall areas and can tolerate a wide range of soils from light sands to heavy clay and gives reasonable yields on comparatively infertile soils. The time of maturity varies between 80 - 120 days depending upon the variety; giving a good yield as other crops of much longer duration. The ear head is medium in size, slightly thick and compact seed densely packed with uniform spread of bristles arranged symmetrically.

The chemical composition of foxtail millet reported by different workers is given in Table 4. The relatively high fibre content, along with the coarseness of the seeds and the presence of hulls of high level of tannins limits from the usefulness of foxtail millet as energy feed ingredient.

Feeding value of Foxtail millet (Kangni)

Baghel and Netke (1979) used the *kangni* in place of corn in Corn - GNC rations. There was not any significant ($P < 0.05$) effect on the growth rate and feed consumption. The feed conversion efficiency was not affected upto 30% level of *kangni* in the diets. At levels above 30% feed conversion efficiency

Table 4 : Chemical composition of Foxtail millet (*kangni*)

Sl. No.	ME (Kcal/kg)	DM	CP(%)	EE(%)	CF(%)	NFE(%)	Total ash(%)	Available Carbohydrate	Ca%	P%	Reference
1.	3244	89.06	10.94	2.30	10.60	60.81	3.80	-	-	-	Netke and Baghel , 1982
2.	-	88.45	10.94	2.30	10.6	60.81	3.80	-	-	-	Baghel and Netke, 1982
3.	3400	88.36	10.81	2.28	10.53	60.98	3.76	-	-	-	Baghel *et al.*, 1985
4.	2863	90.60	10.60	4.80	9.10	71.90	3.60	74.00	-	-	Bhaskara *et al.* 1997
5.	2645	-	10.90	8.60	8.80	-	-	-	0.21	0.03	Singh, 1982
6.	3319	88.45	10.94	2.30	10.60	-	-	-	-	-	Baghel and Netke, 1987
7.	-	-	15.80	6.80	6.30	65.40	5.70	-	0.61	0.11	Ramanathan *et al.*, 1975
8.	3550	89.00	10.00	2.50	2.00	73.00	-	-	0.20	-	Platt, 1962

significantly improved. When the autoclaved soyabean meal or soyabean extractions were used as the sole protein supplement in place of GNC the performance of birds improved with the increase in level of *kangni*. The PER value of *kangni* diets did not differ from that of corn - *kangni* mixed diets. Further studies on *kangni* - GNC diets indicated that the diet was much superior to corn - GNC plus 11% or 16% fishmeal diets in its growth promoting action. The *kangni* GNC diet in its turn was further improved by supplementation with upto 11% fishmeal. It thus, appeared that *kangni* can replace entire maize in starter chicks ration with advantage.

In another feeding trial Baghel and Netke (1982) replaced corn with *kangni* in starter chicks diet. When *kangni* replaced corn in corn - GNC diets containing either soyabean meal or soyabean extraction as the protein supplement significant improvement in weight gains of chicks was noted. Though *Kangni* contained higher levels of lysine and methionine than corn, however, *kangni* GNC diets was still deficient in lysine, methonine and some other amino acids. Similarly Mosse et. al. (1989), studied the amino acid composition of 13 samples of *S. italica* from 6 Chinese and 1 French cultivar was determined as a function of their N content which ranged from 1.82 to 3.65 g/100 g grain DM. The levels of amino acids in grain DM increased linearly with N content, with correlation coeff. close to 1 for most of them regardless of genotype or phenotype. Amino acid contents in grain CP changed as quadratic functions of N content. Glycine, cysteine, lysine, histidine and arginine contents in the CP were 92, 48, 150, 42 and 72% , resp., lower in low-protein gain (1 g/100 g DM) than in high-protein grain (4g/100 g DM). Valine, threonine, tyrosine, methionine and aspartate + asparagine contents in the CP were not affected by grain N content. Alanine, proline and glutamate +

GNC - Fish meal diet. These findings would suggest that *kangni* could be used as a substitute for maize either in GNC - fishmeal based or soyabean extraction based diet. Similarly Kraft *et. al.*, (1971) totally replaced maize with foxtail millet, did not found any significant difference in body weight gain .

Reddy and Narahari (1997 b), incorporated foxtail millet in white leghorn layers diet at graded levels of 0,10,20,30 and 40 percent in first experiment and at 0, 33 and 65 percent levels in second experiment by replacing the maize at 50 and 100 percent on isonitrogenous and isocaloric basis. The egg weight, body weight, body weight gain, fertility, hatchability, albumin index, yolk index were comparable between dietary treatments. The foxtail millet in layer diets at 40 percent and above levels increased feed intake significantly ($P<0.01$) and decreased feed efficiency.

Nooruddin *et.al.*, (1997) conducted an experiment on broiler chicks to evaluate the feeding value of foxtail millet as energy source in the ration of broiler, in which foxtail millet was replaced at 50%, 75% and 100% of maize (w/w) for both starter and finisher ration .There was a non-significant influence on body weight gain, FCR and PI by replacement upto 50%. It was, thus, concluded that foxtail millet can safely replace 50% of maize in broiler diets without any adverse effect on body weight gain and feed efficiency.

v) Comparative utilization of sorghum, pearl millet, finger millet and kangni vis-a-vis maize.

Singh and Barsaul (1976) conducted experiments to replace maize by coarser grains like barley, sorghum and pearl millet in poultry mashes. For this glutamine showed increases of 94, 76 and 62% respectively., in high-protein grain. Lysine was the only limiting essential amino acid. The N-to-protein conversion factor increased markedly with grain N content and was higher than in rye, sorghum or maize. The prolamin:glutelin ratio was about 3 and was independent of grain N content.

Reddy and Narahari (1997a), experimented with foxtail millet (*Setaria italica*) by incorporating it at 0, 10, 20, 30 and 40% levels in experiment 1. In experiment 2 maize replaced with ground, germinated and pelleted foxtail millet each at 0, 50 and 100% level on isonitrogenous and isocaloric basis in broiler diets. The weight gain was in favour of 40% foxtail millet, but the feed intake and feed efficiency did not reveal any trend irrespective of the dietary levels of foxtail millet. Consequently insignificant variations were observed at 8 weeks of age. Pelleting of foxtail millet improved the performance of broilers compared to raw, germinated and maize-based diets. However, the weight gain was depressed with the total replacement of maize by germinated foxtail millet. The income over feed cost per bird was more or less directly proportional to the dietary level of raw and pelleted foxtail millet, but it was lower in germinated foxtail millet group.

Netke and Baghel (1982) conducted feeding trial in broiler by replacing maize with *kangni*. The studies indicated that complete replacement of maize by *kangni* in conventional Maize - GNC starter diet did not adversely affect the performance of the birds except for feed efficiency. The inferior feed efficiency of the *kangni* diet is because of the lower ME value. As expected, when soyabean extraction was used in place of GNC and fishmeal, performance of the birds fed *kagni* - soyabean extracted diet was found superior to those of birds fed Maize -

white Leghorn and Rhode Island Red breed were taken. Two metabolic trials being conducted. No difference in the digestibility coefficients and balance of nutrients in two breeds was found at third and ninth weeks respectively. The balances of nitrogen, calcium and phosphorus in all the groups were positive. The feed conversion ratio was better in pearl millet group than in other groups. Thus, it was concluded that maize could be completely replaced by barley, sorghum or pearl millet in mashes for growth production.

Nagra *et al.* (1987) studied comparative feeding value and economics of feeding maize, triticale, *jowar*, barley, rice kani and pearl millet. The test cereals in the diets replaced half the quantity of maize (W/W). Growth rate of starter pullets (2 - 8 weeks) was not affected by treatment but efficiency of feed utilization was significantly (P < 0.05) low in barley containing diet. During grower period (9 - 20 weeks) the growth rate of pullets fed test cereals was comparable to the control except maize : barley group. The efficiency of feed utilization was significantly (P < 0.05) lower on maize : barley and maize : jowar diets.

Sinha *et al*, (1980), determined the comparative efficiency of utilization of maize, pearl millet, sorghum, wheat and rice polish in broiler chicks. Weight gains in birds were comparable in diets containing maize, pearl millet and rice polish, sorghum and wheat. The efficiency of conversion of dietary protein and ME into carcass energy and nitrogen was the highest with pearl millet in diet, ~~closely followed with pearl millet in diet~~ closely followed by the maize in the diet. The ME value of maize, pearl millet, sorghum, wheat and rice polish was determined to be 3440, 2665, 2593, 3045 and 2778 Kcal/kg, respectively.

Abate and Gomez (1984), conducted two experiments to substitute finger millet (*Elensine coracana*) and bulrush millet (*Pennisetum typhoides*) ~~experiment was conducted~~ to determine acceptability levels and growth performance when bulrush millet or finger millet was substituted for maize at 0, 20, 40 or 60% in both broiler starter and finisher feeds. The chicks fed on the bulrush millet gave significantly ($P \leq 0.01$) higher weight gain (1649 g/chick at 55 days) than those containing finger millet (1580 g/chick) over the 8-week experimental period. However, the differences in body weight gain between the treatments and control (1594 g/chick) were not significant. Birds fed on finger millet diets utilized the feed properly; the FCE value over 0 - 5 weeks being 2.18, the value significantly different ($P \leq 0.01$) from those observed for bulrush millet (1.97) or the control (1.97). However, the feed utilization on finger millet diets improved during the last three weeks (finisher stage) of the trial, to give an overall value comparable to values noted for the bulrush millet treatments and the control. In view of the higher protein content in the bulrush millet tested, subsequent experiments were conducted to determine the value of using bulrush millet not only as an energy source but also as a part substitute for protein supplemented in broiler diets. The bulrush millet included at 70% was shown to effectively replace part of the vegetable protein supplement provided the diet was supplemented with upto 0.3% lysine.

Asha Rajini (1986), experimented using jowar (*Sorghum vulgare*), *ragi* or finger millet (*Elensine coracana*) and pearl millet (*Pennisetum typhoides*) replacing maize in control diet at the level 37.5% of diet. There was a significant ($P < 0.01$) improvement in weight gain of broilers when maize in the control diet was completely replaced by *ragi* at eight weeks of age. There was no significant difference in feed intake or feed efficiency. Similarly, no significant different in the feed intake, weight or feed efficiency was observed when maize was replaced by *jowar*. It appeared from this study that ragi or pearl millet could form entire grain part of broiler diet.

Purushothaman and Thirumalai (1995a), experimented with egger strain chick, for inclusion of sorghum or pearl millet or finger millet or a mixture of these millets and to compare the efficiency between the millets and maize. The final weight gain of birds fed millet except pearl millet based diet was significantly lower than control. The effect of mixture of the millet diet was comparable with pearl millet based diet, but significantly lower than control. However, feeding or finger millet or pearl millet or sorghum or mixture of millet was recorded to provide comparable growth as that of maize.

The progressive feed consumption was comparable in all the diets except the finger millet group where feed intake was significantly low. The efficiency of feed conversion was poorer in sorghum, pearl millet and mixed millet diets, whereas finger millet based diet was comparable with the control.

Sadagopan *et.al* (1996), reviewed the efficiency of pearl millet (PM), finger millet (FM) and sorghum (SG) as individual sources of energy in place of yellow corn (YC) was evaluated in two broiler feeding trials. In trial 1, YC was totally replaced with PM ungrounded FM and SG without balancing for calorific value of diets. A commercial multienzyme mix was added to the second set of the three test diets. Seven experimental diets were formulated and each was fed to 24 pure bred broilers from 1 to 7 weeks. In trial 2, isocaloric diets having two ME level, 2530 and 2750 Kcal/kg were formulated using separately YC, PM ground

FM, ungrounded FM and SG. Each of the ten experimental diets was fed to 30 commercial broilers from 1 to 7 weeks. Performance of broilers fed PM and SG in terms of body weight (1164-1217g), feed efficiency (2.09-2.36) and dry matter digestibility (54.6-67.0%) was statistically similar to YC, irrespective of differences in energy levels (trial 1). When the diet were balanced for energy, PM and SG produced significantly better body weight (1847 g), feed efficiency (1.89) and dry matter digestibility (68-70.4%) over YC and FM. Ungrounded FM adversely affected the performance and grinding significantly improved its feeding value. Performance of broilers was significantly better at 2750 Kcal for all the cereals over over 2530 Kcal. However, low energy diets containing PM and SG was as efficient as high-energy YC diets. Enzyme supplementation showed a marginal improvement in PM and SG diets. Processing yield were similar in all groups but weights of gizzard lining and abdominal fat were significantly more in PM and SG groups. Weights of gizzard and giblets and length of small intestine were significantly more in FM and low energy diets. The results clearly reflect the utility of PM and SG as effective alternatives to YC, particularly in low energy diets.

French (1947), included as much as 60% bulrush millet or white seeds finger millet in layer's diets without any reduction in egg production. He concluded that there was little or no difference in feeding value for poultry between bulrush millet, white seed finer millet and maize. Further studies (Johnson and Raymond, 1964; Rachie and Peters, 1977) have shown that the amino acid make-up of finger millet and bulrush millet protein makes them reliable sources of all essential amino acids except lysine.

Purushothaman and Thirumalai(1995b)experimented with egger strain pullet by replacing maize with sorghum ,bajra and finger millet and their combination in 1:1:1 ratio. During the growing phase, the weight gain, feed consumption and feed efficiency were comparable in all the diets, except for *bajra* based diet where reduced weight gain and feed efficiency were observed.

vi) Anti-nutritional factors present in milo and millets

Inclusion of milo and millets in poultry rations are being limited due to presence of some anti-nutritive factors. The level of anti-nutritive factors may vary according to the type and cultivar of these small grains. The high content of tannin ranging from 0.24 - 0.46% (Wessles, 1970; Vohra *et al.*, 1966; Chang and Fuller, 1964) of sorghum makes incompatible for poultry in utilization of the nutrients. The pearl millet is reported for content of some anti-nutritional factors, possibly tannin (Alagianagalinngam 1978). Similarly, high tannin content and coarseness (Ramchandra *et al.*, 1977; Singh *et al., 1987*) makes ragi unsatisfactory for use in poultry ration. Likewise, the high content of fibre in foxtail millet (9.1 - 10.1%) and tannin content, 1.3 g/kg (Bhaskara *et al.*, 1997) has made the grain inefficient in nutrient utilisation in broiler diets.

It has been established that tannin binds protein (Oh *et al.,* 1980) and inhibits digestive enzymes (Tamir and Alumot, 1969) makes its limited feeding value. Besides, this tannin has an astringent effect and saliva mixed with tannin makes reduced feed intake and malabsorption of nutrient in the intestine. Gous *et al.* (1983) established a negative correlation between ME and tannic acid content because of decreased digestibility with increasing tannic acid content.

The feed stuffs of plant origin have a complex chemical structure. The cell wall of such feed stuffs are not uniformly nutritious because of their principal component consist of cellulose, hemicellulose, silica, pectin etc. These contents in general are called Non starch polysaccharides (NSP). The NSP and lignin constitute the deitary fibre (Trowell *et al.*, 1976). The fibre is considered to be indigestible in acidic and alkaline medium. The higher the level of the fibre the more bulky the ration becomes and therefore the supply to the bird of the digestible portion of the diet is restricted. Conversely, lower the fibre content, the more efficient will be the conversion of feed into meat. ISI recommends a maximum of 6% crude fibre in broiler ration, therefore, rations cotaining 10 - 20% crude fibre may on occasion be suggested as fibre serves as a nutrient diluent due to its poor digestibility and reduces available energy content of the diet (Prabhakaran, 1982).

Besides the above-mentioned NSP fraction there are other NSP polymer chiefly found in cereals and legumes. The polymer β - D - glucans and pentosans form the major soluble NSP components in the cereal endosperm cell wall. The water-soluble portion of NSP, is notorious for forming a gel like viscosity in the intestinal tract. Increased viscosity in intestine results in decreased feed intake, lowered food passage in intestine, lowered fat digestibility (Salih *et al.*, 1991) reduced rate of diffusion in intestine impaired diffusion and connective transport of lipase, oils and bile salts micelle within gastrointestinal contents potential nutrients (*eg.* fat) and digestive secretion (i.e. Lipase, bile salts) and transport to epithelial surface, increased enzyme activity in gastrointestinal tract and increased fermentation in small intestine (Choct *et al.*, 1996). Increased viscosity causes proliferation rate of enterocytes of the jejunum, distal ileum and decreased activity of specific epithelial surface enzymes.

B. Importance of exogenous digestive enzymes in improving the productive value of feed ingredients and compound feed.

The starch is located within the endosperm of cereal grain in protein matrix. The cells are differentiated by a complex wall composed of carbohydrate fractions with lesser amount of protein and phenolic acids. Adams (1992) opined that extra hydrolytic activity supplied by a multi-enzymes complex such as cellulolytic and hemicellulolytic enzymes might well improve the ability of the host digestive tract to better digest the feed ingredient. The break down of endosperm cell walls surrounding the starch granules and protein bodies makes available nutrients previously protected by intact cell walls. The liberation of enclosed nutrients may be a major mode of action of enzymes used in feeds.

Fibres and various non - starch polysacharides (NSPs) are the most important anti - nutritional factors in the Indian poultry diets. The predominant NSPs in cereal grain are cellulose. The hemicelluloses, encountered in the cereals are predominantly Pentosans and β - glucans. These two components, cellulose and hemicellulose are rather inert, relatively insoluble and resistant to digestion forms insulating coat on digestible nutrients thus reducing the nutrient supply. Soluble fibres slow down the transit rate, but their getting ion exchange and absorbing characteristics retard digestion and absorption (Krogdahl, 1986).

