EFFECT OF BAKER'S YEAST ON GROWTH AND NUTRIENT UTILIZATION IN CROSSBRED (LARGE WHITE YORKSHIRE X DESI) PIGS

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Thesis submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that this thesis entitled **"EFFECT OF BAKER'S YEAST ON GROWTH AND NUTRIENT UTILIZATION IN CROSSBRED (LARGE WHITE YORKSHIRE X DESI) PIGS"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"EFFECT OF BAKER'S YEAST ON GROWTH AND NUTRIENT UTILIZATION IN CROSSBRED (LARGE WHITE YORKSHIRE X DESI) PIGS"** is a record of research work done independently by **Shri. SEKAR, M.,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Sekar, M.

Dedicated to My

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Introduction

1. INTRODUCTION

Swine rearing in India is carried out under a variety of adverse social, climatic and environmental conditions. At present India has a population of about 11 million pigs, which is only one per cent of the world population (Ranjhan, 2001). The per capita availability of animal protein is about 9.6 g in India against the world average of 24.7 g and Indian Council of Medical Research recommended the average of 34 g (Shanmugasundaram, 1997). In Kerala majority of the people are non vegetarians. As there are no taboos and people have high literacy, are health conscious and are aware of the nutrient requirements, pork consumption has increased in Kerala compared to other states.

Pork as a source of animal protein is gaining popularity in India and pork products are in great demand mainly in urban areas and among the employed people. Carcass yield of pigs has been known to be the highest among food animals. Pigs can efficiently help in satisfying the animal protein requirements of large segment of rural population. Nowadays, a number of piggeries have come up where hogs are raised on scientific lines and manufacture of piggery products is carried out under modern conditions. This will check the escalation in the price of mutton/chevon. It is hoped that swine development will go a long way in solving the problem of protein hunger prevailing in developing countries.

Feed plays an important role in successful pig production. Feed cost represents about 80 per cent of the total cost of production of pigs. Pig being an omnivorous animal has the unique capacity of converting inedible or low quality feed, agricultural and abattoir byproducts into valuable meat in a span of six to eight months. Many of the small holding livestock producers have resorted to pig farming. Compared to dairy and other livestock farming pig production is more lucrative and the farmers get the financial return quickly.

Attaining market weight quickly with growth promoting agents is a common practice in swine. Antibiotics and antimicrobials have been largely used as additives in the ration of swine. In recent years, the use of sub-therapeutic levels of antibiotics as growth promoters has been reduced. This is because of the possibility of antibiotic residue in animal products and development of resistant organisms against the antibiotics used as growth promoter. In order to overcome the defects of antibiotics, nowadays probiotics are used as an alternative.

Probiotics are live microbial feed supplements, which has a beneficial effect on the host animal by affecting its gut flora (Fuller, 1989). The most commonly used probiotic cultures in swine ration are strains of Lactobacillus, Streptococcus, Bacillus and Yeast.

Yeast, the unicellular fungi are known for their fermentative ability and produce enzymes, vitamins and unidentified growth factors. The most important species of yeast used in animal nutrition is *Saccharomyces cerevisiae,* also known as baker's yeast. Yeast culture is defined as a "dry product composed of yeast and media on which it was grown, dried in such a manner to preserve the fermenting capacity of the yeast". Yeast cells sporulate during the process of culture and drying. Therefore, gastric juice, antibiotics, sulfa drugs or any other unfavourable environment do not affect the activity of yeast.

Efficacy of probiotic is influenced by the wide spectrum of variables such as inoculant level fed, stage of maturity of animal, level of stress and rearing environment. The use of probiotics in pigs revealed conflicting reports concerning growth performance and carcass quality.

In view of aforesaid facts, the present study was conducted with the objective of finding the effect of baker's yeast on growth, nutrient utilization, carcass characteristics and cost effectiveness in crossbred pigs.

Review of Literature

2. REVIEW OF LITERATURE

2.1 UTILIZATION OF YEAST AS FEED SUPPLEMENT

The use of yeast in swine production has a short history. But yeast has been used as proteinacious feed for lactating cows in early part of 20[th] century itself (Eckles and Williams, 1925). Sporadic works on the use of large amount of yeast in ruminant feeding continued.

Yeast culture supplementation has been shown to increase concentrations of cellulolytic bacteria in ruminants (Harrison *et al.*, 1988; Dawson *et al.*, 1990). Yeast culture supplements containing *Saccharomyces cerevisiae* is known to be rich source of enzymes, vitamins and other nutrients and have been reported to produce a variety of beneficial actions such as improved growth rate, feed efficiency and reproductive performances in pigs, poultry, horses and ruminants (Dawson, 1993). Addition of yeast culture to the diet of sows resulted in an increase in the number of total and live pigs farrowed per litter (Stockland, 1993). He also reported that the rate of gain and weaning weight of the piglet increased when yeast culture was added to the sow diet and increased body weight of sows at 1, 2 and 3 weeks post farrowing and a higher gain per pig from farrowing to weaning.

Probiotics including yeast and lactobacilli culture in small quantities have been reported to improve performance of weaned pigs (Kornegay *et al.*, 1995). Harker (1998) reported an increase in the number of pigs weaned per litter and an increase in the survival rate of young pigs nursing sows fed diets containing Lacto-sacc.

Cromwell *et al.* (1978), Chapple (1979a), Chapple (1979b) and Murry (1994) who reported no improvement in phytate phosphorus utilization, as measured by performance, apparent absorption of phosphorus and bone mineralization when yeast culture was included in the diet at levels of 0.5 to 2 per cent.

2.1.1 Mechanism of Action of Probiotics

Probiotics means "for life" as opposed to antibiotics which means "against life". Fuller (1989) defined probiotic as a live microbial feed supplement, which beneficially affects the host animal by improving its intestinal microbial balance. He also pointed that the absolute mode of action of probiotic is still elusive. The possible modes of action are suppression of undesirable bacterial count by production of certain organic acids like formic acid, acetic acid and lactic acid etc., which decrease the pH of the gastrointestinal tract, production of antibacterial compounds, competition for nutrients and adhesion sites; alteration of microbial metabolism by increased and decreased enzyme activity and by stimulation of immunity through increased antibody levels and increased macrophage activity.

2.1.2 Viability of Yeast Culture

Only few workers reported the viability of yeast culture. Arambel and Kent (1990) reported 2.0×10^6 live cells of *Saccharomyces cerevisiae* per gram of a yeast culture. Dawson *et al.* (1990) used a yeast culture (Yea-sacc, Alltech Inc., U.S.A.) in their trial and found to contain 2.04×10^9 live yeast cells/g.

Moore (1993) reported that metabolic activity rather than reproductive ability was the important factor for the success of yeast culture as a feed additive. In her opinion, total cell count including dead cells should be considered while expressing the yeast cell count. Metabolic activity of a yeast cell measured by the amount of gas produced from fermentation of sugars. The metabolic activity of yeast heated to 70°C was not affected regardless of duration of heating. The yeast culture heated to 80°C retained 90 per cent of the metabolic activity of the control sample after 5 minutes and 70 per cent of the activity of the control sample after 15 minutes.

The number of viable cells in the different batches of yeast culture varied from 1 to 6 x 10^5 cfu/g (Kamalamma *et al.*, 1996). Similarly, Krishnamoorthy *et al.* (1996) also found that the concentration of viable cells in two commercial yeast culture varied from 3 x 10^5 cfu/g to 6 x 10^6 cfu/g.

2.1.3 Proximate Composition

Arambel and Kent (1990) reported that a yeast product contained 14 per cent crude protein and <0.80 per cent crude fibre. Crude protein, crude fibre and ether extract contents of yeast culture were 26, 1.25 and 5.6 per cent, respectively (Natarajan, 1999).

2.1.4 Mineral Composition

Yeast culture contained 1.80, 0.70, 0.01, 0.20 and 0.70 per cent of calcium, phosphorus, magnesium, sulphur and potassium, respectively (Arambel and Kent, 1990). Natarajan (1999) reported that calcium, phosphorus and magnesium contents of the yeast culture were 0.40, 0.18 and 0.53 per cent, respectively.

2.2 BODY WEIGHT AND BODY WEIGHT GAIN

2.2.1 Pigs

Bonomi *et al.* (1978) evaluated the effect of dietary supplementation of live yeast culture to Large White Yorkshire pigs and found that there was significant improvement in body weight gain with 0.2 per cent yeast culture than those fed control diet. Probiotics in pig feed reduced the stress, improved the body weight gain and acted as a natural growth promoter (Chapman and Lyons, 1988). Rate of gain and daily feed consumption in pigs were improved by the addition of yeast culture at 1 per cent level in the diet, but were depressed when yeast culture was added to the diet containing antibiotic (Jurgens, 1995).