The poultry being a monogastric animal, its gastro - intestinal tract, is incapable of digesting plant cell wall components due to lack of degrading enzymes of these components. Besides, this another physiological limitation of presence of low density of micro - organisms in caeca makes the dietary fibres to approach intact in the hindgut. Three different enzymes of the multicomponent cellulose system is cellobiohydrolase, endo - glucanase and β - glucosidase are involved in the degradation of crystalline cellulose in glucose.

Insufficient production of enzymes such as cellulose, hemicellulose and β - glucanase is the main reason for escape of some potentially digestible starch and proteins from the small intestine of poultry without undergoing degradation. (Grahan *et al.,* 1988; Pettersson and Aman, 1989; Low and Longland, 1990). Therefore, dietary enzyme supplementation will be of practical importance in improving the feed value of low energy and high fibre feed for poultry. Enzymatic treatments such as cellulytic enzymes combined with commercial proteolytic enzymes have been found effective in chemical alteration of high fibre feed stuffs resulting in improvement of protein digestibility and metabolizable energy. Enzyme supplementation, therefore, has been beneficial in four ways.

a) by removing deleterious incriminating factors.
b) by increasing the crude fibre digestion
c) by rendering the nutrient more available for digestion
d) by supplementing host endogenous enzyme production during adverse climatic condition

C. Effects of enzyme supplementation on the performance and nutrient utilization in broilers

Taking into the above consideration, several works have tried the enzymatic supplementation with positive effect on performance in broiler diets.

Sinha *et al*, (1981) reported that in poultry digestive enzymes are present in less than optimum quantity and their extra provision from exogenous sources would improve the overall feed utilization, while Rakshit and Rao (1994), stated that predigestion of fibrous feed using microbial enzymes could allow their utilization in poultry feeding. Feeding of novel items together with exogenous feed grade enzymes has been reported to be capable of supporting the broiler performance (Devegowda and Nagalakshmi, 1992; DE Koning and Perdok, 1996; Hadorn and Widemer, 1996).

Arunbabu and Devegowda (1997) supplemented a multienzyme mix (Nutrienzyme®) to diets having varying CF level. A general trend of decrease in feed conversion efficiency was noted with increase in dietary fibre level. However, feed conversion efficiency improved significantly with enzyme supplementation in 5 percent crude fibre level upto 4 weeks of age; Bedford (1990) attributed the improvement of broiler performance with enzyme supplementtion to the lowered viscocity of intestinal contents, reduced rate of passage and an eventual enhanced utilization of nutrients. Also Devegowda and Nagalakshmi (1992) and Suresh (1995) observed significant improvement in feed efficiency with enzyme supplementation.

Bhatt *et al*, (1991) reported that Novozyme SP - 243, a fibre degrading enzyme, containing cellulose and hemicellulose activity has a significant effect (P

< 0.05) on body weight and feed efficiency when it was added at 20 g/100 kg in broiler diet. Moreover, the digestibility coefficient of different nutrients increased with the supplementation of enzyme which, however, failed to correspond with the biological performance of broiler chick.

Suresha and Devegowda (1996), reported that supplementation of cellulolytic enzyme improved the performance of broiler. The enzyme used contained cellulase, β - glucosidase, hemicellulase supplemented at 0.75 and 1.5 kg per ton of feed containing 5.5, 6.5 and 7.5% crude fibre. It was found that enzyme at 1.5 kg per ton of feed resulted in significant ($P < 0.05$) improvement in body weight in the diet fed containing 5.5 and 6.5% crude fibre and feed efficiency was improved in the group fed diet containing 5.5 and 7.5% crude fibre. It was thus concluded that improvement in performance might be attributed to better utilization of energy from fibrous material.

Kaoma *et. al.* (1995), experimented with broiler chickens which were fed on a starter, followed by a finisher, diet based on wheat, barley, soyabean-meal, fish meal, meat - and - bone meal and mineral - and - vitamin premix, or that diet supplemented with an enzyme preparation containing β - xylanase and arabinoxylanase. The enzyme preparation given to the 5th group in both experiments was a development product also containing β - glucanase and arabinoxylase activities. The basal diet was given as mash in experiment 1 and pelleted in experiment 2. In experiment 1 liveweight gain from 1 to 42 days old was 1310.1, 1383.4, 13834.4, 1368.2, 1462.2 and 1436.5 g respectively. Corresponding gain for experiment 2 was 1479.8, 1643.5, 1704.4, 16128.8 and 1614.3 g. Feed : gain ratio was 2.31, 2.22, 2.13, 2.09 and 2.09 and 2.04 in experiment 1 and 2.25, 1.97m 2.03, 2.10 and 2.01, in experiment 2. The enzyme preparations were more effective with the starter diet than with the finisher diet.

Pisarski and Wojcik, (1995) in a trial with 810 Pentra chickens fed on a diet based on wheat or barley and supplemented with glucanase 1 or 2 g/kg for 1 to 21, 22 to 49 or from 1 to 49 days old. The amount of glucanase given did not affect body weight gain, feed conversion efficiency, dressing percentage, carcass meat content and abdominal fat content. However, duration of application of glucanase influenced body weight, feed conversion efficiency and carcass values.

In the another experiment, the same author used enzyme pentosanase, added to the diet based on triticale, barley or rye, or both and given to 780 caged Petra chickens, significantly increased body weight gain during the second phase of finishing. There was a cereal × enzyme interaction with respect to body weight gain. Pentosanase increased dressing percentage, but had no effect on carcass meat content or percentage of abdominal fat.

Kumararaj *et al.* (1993), studied the influence of pelleting and enzyme supplementation of pearl millet for broiler. In a 3 × 2 × 2 factorial experiment three levels (0, 50, 100%) of pearl millet replaced maize with and without pelleting and enzyme supplementation. The broiler starter feed with maize replaced by pearl millet at 100% level supplemented with enzyme produced the heaviest broiler at the end of 2nd and 4th week of age. At 6th and 8th week, enzyme supplementation group did not show any signficant difference in body weight, feed consumption did not reveal significant difference. Increased, feed consumption was noticed in 100% pearl millet group. The best FCR was in broilers fed with 100% pearl millet replaced from 0 - 4 weeks but from 5 - 8 weeks 100% maize fed group had better feed efficiecny.

Aravind *et al.* (1993) conducted a study to replace maize by sorghum variety CSH - 5 with or without enzyme amylase in isocaloric and isonitrogenous broiler starter diets (0 - 4 weeks). Maize was substituted with sorghum at 0, 50 and 100% with or without addition of amylase. Inclusion of sorghum at the expense of maize part per part did not affect the feed intake. Significantly better weight gain and feed efficiency was observed by complete replacement of maize with sorghum. No improvement in either weight or feed efficiency was observed upon the enzyme supplementation at both levels of inclusion of sorghum.

Supic (1996) experimented with Hybro chickens for 42 days. 4 groups of birds were fed on basal starter and finisher diets of maize, soyabean oil meal, sunflower oil meal, fishmeal, ʃand and minerals and vitamins. The starter and finisher diets were given from 1 to 21 and from 22 to 42 days old, respectively. Basal diets were given without or with the enzyme preparation "Bio - feed Alfa" 300 g/tonne singly or combined. Average live weight at 6 weeks old was 2116.8, 2074.8, 2122.9 and 2136.2 g, respectively. Percentage mortality was 0, 2, 4 and 2% feed : gain ratio was 1.98, 2.08, 2.04 and 1.98.

Prakash and Morton (1996) conducted a study to assess the beneficial effects of cellulase and protease enzymes supplemented to high fibre diets on the performance of commercial layers. Four diets having different energy and fibre levels classified as low, medium high and very high fibre diets fed in twelve dietary treatments of 3 replicates each replicate having 32 birds. Egg production, feed intake, mortality, egg weight and health status was recorded on a daily basis and feed efficiency per egg was estimated. Significant differences (P < 0.05) in feed consumption, feed efficiency and egg production was noticed between treatments. Cellulase enzyme supplemented to high fibre diets significantly improved egg production whereas supplementation of protease enzyme did not have any influence. Enzyme inclusion in different dietary treatments did not have any influence on egg weight or survivability but reduced the moisture content in droppings. In conclusion supplementation of cellulase enzyme appear to be more beneficial than supplementation of protease enzyme to diets.

Rao and Devegowda (1996) explored the possibility of effective utilization of standard broiler diets or diets containing low quality agricultural by - products by supplementing with suitable enzyme preparations which were examined in 3 experiments. An *in vivo* study by employing forced feeding method was also conducted to study the digestabilities of these enzymes. Birds consumed more feed and attained better body weights with low energy diets in experiment 1 irrespective of protease of superzyme or their combined supplementation. When maize and wheat based rations were supplemented with a combination of xylanase, protease and amylase in experiment 2, feed consumption was increased irrespective of energy variation in diets and birds attained less body weight in low energy fed groups.In experiment 3 performance of birds varied depending on the level of salseed inclusion in diets and supplementation of these diets with tannase did not produce significant influence on performance of birds. Similarly "selfeed" and "canolzyme" failed to produce significant improvement in non - salseed fed group. Metabolic study revealed that supplementation of enzymes reduced moisture content of droppings, improved fibre digestibility and reduced tannin content of feeds.

Suresh and Devegowda (1996) revealed that energy is a major limiting factor in poultry feed formulation rather than protein in many of the developing countries. Therefore, an attempt was made to study the efficacy of celluloytic enzymes to derive more energy by improving digestibility of fibre. Diets were formulated so as to contain 5.5, 6.5 and 7.5% crude fibre supplementation with an enzyme proportion containing cellulose, β - glucosidase, hemicellulase at three levels 0, 0.75 and 1.5 kg per ton of feed. Body weight, feed intake and mortality were recorded. Supplementation of enzyme at 1.5 kg per ton of feed resulted in significant ($P < 0.05$) improvement in body weight in groups fed diet containing 5.5 and 6.5% crude fibre and feed efficiency in group fed diet containing 5.5 and 7.5% crude fibre. In conclusion, improvement in performance may be attributed to the better utilization of energy from fibrous materials.

Hesselman *et al.* (1981;1982), stated that on enzymatic addition eg. β - glucanase as well as reconstitution in broiler chicken diets resulted in improved feed consumption and weight gain. The action of β - glucanase is to hydrolyze the highly viscous β - glucan in barley feed which lead to improvement in feed efficiency for poultry. Treatment of low - or - high viscosity barley feed which leads to improved feed efficiency for chicken showed increased weight gain and feed efficiency (Hesselman and Aman, 1986).

Madacsi (1998) experimented with low tannin sorghum to determine nutritive value of grain included an addition of α - amylase, β - glucanase and an enzyme blend (Pigase) containing amylases, proteinase and celluloses in different treatments. In all treatments the feed consumption was non - significant except pigase where a significant ($P < 0.05$) increase in feed consumption was observed in comparison to corn and sorghum without enzyme. The feed consumption was non - significant for all the treatment groups, however, numerical value for diets containing α - amylase, α - amylase + β - glucanase and pigase were high in comparison to corn and sorghum containing diets. β - glucanase diet was having non - significantly less body weight gain than corn diet but more that the diet consisting sorghum. Likewise, the feed efficiency ratio was non - significant, but the efficiency for sorghum was better than maize and also better in case of diet supplemented with pigase. The diet containing α - amylase, β - glucanase, α - amylase + β - glucanase wer0e having poor feed efficiency.

Rosi *et al.* (1987) found a significant improvement in ME value for barley after addition of multienzyme and a tendency for carbohydrate and fat digestibility to increase.

D. Carcass quality affected by nutritional factors

With the increased acceptance of chicken meat the demand for broiler has risen steeply. In a country with as large a population as India, the fastest way to provide animal protein is through broiler meat. Global pattern also reveals that meat consumption is increasing towards pork and poultry since seventies. Such a demand has stimulated the formulation of ration for a particular weight and body composition at marketing. The inclination of poultry farmers is to produce broilers with less body fat and more lean meat as the excessive body fat can pose waste management problems and in future processing the lean fat attached to broiler backs poses a labour problem. Therefore, the carcass composition is as important as the weight gain and feed efficiency of meat type chickens.

Effect of replacing maize with milo & millets on carcass traits.

In a ten week feeding trial Sharda and Thakur (1977) showed that the birds fed 75 and 100% sorghum in the diet showed comparatively higher carcass weights than those of the chicks of other groups being fed 50%, 25% and 0% sorghum in their diets. The dressing percentage was similar in all groups. The live weight, dressed weight and eviscerated weight of the chicks of sorghum groups were slightly higher than those of the birds of maize group. The differences among the different treatments were not found to be statistically significant ($P < 0.05$). The replacement of maize with sorghum, however, affected yellow pigmentation in the broiler shanks and skin. The maximum pigmentation was observed in the maize group and its intensity diminished gradually as the maize was increasingly replaced by sorghum. Sanford (1972) observed maximum yellow pigmentation in the shanks and skin of broilers fed yellow corn endosperm grain and regular sorghum grain. The weight of different organs expressed as percentages of body weights did not differ significantly due to the difference in treatments. Thakur *et. al.* (1980), also found no significant differences for dressed and eviscerated weight when maize was replaced by tannin free sorghum in broiler ration.

Petersen (1969) reported that variation existed in chemical composition of chicken meat and the variations were much greater for fat, moisture or dry matter content. The fat content was highest with sorghum and lowest with barley, 11.5% and 8% respectively. He further opined that fat was deposited at the expense of moisture, which was seen from the fact that the sum of these two components was almost constant for all treatments. Results also indicated that female chicken contained less protein and more fat than males. The differences in this respect were as great as 15%. In consequence, difference in meat protein was observed between male and females were significant. It was also revealed that fat synthesis in chicken might also vary according to the grain used in the diet. Chickens fed on the sorghum diet had the highest fat deposition while fat content of the chicken fed on sorghum plus tannin diet was 20% less.

Work of Reddy *et al.* (1991) revealed that percent liver and ready - to - cook yields were not significantly influenced by inclusion of either ground or unground pearl millet in place of maize. However, percent gizzard and giblets were significantly ($P < 0.05$) influenced by incorporation of *bajra* in diets. Lowest gizzard and giblet weights were recorded in the broilers reared on the diets containting 50% maize and 50% ground pearl millet and maximum gizzard weight was recorded in the broilers fed on the diet continuing 100% ground maize and the values were statistically significant.

Reddy and Narahari (1997a) studied the effect of feeding foxtail millet and its processed forms at different levels on carcass quality and hematological character. It was found that ready - to - cook yield carcass protein were not influenced by foxtail millet and its processed format and level.

Purushothaman and Natanam (1997) reported that inclusion of little millet (*Panicum sumatrense*) at 40% level resulted in an increased dressing percentage whereas no variation was observed in liver and trimmable fat.

Pander and Sahoo (1991) have shown that dietary crude fibre affected significantly the pre slaughter live weight, weight of blood, head, shank and feet, giblets and eviscerated weight. Chicks fed on crude fibre level of 7.5 to 9.0% had higher pre - slaughter weight, lever weight, with of blood, head, shank and feet was also higher in chicks fed on 7.5 to 9.0% crude fibre level. Weight of giblet and pre - slaughter live weight were also higher in chicks fed on 7.5 to 9.0% crude fibre level.

Leeson *et al.* (1996) examined the effect of commercial enzyme, Roxazyme, on performance and carcass characteristics of turkeys and chickens. It was noticed that there was an increment ($P < 0.05$) in carcass weight of Roxazyme - fed chickens (1848 Vs 1942 g) which was associated with increased fat deposition (33.4 Vs 41.9 g) and a 6% increase ($P < 0.01$) in breast meat yield (397 Vs 421 g).

Lessire, (1995) reviewed the relation between dietary factors and fat deposition in poultry. The determinant roles of increased energy intake and energy to protein ratios rather than lipid intake on fat deposition and the effect of the origin and composition of dietary lipids on fatty acid profiles in adipose tissue was examined.

Pisarski and Wojcik (1995) studied the effect of glucanase supplementation and period of application on the broiler chicken. The amount of glucanase given (dosage) did not affect dressing percentage, carcass meat content and abdominal fat content. However, duration of application of glucanase influenced carcass values. Similarly, pentosanase addition increased dressing percentage, but had no effect on carcass meat content or percentage of abdominal fat.

Thakur and Kulkarni (1991) studied the effect of Novozyme SP - 243, a fibre degrading enzyme, on carcass component of broiler. The values of dressing percentage of total edibles, inedible and various cuts were also comparable in three groups showing no effect of Novozyme on the yield of carcass components.

Sadagopan *et al.* (1996) studied the comparative efficiency of pearl millet, finger millet and sorghum as alternative to yellow corn in broiler rations. They found that processing yields were similar in all groups but weights of gizzard lining and abdominal fat were significantly more in pearl millet and sorghum group. Weights of gizzard and giblets and length of small intestine were significantly more in finger millet low energy diets. The results clearly reflected the utility of pearl millet and sorghum.

Dixit and Baghel (1998) conducted an experiment involving eighty chicks to study the carcass traits of broilers influenced by incorporation of sorghum instead of maize in their diet. Studies indicated that use of sorghum instead of maize did not influence ($P < 0.05$) the dressed, eviscerated and drawn weights (eviscerated + giblet weights) as well as blood, head and feather losses of broilers, while most of the organs weight and shank plus wingtip losses were significantly ($P < 0.05$) higher in broilers fed sorghum based diet.

Chapter 3

Materials and Methods

Materials and Methods

The present experiment was conducted on day old broiler chicks for a period of seven weeks in the Department of Animal Nutrition, Bihar Veterinary College, Patna with the collaboration of Poultry Unit of Animal Production Research Institute, Rajendra Agricultural University, Pusa, Samastipur (Bihar). The techniques adopted for the selection and maintenance of experimental birds, collection and analysis of data are presented below.

A. Procurement of Digestive Multienzyme and its composition

A propriety multienzyme (Polyzyme) manufactured by M/S ZEUS BIOTECH PRIVATE LIMITED, CH - 26, 7th Main Saraswathipuram, Mysore - 570009, INDIA was used in this experiment. This multienzyme feed additive was produced from *Trichoderma longibrachiatum Rifai* by solid state fermentation, which contained the following mentioned enzymes as declared by the company.

Endoxylanase	-	2000 U/g
Beta - glucanase	-	600 U/g
Pectinase	-	60 U/g
Amylase	-	1500 U/g
Cellulose	-	15 U/g
Protease	-	600 U/g
Phytase	-	20 U/g

B. Selection of feed ingredients and computation of mashes

The feed ingredients, to be used for study, were procured in one lot, consisted of maize, milo (*sorghum*) and millets - Pearl millet (*bajra*), Finger millet (*ragi*) and Foxtail millet (*Kangni*) which served as energy source. A vegetable protein mixture with soyabean meal, mustard oil cake and sunflower cake in 2:1:1 ratio was prepared and fishmeal as animal protein source was incorporated in ration. All the ingredients were analysed for the proximate principles and minerals (AOAC, 1975). The proximate composition of the grains and protein sources used in preparing experimental ration are presented in table 5.

C. Formulation of experimental rations for different dietary treatments

Based on analysed crude protein value and published metabolizable energy value, nine experimental diets for both starting and finishing phases of growth were formulated. A basal ration consisting of maize as major energy source was formulated as per standard recommendation (BIS, 1991) which served as control diet. Other experimental diets were prepared in such a way that maize of the control diet was totally substituted by milo (Sorghum) and millets (*bajra, mandua/ragi and kangani*) quantitatively without and with polyzyme at the rate of 50 g/100 kg (0.05%) of ration. The rate of inclusion of polyzyme in both starter and finisher rations were same. The composition of diets (both starter and finishers) used in feeding experiment are given in table 6 and 7, respectively. Feed ingredients, feed supplements, additives and enzyme were homogeneously mixed.

Table 5: Percentage chemical composition and ME of feed ingredients used in experiment (On D.M. Basis)

Ingredients	Analysed Values								ME (Kcal/kg) *Published Values*
	DM	CP	CF	EE	NFE	Total ash	Ca	P	
Maize	90.80	9.32	2.50	3.06	83.40	1.72	0.16	0.43	3417.00 *(NRC, 1971)*
Sorghum	88.50	10.68	2.90	2.98	81.60	1.84	0.23	0.44	3100.00 *(Singh, 1975)*
Pearl millet	90.25	12.71	1.80	5.20	77.69	2.60	0.30	0.77	3300.00 *(Harris et.al, 1982)*
Finger millet	90.60	9.30	6.50	2.16	79.02	3.02	0.32	0.29	3000.00 *(Ranvindra & Blair, 1991)*
Foxtail millet	89.00	10.55	9.70	3.10	72.98	3.67	0.23	0.07	2950.00 *(Reddy & Narhari, 1997)*
Soyabean meal	90.40	46.20	5.89	1.06	37.63	8.22	0.37	0.89	2694.00 *(Panda, 1997)*
Sunflower Cake	89.20	28.90	16.35	2.90	43.87	7.98	0.48	1.30	2230.00 *(Sadagopan & Bose, 1971)*
Mustard oil Cake	91.70	35.20	10.40	11.70	36.00	6.70	0.89	1.32	2332.00 *(Singh, 1975)*
Fish meal	93.90	43.40	3.25	4.19	29.06	20.10	0.80	1.81	1940.00 *(Reddy & Vaidya, 1973)*

Table 7 - Percentage composition of experimental rations (Finisher)

Feed Ingredients	Treatment Groups								
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Maize	60.00	-	-	-	-	-	-	-	-
Sorghum	-	60.00	60.00	-	-	-	-	-	-
Pearl millet	-	-	-	60.00	60.00	-	-	-	-
Finger millet	-	-	-	-	-	60.00	60.00	-	-
Foxtail millet	-	-	-	-	-	-	-	60.00	60.00
Vegetable Protein mixture	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Fish meal	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
Vitamin and mineral mixture	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Additives	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Polyzyme	-	-	0.05	-	0.05	-	0.05	-	0.05
	Analysed Value								
Crude Protein	20.57	21.39	21.39	22.61	22.61	20.56	20.56	21.31	21.31
ME (Kcal/kg)	2951.65	2761.45	2761.45	2881.45	2881.45	2701.45	2701.45	2671.45	2671.45
ME: Protein ratio	143.49	129.10	129.10	127.44	127.44	131.39	131.39	125.36	125.36

Vitamin/ Mineral mixture contained (per kg) : Vit A 20,00,000 I.U.; Vit D_3 4,00,000 I.U.; Vit E 320 mg; Vit k_3 0.40; Vit B_2 1.20 g; Vit B_6 0.40; Vit.B_{12} 4.00 mg; Calcium panthonate 1.20 g; Niacin 8.00 g; Choline chloride 60 g; Calcium 320 g; Phosphorous 20.00 g; Manganese 12.00 g; Iodine 0.40 g; Iron 3.20; Zinc 8.00 g ;Copper 1.00 g ; Cobolt 0.20 g.

Additives contained : Salt (Nacl) 400 mg; Bifuran (Nitrofurazone 25%; Furazolidone 3.60%) 50 g; Vetclin - 112 (0.112 g Tetracycline hcl/kg) 50 g.

Extra care was taken for mixing the enzymes homogeneously and uniformly in the experimental rations. The outline of the plan of work is given below :

T_1 - with maize as principal source of energy (Control)

T_2 - Maize of control diet completely replaced by *jowar/milo.*

T_3 - As in T_2 supplemented with multienzyme (Polyzyme) @ 0.05%

T_4 - Maize of control diet completely replaced by *bajra.*

T_5 - As in T_4 supplemented with multienzyme (Polyzyme) @ 0.05%

T_6 - Maize of control diet completely replaced by finger millet.

T_7 - As in T_6 supplemented with multienzyme (Polyzyme) @ 0.05%

T_8 - Maize of control diet completely replaced by *kangni.*

T_9 - As in T_8 supplemented with multienzyme (Polyzyme) @ 0.05%

D. Selection of Birds

200-day-old broiler chicks of commercial strain, from same hatch, were procured for the experiment. Then chicks were kept in single pen under electric brooder for three days. On the first day chicks were given only ground maize and then standard ration containing 22% crude protein for later two days. On fourth day 180 chicks were selected for experiment and chicks that were crippled and those having extreme body weight were discarded. Selected chicks were vaccinated against Ranikhet and Gumboro diseases, wing banded and randomly distributed into nine groups of twenty chicks replicated twice with ten chicks in each replicate. The mean body weights were similar in all groups. On the day of assigning the treatments live weight of chicks were ranged from 42 to 53 grams.

The chicks were reared under electrically heated brooder upto three weeks and thereafter the intensity of light was reduced in a gradual manner.

E. Housing, Feeding and Watering of Experimental Birds

Before starting the feeding trial, the pens to be used for experimental purpose were thoroughly cleaned and disinfected with 2% phenol. The chicks were housed in floor pens and maintained on deep - litter system having saw - dust as bedding material. The litter was kept 2.5 inches thick for the first month and then the thickness was raised to approximately 4 inches. The litter was racked weekly to prevent any cake formation. Heat was provided by a suspended heat lamp adjusted the height of which was adjusted as per requirement. The chicks were provided 24 hours light from fluorescent lamps located on the ceiling of the barn. An all mash-feeding practice was followed throughout the experimental period. Feeds were offered *ad libitum* in linear feeders and the weighed quantities of formulated rations for different dietary treatments offered to respective groups, once daily. The wastage of feed was minimized by placing the feeders on spreaded plastic sheets and collected back the spilled over feed material into feeders. A weekly record of feed offered and feed leftover was maintained for each group throughout the experimental period to assess the actual feed intake. In rearing pens the chicks were served fresh and clean drinking water *ad - libitum* through fountain system which was changed twice daily in the morning and afternoon.

The broilers were reared under uniform conditions of housing including brooding, feeding, watering, lighting and other management.

F. Observation and sampling

The following recording and sampling procedures were adopted during experimental period.

i) *Feed intake*

A weekly record of feeds offered and weigh back was maintained for each group to calculate the feed consumption.

ii) *Body weight*

The chicks were weighed individually at the start of the experiment and subsequently at weekly intervals. The weekly live weight gain was calculated from the difference in body weight attained at the end and at the start of the period in question.

iii) *Feed Conversion Ratio (FCR)*

The feed conversion ratio was calculated by using the following formula :

$$FCR = \frac{\text{Total amount of feed consumed (g)}}{\text{Body weight gain (g)}}$$

iv) Performance Index (PI)

In order to take into account of feed efficiency as well as growth rate, an index was obtained for each experimental diet by dividing the average weight gained by the feed conversion figure (Bird, 1955). It was calculated as :

$$PI = \frac{Body\ weight\ gain\ (g)}{FCR}$$

v) Mortality rate

Regular observations were made to record the occurrence of death in experimental broilers to estimate mortalities relative to experimental groups.

G. Carcass Study

At the end of seventh week, four birds from each group having two from each replicate were randomly selected for slaughter and processing. The birds to be slaughtered were not offered any feed for 24 hours but were given water *ad - libitum.* Each bird was weighed immediately before slaughter. The difference between live weight and immediately before slaughter was recorded as shrinkage and was calculated as percentage of live weight. The birds were bled by clean incision at the base of ear lobes and allowed to bleed completely and weighed. The weight loss before slaughter and after slaughter was recorded as blood loss. The birds were immersed in hot water (70°C) for 30 seconds (hard scalding). The scalded birds were hands plucked to remove body feathers perfectly, dried and weights were recorded which reflected feather loss. The head was removed by severing the cervical at the base of the occipital bone and feet as well as shanks were cut at the tibio-tarsal joints, wing tips were removed and dressed weight of the carcass was recorded. Thus, the dressed weight consisted of fasted weight minus blood, feather, head, feet, shanks and wingtips, keeping the viscera intact. The skin was removed from the carcass of each group and their weight was recorded. Removing the crop, gullet, trachea and viscera birds were then eviscerated. The lungs were scrapped off. The giblets (heart, liver and gizzard) were removed from the viscera. Gall bladder was removed from the liver with care to avoid puncture and weight of liver was recorded. Gizzard was opened; the contents were washed out and the lining was pulled off and the weight was recorded. The heart was freed from blood clots and adhering vessels and weighed. The weight of the carcass along with giblet was recorded as eviscerated weight. The dressing percentage and eviscerated percentage were calculated on the basis of pre - slaughter live weight at seventh week of age.

The neck of the four carcasses from each group was removed as closely to the clavicles as possible, weight of neck and giblets were recorded separately. The ready-to-cook weight was calculated by subtracting the weight of neck and giblets from the eviscerated weight of the carcass. Samples of breast and thigh muscles were taken from carcasses of each group with a scissors and scalpel. The samples were wrapped in polyethene bag and kept in deep freeze for proximate analysis.

For determination of meat/bone ratio, the carcasses were then cooked n enameled tray for one-and-half hour in an oven at 163°C (Dawson, *et al.*, 1957). After every 25 minutes the chicks were turned side up so that each chicken was ompleted by cooking the carcass until the internal temperature of breast muscle reached 94°C. After boiling the carcasses along with trays were removed from the oven and individually weighed to obtain the cooked weight of the carcass.

Edible meat and bone were separated manually. The bones were dried in oven to a constant weight at 80°C, the weight of the dried bone was recorded and this weight was deducted from the ready-to-cook weight. The difference constituted the raw edible meat. The meat/bone ratio was calculated by dividing the weight of the raw edible meat with weight of the bone.

$$Meat/Bone\ ratio = \frac{Ready\ to\ cook\ weight - Weight\ of\ oven\ dried\ bone}{Weight\ of\ oven\ dried\ bone}$$

Methods of Analysis

Samples of feed ingredients and formulated rations were analysed for moisture, crude protein, crude fibre and ash according to procedures laid down by AOAC (1975). Calcium and phosphorus in feed samples were determined by using the method of Maccrudden and Newmann as modified by Talapatra *et al.* (1940). The moisture content of breast and thigh muscles were determined by drying 10 g. samples in oven at 100°C for 180 hours. For ether extract and nitrogen (Kjeldahl) determination the samples were grinded in glass pestle and mortar and representative samples were taken for determining nitrogen and ether extract as outlined by AOAC (1974)

Statistical Analysis

The data of treatment means in respect of the parameters studied were subjected to statistical analysis in a completely randomized design following the ached 94°C. After boiling the carcasses along with trays were removed from the ven and individually weighed to obtain the cooked weight of the carcass.

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Statistical Analysis

The data of treatment means in respect of the parameters studied were subjected to statistical analysis in a completely randomized design following the procedure of Snedecor and Cochran (1967). The differences between the treatments were tested for significance by Duncan's new multiple range test (1955). The percentage figure related to different parameters were converted into arc sine as per C.I. Bliss (1937) and then subjected to statistically analysis for different treatment means alongwith their standard error.

Chapter 4

Result and Discussion

Results and Discussion

The present investigation was carried out to evaluate milo and millets with and without enzyme as replacer of maize in broiler ration. Results obtained in relation to different parameters are presented below :-

Body Weight Gain

The average weekly body weight gain during different experiment period (0 - 4, 4 - 7 and 0 - 7) for different dietary treatments and the statistical analysis of treatment means are presented in table 8 - 9 and appendix table 1. The treatment means of different dietary treatments are also represented through bar diagram shown in figure1.

0 - 4 weeks

The average weight gain during 0 - 4 weeks ranging from 484 to 663 g was significantly affected ($P < 0.05$) by dietary treatments. Chicks fed sorghum based diet without enzyme supplementation (T_2) showed significantly ($P < 0.05$) lower weight gain than control but was comparable with finger millet based diet (T_6) which in turn was also comparable with foxtail millet based diet (T_8). The lowest weight gain (484 g) was obtained in chicks fed diet in which maize was completely replaced by foxtail millet (T_8) and was significantly ($P < 0.05$) lower than all other diets except finger millet based diet (T_6). Chicks fed pearl millet based diet without enzyme (T_4) showed significantly ($P < 0.05$) higher body weight gain (641 g) than all other enzyme supplemented diet. Supplementation of enzyme showed beneficial effects in finger millet (T_7) and foxtail millet (T_9) based diet and was significantly (P < 0.05) higher than their unsupplemented group. No beneficial effect of enzyme supplementation was seen either in sorghum (T_3) or pearl millet (T_5) based diets. The weight gain of chicks fed enzyme supplemented finger millet (T_7) and foxtail millet based diets (T_9) were comparable and did not differ significantly (P < 0.05) from control diet.

4 - 7 weeks

The body weight gain was significantly (P < 0.05) influenced by dietary treatment, which ranged from 657 to 898 g. The groups fed diets in which maize was completely replaced by sorghum (T_2) finger millet (T_6) and foxtail millet (T_8) without enzyme supplementation showed significantly (P < 0.05) lower weight gain than control diet (T_1). Foxtail millet based diet (T_8) showed significantly lowest weight gain than all other groups except finger millet based diet (T_6), which were comparable. Supplementation of enzyme in various groups showed only positive effect in foxtail millet based diet while in other groups no beneficial effect of supplementation of enzyme was seen during this phase of growth. Chicks fed sorghum based diet with or without enzyme supplementation (T_2 & T_3) and finger millet or foxtail millet based diet with enzyme supplementation (T_7 & T_9) were not significantly (P < 0.05) different, but were significantly (P < 0.05) lower than control group (T_1). The highest weight gain (898 g) was achieved in the group fed enzyme supplemented pearl millet based diet and was significantly (P < 0.05) higher than all other groups except their unsupplemented enzyme group (T_4). The unsupplemented pearl millet fed group (T_4) did not differ significantly ($P < 0.05$) with the control group during this phase of growth.

0 - 7 weeks

The weight gain during combined period of growth was significantly ($P < 0.05$) influenced by dietary treatments. Treatment means of body weight gain ranged from 1138 to 1561 g. Among the groups fed diet in which maize was completely replaced by pearl millet (T_4) gave significantly ($P < 0.05$) higher weight gain in comparison to control and other groups. The groups fed sorghum (T_2), finger millet (T_6) and foxtail millet (T_8) based diets showed significantly ($P < 0.05$) lower weight gain than control (T_1) and pearl millet based diet (T_4). Improvement in weight gain by supplementation of enzyme was seen in finger millet (T_7) and foxtail millet (T_9) based diet with their respective unsupplemented diet but not at par with the control group (T_1). No beneficial effect of supplementation of enzyme was observed either in sorghum (T_3) or pearl millet (T_5) based diet with their respective unsupplemented diets. Enzyme supplementation in finger millet and foxtail millet based diet showed positive effect during starting phases of growth and the weight gains were comparable with control group but this effect was not seen during finishing phases of growth and during combined period of growth. During the entire experimental period, the best weight gain (1561 g) were obtained by feeding pearl millet based diet with enzyme supplementation (T_5) followed by pearl millet based unsupplemented (1526 g) and control diet (1442 g).