Mathew *et al.* (1998) observed that weanling pigs fed diet containing yeast culture tended to consume more feed and gained more weight. In an experiment with baby pigs conducted on a commercial farm shown that the inclusion of a probiotic had a positive effect on live weight gain (Lopez, 2000). Similarly, Naskar *et al.* (2000) concluded that probiotic alone (30 g/kg feed) and in combination with mineral mixture (20 g/kg feed) had the beneficial effect on pigs in improving the live weight and absolute gain in weight.

Effects of supplementation of yeast (*Saccharomyces cerevisiae)* 0.1 per cent or *Lactobacillus acidophilus* 20 g or both in the diet were assessed for the growth promotion of crossbred pigs (Ravi *et al.*, 2000). It was observed that supplementation of *Lactobacillus acidophilus* at 20 g/day was beneficial for growing pigs.

Heugten and Dorton (2001) stated that supplementation of yeast culture at 0.3 per cent to the weanling pig diets containing zinc, copper and antibiotics improved the body weight gain after the six weeks nursery period. Litters from sows fed diet supplemented with live yeast culture were 15 per cent heavier at weaning compared to litter from sows fed on control diet without yeast culture (Mavromichalis, 2002). Mannan oligosaccharides derived from the yeast cell wall improved the growth performance in early weaned pigs (Pettigrew and Miguel, 2003).

Veum *et al.* (1995) concluded that yeast culture supplements at various levels to sows in gestation and lactation did not affect the growth rate. Jurgens *et al.* (1997) reported that an active dry yeast supplement in corn-soyabean meal based diet to sows during late gestation, lactation and before and after weaning did not alter litter weight at birth or weaning. They also observed an increase in gamma globulin content of sow's milk and improved post weaning rate and efficiency of weight gain of pigs. Similarly, Harper (2002) reported that the dietary inclusion of probiotic (Bioplus-2B^{TM}) at the rate of 0.1 per cent to nursery pigs did not result in improved growth rate and feed intake.

2.2.2 Poultry

Manickam *et al.* (1994) reported that the effect of inclusion of probiotic at the rate of 1 g/L of drinking water to broilers up to six weeks of age significantly increased the total body weight gain. Bhatt *et al.* (1995) tested the different strains of *Saccharomyces cerevisiae* (Y_1, Y_3, Pigeon yeast and Yea-sacc^{1026}) in broiler diet up to six weeks. Significantly higher weight gain were recorded with Y_3 and Pigeon yeast strain supplemented groups. Kumararaj *et al.* (1997) compared the three different commercial probiotics such as Biospur, Biofac and Probiolac on the performance of Japanese quail up to six weeks by feeding at levels of 0.5, 0.5 and 0.1 g/kg diet, respectively. They found that birds fed Probiolac showed the highest body weight followed by Biospur and Biofac; while those fed with control diet gave the lowest body weight.

Baidya *et al.* (1993) observed that the addition of probiotics containing live yeast culture of *Saccharomyces cerevisiae* (10 g/100kg) in broiler diet up to six weeks had no effect on body weight gain. The body weight of birds fed 0, 0.2, 0.6 and 1.0 per cent of baker's yeast daily in the feed did not differ significantly due to the low levels of probiotic (Yadav *et al.*, 1994). Final body weight of broilers were not affected significantly by the supplemental levels (0, 0.1, 0.3 or 0.5 per cent w/v) of baker's yeast in drinking water (Yadav *et al.*, 1996). Similarly, Sarkar *et al.* (1997) studied the effect of yeast culture (5×10^{10} cfu) and antibiotic either singly or in combination as well as phase feeding of the same in the ration of broilers up to six weeks of age. Body weight gain did not differ significantly among different treatments.

Mahajan *et al.* (1999) reported that the addition of probiotic Lacto-sacc containing live yeast culture (Yea-sacc^{1026}, 4.9×10^9), *Lactobacillus acidophilus* 10^8 and *Streptococcus faecium* 10^8 cfu/g at 25 g per *quintal* of feed up to six weeks did not increase the body weight gain significantly during winter months, whereas during summer months there was significant increase in body weight gain.

Panda *et al.* (1999) found that the dietary inclusion of commercial probiotic containing six different strains of organisms with 27 billion colony forming units per 100 g of the product, at the rate of 0, 100, 150 or 200 mg per kg broiler diet up to six weeks of age had no significant effect on body weight gain. Saha *et al.* (1999b) studied the effect of live baker's yeast supplementation at 0.25 per cent level in broiler diet up to eight weeks of age and inferred that the yeast supplementation had no effect on body weight gain.

2.2.3 Rabbits

Onifade *et al.* (1999) supplemented pure culture of *Saccharomyces cerevisiae* at 0, 1.5 and 3.0 g/kg of rabbit diets and found that the body weight gain was significantly increased for the group fed with 3.0 g yeast/kg of basal diet.

2.3 FEED EFFICIENCY AND AVERAGE DAILY GAIN

2.3.1 Pigs

Yeast culture improved feed intake, daily gain and feed efficiency at all levels (0, 0.75, 1.25 and 1.75 per cent) in weanling pigs (Veum *et al.*, 1988). Jurgens *et al.* (1997) added active dry yeast (15 x 10^9 cfu/g) at 0, 0.1 or 0.2 per cent of the sow gestation diet, 0, 0.15 or 0.3 per cent of the sow lactation diet, 0, 0.2 or 0.4 per cent of the pig prestarter diet, one week before and one week after weaning and 0, 0.125 or 0.25 per cent during the last three weeks in the nursery. They found that no significant difference in feed intake, but significant improvement in average daily gain and feed efficiency. Similarly, Naskar *et al.* (2000) found that there was significant increase in average daily gain and feed efficiency in probiotic supplemented pigs (30 g/kg feed) than control pigs.

Saccharomyces cerevisiae has been reported to increase growth performance and feed efficiency in sows and weaned pigs (Reddy, 2001). He also stated that growing pigs fed diets containing lactic acid bacteria plus yeast culture combination (Lacto-sacc; Alltech, Inc.) were heavier at 56 days and converted feed 9.6 per cent more efficiently than those in the control group. It was therefore proposed that some of the response in terms of growth and feed efficiency was due to the effect of yeast culture on hind gut fermentation by mechanism similar to that occurring in rumen. Heugten *et al.* (2003) stated that live yeast supplementation (2.4 x 10^7 cfu of *Saccharomyces cerevisiae* sc 47/g of feed) had a positive effect on average daily gain of pigs when their diets contained growth promoting levels of antimicrobials.

Addition of yeast culture and fibre source in the diet of weanling pigs did not significantly influence daily gain and daily feed intake (Rhein-welker *et al.*, 1992). Pigs fed a combination of yeast culture and eight per cent peanut hull had an overall average daily gain similar to control, whereas pigs fed diets containing yeast culture alone or a combination of yeast culture and 18 per cent peanut hull had a lower overall average daily gain than control pigs (Kornegay *et al.*, 1994). Kornegay *et al.* (1995) observed that inclusion of yeast culture at 0.75 per cent level to pig starter diets containing whey or one of the two fibre sources had no effect on average daily gain and average feed intake. Similar results were also reported by Bekaert *et al.* (1996) in pigs fed diets containing live yeast culture (Levucell SB2 – *Saccharomyces cerevisiae*) at 0, 500 or 1000 g/t. Sikka (1997) found that addition of 15 per cent inactivated yeast as protein supplement in growing pig rations reduced the feed conversion ratio.

2.3.2 Poultry

Manickam *et al.* (1994) reported highly significant difference between control and birds supplemented with probiotic at 1 g/L of drinking water in terms of feed efficiency. Kadari (2001) reported that 0.025 per cent probiotic fed group had significantly better feed efficiency when compared to those fed control diet and 0.05 per cent probiotic containing diet in broilers.

Yadav *et al.* (1994) and Saha *et al.* (1999a) reported that the feed efficiency was not affected by dietary supplementation of baker's yeast culture at various levels in broiler ration. Singh and Prasad (2000) found that the differences in feed conversion ratio between control and the experimental groups were non-significant upon dietary supplementation of live baker's yeast at 0.1, 0.2, 0.3 and 0.4 per cent up to five weeks of age in caged broilers.

Baidya *et al.* (1993) reported that the feed efficiency did not differ significantly upon addition of different commercial probiotic preparations in broiler diet up to six weeks. Baidya *et al.* (1994) opined that the feed conversion ratio did not differ significantly among the control and birds supplemented with probiotic at 50 g per 100 kg of broiler diet. Bhatt *et al.* (1995) compared the different strains of *Saccharomyces cerevisiae* in broiler diet up to six weeks and found that feed efficiency did not differ significantly. Yadav *et al.* (1996) reported that the feed efficiency was not affected by live baker's yeast supplementation in drinking water of broilers up to six weeks. Similarly, Saha *et al.* (1999b) studied the effect of live baker's yeast supplementation at 0.25 per cent level in broiler diet and found that the feed efficiency did not differ significantly.