Results of body weight gain indicated a variable response in promoting growth by milo and millets when completely replaced maize based diet. Sorghum

Table 8 : Treatment means of body weight gain (g/chick) and feed intake (g/chick) in different periods

Treatment No.	1st Week		2nd Week		3rd Week		4th Week		5th Week		6th Week		7th Week	
	Weight gain	Feed intake	Weight gain	Feed intake	Weight gain	Feed intake	Weight gain	Feed intake	Weight gain	Feed intake	Weight gain	Feed intake	Weight gain	Feed intake
T_1	68	114.44	116	210.40	176	330.11	227	500.63	276	645.84	327	774.99	254	842.79
T_2	65	117.00	104	190.32	142	288.69	210	480.90	230	524.40	300	699.00	170	750.54
T_3	58	104.98	112	204.84	151	294.54	215	494.00	242	556.60	303	705.99	180	721.56
T_4	63	116.55	121	232.32	193	348.97	264	541.52	290	690.20	345	839.01	250	845.25
T_5	60	111.69	132	252.02	200	359.84	271	550.40	300	713.00	340	816.00	258	823.44
T_6	59	103.84	102	189.72	149	289.06	191	464.27	222	572.86	278	723.84	178	734.92
T_7	61	106.75	119	212.34	166	313.05	219	504.65	240	532.88	290	650.80	174	718.48
T_8	60	111.60	100	197.00	138	269.91	186	476.40	212	610.92	241	678.40	204	748.53
T_9	56	103.60	120	230.40	171	338.58	225	473.15	250	595.00	294	631.33	176	720.30

produced a lower body weight gain and even supplementation of enzyme could not produce desired gain. The growth depressant effect of sorghum in comparison to maize might be attributed to the presence of tannic acid in quantity sufficient to reduce growth. The content of tannic acid may be different in different varieties of sorghum and the sorghum grain used in this experiment may contain higher amount of tannic acid. The result are in agreement with the results obtained by several workers (Petersen, 1969; Thakur *et al.*, 1984; Sadagopan, 1994; Nagra *et al.*, 1990; Eshwaraiah, 1990; Dixit and Baghel, 1997; Rostango, *et al.*, 1973; Purushothaman and Thirumalai, 1995b; Sinha *et al.*, 1980). Chang and Fuller (1963) reported that high tannin grain sorghum resulted in growth retardation which was similar in magnitude to that caused by equivalent levels of tannic acid. Further they also suggested that tannin of grain sorghum differed chemically from the tannic acid (digallic acids) and its presence in grain sorghum induced a choline and/or methionine deficiency, however, other workers (Eshwaraiah, 1994; Thakur and Sharda, 1974) obtained better weight gain by partly or wholly replacement of maize with sorghum while several workers did not obtained any differences in body weight gain when sorghum replaced partly or wholly maize in poultry diet (Thakur *et.al.*,1985;Damron *et. al.*, 1968; Jacob *et. al.*, 1996a; Sharma and Singh, 1979; Asha Rajini, 1986; Sharma *et. al.*, 1979; Hulan and Proudfoot, 1982; Singh and Barsaul, 1976; Ozement*et.al*1962). Supplementation of enzyme could not produce the desired weight might be due to composition of enzyme which did not contained tannase.

The higher growth obtained in pearl millet fed groups was in agreement with the results of several workers who obtained a significant ($P < 0.05$) higher weight gain (Asha Rajini *et al.*, 1986; Abate and Gomez, 1984; Prasad *et al.*, 1997; Sharma *et al.*, 1979; Reddy *et al.*, 1989; Asha Rajini and Vedhanayagam, 1983).

The good response of pearl millet based diet might be due to higher protein content with better balancing of amino acid and lower amount of fibre as well as absence of anti-nutritive factors in comparison to maize. The variety used in this experiment seemed to be of better quality. Some workers, however, have reported adverse effect on body weight gain (Purushothaman and Thirumalai, 1995b) while Qureshi (1967) found lower weight gain by incorporating pearl millet in broiler ration. Many reports indicated no significantly differences by feeding pearl millet based ration in poultry (Purushothaman and Thirumalai, 1995a; Singh and Barsaul, 1976; Nagra *et al.*, 1987; Reddy *et al.*, 1991; Thakur and Prasad, 1992). The non - significant ($P < 0.05$) positive response by supplementation of enzyme was due to the presence of enzyme in multienzyme preparation whose supplementation did not require additional benefits.

Finger millet and foxtail millet based diet could not supported higher growth as compared to maize diet, which might be due to presence of high fibre as well as other anti-nutritive factors. The results are in agreement with the results obtained by several workers who obtained significantly lower weight gain (Rao *et al.*, 1996; Reddy *et al.*, 1996; Purushothaman and Thirumalai, 1995a) in finger millet and foxtail millet based diets. A good response was obtained by supplementation of enzyme in these diets, which might be due to reduction or removal of these anti-nutritive factors by the specific enzymes present in the multienzyme preparation. Rao *et al.* (1994), obtained no significant differences in weight gain when finger millet was used upto level of 50% and beyond that level

Table 9 : **Treatment means for body weight gain (g/chick), feed consumption (g/chick), during different experimental periods**

Treatment	Weight gain			Feed consumption		
	0 - 4 weeks	4 - 7 weeks	0 - 7 weeks	0 - 4 weeks	4 - 7 weeks	0 - 7 weeks
T_1	$587^{d} \pm 6.90$	$857^{d} \pm 10.46$	$1442^{e} \pm 15.04$	$1155.58^{cd} \pm 45.98$	$2263.62^{c} \pm 22.42$	$3419.20^{b} \pm 68.40$
T_2	$521^{bc} \pm 6.24$	$700^{bc} \pm 12.49$	$1221^{bc} \pm 15.19$	$1076.91^{bc} \pm 20.91$	$1973.88^{ab} \pm 26.84$	$3050.79^{a} \pm 47.75$
T_3	$536^{c} \pm 10.35$	$725^{c} \pm 13.86$	$1261^{cd} \pm 18.32$	$1098.67^{bc} \pm 21.29$	$1984.15^{ab} \pm 36.03$	$3082.82^{a} \pm 57.32$
T_4	$641^{e} \pm 13.14$	$885^{de} \pm 11.90$	$1526^{f} \pm 22.43$	$1239.36^{de} \pm 28.56$	$2374.46^{d} \pm 17.19$	$3613.82^{c} \pm 45.75$
T_5	$663^{e} \pm 9.05$	$898^{e} \pm 7.94$	$1561^{f} \pm 14.17$	$1272.96^{e} \pm 24.86$	$2352.44^{d} \pm 23.96$	$3628.66^{c} \pm 41.82$
T_6	$501^{ab} \pm 12.48$	$678^{ab} \pm 13.37$	$1180^{ab} \pm 23.59$	$1046.89^{ab} \pm 19.11$	$2041.62^{b} \pm 22.53$	$3088.52^{a} \pm 41.67$
T_7	$565^{d} \pm 8.50$	$704^{bc} \pm 9.39$	$1269^{cd} \pm 14.45$	$1136.79^{c} \pm 26.01$	$1902.16^{a} \pm 11.91$	$3038.95^{a} \pm 37.92$
T_8	$484^{a} \pm 12.41$	$657^{a} \pm 13.08$	$1138^{a} \pm 21.62$	$981.29^{a} \pm 34.79$	$2038.42^{b} \pm 39.50$	$3019.71^{a} \pm 74.29$
T_9	$572^{d} \pm 11.06$	$720^{c} \pm 9.83$	$1292^{d} \pm 17.37$	$1145.73^{c} \pm 13.50$	$1946.63^{a} \pm 14.17$	$3092.35^{a} \pm 27.67$
CD ($P < 0.05$)	27.92	31.01	48.38	86.32	82.30	153.51

Means with same superscript in a column do not differ significantly ($P < 0.05$)

Figure 1

Weight gain during different experimental period

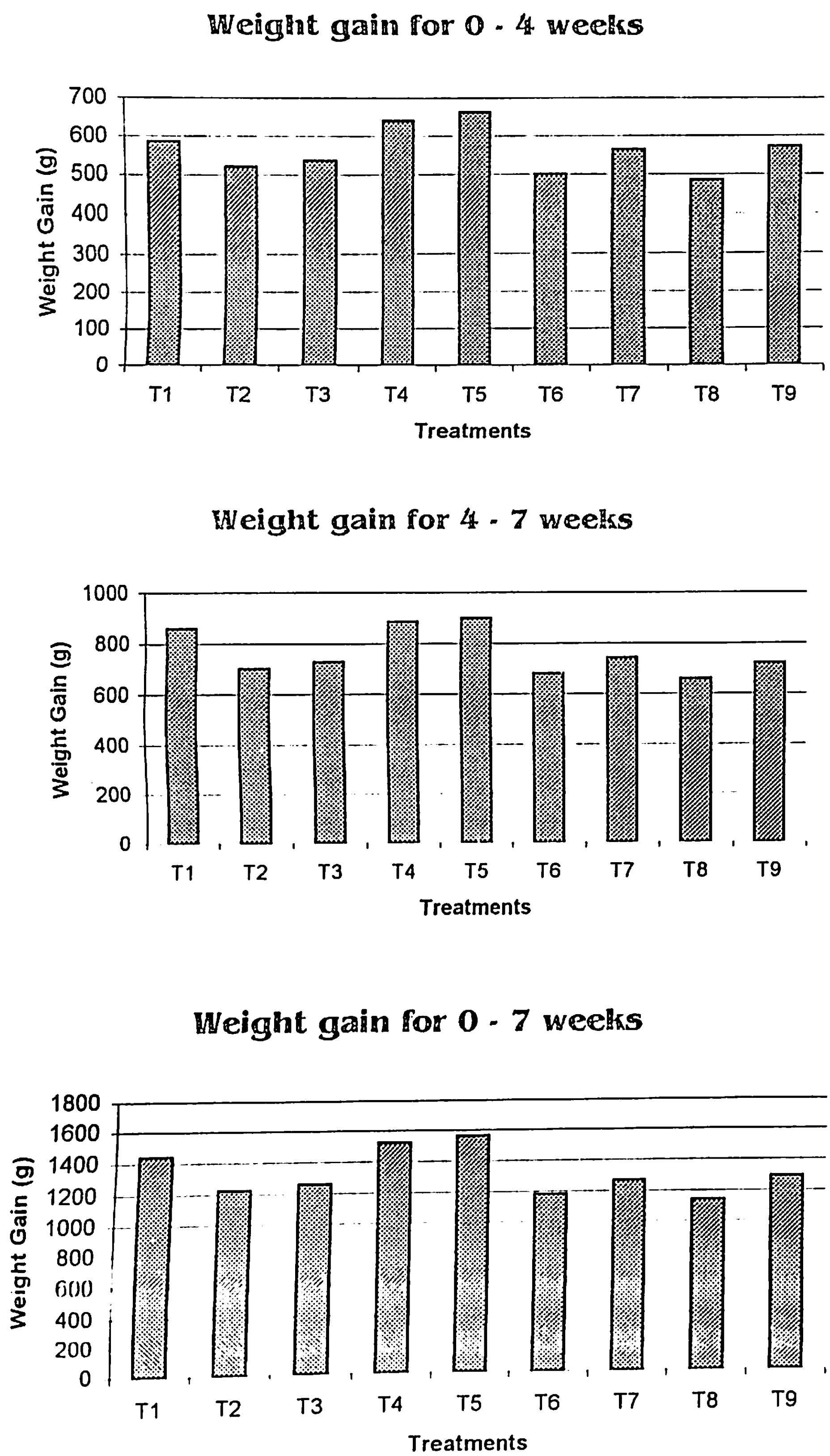
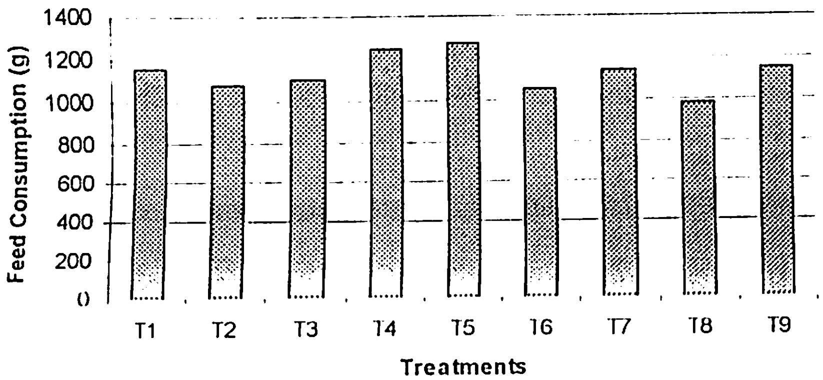


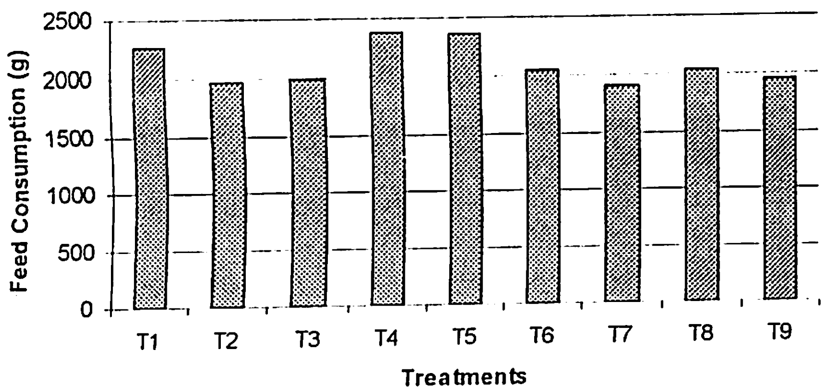
Figure 2

Feed Consumption during different experimental period

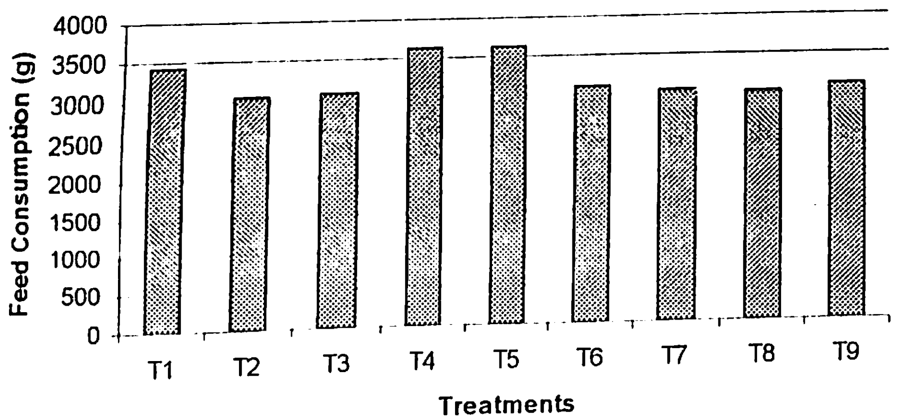
Feed Consumption for 0 - 4 weeks



Feed Consumption for 4 - 7 weeks



Feed Consumption for 0 - 7 weeks



growth depressant effect was noticed. Several reports also indicated a non - significant differences by feeding these millets in broiler diets (Yeong and Ali, 1976; Abate and Gomez, 1984; Rao, 1994; Ayyaluswami and Jaganathan, 1967; Thanbalan, 1992; Reddy and Narahari, 1997a; Kraft *et al.*, 1971; Baghel and Netke, 1979; Reddy and Narahari, 1997b; Netke and Baghel, 1982; Baghel and Netke, 1982). Supplementation of enzyme in foxtail millet based diet was substantial than unsupplemented or finger millet based diet, which might be due to better utilization of crude fibre from foxtail millet (Suresh and Devegowda, 1996; Arora *et al.*, 1990; Sharma, 1990). Results also indicated a better effect of supplementation of enzyme during starting than finishing phases of growth (Cambell, 1980; Bhatt *et al.* 1991). The results corroborated the findings of Abate and Gomez (1984) who showed a trend of decreasing weight gain as the level of finger millet was increased in starting phase while the trend was not systematic in the later stages of growth. The improvement in weight gain during different phases of growth could have been due to the older chicks are more tolerant to anti-nutritive factors than the young chicks thus leading to a better utilization of the ingested feed.

Feed Consumption

The data on weekly feed consumption and the average feed consumption during different experimental periods with their statistical analysis are presented in their Table 9 and appendix table 2. The treatment means of different dietary treatments are also represented through bar diagram shown in fig. 2.

0 - 4 weeks

The feed intake during 0 - 4 weeks ranged from 981 to 1273 g and was significantly ($P<0.05$) influenced by dietary treatments. The feed consumption of milo and millets based diets except pearl millet was found to be lower than control group. Birds fed finger millet (T_6) and foxtail millet (T_8) based diets consumed significantly ($P < 0.05$) lower amount of feed than control group (T_1) whereas pearl millet based diet was consumed significantly ($P < 0.05$) more. Sorghum and pearl millet based diet (T_2, T_3, T_4 and T_5) showed comparable value. Supplementation of enzyme in milo and millets based diet improved feed consumption in birds, however, the supplementation of enzyme showed significant ($P<0.05$) improvement in feed consumption only with finger millet and foxtail millet based diet (T_7 and T_9) with respect to their unsupplemented groups, whereas pearl millet and sorghum based diets with or without supplementation (T_2, T_3, T_4, and T_5) showed comparable values. Feed consumption of birds fed finger millet and foxtail millet based diet supplemented with enzyme (T_7 and T_9) consumed similar amount of feed as the birds of control group (T_1).

4 - 7 weeks

During this phase of growth the feed consumption of birds ranging from 1902 to 2374 g was significantly ($P<0.05$) influenced by dietary treatments. The groups fed diet based on sorghum (T_2), finger millet (T_6) and foxtail millet (T_8) consumed lesser amount of feed than control (T_1) but a significantly ($P < 0.05$) higher feed consumption was observed in the groups fed pearl millet based diet(T_4) than control diet(T_1). A reverse trend in feed consumption was observed through supplementation of enzyme in all milo and millet based diets. Birds reared on diet based on finger millet and foxtail millet (T_7 and T_9) showed significantly ($P < 0.05$) lesser amount of feed consumption by supplementation of enzyme but no significant ($P < 0.05$) differences in feed consumption was observed in sorghum (T_3) and pearl millet(T_5) based diets supplemented with enzyme. The highest feed consumption was obtained in pearl millet based unsupplemented diet (T_4) followed by the same diet supplemented with enzyme (T_5).

0 - 7 weeks

The feed consumption during entire experimental periods was significantly influenced ($P<0.05$) by dietary treatments. It ranged from 3020 g to 3629 g. Birds fed sorghum, finger millet and foxtail millet based diet consumed significantly ($P < 0.05$) lower amount of feed than control groups. However, a significantly ($P < 0.05$) higher amount of feed consumption was recorded in pearl millet based diet (T_4) than control group (T_1). Supplementation of enzyme in all replacement diets did not influence feed consumption with respect to their unsupplemented diets. The feed consumption of birds fed sorghum, finger millet and foxtail millet with or without supplementation of enzyme were comparable and not significantly ($P < 0.05$) different from each other though these values were significantly ($P<0.05$) lower than control group. Similarly, the values for feed consumption in pearl millet based diet with or without enzyme supplementation (T_4 and T_5) were comparable and were significantly ($P<0.05$) higher than control group (T_1).

Results of feed consumption indicate variable response in feed consumption with respect to milo and millets based diet. Those milo and millets which contained more amount of anti-nutritive factors was consumed by birds in lower amounts whereas results also revealed that birds consumed more amount of feed in peal millet based than maize based diets. Feed intake in birds is affected by the presence of anti-nutritive factors was also reported by Netke and Baghel, (1982); Purushothaman and Thirumalai, (1995); Nagra *et al.*, (1990); and Asha Rajini *et. al.*,, (1986).

High feed intake as observed in pearl millet based diet was also obtained by Prasad *et al.* (1997); Reddy *et al.*, (1989); Thakur and Prasad, (1992); Nagra *et al.*, (1987). However, several workers found no differences in feed consumption by inclusion of milo and millets in broiler diets (Thakur *et al.*, 1985; Sadagopan, 1984; Sharma and Singh, 1979; Sharma *et al.*, 1979; Purushothaman and Thirumalai, 1995; Sinha *et al.*, 1980; Nagra *et al.*, 1987; Naphade and Tripathi, 1974; Ozement *et al.*, 1963; Purushothaman and Thirumalai, 1997; Asha Rajini, *et. al.*, 1986; Yeong and Ali, 1976, Baghel and Netke, 1979, Reddy and Narahari, 1997a). Some reports also indicated a higher amount of feed consumption in order to satisfy their energy needs (Reddy and Narahari, 1997b; Baghel and Netke, 1982; Ayyaluswami and Jaganathan, 1967). Enzyme supplementation increased the feed consumption also obtained in the present experiment by supplementation of enzyme in foxtail millet and finger millet based diet,as obtained by other workers.

Feed Conversion Ratio & Performance Index

Feed Conversion Ratio (FCR)

The feed conversion ratio and performance index of birds under different dietary treatments and their analysis of variance are presented in Table 10 and appendix table 3 and 4. FCR and PI of different dietary treatments are also represented through bar diagram shown in figure 3 and 4 respectively.

0 - 4 weeks

The FCR during this period was not significantly ($P<0.05$) influenced by dietary treatment. Feed per unit gain ranged from 1.92 to 2.09. The FCR value of sorghum, finger millet and foxtail millet based diets were numerically higher than control but not - significantly ($P<0.05$) different. Birds fed diet based on pearl millet showed lower FCR value than control. Supplementation of enzyme in all replacement groups showed lower non-significant FCR value as compared to their unsupplemented group.

4 - 7 weeks

The FCR during this phase of growth was significantly ($P<0.05$) affected by dietary treatments. It ranged from 2.62 to 3.10. Birds fed sorghum (T_2), finger millet (T_6) and foxtail millet (T_8) based diet showed higher ratios than control. The values obtained in pearl millet based diet was not significantly ($P<0.05$) different from control group. The highest FCR (3.1) value was obtained in foxtail millet (T_9) based diet. Supplementation of enzyme lowered the FCR value in all replacement groups, however, the values was found to be significantly ($P<0.05$) lower in finger millet (T_7) and foxtail millet (T_9) based diet. Supplementation of enzyme in sorghum (T_3) and pearl millet (T_5) based diet did not affect much in lowering the FCR value and the values were not significantly different ($P < 0.05$) from control group (T_1).

0 - 7 week

The FCR value during entire experimental period ranging from 2.32 to 2.66 was significantly ($P<0.05$) affected by dietary treatments. The values for FCR were found to be significantly ($P < 0.05$) higher in sorghum (T_2), finger millet (T_6) and foxtail millet (T_8) based diets than control (T_1), however, the values obtained in pearl millet based diet (T_4) was not significantly ($P < 0.05$) different from control group. Supplementation of enzyme in the entire replacement group showed positive effect in lowering the FCR value, but the value obtained in sorghum (T_3) and pearl millet (T_5) based diet was comparable with their unsupplemented groups. Supplementation of enzyme in finger millet (T_7) and foxtail millet (T_9) improved feed utilization through lowering FCR value and were not significantly ($P<0.05$) different from control group. In general supplementation of enzyme in all the replacement group reflected comparable FCR values and was not significantly ($P<0.05$) different from control. The lowest FCR value (2.32) was obtained in pearl millet based diet supplemented with enzyme (T_5).

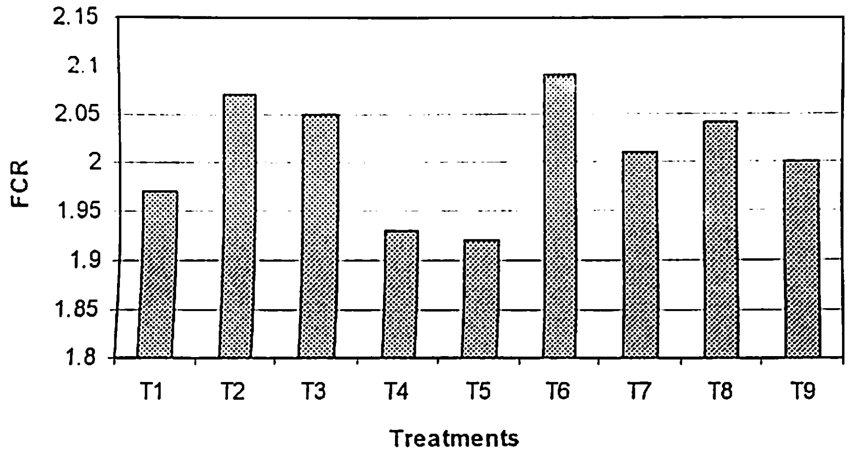
Table 10 : Treatment means for feed conversion ratio (FCR) and Performance Index (PI) during different experimental periods

Treatment	Feed Conversion Ratio			Performance Index		
	0 - 4 weeks	4 - 7 weeks	0 – 7 weeks	0 - 4 weeks	4 - 7 weeks	0 - 7 weeks
T_1	$1.97^{NS} \pm 0.07$	$2.64^{a} \pm 0.04$	$2.37^{ab} \pm 0.05$	$298.00^{d} \pm 9.32$	$325.10^{e} \pm 6.44$	$608.44^{e} \pm 11.76$
T_2	$2.07^{NS} \pm 0.07$	$2.82^{b} \pm 0.007$	$2.50^{cd} \pm 0.03$	$252.00^{ab} \pm 11.90$	$248.23^{C} \pm 5.14$	$488.40^{bc} \pm 0.76$
T_3	$2.05^{NS} \pm 0.01$	$2.74^{ab} \pm 0.005$	$2.44^{abc} \pm 0.01$	$261.50^{abc} \pm 7.62$	$265.58^{d} \pm 0.70$	$515.74^{cd} \pm 2.76$
T_4	$1.93^{NS} \pm 0.03$	$2.68^{ab} \pm 0.001$	$2.37^{ab} \pm 0.005$	$332.64^{e} \pm 3.46$	$330.22^{e} \pm 2.23$	$647.03^{ef} \pm 1.30$
T_5	$1.92^{NS} \pm 0.005$	$2.62^{a} \pm 0.02$	$2.32^{a} \pm 0.01$	$345.31^{e} \pm 7.52$	$342.75^{f} \pm 3.49$	$672.84^{f} \pm 15.67$
T_6	$2.09^{NS} \pm 0.06$	$3.01^{C} \pm 0.01$	$2.62^{de} \pm 0.08$	$240.00^{a} \pm 9.28$	$225.58^{b} \pm 13.33$	$450.38^{ab} \pm 21.97$
T_7	$2.01^{NS} \pm 0.03$	$2.70^{ab} \pm 0.06$	$2.39^{ab} \pm 0.05$	$281.59^{bcd} \pm 1.96$	$260.00^{d} \pm 10.88$	$530.10^{cd} \pm 13.30$
T_8	$2.04^{NS} \pm 0.03$	$3.10^{C} \pm 0.02$	$2.66^{e} \pm 0.004$	$237.25^{a} \pm 14.46$	$212.00^{a} \pm 1.37$	$427.81^{a} \pm 12.04$
T_9	$2.00^{NS} \pm 0.02$	$2.71^{ab} \pm 0.07$	$2.40^{ab} \pm 0.05$	$286.00^{cd} \pm 11.79$	$266.66^{d} \pm 14.71$	$538.33^{d} \pm 24.60$
CD ($P < 0.05$)	---	0.16	0.13	30.03	10.08	45.64

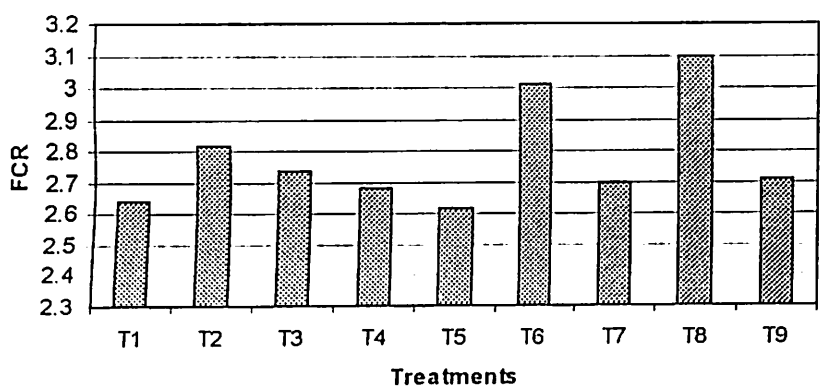
Means with same superscript in a column do not differ significantly ($P < 0.05$)

Figure 3
Feed Conversion Ratio during different experimental period

FCR for 0 - 4 weeks



FCR for 4 - 7 weeks



FCR for 0 - 7 weeks

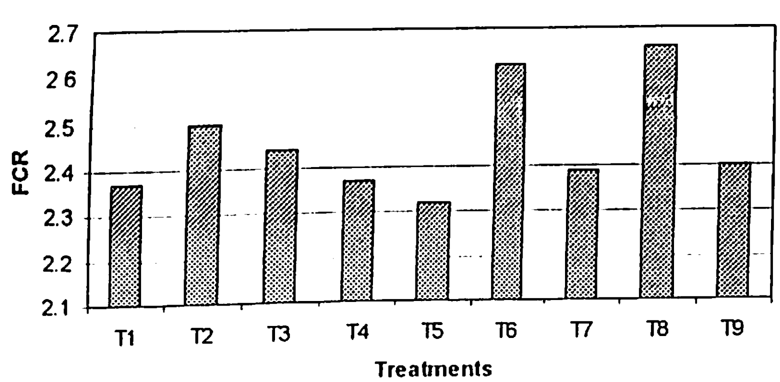
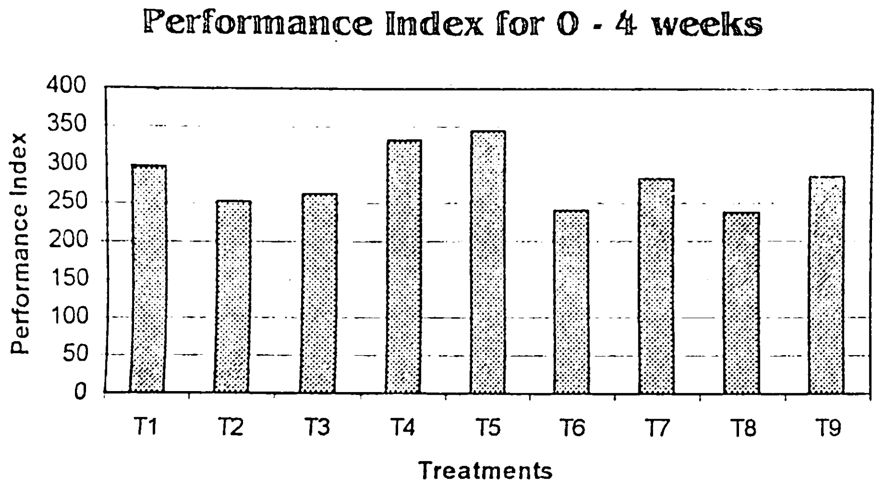
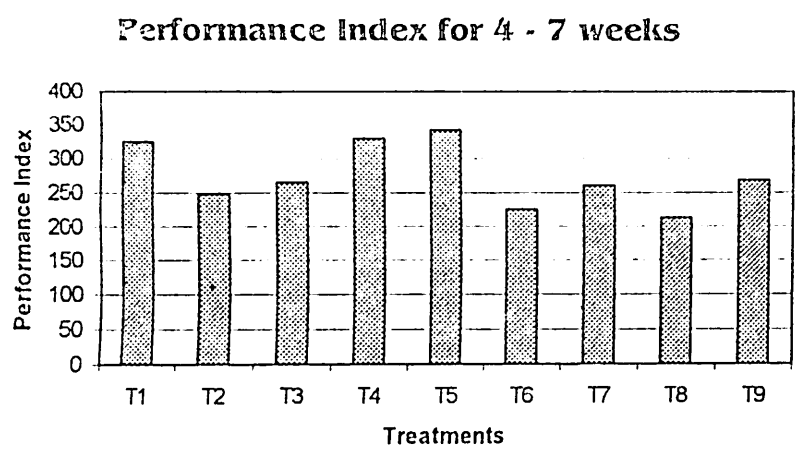


Figure 4

Performance Index during different experimental period





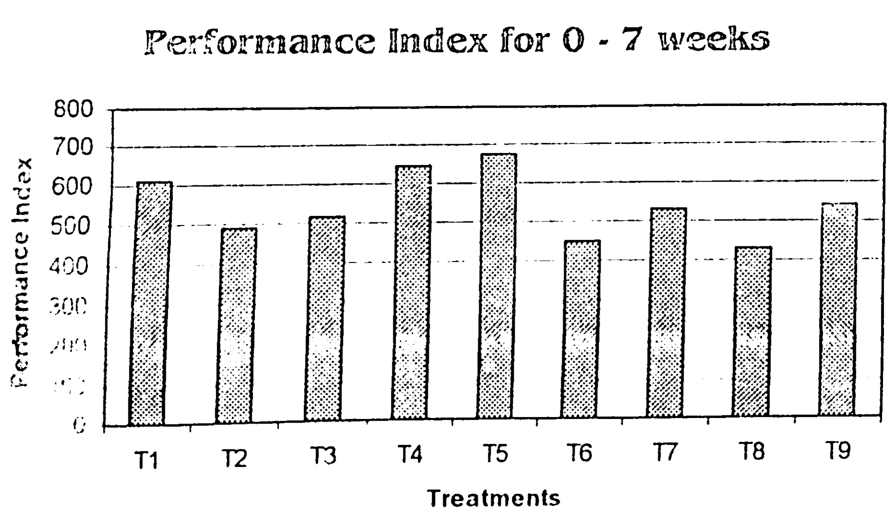
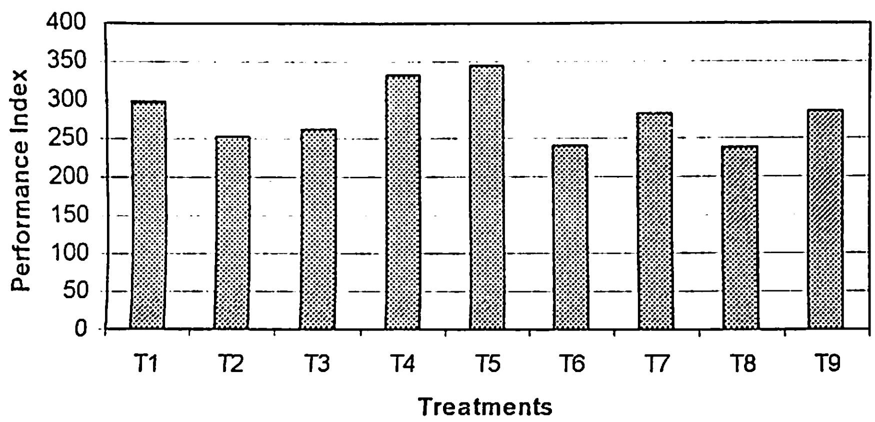