2.3.3 Rabbits

Onifade *et al.* (1999) in their study using pure culture of *Saccharomyces cerevisiae* at 0, 1.5 and 3.0 g/kg of rabbit feed, observed significant increase in feed conversion ratio in the group supplied with 3.0 g yeast /kg of basal diet.

2.4 APPARENT DIGESTIBILITY OF NUTRIENTS

2.4.1 Digestibility Measurements by Indicator Method

Kohler *et al.* (1990) used chromic oxide and titanium oxide as solid phase markers and Co-EDTA as liquid phase marker in pigs. The recovery rate of markers depended on fibre content of diets and marker recoveries were lowered in the pectin and fibre rich diet. Moughan *et al.* (1991) observed that total faecal collection gave higher apparent digestibility coefficient than those calculated by reference to chromic oxide for dry matter, organic matter and gross energy, but there was no differences in digestibility of nutrients determined by total collection and by using acid insoluble ash as marker. The most appropriate inert marker for the determination of ileal and faecal apparent digestibility in pigs was titanium dioxide added at the level of 1 g/kg feed (Jagger *et al.*, 1992).

Saha and Gilbreath (1993) developed a modified chromic oxide indicator ratio technique for accurate determination of nutrient digestibility. The method considered analytical chromium recovery in diets and faeces and faecal recovery of dietary chromium when used as a marker.

The indicator most commonly added to feed to determine the digestibility coefficient of nutrients was chromium in the form of chromic oxide (McDonald *et al.*, 1995; Reddy, 2001). Hill *et al.* (1996) stated that the ileal recovery of chromic oxide was almost complete (94 per cent) and was greater than faecal recovery (87 per cent). Kemme *et al.* (1996) concluded that there were only small differences in the apparent total tract digestibility of phosphorus and calcium between the chromic oxide marker method and quantitative collection method. Titgemeyer *et al.* (2001) reported that the faecal recovery of titanium dioxide (TiO_2) averaged 90 per cent, whereas that of chromic oxide (Cr_2O_3) averaged 98 per cent when steers were fed corn based diet *ad libtium.* Digestibilties calculated with reference to TiO_2 were under estimated by 1.6 to 4.3 percentage units, whereas those calculated with reference to Cr_2O_3 were not different from those based on total faecal collections.

Schiavon *et al.* (1996) suggested that seven days adaptation and four days collection were sufficient to obtain constant digestibility coefficient for organic nutrients when chromic oxide was used as an external indicator for determining apparent digestibility in pigs. Garcia *et al.* (1999) used microwave digestion and atomic absorption spectrophotometer to determine chromic oxide as a digestibility marker in feed, faeces and ileal content.

2.4.2 Influence of Yeast Culture

2.4.2.1 Pigs

Yeast culture has been found to increase apparent protein digestibility in growing pigs and digestibility of fibre in sows fed high fibre diets (Wenk, 1990; Gombos, 1991). Addition of yeast culture to corn-soyabean meal diets over two consecutive reproductive cycles improved crude protein digestion during gestation of sows (Murry and Dawe, 1996). Naskar *et al.* (2000) conducted an experiment to find out the effect of probiotic on growth performance of crossbred pigs. They concluded that the probiotic controlled the metabolic activities of gut microflora, which led to better digestion and absorption of nutrients and therefore, probiotic treated group showed better live weight gain. Park *et al.* (2003) opined that the addition of yeast culture (0.1 and 0.2 per cent) to the growing-finishing pigs diet increased the digestibility of protein and fibre than those of control.

Apparent digestibilities of energy, crude protein, fat, acid detergent fibre, neutral detergent fibre and ash were similar among the treatments supplied with different levels of yeast culture in pigs (Reyes *et al.*, 1991). The addition of yeast culture to pig starter diets did not affect the digestibility of any of the nutrients (Kornegay *et al.*, 1994). Similar results were also reported by Kornegay *et al.* (1995) in weanling pigs fed diets containing different levels of yeast culture.

Veum *et al.* (1995) observed that supplemental yeast culture (0, 0.5, 1.0 and 2.0 per cent) in gestation and lactation diets of sow containing alfalfa meal did not affect apparent digestibility of nutrients and reproductive performances.

*2.4.2.2 **Ruminants***

Weidmeier *et al.* (1987) stated that the addition of viable fungal supplements containing *Aspergillus oryzae* and yeast culture increased the digestibility of the structural carbohydrate portion of the diets in cattle. Wholt *et al.* (1991) found that protein and cellulose digestibilities were improved by yeast when cows fed diets of corn silage and grains in 1:1 ratio and 0.9 kg/day of hay and were supplemented by 10 g yeast, from late pregnancy to early lactation. Erasmus *et al.* (1992) reported that addition of yeast culture at 10 g/day/cow had increased the apparent digestibility of crude protein and acid detergent fibre. Crude protein digestibility improved significantly when yeast was added at 10 g/animal/day to steers fed either a low quality (4 kg barley straw plus 2.5 kg barley/soybean meal) or a high quality (2 kg straw and 8 kg barley/soyabean meal) diet (Moloney and Drennan, 1994).

Lambs fed with yeast culture had higher apparent dry matter and nitrogen digestibilities, nitrogen retention and sodium absorption than lambs fed control diet (Cole *et al.*, 1992). Newbold *et al.* (1995) found that addition of yeast culture at 2 g/day/sheep had a trend for a higher crude protein digestion with hay as the substrate. Similarly, digestibility coefficient of dry matter, organic matter, crude protein and crude fibre in lambs fed with yeast culture recorded an increase over that of the control (Natarajan, 1999).

Addition of yeast culture to the diets of lactating cows did not affect the apparent digestibilities of dry matter, neutral detergent fibre, acid detergent fibre or starch and increases in number of cellulolytic bacteria did not correspond to increase in digestion of cell wall components (Harrison *et al.*, 1988). Similarly, Mustvangwa *et al.* (1992) reported no improvement in digestibility of nutrients in crossbred bulls fed concentrate diet containing yeast culture at the rate of 1.5 kg/t of feed.

2.4.2.3 Poultry

Saha *et al.* (1999b) found that supplementation of baker's yeast at 0.25 per cent to the broilers did not affect apparent organic matter and crude protein digestibility significantly but increased ether extract digestibility.

Yadav *et al.* (1994) reported that addition of yeast culture had no significant effect on digestibility of nutrients in broilers. Yadav *et al.* (1996) and Saha *et al.* (1999a) also obtained similar results.

2.4.2.4 Horses

Glade and Biesik (1986) found that supplementing horse diet with yeast culture resulted in 7 to 13 g increase in daily net nitrogen retention as well as increase in hemicellulose digestibility. Glade and Sist (1988) reported that the feed utilization has been enhanced by supplementation of horse diet with 8 g of yeast culture per day. Dry matter, dietary fibre, hemicellulose, cellulose and nitrogen digestibilities increased significantly. Similarly, the addition of 20 g of yeast culture per day to the diet of pregnant mares for two weeks increased the digestibilities of dietary energy, dry matter and acid detergent fibre (Glade, 1991).

Inclusion of Yea-sacc (8 g/head/day) significantly increased neutral detergent fibre, hemicellulose and nitrogen digestibilities of diet given to yearling horses (Reddy, 2001). He concluded that dietary supplementation of yeast culture increased hindgut fermentation, thereby increased the nutritive value of equine feeds.

2.5 INFLUNCE OF YEAST CULTURE ON CARCASS CHARACTERISTICS

2.5.1 Pigs

Pigs given fresh brewer's yeast supplements had carcasses with leaner meat and better loin quality (Caleffi and Broccaioli, 1991). At slaughter, lumbar thickness, *Longissimus dorsi* muscle area and ham weight were greater in yeast supplemented pigs (Savoini *et al.*, 1996). Carcass characteristics such as back fat thickness, loin eye area, ham weight and dressing percentage were enhanced by 7 per cent dried yeast supplementation in the diet of pigs (Moreira *et al.*, 1998).

Bowman and Veum (1973) observed that supplementation of swine diet with yeast culture did not influence the carcass quality. Mazzocco and Bolla (1989) reported that carcass quality was not affected by giving 10 per cent liquid brewer's yeast in the pigs diet, however, yield of ham was higher in the pigs given the yeast diet. Kronka *et al.* (1991) reported that dressing percentage, loin eye area, carcass length and ham percentage were similar among the different dietary treatments containing various levels of dried sugarcane distiller's yeast. Filho *et al.* (1993) recorded loin eye area that ranged from 28.5 to 31.8 cm^2 when pigs were fed diets containing different levels of *Saccharomyces cerevisiae* yeast which did not differ significantly among the differ treatments.

Murry (1994) reported that the carcass characteristics were not significantly different due to supplementation of yeast in the diet or because of sex. Similarly, Gutierrez *et al.* (1999) observed no differences in carcasses (yield, back fat thickness and percentage of lean meat) due to supplementation of yeast in the diet. The pH, purge loss, cooking loss and colour of loin eye muscle were not affected by dietary supplementation of yeast culture at different levels (0, 0.1, 0.2 and 0.4 per cent) in pigs (Park *et al.*, 2003).

2.5.2 Poultry

Supplementation of live baker's yeast on graded levels had no effect on carcass quality of broilers (Yadav *et al.*, 1994). Lipid in meats increased, while water in thigh meat decreased in male broilers administered the probiotic (Endo and Nakano, 1999). In the probiotic fed group, the cholesterol concentration of thigh meat and liver decreased, but linoleic acid and the unsaturated fatty acids/saturated fatty acid ratio in pectoral meat were increased.

The addition of probiotic at the rate of 100, 150 or 200 mg per kg of broiler diet showed no difference in weight of organs. There was a trend for a higher dressing percentage in the 200 mg probiotic supplemented group (Panda *et al.*, 1999).

Saha *et al.* (1999a) also studied the effect of baker's yeast on carcass quality of broilers and found that no significant difference possibly due to low level of baker's yeast in the ration. Mahajan *et al.* (2000) observed that meat from Lacto-sacc fed birds possessed significantly higher percentage of moisture, protein, ash, water holding capacity, emulsifying capacity, emulsion stability and lower fat per cent, moisture:protein ratio, pH, shear press value, total viable count, coliforms, faecal Streptococci and Staphylococci count as compared to meat obtained from control birds.

2.6 COST BENEFIT ANALYSIS

2.6.1 Pigs

Dietary supplementation yeast culture had no significant effect on performance in finishing pigs. Although there was an economical improvement in the cost/lb of gain of nearly 7.5 per cent for those hogs receiving yeast culture (Mazzocco and Bolla, 1989).

2.6.2 Poultry

Buche *et al.* (1992) revealed that the inclusion of 0.02 per cent probiotic to the broiler diet numerically lowered the cost of feed per kg live weight compared to that of control and the higher level of (0.04 per cent) probiotic fed groups.

Baidya *et al.* (1993) opined that the addition of probiotic at 50 g per 100kg diet was found to be economic in broilers. Similarly, Baidya *et al.* (1994) reported that the income per bird was found to be highest in groups fed with antibiotic at 50 g per100 kg broiler diet for the first three weeks followed by probiotic at 50 g per 100 kg for the next three weeks. Sarkar *et al.* (1997) reported that from economic point of view the feeding of yeast culture in the finisher phase in broilers was best.

Materials and Methods

3. MATERIALS AND METHODS

3.1 ANALYSIS OF YEAST CULTURE

Baker's yeast culture was analyzed for the proximate composition, mineral contents and live and total cell counts.

3.1.1 Proximate Composition

Samples of yeast culture were analyzed for dry matter, organic matter, crude protein, ether extract and crude fibre according to the methods of AOAC (1990). The nitrogen free extract was calculated by difference.

3.1.2 Mineral Composition

Calcium, phosphorus, magnesium, iron, zinc, manganese, cobalt and copper contents of baker's yeast were estimated using Atomic Absorption Spectrophotometer (Perkin-Elmer model – AAS-3110) and phosphorus by colorimetric method using Spectrophotometer (Spectronic 1001 plus, Milton Roy Co., USA).

3.1.3 Viable and Total Yeast Cell Counts

The viable cell count was carried out by using the dilution plate technique of Andrews (1992) with Sabouraud agar medium incorporating chloramphenicol to prevent bacterial contamination. Live and dead cell counts were carried out with methylene blue dye staining method using a haemocytometer.

3.2 EXPERIMENTAL ANIMALS

Thirty Large White Yorkshire x Desi crossbred (75:25) weaned piglets (15 barrows and 15 gilts) with an average body weight of 13.5 kg were selected at random as experimental animals from the Centre for Pig Production and Research, Mannuthy.

The 30 piglets were divided into three homogeneous groups of ten each with respect to age, sex and body weight. Ten piglets in each treatment were randomly distributed into five replicates of two each. The three groups of piglets were randomly allotted to three dietary treatments (T_1, T_2 and T_3). Each replicate was housed in separate pen. All the pigs were dewormed before the commencement of the experiment and maintained under identical managemental conditions during the experimental period of five months.

3.3 EXPERIMENTAL DIETS

The experimental rations consisted of grower rations containing 18 per cent crude protein and 3200 kcal of digestible energy per kg and finisher rations containing 14 per cent crude protein and 3100 kcal of digestible energy per kg. They were fed on their respective grower ration till they attained an average body weight of 50 kg and thereafter changed to finisher ration until the pigs were slaughtered on completion of seven months.

Piglets in group I, II and III were allotted to the following three dietary treatments.

T_1 - Control (standard ration)

T_2 - Control diet supplemented with 0.25 per cent baker's yeast culture.

T_3 - Control diet supplemented with 0.5 per cent baker's yeast culture.

The method described in Association of Official Analytical Chemists (AOAC, 1990) was followed to estimate the chemical composition of the diets. The ingredient composition and the chemical composition of grower and finisher rations are given in Tables 1, 2 and 3, respectively.

3.4 FEEDING TRIAL

The piglets of each pen were group fed. They were fed in the morning (7.30 AM) and evening (4.30 PM) and were allowed to consume as much feed as they could, within a period of one hour. Potable water was also provided *ad libitum* in all the pens throughout the experimental period. The quantity of feed given was increased every fortnight according to their requirement. Records of daily feed intake and fortnightly body weight were maintained throughout the experimental period.

3.5 DIGESTIBILTY TRIAL

Digestibility trial was conducted at the end of the experiment to determine the digestibility coefficient of nutrients in the experimental diets. Chromic oxide was added @ 0.05 per cent to each experimental diet as an external indicator for measuring the digestibility coefficients. Chromic oxide was mixed first with a small quantity of feed and then with the already mixed feed in a vertical feed mixer for 15 minutes to ensure proper mixing. The pigs were fed with rations containing chromic oxide for a period of four consecutive days. Faeces were collected for three days from the second day onwards.

Faecal grab samples uncontaminated with urine and water were collected from different places of pen thrice daily during the collection period of three days. The samples of faeces taken from each pen daily were placed in double lined polythene bags. The bags were labelled and kept in the deep freezer (- 20^0 C) until analysis. The feed and faecal samples collected during the digestibility trial were analyzed for proximate composition according to methods prescribed by AOAC (1990).

The chromium content was determined using Atomic Absorption Spectrophotometer. The digestibility coefficient of nutrients were calculated using appropriate formulae (Maynard *et al.*, 1979; McDonald *et al.*, 1995).

Table 1. Ingredient composition of experimental diets, %

Ingredients	Grower diet (%)	Finisher diet (%)
Yellow maize	34.0	41.5
Soyabean meal	14.5	5.5
Rice polish	39.0	-
Wheat bran	-	40.5
Fish meal	10.0	10.0
Mineral mixture*	2.0	2.0
Salt	0.5	0.5

*Mineral mixture without salt (Pristine Nutrition Pvt. Ltd., Bangalore) containing Calcium – 23%, Phosphorus – 12%, Magnesium – 6.5%, Sulphur – 0.5%, Iron – 0.5%, Zinc – 0.38%, Manganese – 0.12%, Copper – 0.07%, Iodine – 0.03%, Cobalt – 0.01%, Fluorine (max) – 0.07%, Acid insoluble ash (max) – 2.5% and moisture (max) – 5%.

Live yeast culture "**Provisacc**" (M/s. Vetcare, Bangalore in Collaboration with Provimi Holding, Netherlands) which contained *Saccharomyces cerevisiae* ($5x10^9$ cfu /g) was added at the rate of 0, 0.25 and 0.5 per cent to the three experimental diets.

Indomix – A, B_2, D_3 (Nicholas Piramal India Ltd., Mumbai) containing Vitamin A – 40,000 IU, Vitamin B_2 – 20 mg, Vitamin D_3 – 5,000 IU per gram was added @ 25 g per 100 kg feed mixed.

Rovi – BE (Roche Products Limited, Derbyshire, UK.) containing Vitamin B_1 – 4 mg, Vitamin B_6 – 8 mg, Vitamin B_{12} – 40 mcg, Niacin – 60 mg, Calcium panthothenate – 40 mg, Vitamin E – 40 mg. per gram was added @ 25 g per 100 kg feed mixed.