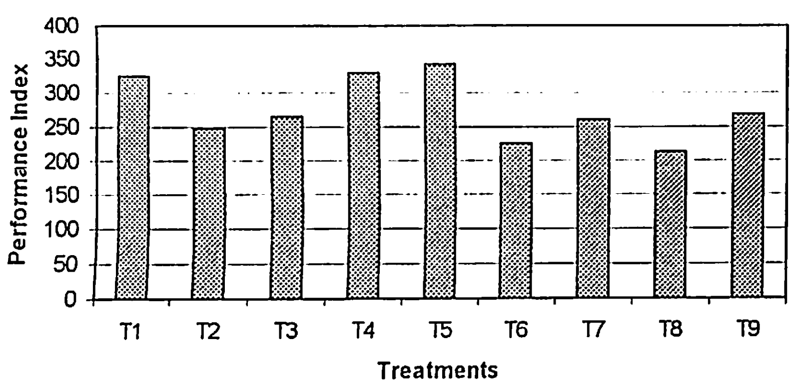
Figure 4

Performance Index during different experimental period

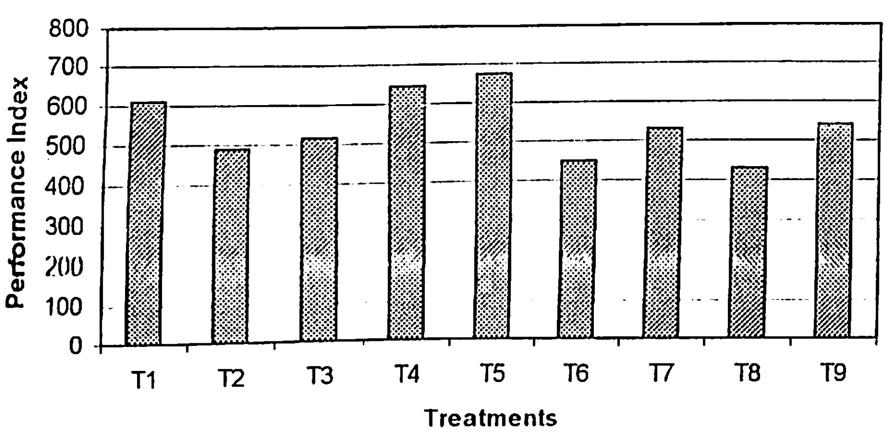
Performance Index for 0 - 4 weeks



Performance Index for 4 - 7 weeks



Performance Index for 0 - 7 weeks



Performance Index (PI)

0 - 4 weeks

The performance index during 0 - 4 weeks was significantly ($P < 0.05$) influenced by dietary treatments. It ranged from 237 to 345. Birds fed diet based on sorghum (T_2), finger millet (T_6) and foxtail millet (T_8) showed significantly ($P<0.05$) lower index than control group. The performance index was found to be significantly ($P<0.05$) higher in pearl millet based diet (T_4) in comparison to control (T_1) and other replacement groups. The values for index obtained in sorghum (T_2), finger millet (T_6) and foxtail millet (T_8) based diets were comparable and not significantly ($P < 0.05$) different from each other. Enzyme supplementation improved the index in all replacement groups. The effects of supplementation were seen more in case of finger millet (T_7) and foxtail millet (T_9) based diets. The values obtained in these diets were not significantly ($P<0.05$) different with control. Supplementation of enzyme either in pearl millet (T_5) or sorghum (T_3) based diet did not significantly ($P < 0.05$) improved the index as compared to unsupplemented diet. The higher PI value (345) was obtained in pearl millet based enzyme supplemented diet (T_5), though comparable with their unsupplemented diet but significantly ($P<0.05$) higher than other dietary treatments.

4 - 7 weeks

During this phase of growth the value for performance index ranging from 212 - 343 g were significantly influenced by dietary treatments. The lowest index value (212) was obtained in groups fed foxtail millet based diet (T_8) and was significantly ($P < 0.05$) lower than control and other replacement groups. The highest index value (330) was obtained in pearl millet based diet (T_4) though comparable with control diet (T_1) but significantly ($P<0.05$) higher than all other replacement diets. Each values for performance index is replacement group were significantly ($P<0.05$) different from each other. Supplementation of enzyme in all replacement groups produced significant effect in increasing the index values. Birds fed diet based on sorghum (T_3), finger millet (T_7) and foxtail millet (T_9) supplemented with enzyme were comparable and not significantly ($P<0.05$) different from each other. However, these values were significantly ($P<0.05$) lower than control group. The highest value of for performance index (343) was obtained in groups fed pearl millet based diet supplemented with enzyme (T_5) was significantly higher than other replacement group.

0 - 7 weeks

The performance index during the entire experimental period was significantly ($P<0.05$) influenced by dietary treatments. It ranged from 428 to 673. Birds fed sorghum (T_2), finger millet (T_6) and foxtail millet (T_8) based diet showed significantly ($P < 0.05$) lower index value than control group, however, the value for index in pearl millet based diet (T_4) and maize based diet (T1) was not significantly ($P < 0.05$) different but was significantly ($P < 0.05$) higher than other replacement groups. Milo and millets based diets supplemented with enzyme increased the index value than without supplemented with enzyme increased the index value than without supplementation. A significant ($P < 0.05$) increased index value was obtained in finger millet (T_6) and foxtail millet(T_8) based diets while no significant($P<0.05$) increase in index value was obtained in sorghum(T_3) and pearl millet(T_5) based diet through supplementation of enzyme. The values obtained for index in sorghum (T_3), finger millet(T_7) and foxtail millet(T_9) based diet with supplementation of enzyme were not significantly ($P < 0.05$) different but was found to be lower than control group(T_1). The highest index value (673) was obtained in group fed pearl millet supplemented with enzyme (T_5) though not significantly ($P < 0.05$) different from respective unsupplemented group (T_4) but was significantly higher than control (T_1) and other replacement groups.

The efficiency of the feed utilization was found to be lower in milo and millet based diet than maize based diet except the groups reared on pearl millet based diet .The lower efficiency of feed utilization might be due to increased NSPs and other anti -nutritive factors present in the millets and milo. In case of foxtail millet based diet, the adverse effect may be due to high fibre content in comparison to maize as the birds do not posses the ability to deal with the feed ingredients of high fibre content due to lack of proper enzyme. An adverse effect on weight gain was also seen in the groups fed sorghum based diet Sorghum used in this ration may contain high tannin, a depressant growth factor and also in case of finger millet which may contain NSPs and other anti- nutritive factors (Ramchandra *et. al.*, 1977; singh *et. al.*, 1987). High fibre and other anti-nutritive factors could affect the efficiency of feed utilization was also reported by several workers (Thakur *et.al.*, 1984; Malik and Quisenberry, 1963; Rostango *et.al.*, 1973; Shafique,1973; Sadagopan,1994; Dixit and Baghel 1997; Purushothaman and Thirumalai,1995a; Sinha *et.al.*, 1980; Singh and Barsaul,1976).Better feed utilization and PI value on pearl millet based diet in comparison to maize might be due to the variety used in this experiment could be of good quality. Results obtained in this experiment also agreed well with the findings of Asha Rajini *et.al.*, 1986; Sharma *et. al.,* 1979; Sinha *et al.,1980*. However, Nagra *et al.*, 1987; Reddy *et al* 1989; Reddy *et al.*, 1991; Qureshi, 1967; Asha Rajini and Vedhanayagam , 1983,could not get any improvement in feed utilization by pearl millet based diet than maize based diet which might be due to variety differences. Supplementation of enzyme produced positive effect in efficiency of feed utilization and index value in the groups fed finger millet and foxtail millet based diets. The beneficial effect in improving the efficiency of feed utilization might be due to specific enzyme able to remove or destroy the NSPs and other anti-nutritive factors present in multienzyme. No such effect was seen in either sorghum based diet or pearl millet based diet for which the reasons have already been outlined. Supplementation of enzyme in improving the efficiency of feed utilization and performance index of the birds diets with high fiber and other anti-nutritive factors was also reported by (Arunbabu and Devegowda, 1997; Bhatt *et al.*, 1991;., 1986; Herstad *et al.*, 1975; Broz, 1987; Madacsi *et al.*, 1998; Cambell, 1986; Rotter *et al.*, 1989; Arora, 1990; Sharma, 1990;Devegowda and Nagalakshmi,1992; Suresha,1995).Some reports are also available in which they could not find any significant differences in efficiency of feed utilization with these millet based diets. Abate and Gomez (1984) reported that in finger millet based diet feed conversion efficiency was poor during starting phase but an improvement was noticed during finishing phases of growth and the overall feed efficiency was comparable to maize at the end of experiment. Baghel and Netke (1982) suggested that foxtail millet based diet could produce better effect in the efficiency of feed utilization when fed along with soyabean meal instead of groundnut cake and fishmeal. Rao *et al.*,(1996) found a significant improvement in feed efficiency when maize was replaced by supplementation of enzyme in finger millet based diet, also testified the results in this experiment.

Carcass traits

The data on carcass traits with respect to different parameters and their analysis of variance are given in table11, 12 and13 and appendix table 5 to 9 respectively. All the percentage figure have been converted into arcsin as per C. I. Bliss and then statistically analysed.

Processing Losses

The shrinkage percentage expressed as percentage of live weight ranged from 3.15 to 3.31 was not significantly influenced by dietary treatments chicks fed either control diet(T_1) or milo and millets based diet(T_2-T_9) did not show any variations in shrinkage percentage and the values obtained were within the normal range. The blood loss percentage and feather loss percentage expressed, as percentages of preslaughter weight were significantly ($P < 0.05$) influenced by dietary treatments Blood loss percentages in chicks fed maize based control diet had significantly ($P < 0.05$) higher blood loss in comparison to other replacement diets. The blood loss percentage ranges from 4.41 to 5.70 percent. Diet based on milo and millets has similar blood loss percentage and were not significantly ($P < 0.05$) different from each other. The feather loss percentage ranging from 5.98 to 6.68 did not show a clear cut trend. Sorghum based diet without any enzyme supplementation showed highest feather loss percentage and was significantly ($P<0.05$) higher than control and other replacement diets.

Dressing and Eviscerated percentage

The dressing percentages was significantly ($P < 0.05$) influenced by the dietary treatments and ranged from 76.1 to 80.56 percent. Birds fed pearl millet based diet with or without supplementation of enzyme (T_4andT_5) showed significantly($P<0.05$) higher dressing percentage in comparison to control and other diets. The dressing percentage of chicks fed either finger millet or foxtail millet based diet with or without enzyme supplementation showed comparable dressing percentages and was significantly ($P<0.05$) lower than control diet. Similarly, sorghum based diet with or without enzyme supplementation showed comparable dressing percentage value and was significantly ($P < 0.05$) lower than control but higher than other millet based diets.

The eviscerated percentage ranging from 67.16 to 70.4 was significantly ($P < 0.05$) influenced by the dietary treatments. The eviscerated percentages of different dietary treatment showed similar trend as was observed in dressing percentage with slight variations. Sorghum, finger millet and foxtail millet based diet showed comparable percentages than control and pearl millet based groups. The highest eviscerated percentage were obtained in the group fed pearl millet based diet with or without enzyme supplementation and was significantly ($P<0.05$) higher than control and other experimental group. In general both dressing and eviscerated percentage were found to be higher in groups which had higher preslaughter weight.

Results indicated that supplementation of enzyme decrease the eviscerated percentage which may be due to lower pre-slaughter weight of the birds selected for carcass study. In general heavier birds with higher body weight had the higher eviscerated percentage. Raina (1974) and Pandey (1992) also gave such reports that chicks with higher body weight had higher dressing and eviscerated percentage. However, Sunaria (1977) reported no significant effect on dressing or eviscerated percentage, though the live weight was significantly reduced by the dietary treatments.

Bone Percentage, Meat and Bone ratio

Ready to cook weight, Bone weight, weight of raw edible meat, meat and bone ration and bone percentage (as percentage of ready to cook) and their analysis of variance is presented in table 12 and their analysis of variance in appendix table 7.

The ready to cook weight, bone weight and percentage of bone, expressed as ready to cook weight were significantly ($P<0.05$) influenced by dietary treatments. The bone percentage ranged from 16.08 to 19.88 were converted to corresponding arcsin value and then statistically analysed. From the data it appeared that the birds which had higher ready to cook weight reflected lower percentage of bone. The lowest bone percent (16.08) was obtained in chicks fed pearl millet based diet supplemented with enzyme (T_5) and was comparable with the same diet without any supplementation (T_4) and control diet (T_1), but significantly ($P < 0.05$) lower than other milo and millets based diet. The highest bone percentage was obtained in chicks fed foxtail millet based diet without enzyme supplementation (T_8) and was significantly ($P<0.05$) higher than all

Table 11 : Treatment means, SE of angles corresponding to the percentages (Angle = Arcsin √Percentage) of carcass traits of broilers at the end of experimental period.

Treatment	Live weight (g)		As % of live weight	As % of Pre - slaughter weight			
		Pre-slaughter wt. (g)	Shrinkage %	Blood Loss %	Feather loss %	Dressing %	Eviscerated %
T_1	$1474^{d} \pm 20.61$	$1427^{d} \pm 19.70$	(3.18) $10.26^{NS} \pm 0.07$	(5.70) $13.81^{b} \pm 0.05$	(6.10) $14.3^{a} \pm 0.06$	(78.65) $62.52^{d} \pm 0.41$	(68.55) $55.89^{c} \pm 0.16$
T_2	$1276^{bc} \pm 29.47$	$1236^{bc} \pm 29.01$	(3.13) $10.22^{NS} \pm 0.08$	(4.54) $12.32^{a} \pm 0.13$	(6.68) $15.00^{b} \pm 0.18$	(77.29) $61.53^{c} \pm 0.17$	(67.67) $55.32^{b} \pm 0.05$
T_3	$12.66^{bc} \pm 21.96$	$1225^{b} \pm 20.90$	(3.23) $10.38^{NS} \pm 0.14$	(4.61) $12.42^{a} \pm 0.08$	(5.61) $14.92^{ab} \pm 0.15$	(77.23) $61.51^{c} \pm 0.05$	(67.56) $55.27^{ab} \pm 0.12$
T_4	$1571^{f} \pm 32.92$	$1517^{e} \pm 32.23$	(3.31) $10.51^{NS} \pm 0.07$	(4.45) $12.18^{a} \pm 0.24$	(6.00) $14.18^{a} \pm 0.04$	(80.16) $63.55^{e} \pm 0.06$	(70.07) $56.84^{d} \pm 0.03$
T_5	$1557^{e} \pm 29.53$	$1506^{e} \pm 28.98$	(3.27) $10.43^{NS} \pm 0.07$	(4.52) $12.32^{a} \pm 0.19$	(4.52) $14.18^{a} \pm 0.19$	(80.56) $63.85^{e} \pm 0.06$	(40.40) $57.04^{d} \pm 0.18$
T_6	$1208^{ab} \pm 13.58$	$1171^{ab} \pm 13.31$	(3.06) $10.06^{NS} \pm 0.05$	(4.47) $12.21^{a} \pm 0.25$	(6.12) $14.36^{a} \pm 0.15$	(76.44) $60.99^{ab} \pm 0.06$	(67.40) $55.18^{ab} \pm 0.04$
T_7	$1255^{bc} \pm 22.17$	$1215^{b} \pm 20.61$	(3.18) $10.22^{NS} \pm 0.19$	(4.42) $12.18^{a} \pm 0.19$	(6.08) $14.30^{a} \pm 0.08$	(76.37) $60.94^{a} \pm 0.08$	(87.52) $55.32^{b} \pm 0.02$
T_8	$1164^{a} \pm 14.46$	$1125^{a} \pm 13.91$	(3.25) $10.34^{NS} \pm 0.07$	(4.41) $12.14^{a} \pm 0.26$	(5.98) $14.15^{a} \pm 0.12$	(76.09) $60.70^{a} \pm 0.03$	(67.16) $55.03^{a} \pm 0.03$
T_9	$1298^{c} \pm 20.89$	$1257^{c} \pm 20.09$	(3.15) $10.23^{NS} \pm 0.08$	(4.47) $12.21^{a} \pm 0.20$	(6.09) $14.30^{a} \pm 0.08$	(77.14) $61.41^{bc} \pm 0.04$	(67.83) $55.45^{b} \pm 0.01$
CD ($P < 0.05$)	68.77	66.68	--	0.56	0.35	0.46	0.27

Means with same superscript in a column do not differ significantly ($P < 0.05$)
Figures within parentheses indicate actual percentage.