Table 2. Chemical composition of grower rations*, %

Item	Treatments		
	T_1	T_2	T_3
Dry matter	88.29	88.70	88.30
Crude protein	18.05	18.38	18.53
Ether extract	5.65	5.72	5.80
Crude fibre	6.94	7.15	7.15
Nitrogen free extract	55.80	55.78	55.67
Total ash	13.56	12.97	12.85

* On dry matter basis

Table 3. Chemical composition of finisher rations*, %

Item	Treatments		
	T_1	T_2	T_3
Dry matter	88.08	88.46	88.31
Crude protein	14.25	14.41	14.54
Ether extract	2.25	2.40	2.41
Crude fibre	11.95	11.79	11.62
Nitrogen free Extract	60.14	59.85	60.08
Total ash	13.35	13.4	13.22

* On dry matter basis

3.6 CARCASS CHARACTERISTICS

On completion of seven months of age, six pigs from each treatment were selected randomly. They were humanely slaughtered and dressed in packer style at the Centre of Excellence in Meat Science and Technology, Mannuthy.

Carcass was decapitated at the atlanto-occipital joint and the dressed weight of the carcass without head was recorded to determine the dressing percentage of hot carcass. The carcass characteristics, viz., hot carcass weight, dressing percentage, meat yield percentage, meat bone ratio, carcass length, back fat thickness, loin eye area, colour of the lean and consistency of fat were studied.

Carcass length was measured as a distance between the front edge of the first rib near the cervical vertebrae to the anterior edge of the pubic bone. Back fat thickness was measured at the first thoracic, last thoracic and last lumbar vertebrae. The mean of the three measurements were used in determining the back fat thickness. Loin eye area at tenth rib was measured by tracing the perimeter of the cut end of the *Longissimus dorsi* muscle on butter paper. The area was calculated using graph paper.

3.7 STATISTICAL ANALYSIS

The data obtained were statistically analyzed by using the MS Excel and Statistical Software Package 'MSTATC'. Data on body weight of pigs maintained on the three dietary treatments were analyzed by the Covariance technique.

To test the statistical significance of the effect of baker's yeast on fortnightly cumulative average daily gain, fortnightly cumulative feed conversion efficiency, digestibility coefficient of nutrients and carcass characteristics, Completely Randomized Design (CRD) method as described by Snedecor and Cochran (1985) was used. The means were compared using the Least Significant Difference (LSD) test.

Results

4. RESULTS

4.1 ANALYSIS OF YEAST CULTURE (*Saccharomyces cerevisiae*)

4.1.1 Proximate Composition of Yeast

Proximate composition of yeast used for the experimental purpose is presented in Table 4. The average values in percentage for various constituents were: dry matter 96.3, crude protein 31.2, ether extract 5.2, crude fibre 1.5, ash 7.1 and nitrogen free extract 55.1.

4.1.2 Mineral Composition of Yeast

Mineral contents such as Ca, P, Mg, Fe, Zn, Mn, Co, and Cu of the baker's yeast were 0.78 per cent, 0.32 per cent, 0.13 per cent, 232.0 mg/kg, 142.7 mg/kg, 35.7 mg/kg, 27.1 mg/kg and 2.9 mg/kg, respectively.

4.1.3 Viable and Total Yeast Cell Counts

Estimated viability of yeast culture used in the study varied from 0.9×10^8 to 1.2×10^9 cfu/g. The live and dead cell counts per gram of yeast ranged from 18.7 to 23.1×10^9 cells.

Table 4. Composition and viability of yeast culture

Proximate composition (% DM)	
Dry matter	96.25
Crude protein	31.20
Ether extract	5.20
Crude fibre	1.45
Total ash	7.10
Nitrogen free extract	55.05
Mineral composition (DM)	
Ca	0.78 %
P	0.32 %
Mg	0.13 %
Fe	232.00 mg/kg
Zn	142.72 mg/kg
Mn	35.68 mg/kg
Co	27.06 mg/kg
Cu	2.90 mg/kg
Viability	
Colony forming units per g	0.9×10^8 to 1.2×10^9
Live and dead cell count (no./g)	18.67 to 23.12×10^9

4.2 FINAL BODY WEIGHT AND BODY WEIGHT GAIN

The mean live body weight of pigs under the three dietary treatments T_1, T_2 and T_3 recorded at fortnightly intervals are presented in Table 5 and graphically represented in Fig. 1. The mean slaughter weight of pigs of the three treatments were 66.4, 71.0 and 74.4 kg, respectively at the end of seven months of age. Mean body weight gain of pigs belonging to the groups T_1, T_2 and T_3 from second to seventh month of age were 52.8, 57.4 and 60.8 kg, respectively (Fig. 2).

4.3 AVERAGE DAILY GAIN AND FEED CONVERSION EFFICIENCY

The results on the fortnightly cumulative average daily gain and average feed conversion efficiency of pigs under the three dietary treatments T_1, T_2 and T_3 are presented in Tables 6 and 7. Summarized data on average daily gain (g) and feed conversion efficiency of pigs of three dietary treatments are presented in Table 8 and graphically represented in Fig. 3 and 4, respectively. The values were 352 and 4.36, 383 and 4.05 and 405 and 3.83, respectively for the groups T_1, T_2 and T_3.

4.4 APPARENT DIGESTIBILITY COEFFICIENT OF NUTRIENTS

Chemical composition of faeces of pigs fed with different experimental diets is shown in Table 9. Data on apparent digestibility coefficient of nutrients of the three experimental diets T_1, T_2 and T_3 are presented in Table 10 and graphically represented in Fig. 5. The digestibility coefficient of dry matter for T_1, T_2 and T_3 were respectively, 58.4, 59.2 and 63.5; 68.9, 70.0 and 73.3 for crude protein; 53.0, 57.0 and 61.2 for ether extract; 22.3, 25.5 and 32.8 for crude fibre and 73.4, 75.0 and 76.3 for nitrogen free extract.

Table 5. Fortnightly body weight of pigs maintained on three dietary treatments, kg (Mean ± SE)[1]

Fortnights	Treatments			P value
	T_1	T_2	T_3	
0	13.53 ± 0.79	13.58 ± 1.09	13.53 ± 0.87	- (NS)
1	18.70 ± 1.04	19.08 ± 1.09	18.15 ± 1.25	0.25 (NS)
2	24.65 ± 1.26	25.55 ± 1.16	25.85 ± 1.06	0.31 (NS)
3	31.25 ± 1.34	31.05 ± 1.15	31.25 ± 1.06	- (NS)
4	35.65 ± 1.43	36.15 ± 1.15	36.90 ± 1.26	- (NS)
5	39.95 ± 1.28	41.75 ± 1.50	41.70 ± 1.24	0.33 (NS)
6	44.60 ± 1.24	46.35 ± 1.48	46.45 ± 1.40	- (NS)
7	49.15 ± 1.35	51.65 ± 1.54	52.30 ± 1.51	0.20 (NS)
8	54.60 ± 1.40	56.80 ± 1.67	58.40 ± 1.53	0.17 (NS)
9	62.00 ± 1.51	64.85 ± 1.81	67.23 ± 1.82	0.09 (NS)
10*	66.35 ± 1.66^{a}	71.00 ± 2.01^{ab}	74.40 ± 2.17^{b}	0.014

1 Mean of ten values

a, b Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)

NS Non significant

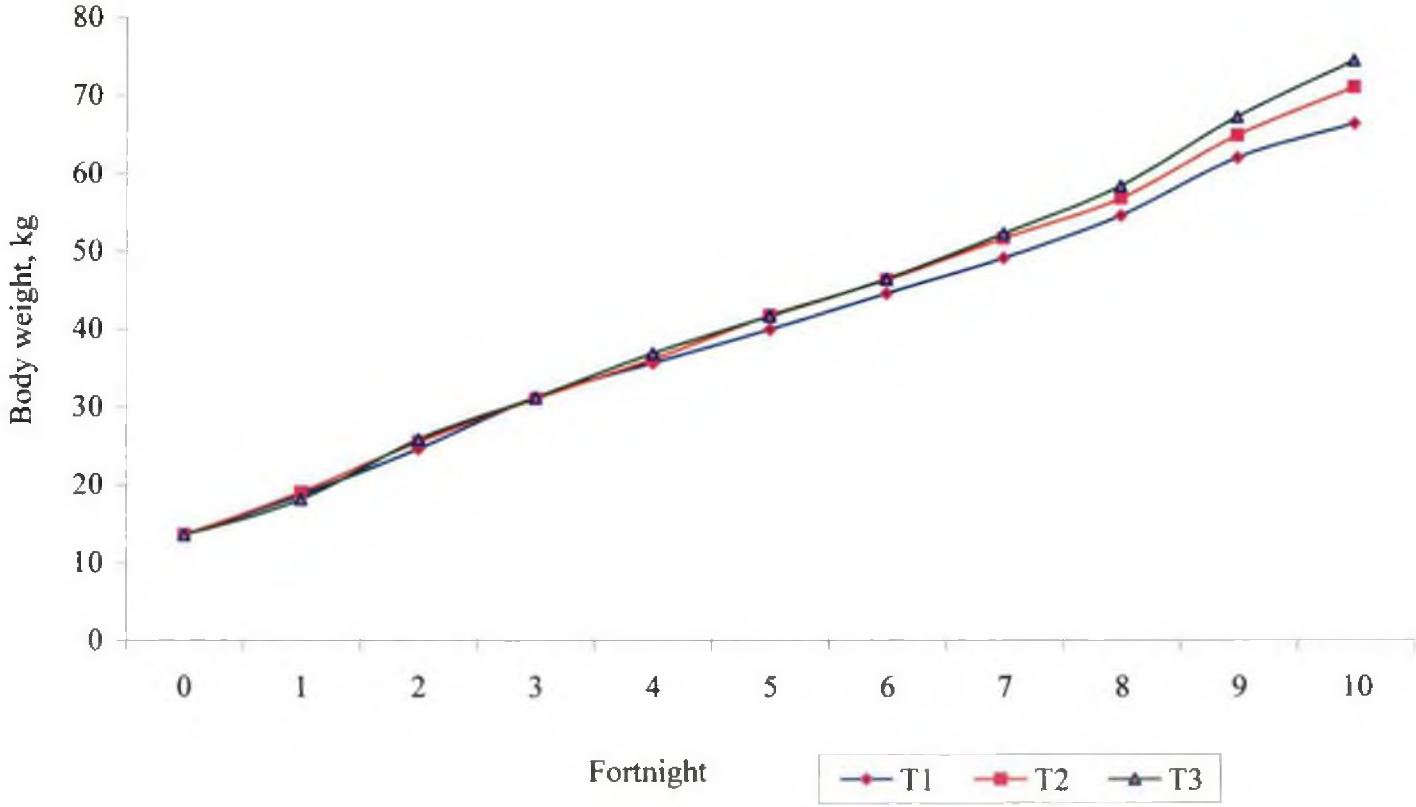

Fig. 1. Fortnightly average body weight of pigs maintained on three dietary treatments

Table 6. Fortnightly cumulative average daily gain of pigs maintained on three dietary treatments, g (Mean ± SE)[1]

Fortnights	Treatments			P value
	T_1	T_2	T_3	
1	345.00 ± 32.21	366.67 ± 17.03	305.00 ± 29.19	0.28 (NS)
2	370.83 ± 21.63	399.17 ± 15.64	409.17 ± 15.93	0.31 (NS)
3	393.89 ± 17.62	388.33 ± 09.53	392.78 ± 11.54	0.95 (NS)
4	368.75 ± 15.61	376.25 ± 08.87	388.75 ± 14.46	0.57 (NS)
5	352.33 ± 11.18	375.67 ± 10.28	375.00 ± 14.41	0.31 (NS)
6	345.28 ± 09.22	364.17 ± 09.86	365.28 ± 15.20	0.41 (NS)
7	339.29 ± 10.17	362.62 ± 08.74	368.81 ± 15.12	0.19 (NS)
8	342.29 ± 08.06	360.21 ± 10.21	373.54 ± 14.78	0.17 (NS)
9	359.07 ± 08.56	379.82 ± 09.62	397.45 ± 15.53	0.08 (NS)
10*	352.17 ± 8.51^{a}	382.83 ± 09.26^{ab}	405.48 ± 15.80^{b}	0.012

1 Mean of ten values

a, b Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)

NS Non significant

Table 7. Fortnightly cumulative feed conversion efficiency (kg feed/kg gain) of pigs maintained on three dietary treatments (Mean ± SE)[1]

Fortnights	Treatments			P value
	T_1	T_2	T_3	
1	2.88 ± 0.22	2.67 ± 0.14	3.35 ± 0.39	0.24 (NS)
2	2.66 ± 0.04	2.48 ± 0.08	2.42 ± 0.07	0.06 (NS)
3	2.60 ± 0.05	2.64 ± 0.07	2.61 ± 0.05	0.87 (NS)
4	2.97 ± 0.07	2.91 ± 0.05	2.81 ± 0.05	0.19 (NS)
5	3.26 ± 0.06	3.06 ± 0.03	3.07 ± 0.08	0.58 (NS)
6	3.50 ± 0.05	3.31 ± 0.04	3.32 ± 0.12	0.23 (NS)
7	3.81 ± 0.09	3.56 ± 0.03	3.52 ± 0.12	0.07 (NS)
8*	4.04 ± 0.07^{a}	3.83 ± 0.06^{ab}	3.70 ± 0.08^{b}	0.02
9**	4.09 ± 0.07^{a}	3.86 ± 0.05^{ab}	3.70 ± 0.08^{b}	0.007
10**	4.36 ± 0.06^{a}	4.05 ± 0.04^{b}	3.83 ± 0.08^{b}	0.0002

1 Mean of ten values

a, b Means with different superscripts within the same row differ significantly

* Significant (P<0.05)

** Significant (P<0.01)

NS Non significant

Table 8. Average daily gain and feed conversion efficiency of pigs maintained on three dietary treatments (Mean ± SE)

Item	Treatments		
	T_1	T_2	T_3
Initial body weight (kg)	13.53 ± 0.79	13.58 ± 1.09	13.53 ± 0.87
Final body weight (kg)	66.35 ± 1.66	71.00 ± 2.01	74.40 ± 2.17
Body weight gain (kg)*	52.83 ± 1.28^{a}	57.43 ± 1.39^{ab}	60.82 ± 2.41^{b}
Total feed intake (kg)/pig	230.35	232.45	232.45
Average daily gain (g)*	352.17 ± 8.5^{a}	382.83 ± 9.26^{ab}	405.48 ± 15.8^{b}
Feed conversion Efficiency** (kg feed/kg gain)	4.36 ± 0.06^{a}	4.05 ± 0.04^{b}	3.83 ± 0.08^{b}

a, b Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)