Table - 12 : Treatment means of carcass traits of broiler at the end of experimental period

Treatment	Ready - to - cook weight (g)	Bone weight (g)	Bone (%)*	Raw edible meat weight (g)	Meat/bone ratio
T_1	$873^{d} \pm 9.83$	$143^{d} \pm 1.29$	(16.38) $23.87^{ab} \pm 0.09$	$730^{d} \pm 8.80$	$5.10^{e} \pm 0.04$
T_2	$753^{c} \pm 17.65$	$128^{a} \pm 2.58$	(17.00) $24.35^{bc} \pm 0.18$	$625^{c} \pm 15.69$	$4.88^{de} \pm 0.09$
T_3	$743^{bc} \pm 13.38$	$131^{ab} \pm 1.22$	(17.64) $24.82^{cd} \pm 0.27$	$612^{bc} \pm 13.57$	4.67^{cd} 0.12
T_4	$944^{e} \pm 19.12$	$154^{e} \pm 1.82$	(16.31) 23.81^{ab} 0.18	$790^{e} \pm 17.94$	$5.13^{ef} \pm 0.09$
T_5	$945^{e} \pm 19.04$	$152^{e} \pm 0.91$	(16.08) $26.68^{a} \pm 0.17$	$793^{e} \pm 18.18$	$5.22^{f} \pm 0.08$
T_6	$706^{ab} \pm 7.88$	$129^{a} \pm 1.22$	(18.27) $25.29^{de} \pm 0.20$	$577^{ab} \pm 8.10$	$4.47^{bc} \pm 0.08$
T_7	$741^{b} \pm 12.65$	$138^{c} \pm 1.82$	(18.63) $25.29^{e} \pm 0.16$	$603^{b} \pm 11.38$	$4.37^{b} \pm 0.06$
T_8	$679^{a} \pm 8.58$	$135^{bc} \pm 2.38$	(19.88) $26.47^{f} \pm 0.29$	$544^{a} \pm 8.64$	$4.03^{a} \pm 0.05$
T_9	$772^{c} \pm 12.06$	$137^{c} \pm 1.47$	(17.75) $24.91^{cd} \pm 0.26$	$635^{c} \pm 12.25$	$4.64^{bcd} \pm 0.11$
CD ($P < 0.05$)	40.64	4.80	0.62	38.52	0.27

* As percentage of ready to cook weight.
Means with same superscript in a column do not differ significantly ($P < 0.05$)
Figures within parentheses indicate actual percentage.

experimental groups. Trend of the result showed that lighter birds had higher bone percentage than heavier bird.

The ratios of edible meat to bone were significantly ($P<0.05$) influenced by different dietary treatments. The highest ratio (5.22) was obtained in chicks fed *barja* based diet supplemented with enzyme (T_5) followed by the diet without supplementation (T_4) and both were comparable while the latter did not differ significantly ($P < 0.05$) with control diet(T_1). Foxtail millet and finger millet based diet without and with enzyme supplementation showed significantly lower ratios than control diet. The lowest ratio (4.03) was obtained in finger millet based diet without enzyme supplementation(T_6) and was significantly($P<0.05$) lower than other experimental diets. The ratios in sorghum and finger millet based diets were not significantly different from their respective enzyme supplemented diet.

Results indicated that the heavier birds had high degree of fleshing in comparison to bone due to the fact that the muscle in comparison to bone have high content of protein showing its efficient utilization. The lower ratios in milo and millets based diets with or without enzyme supplementation might be due to improper utilization of nutrients reflecting lower body weight gain. Dawson et al. (1957) also reported that bone percentage increased with the lower body size and decreased with the higher body size.

Weight of different body organs

The weight of different organs (liver, gizzard and heart as well as neck) expressed as percentage of preslaughter weight and their analysis of variance are given in table 13 and appendix table 8 & 9 respectively. The percentage figures were converted to arcsin and then statistically analysed.

Liver Weight

The liver weight expressed as percentage of preslaughter weight was significantly ($P < 0.05$) influenced by dietary treatment and ranged from 2.10 to 2.73 percent. The highest weight of liver was observed in group fed pearl millet based diet without enzyme supplementation (T_4) and was not significantly ($P < 0.05$) different from enzyme supplemented diet (T_5) and sorghum based diet (T_3). However, it differed from control and other milo and millets based diets with without enzyme supplementation. The lowest weight of liver was obtained in diet based on foxtail millet supplemented with enzyme (T_9) and was comparable with T_2, T_7 and T_8.

Gizzard Weight

The weight of gizzard expressed as percentage of preslaughter weight, ranging from 1.78 to 2.12, was significantly ($P < 0.05$) influenced by dietary treatments. Chicks fed finger millet based diet without enzyme supplementation (T_6), produced heavier gizzard in comparison to all other diets except foxtail millet based diet without supplementation (T_8). The latter group did not differed significantly ($P < 0.05$) with pearl millet based diet with or without supplementation. Supplementation of enzyme in sorghum and foxtail millet diet showed lower weight of gizzard than other groups. Supplementation of enzyme in pearl millet based diet did not produced any significant ($P < 0.05$) effect in the

Table 13 : Treatment mean and S.E of angles corresponding to the percentages (Angle =Arc sin √percentage) of different body/organ cuts at the end of experimental period.

Treatment	Liver %	Gizzard %	Heart %	Giblet %	Neck %	Neck + Giblet %
T_1	(2.39) $8.91^{bc} \pm 0.07$	(2.03) $8.18^{c} \pm 0.05$	(0.70) $4.80^{e} \pm 0.04$	(5.12) $13.08^{e} \pm 0.03$	(2.26) $8.67^{c} \pm 0.04$	(7.38) $15.79^{f} \pm 0.04$
T_2	(2.24) $8.63^{ab} \pm 0.05$	(1.90) $7.97^{b} \pm 0.10$	(0.64) $4.58^{cd} \pm 0.09$	(4.78) $12.63^{c} \pm 0.03$	(1.96) $8.02^{b} \pm 0.06$	(6.74) $15.06^{bc} \pm 0.07$
T_3	(2.56) $9.24^{cde} \pm 0.04$	(1.81) $7.76^{a} \pm 0.05$	(0.59) $4.41^{ab} \pm 0.04$	(4.96) $12.86^{d} \pm 0.03$	(1.94) $8.03^{b} \pm 0.06$	(6.90) $15.23^{d} \pm 0.06$
T_4	(2.73) $9.50^{e} \pm 0.13$	(2.04) $8.23^{cd} \pm 0.05$	(0.72) $4.87^{e} \pm 0.05$	(5.49) $13.53^{h} \pm 0.03$	(2.34) $8.82^{c} \pm 0.05$	(7.83) $16.25^{h} \pm 0.01$
T_5	(2.60) $9.28^{de} \pm 0.16$	(2.05) $8.23^{cd} \pm 0.05$	(0.68) $4.73^{de} \pm 0.05$	(5.33) $13.34^{g} \pm 0.03$	(2.31) $8.77^{c} \pm 0.04$	(7.64) $16.06^{g} \pm 0.05$
T_6	(2.46) $9.00^{cd} \pm 0.05$	(2.15) $8.48^{e} \pm 0.05$	(0.62) $4.51^{c} \pm 0.08$	(5.23) $13.21^{f} \pm 0.03$	(1.86) $7.82^{a} \pm 0.06$	(7.09) 15.45 ± 0.04
T_7	(2.20) $8.52^{a} \pm 0.17$	(1.84) $7.82^{ab} \pm 0.06$	(0.63) $4.55^{cd} \pm 0.03$	(4.67) $12.46^{b} \pm 0.50$	(1.93) $7.97^{ab} \pm 0.05$	(6.66) $14.92^{b} \pm 0.05$
T_8	(2.21) $8.58^{ab} \pm 0.04$	(2.12) $8.38^{de} \pm 0.05$	(0.60) $4.44^{ab} \pm 0.07$	(4.93) $12.82^{d} \pm 0.06$	(1.84) $7.82^{a} \pm 0.06$	(6.77) $15.12^{cd} \pm 0.06$
T_9	(2.10) $8.33^{a} \pm 0.18$	(1.78) $7.71^{a} \pm 0.08$	(0.56) $4.29^{a} \pm 0.07$	(4.44) $12.18^{a} \pm 0.04$	(1.99) $8.08^{b} \pm 0.05$	(6.43) $14.68^{a} \pm 0.05$
CD ($P < 0.05$)	0.34	0.18	0.18	0.11	0.16	0.16

Means with same superscript in a column do not differ significantly ($P < 0.05$)
Figures in parentheses indicate actual percentage.

weight of gizzard. The lowest weight of gizzard was observed in groups fed foxtail millet based diet with enzyme supplementation (T_9) and was statistically non - significant ($P < 0.05$) with T_3 and T_7. The other dietary treatments T_1, T_4 and T_5 were comparable.

Results indicated a trend of significant decrease in liver weight on enzyme supplementation was found in milo and millets based diets, which corresponded with lower preslaughter weight. No clear cut trend was found. A significant increase in gizzard weight in case of finger millet and foxtail millet based diets without enzyme supplementation in comparison to other dietary treatment was indicated which might be due to higher fibre content in the finger millet and foxtail millet. Hakansson (1978) and Sadagopan et al. (1996) have also reported the increased weight of gizzard on high fibre nutrient deficient diet.

Heart Weight

The weight of heart expressed as percentage of preslaughter weight,ranged from 0.06 to 0.72, was highest in pearl millet based diet without supplementation of enzyme and was not significantly ($P < 0.05$) different from control and the same diet supplemented with enzyme. No regular trend in weight of heart was observed in different dietary treatments. In some millet there was a tendency to have a heart of lower weight in the groups fed diets supplemented with enzyme,while in others the reverse effect was seen .

The increase weight of some of the organs on high fibre unsplemented diet might be due to stimulated development of gastrointestinal system (Hakansson, 1978).

Giblet Weight

The percentage of giblet ranging from 4.44 to 5.49, was significantly ($P < 0.5$) influenced by dietary treatments. All millet based diet without supplementation of enzyme had higher giblet percentage in comparison to enzyme supplemented diet while a reverse trend was found in milo based diet in which enzyme supplemented group showed higher giblet percentage. The giblet percentage differed each other irrespective of supplementation or without supplementation of enzyme.

Neck weight, Neck + giblet weight

The percentage of neck in different groups differed significantly ($P < 0.05$). Results indicated that the groups with higher preslaughter weight also reflected higher percentage of neck. Pearl millet based diet with (T_5) or without (T_4) higher percentage of neck followed by control(T_1). Supplementation of enzyme in finger millet and foxtail millet based diet showed higher percentage of neck than their respective and unsupplemented diet.

The combined percentage of neck and giblet ranging from 6.43 to 7.83 , presented in table 13 and appendix table 9, were significantly ($P < 0.05$) influenced by dietary treatments. The patterns of result obtained in different groups were similar as was found in giblet percentage. A reduction in neck and giblet percentage was observed in millet based diet supplemented with enzyme but no reduction was found in sorghum based diet with enzyme supplementation (T_3). In general the percentage giblet were the reflection of preslaughter weight in different groups.

Carcass Composition

Data pertaining to chemical composition of thigh and breast muscles in terms of moisture percentage, protein percentage and ether extract percentage and their analysis of variance are given in table 14 and appendix table 10 respectively.

Moisture Percentage

The moisture percentage of thigh and breast muscles ranging from 70.54 to 72.71 and 71.41 to 73.67 were significantly ($P < 0.05$) influenced by different dietary treatments. Chicks fed pearl millet based diet without enzyme supplementation (T_4) had significantly ($P < 0.05$) higher percentages of moisture in comparison to control and other diets in both types of muscles. Supplementation of enzyme produced non-significant effect on the reduction of moisture content of both types of muscles. The moisture content in breast muscle was not affected by supplementation of enzyme in milo and millets based diets while no such trend was obtained in case of thigh muscle. On comparing between thigh and breast muscles, a higher moisture content was obtained in breast muscle than thigh muscle.

Table 14 : Treatment means and S.E of angles (Angle = Arcsin √percentage) corresponding to the percentage of chemical composition of thigh and breast muscle of the birds at the end of experimental period

Treatment	Thigh Muscle			Breast Muscle		
	Moisture %	Protein %	Ether Extract %	Moisture %	Protein %	Ether Extract %
T_1	(71.77) $57.91^{cd} \pm 0.12$	(20.95) $27.24^{c} \pm 0.15$	(5.41) $13.43^{abc} \pm 0.31$	(72.86) $58.88^{b} \pm 0.22$	(22.43) $28.26^{b} \pm 0.14$	(2.68) $9.45^{a} \pm 0.26$
T_2	(72.48) $(50.36^{ef} \pm 0.18$	(21.49) $27.65^{ef} \pm 0.16$	(4.86) $12.75^{ab} \pm 0.32$	(73.66) $59.15^{c} \pm 0.13$	(23.26) $28.83^{c} \pm 0.14$	(2.16) $8.51^{a} \pm 0.25$
T_3	(72.28) $58.25^{def} \pm 0.04$	(21.11) $27.35^{def} \pm 0.07$	(5.58) $13.65^{bc} \pm 0.31$	(73.60) $59.08^{c} \pm 0.11$	(23.21) $28.80^{c} \pm 0.06$	(2.25) $8.72^{a} \pm 0.22$
T_4	(72.71) $58.50^{f} \pm 0.10$	(21.70) $27.66^{f} \pm 0.16$	(4.71) $12.55^{a} \pm 0.23$	(73.67) $59.15^{c} \pm 0.10$	(22.45) $28.32^{b} \pm 0.03$	(2.69) $8.99^{a} \pm 0.32$
T_5	(72.24) $58.19^{de} \pm 0.14$	(21.25) $27.45^{cde} \pm 0.09$	(5.60) $13.67^{bc} \pm 0.39$	(73.56) $59.34^{c} \pm 0.19$	(22.40) $28.25^{b} \pm 0.06$	(2.74) $9.44^{a} \pm 0.38$
T_6	(70.67) $57.23^{ab} \pm 0.24$	(20.14) $26.67^{a} \pm 0.19$	(5.90) $14.06^{c} \pm 0.21$	(71.54) $57.73^{a} \pm 0.08$	(21.41) $27.56^{a} \pm 0.12$	(3.69) $11.09^{b} \pm 0.14$
T_7	(70.54) $57.11^{a} \pm 0.18$	(20.06) $26.62^{a} \pm 0.04$	(5.98) $14.15^{c} \pm 0.13$	(71.41) $57.67^{a} \pm 0.09$	(21.36) $27.56^{a} \pm 0.07$	(3.74) $11.09^{b} \pm 0.14$
T_8	(71.87) $58.01^{cde} \pm 0.07$	(21.10) $27.35^{cd} \pm 0.11$	(5.38) $13.41^{abc} \pm 0.06$	(72.75) $58.82^{b} \pm 0.23$	(22.40) $28.25^{b} \pm 0.13$	(2.85) $9.80^{a} \pm 0.25$
T_9	(71.32) $57.61^{bc} \pm 0.15$	(20.57) $26.96^{b} \pm 0.07$	(5.46) $13.56^{abc} \pm 0.23$	(72.69) $58.50^{b} \pm 0.09$	(22.34) $28.18^{b} \pm 0.08$	(2.73) $9.97^{a} \pm 0.15$
CD ($P < 0.05$)	0.43	0.34	0.76	0.40	0.29	0.72

Means bearing same superscript in a column do not differ significantly ($P < 0.05$).
Figures in parentheses indicate actual percentage.

Protein Percentage

The protein percentage of thigh muscle and breast muscles ranged from 20.06 to 21.70 and 21.36 to 23.26, respectively and were significantly ($P < 0.05$) affected by dietary treatments. The protein percentage in both type of muscles were not affected by enzyme supplementation rather a non -significant ($P < 0.05$) reduction in protein percentage was obtained by supplementation of enzyme in milo and millets based diets.

Results indicated a positive correlation between moisture percentage and protein percentage in both types of muscles in which the groups, which had high percentage of moisture in muscle also, had higher percentage of protein. A comparison between thigh and breast muscle indicated a higher percentage of protein in breast muscle than thigh muscle irrespective of different dietary treatment with or without enzyme supplementation.

Ether Extract Percentage

The ether extract contents of thigh and breast muscles on wet basis ranged from 4.71 to 5.98 and 2.16 to 3.74, respectively and were also significantly ($P < 0.05$) affected by dietary treatments. An increasing content in percentage of ether extract was obtained in thigh muscle by supplementation of enzyme in milo and millets based diets while a reverse trend were noted in foxtail millet based diets for breast muscle. It was further observed that in pearl millet based diet (T_5) there was a significant ($P < 0.05$) increase in ether extract percentage by enzyme supplementation with respect to corresponding unsupplemented group (T_4). In general, the thigh muscle had higher ether extract percentage than breast muscle.

Results of the chemical composition indicated that a significant ($P < 0.05$) effect in carcass composition was noted with the type of diet and enzyme supplementation as was evident in moisture and protein percentages in both types of muscles. In general, the fat content, in muscle was increased as a result of enzyme supplementation whereas moisture and crude protein were decreased.

Results indicated a positive relationship between moisture percentage and protein percentage in both types of muscles while an inverse relationship was obtained between protein percentage and ether extract percentage in both type of muscles.

In general, the fat content, in muscle was increased as a result of the enzyme supplementation whereas water content and crude protein decreased.