** Significant ($P<0.01$)

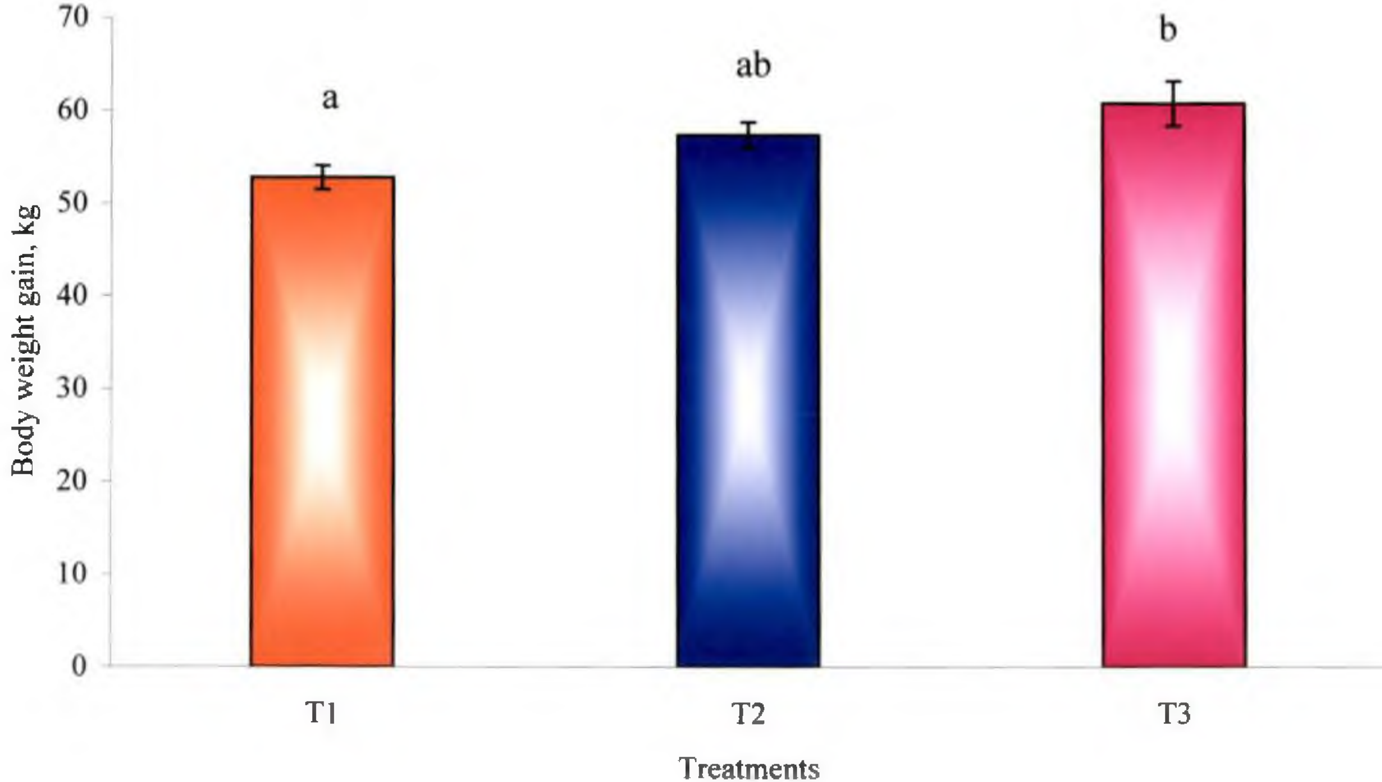

Fig.2. Body weight gain of pigs maintained on three dietary treatments

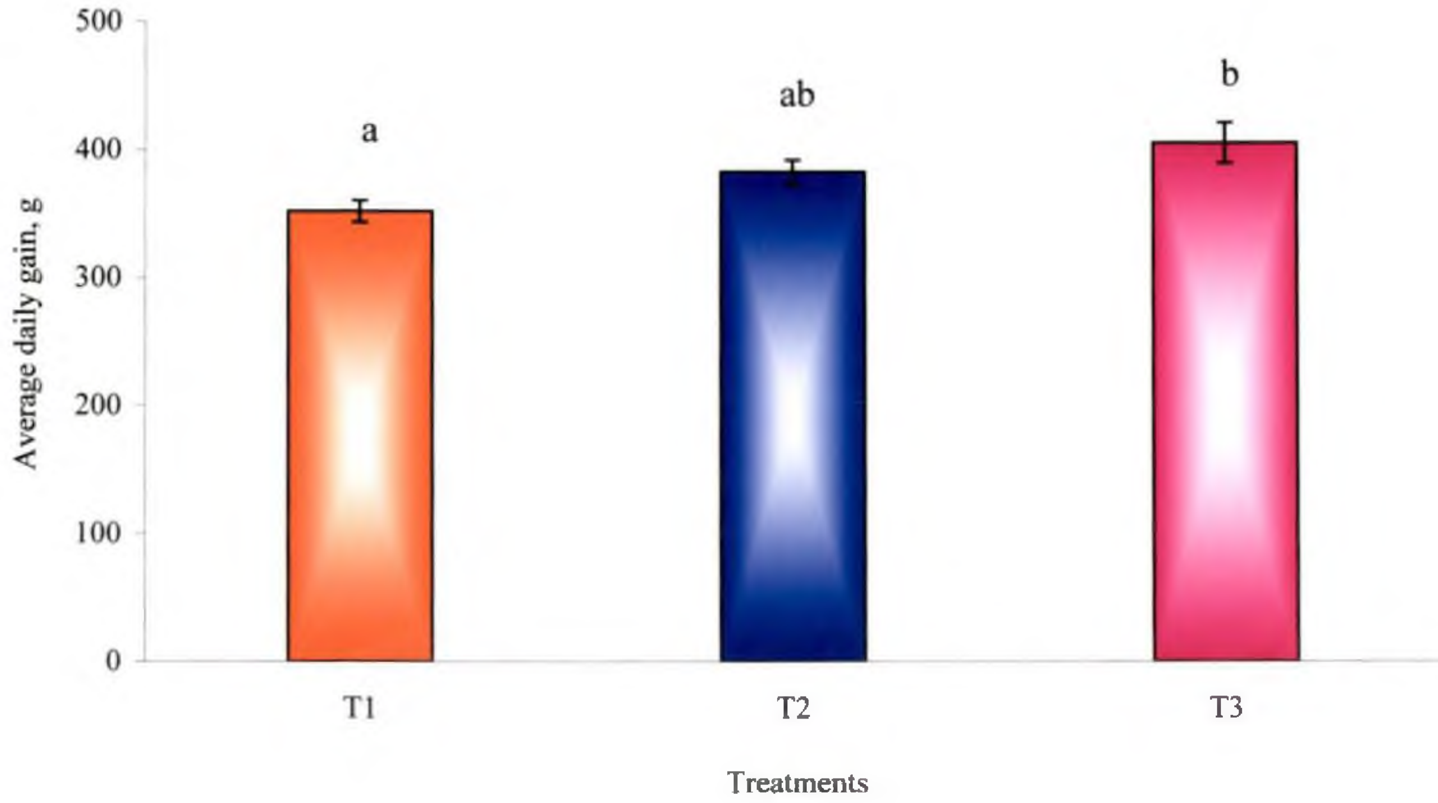

Fig.3. Average daily gain of pigs maintained on three dietary treatments

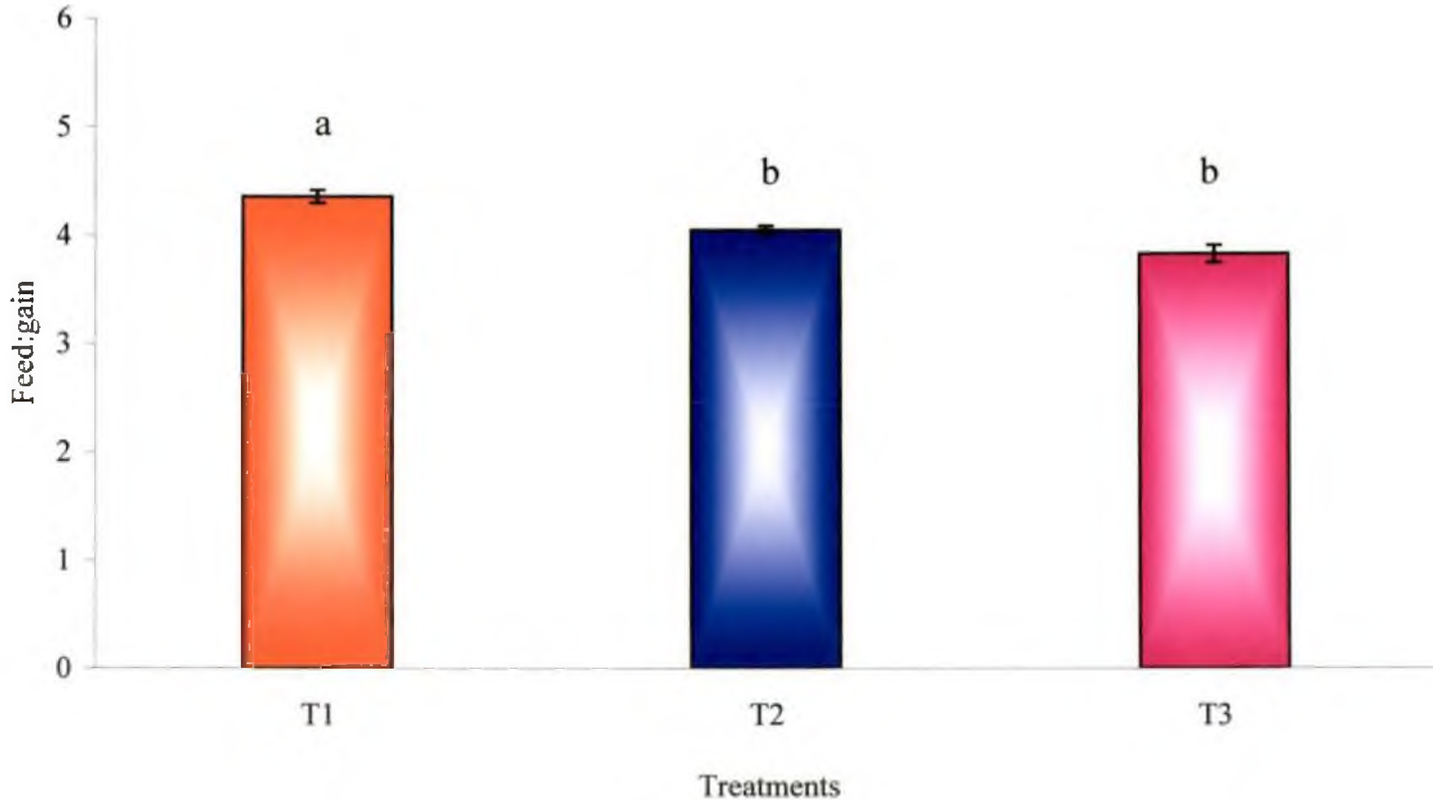

Fig.4. Feed conversion efficiency of pigs maintained on three dietary treatments

Table 9. Chemical composition of faeces of pigs maintained on three dietary treatments*, %