Mortality

Mortality during different weeks is given in the table 15. Out of a total of 180 chicks used for the study, 7 died during the course of entire experimental period. Thus mortality was 3.88 percent of the total. Table 15 reveals that during first week, 5 chicks died. Thus the total mortality during the first week was 2.77 percent. There was no particular trend of deaths among the chicks on various dietary treatments. No mortality was observed during second, third and fourth week. During fifth week of study a total of two chicks died, one in each from T_3 and T_8 raising the total mortality to 3.88 percent. When considered for the entire period of seven weeks, highest mortality was observed in finger millet (T_6) and foxtail millet (T_8) based diet without enzyme which were 10% and no mortality in

Table 15 : Mortality in different weeks

Treatment Group → / Age Weeks ↓	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Birds left over	Total Mortality %
1	-	1	-	1	-	2	-	1		175	2.77
2										175	2.77
3										175	2.77
4										175	2.77
5			1					1		173	3.88
6										173	3.88
7										173	3.88
Total	-	1	1	1	-	2	-	2	-	173	3.88
% mortality		5	5	5	.	10	-	10			

T_1, T_5, T_7 and T_9. However, the mortality percentage in entire experimental period was within the normal range.

Results indicated that higher mortality was observed in T_6 and T_8 with respect to their corresponding enzyme supplemented diet T_7 and T_9 respectively. The higher mortality in these groups could not be explained for want of evidence and might be due to environmental and managemental factors.

Economics

Cost per kg live weight was calculated on the basis of feed cost and cost of survived chicks from 0 - 7 weeks. Actual cost of feed was calculated on the basis of rate of feed ingredients purchased locally plus cost of supplemented enzyme. The cost of both types of rations (Starter and Finisher) ranged from Rs. 7.64 to Rs. 9.16. The variability in the cost of rations used in different treatments was mainly due to varying cost of cereals replaced by maize as well as enzyme supplementation. A reduction in the cost of ration was evident, as millets replaced the maize. However, an increase in cost of rations containing sorghum, with and without enzyme, was more in comparison to control ration as the price of sorghum at that time in local market was higher than maize. Enzyme supplementation in millet based diets increased the cost of ration but the increased cost was compensated with an increase in live weight gain.

The cost of feed per kg live weight were comparatively less in the enzyme supplemented groups of millet based diets and lowest cost was found in case of unsupplemented pearl millet based diets (T_4). Considering the cost of enzyme in relation to increase in body weight, it was found that chicks fed enzyme-supplemented diet gave more economical gain. The increased cost of rations due to enzyme supplementation was compensated more or less by increase in body weight and thus recorded more margin of profit. The marginal reduction in cost per kg live weight in millets based diets than maize was due to increased cost of survived chicks in these groups whereas no mortality occurred in maize based diet during entire experimental period resulting in lower cost of survived chicks.

Table 16 : Economics as influenced by various dietary treatments

Treatments	Cost/kg starter ration (Rs.)	Cost of starter ration consumed (Rs.)	Cost/kg finisher ration (Rs.)	Cost of finisher ration consumed (Rs.)	Total feed cost (Rs.)	Cost of survived chicks (Rs.)	Total cost (Rs.)	Average live weight of chicks (g)	Total cost/kg live weight (Rs.)
T_1	8.28	9.57	8.19	18.54	28.11	15.00	43.11	1442	29.90
T_2	8.61	9.27	8.55	16.88	26.15	15.79	41.94	1221	34.35
T_3	9.16	10.06	9.10	18.06	28.12	15.79	43.91	1261	34.82
T_4	8.01	9.93	7.89	18.73	28.66	15.79	44.45	1526	29.13
T_5	8.56	10.90	8.44	19.85	30.75	15.00	45.75	1561	29.31
T_6	7.66	8.02	7.50	15.31	23.33	16.67	40.00	1180	33.90
T_7	8.21	9.33	8.05	15.31	24.64	15.00	39.64	1269	31.24
T_8	7.64	7.50	7.47	15.22	22.72	16.67	39.39	1138	34.61
T_9	8.19	9.38	8.02	15.61	24.99	15.000	39.99	1292	30.95

Chapter 4

Summary and Conclusion

Summary and Conclusion

Energy and protein constitutes the major nutrients in the formulation of broiler rations, and energy sources constitute more that 50% in the rations. Maize is traditionally used in the practical rations of broilers, providing major source energy supplier. However, under certain circumstances particularly its high demand, low availability, diversions for human consumption are some major constraints, which necessitates to include some alternate source of energy in broiler ration. Researches are being conducted and are still in progress in this direction to explore the possibility of using alternate sources of energy under local conditions in order to replace partially or completely maize in broiler rations. Some of the milo and millets could be regarded as a potential replacer of maize. Various workers have used sorghum and some of the millets like pearl millet, finger millet and foxtail millet as replacer of maize with variable results. Researches have also indicated that enzyme supplementation could produce beneficial effects on the performance of broilers, particularly for those milo and millets based rations which have antinutritive factors present in them. Thus in view of the above facts a feeding trial involving 180-day-old broiler chicks of commercial strain was conducted for a period of seven weeks to evaluate the potentiality of sorghum, pearl millet, finger millet and foxtail millet with or without enzyme as replacer of maize in broiler rations. The dietary treatment consisted of nine groups in which maize based ration served as control (T_1) while other dietary treatments (T_2 to T_9) were formulated in such a way that maize of control diet were replaced completely by sorghum, pearl millet, finger millet and foxtail millet without or with 0.05% enzyme supplementation. The experimental diets were fed from 0 - 4 weeks (starter ration) and 4 - 7 weeks (finisher ration).

Parameters relating to performance and carcass quality were recorded. The following results and conclusion were drawn as follows.

Body weight gain

The average weight gain during 0 - 4 weeks ranged from 484 to 663 g and there was significant improvement in weight gain in chicks fed pearl millet based diet with or without enzyme supplementation. A significant lower weight gain was obtained in chicks fed sorghum based diet than control but comparable with finger millet and foxtail millet based diets. Supplementation of enzyme showed beneficial effect only in finger millet and foxtail millet based diets but no such effect was seen in sorghum or pearl millet based diet.

The body weight gain during 4 - 7 weeks ranged from 657 to 898 g was significantly influenced by dietary treatments. The weight gain showed a similar pattern as was observed during starting phase. However, supplementation of enzyme showed only positive effect in foxtail millet based diet while in other groups no beneficial effect of enzyme was seen during this phase.

The body weight gain during entire experimental period ranged from 1138 to 1561 g. Chicks fed pearl millet based diet showed higher body weight gain while other milo and millets based diet showed significantly lower weight gain than control. Supplementation of enzyme in finger millet and foxtail millet based diet showed positive effect while in other groups supplementation of enzyme could not produce beneficial effects.

Feed Consumption

The feed intake during 0 - 4, 4 - 7 and during entire experimental period (0 - 7 weeks) were influenced by dietary treatments. Birds fed sorghum, finger millet and foxtail millet based diet consumed lower amount of feed while higher amount of feed was consumed in pearl millet based diet than control. Supplementation of enzyme in all replacement diet did not reduce feed consumption with respect to their unsupplemented diet.

Feed Conversion Ratio (FCR) and Performance Index (PI)

The FCR during 0 - 4 weeks, 4 - 7 weeks and 0 - 7 weeks ranged from 1.92 to 2.09, 2.61 - 2.82 and 2.32 to 2.66 and were significantly ($P < 0.05$) affected by dietary treatments. The efficiency of feed utilization was found to be lower in milo, finger millet and foxtail millet based diet than control, while feed efficiency was found to be higher on pearl millet based diet. Supplementation of enzyme lowered the FCR value and was comparable with the control diet.

The performance index value during 0 - 4 weeks, 4 - 7 weeks and 0 - 7 weeks were significantly ($P < 0.05$) influenced by dietary treatments. Birds fed finger millet and foxtail millet based diet showed lower index value than control group while the value of pearl millet and maize based diets showed comparable value. Enzyme supplementation in finger millet and foxtail millet based diet showed beneficial effect in increasing the index value while no such effect was seen in sorghum and pearl millet based diets through supplementation of enzyme.

Carcass Traits

The processing losses in terms of blood loss percentage, feather loss percentage expressed as percentage of preslaughter weight were significantly influenced ($P < 0.05$) by dietary treatments. Diets based on milo and millets have similar blood loss percentage and were not significantly ($P < 0.05$) different from each other but lower than control. Feather loss percentage ranged from 5.98 to

6.68 showed significantly higher loss in sorghum based diets than control and other groups.

The dressing percentage and eviscerated percentage was significantly ($P < 0.05$) influenced by dietary treatments and ranged from 76.10 to 80.56 and 67.16 to 70.40 respectively. Birds fed pearl millet based diet with or without enzyme supplementation showed significantly ($P < 0.05$) higher dressing percentage and eviscerated percentage in comparison to control and other dietary treatments. The dressing percentage of chicks fed milo, finger millet or foxtail millet based diet with or without enzyme supplementation showed comparable dressing percentages and was significantly lower ($P < 0.05$) than control diet. In general higher live weight of birds reflected higher dressing and eviscerated percentages and the values were within normal range.

Bone percentage, meat and bone ratio

The bone percentage ranged from 16.08 to 19.88 was significantly influenced ($P < 0.05$) by dietary treatments. Results indicated that lighter birds had higher bone percentage than heavier birds. A numerical increase in bone percentage was obtained in the diets supplemented with enzyme except pearl millet and foxtail millet based diet where the enzyme supplementation decreased the bone percentage.

The meat to bone ratio was significantly influenced ($P < 0.05$) by different dietary treatments. The ratios were found to be higher in those birds which had higher degree of fleshing corresponding to the higher body weight gain of birds with slight variations.

Weight of different body organs

The weight of liver, gizzard, heart, giblet and neck expressed as percentage of preslaughter weight was significantly ($P < 0.05$) affected by dietary treatments. No regular trend in the weight of liver and gizzard was found either by replacement or by enzyme supplementation.

The highest gizzard weight was found in case of diet based on finger millet based diet without enzyme supplementation while, enzyme supplementation significantly reduced ($P < 0.05$) the gizzard weight in case of milo and millets except *bajra* based diet. No regular trend in weight of heart was observed in different dietary treatments. All the millet based diet without enzyme supplementation had higher giblet percentage in comparison to enzyme supplemented diet while a reverse trend was found in milo based diet. The results indicated that groups with higher preslaughter weight also reflected higher percentage of neck. The pattern of neck + giblet percentage in different groups were similar as found in giblet percentage. In general the percentage giblet were the reflection of preslaughter weight.

Carcass composition

Dietary treatments significantly ($P < 0.05$) affected the chemical composition of thigh and breast muscles. Birds fed pearl millet (*bajra)* based diet without enzyme supplementation showed significantly ($P < 0.05$) higher percentage of moisture, however, enzyme supplementation produced non - significant effect on the reduction of moisture content of both types of muscles. The protein percentage in both type of muscles were not affected by enzyme supplementation rather a non - significant ($P < 0.05$) reduction in protein percentage was obtained by supplementation of enzyme in milo and millets based diets. An increased content of ether extract was obtained in thigh muscle by supplementation of enzyme in milo and millets based diets, while a reverse trend were noted in foxtail millet based diets for breast muscles.

In general, thigh muscle higher ether extract and lower protein and moisture percentage than breast muscle in all dietary treatments.

Mortality

A total mortality of 3.88 percent was obtained in entire experiments. Out of the total mortality during first week itself was 2.77 percent. The mortality percentage was within the normal range. The mortality obtained could not be attributed to dietary treatments but may be due to managemental and other environmental factors.

Economics

A reduction in the cost of ration was evident, as millets replaced the maize, except milo based diet, enzyme supplementation in millets based diets increased the cost of ration but cost per kg live weight was comparable due to an increase in live weight. The cost per kg live weight were comparatively less in enzyme supplemented groups of millets based diet, however, lowest cost was found in case of unsupplemented pearl millet based diets.

Conclusion

Considering the overall performance of broilers, it can be concluded that among different millets studied, pearl millet seemed to be a promising replacer of maize while finger millet and foxtail millet based diet need supplementation of enzyme for optimum performance. The multienzyme preparation used in this experiment was unable to reduce or destroy the antinutritive factor present in milo (sorghum) responsible for adverse effect on the performance of birds.

Chapter 5

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Appendices

Appendix Table 1 : Analysis of variance of body weight gain during different experimental period

Sources of variation	Degree of freedom	0 - 4 weeks		Degree of freedom	4 - 7 weeks		Degree of freedom	0 - 7 weeks	
		Mean square	F - value		Mean square	F - value		Mean square	F - value
Treatment	8	70846.943	32.91**	8	170953.6485	68.26**	8	442892.4045	72.68**
Error	166	2029.3299		164	2504.3077		164	6092.9753	
Total	174			172			172		

** Significant at 1% level (P < 0.01)

Appendix Table 2 : Analysis of variance of feed consumption during different experimental period

Sources of variation	Degree of freedom	0 - 4 weeks		4 - 7 weeks		0 - 7 weeks	
		Mean square	F - value	Mean square	F - value	Mean square	F - value
Treatment	8	16778.63435	11.52**	66345.81295	50.12**	121357.1636	26.35**
Error	9	1456.19713		1323.692067		4605.64266	
Total	17						

** Significant at 1% level (P < 0.01)

Appendix Table 3 : Analysis of variance of feed conversion ratio during different experimental period

Sources of variation	Degree of freedom	0 - 4 weeks		4 - 7 weeks		0 - 7 weeks	
		Mean square	F - value	Mean square	F - value	Mean square	F - value
Treatment	8	0.006912	1.93^{NS}	0.05678	11.64**	0.02724025	8.56**
Error	9	0.003567		0.00488		0.0031824	
Total	17						

** Significant at 1% level (P < 0.01)
^{NS} Non - Significant

Appendix Table 4 : Analysis of variance of Performance Index during different experimental period

Sources of variation	Degree of freedom	0 - 4 weeks		4 - 7 weeks		0 - 7 weeks	
		Mean square	F - value	Mean square	F - value	Mean square	F - value
Treatment	8	2982.5488	16.92**	4544.05795	228.88**	14297.46908	35.13**
Error	9	176.2998		19.8527		407.03248	
Total	17						

** Significant at 1% level (P < 0.01)

Appendix Table 5 : Analysis of variance of live weight preslaughter weight and shrinkage percentage (as % of live weight) at the end of experimental periods

Sources of variation	Degree of freedom	Live weight		Preslaughter weight		Shrinkage %	
		Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value
Treatment	8	72679	32.35**	85833	40.64**	0.073290	1.73^{NS}
Error	27	2246.59		2111.92		0.04234	
Total	35						

** Significant at 1% levels (P < 0.01)
^{NS} Non Significant

Appendix Table 6 : Analysis of variance of carcass traits as angles (Angles = Arcsine √percentage) corresponding to percentages of preslaughter weight at the end of experimental periods

Sources of variation	Degree of freedom	Blood loss %		Feather loss %		Dressing %		Eviscerated %	
		Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value
Treatment	8	1.125632	7.46**	0.40901325	6.81**	5.305	52.47**	2.189271	61.32**
Error	27	0.1508879		0.06004		0.1011		0.035697	
Total	35								

** Significant at 1% levels (P < 0.01)
^{NS} Non Significant

Appendix Table 7 : Analysis of variance of carcass traits as angles (Angle = Arcsin √percentage)corresponding to percentage of ready to cook weight at the end of experimental periods

Sources of variation	Degree of freedom	Ready to cook weight (gm)		Bone weight (gm)		Bone %		Raw edible meat		Ratio of raw edible meat to bone	
		Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value
Treatment	8	40027.83885	51.01**	357.11	32.57**	3.477129	19.12**	33542.07	47.58**	0.622940625	18.48**
Error	27	784.623463		10.9629		0.181841		704.8148		0.0337027	
Total	35										

** Significant at 1% levels ($P < 0.01$)
NS Non Significant

Appendix Table 8 : Analysis of variance of weight of different body/organ cuts as angles (Angle = arcsin √percentage) angles corresponding to percentages of preslaughter weight at the end of experimental periods

Sources of variation	Degree of freedom	Liver %		Gizzard %		Heart %	
		Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value
Treatment	8	0.63596875	11.36**	0.31309375	18.34**	0.1456125	8.50**
Error	27	0.05596018		0.017071		0.016999	
Total	35						

** Significant at 1% levels ($P < 0.01$)
^{NS} Non Significant

Appendix Table 9 : Analysis of variance of weight of different body/organ cuts as angles (Angle = arcsin √percentage) angles corresponding to percentages of preslaughter weight at the end of experimental periods

Sources of variation	Degree of freedom	Giblet %		Neck %		Neck + Giblet %	
		Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value
Treatment	8	0.7618736	125.89**	0.6721	54.52**	1.13553	93.15**
Error	27	0.0060518		0.012326		0.01219	
Total	35						

** Significant at 1% levels ($P < 0.01$)
^{NS} Non Significant

Appendix Table 10 : Analysis of variance of angles (Angle = Arcsin √Percentage) corresponding to percentage of chemical composition of thigh muscle at the end of experimental periods

Sources of variation	Degree of freedom	Moisture %		Protein %		Ether extract %	
		Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value
Treatment	8	0.974459	11.08**	0.658156	11.91**	1.1297	4.12**
Error	27	0.087926		0.055239		0.27441	
Total	35						

** Significant at 1% levels (P < 0.01)

Appendix Table 11 : Analysis of variance of angles (Angle = Arcsin √Percentage) corresponding to percentage of chemical composition of breast muscle at the end of experimental periods

Sources of variation	Degree of freedom	Moisture %		Protein %		Ether extract %	
		Mean Square	F - Value	Mean Square	F - Value	Mean Square	F - Value
Treatment	8	1.3856125	17.83**	0.7937825	20.17**	3.46743	14.10**
Error	27	0.0776926		0.0393592		0.245771	
Total	35						

** Significant at 1% levels (P < 0.01)