Item	Treatments		
	T_1	T_2	T_3
Moisture	67.11	66.27	67.07
Crude protein	10.62	10.59	10.62
Ether extract	2.55	2.53	2.57
Crude fibre	22.35	21.60	21.75
Nitrogen free extract	37.37	36.58	37.90
Total ash	27.11	28.70	27.16
Acid insoluble ash	16.80	17.66	17.13

* Average of ten values on dry matter basis

Table 10. Average digestibility coefficient of nutrients of the experimental diets (Mean ± SE)[1]

Item	Treatments			P value
	T_1	T_2	T_3	
Dry matter*	58.42 ± 0.78^{a}	59.22 ± 0.98^{ab}	63.48 ± 2.08^{b}	0.04
Crude protein	68.93 ± 1.42	70.02 ± 1.41	73.31 ± 1.74	0.13 (NS)
Ether extract*	52.99 ± 1.25^{a}	56.98 ± 1.87^{ab}	61.16 ± 2.23^{b}	0.012
Crude fibre*	22.26 ± 2.68^{a}	25.52 ± 2.02^{a}	32.82 ± 2.53^{b}	0.015
Nitrogen free extract	73.36 ± 0.41	75.03 ± 1.01	76.27 ± 1.54	0.18(NS)

1 Average of ten values on dry matter basis

a, b Means with different superscripts within the same row differ significantly

* Significant ($P<0.05$)

NS Non significant

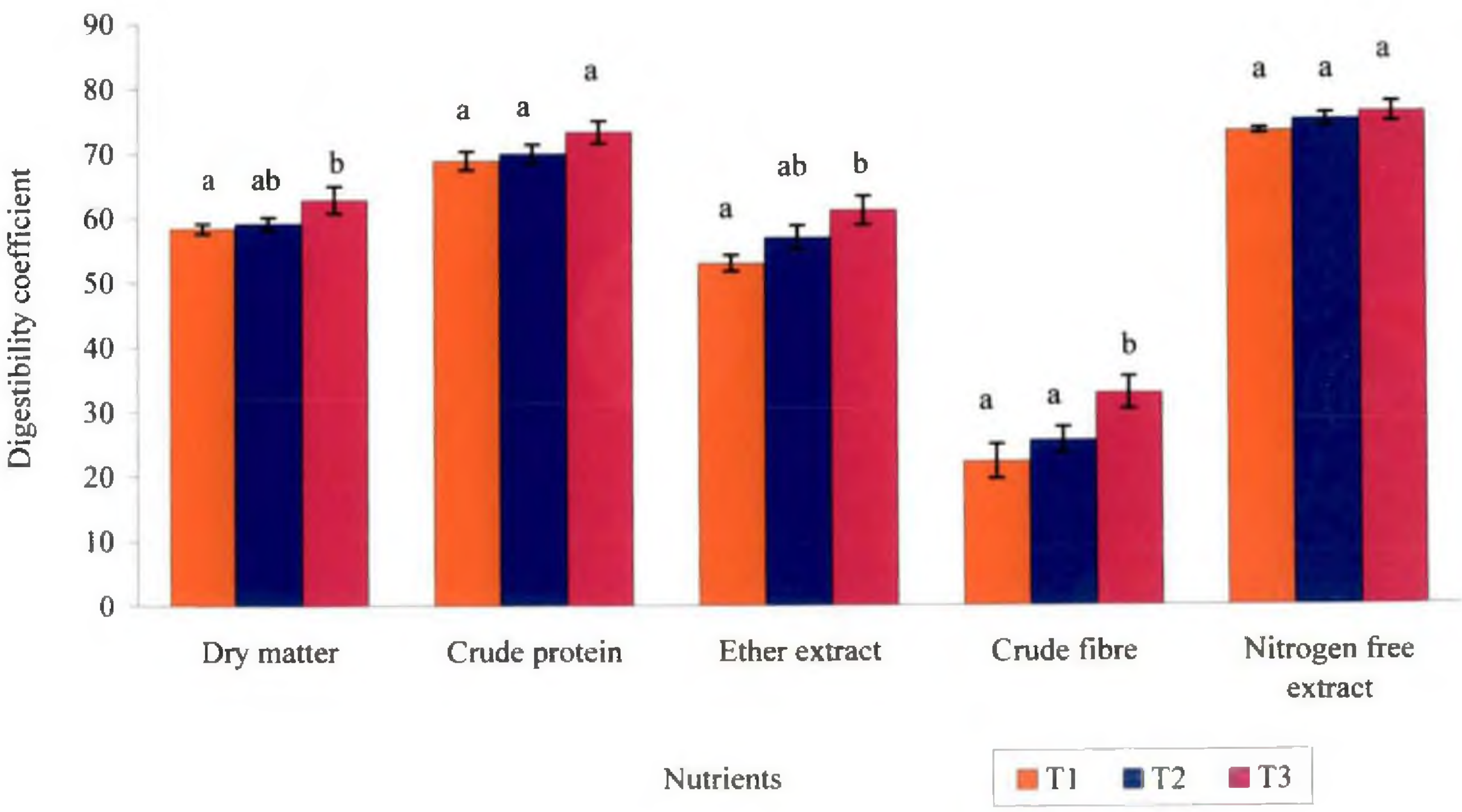

Fig. 5. Average digestibility coefficient of nutrients of the experimental diets

4.5 CARCASS CHARACTERISTICS

Data on carcass characteristics of pigs maintained on three experimental diets T_1, T_2 and T_3 are depicted in Table 11.

Colour of the pork was pale pink and consistency of fat was firm. Slaughter weight of pigs were 65.0, 67.5 and 69.7 kg, respectively for T_1, T_2 and T_3 and 46.7, 48.5 and 50.4 kg for hot carcass weight. The average dressing percentage of pigs for T_1, T_2 and T_3 were 71.7, 72.0 and 72.4, respectively. The average meat yield of pigs slaughtered from groups T_1, T_2 and T_3 were 59.6, 61.2 and 60.9 per cent, respectively.

The average meat bone ratio of pigs slaughtered from groups T_1, T_2 and T_3 were 4.65, 4.63 and 4.82, respectively.

The average back fat thickness of pigs from the three dietary treatments T_1, T_2 and T_3 were 33.5, 32.8 and 33.2 mm, respectively. The average loin eye area of pigs were 22.0, 22.6 and 23.7 cm^2 for T_1, T_2 and T_3 and 60.1, 61.2 and 61.9 cm for carcass length.

4.6 ECONOMICS OF GAIN

Data on cost of feed per kg body weight gain of pigs maintained on the three dietary treatments are presented in Table 12 and graphically represented in Fig. 6. The values were Rs. 36.63, 35.52 and 34.99 for T_1, T_2 and T_3, respectively.

Table 11. Carcass characteristics of pigs maintained on three dietary treatments (Mean ± SE)[1]

Carcass characteristics	Treatments			P value
	T_1	T_2	T_3	
Slaughter weight (kg)	65.00 ± 1.77	67.50 ± 3.07	69.67 ± 3.63	0.54 (NS)
Hot carcass weight (kg)	46.67 ± 1.26	48.52 ± 1.96	50.38 ± 2.55	0.44 (NS)
Dressing percentage	71.68 ± 0.42	71.97 ± 0.76	72.37 ± 0.53	0.34 (NS)
Meat yield (%)	59.59 ± 1.06	61.23 ± 0.76	60.86 ± 0.43	0.34 (NS)
Meat bone ratio	04.65 ± 0.17	04.63 ± 0.26	04.82 ± 0.11	0.76 (NS)
Back fat thickness (mm)	33.45 ± 0.19	32.78 ± 0.08	33.15 ± 0.16	0.95 (NS)
Loin eye area (cm^2)	22.03 ± 0.93	22.63 ± 0.94	23.73 ± 0.95	0.45 (NS)
Carcass length (cm)	60.08 ± 1.05	61.21 ± 0.93	61.88 ± 0.66	0.38 (NS)

1 Mean of six values

NS Non significant

Table 12. Cost of feed per kg body weight gain of pigs maintained on three dietary treatments

Item	Treatments		
	T_1	T_2	T_3
Cost per kg of grower ration[a] (Rs.)	8.69	9.07	9.44
Cost per kg of finisher ration[a] (Rs.)	7.97	8.35	8.72
Total consumption of grower ration (kg/pig)	133.55	135.55	135.55
Total consumption of finisher ration (kg/pig)	94.80	96.90	96.90
Total cost (Rs./pig)	1933.49	2038.55	2124.56
Total body weight gain (kg/pig)	52.83 ± 1.28	57.43 ± 1.39	60.82 ± 2.41
Cost of feed per kg body weight gain (Rs.)	36.63 ± 0.51	35.52 ± 0.38	34.99 ± 0.69

a Cost of feed ingredients is based on the rate contract fixed for the supply of various feed ingredients to the farm for the year 2002-03.

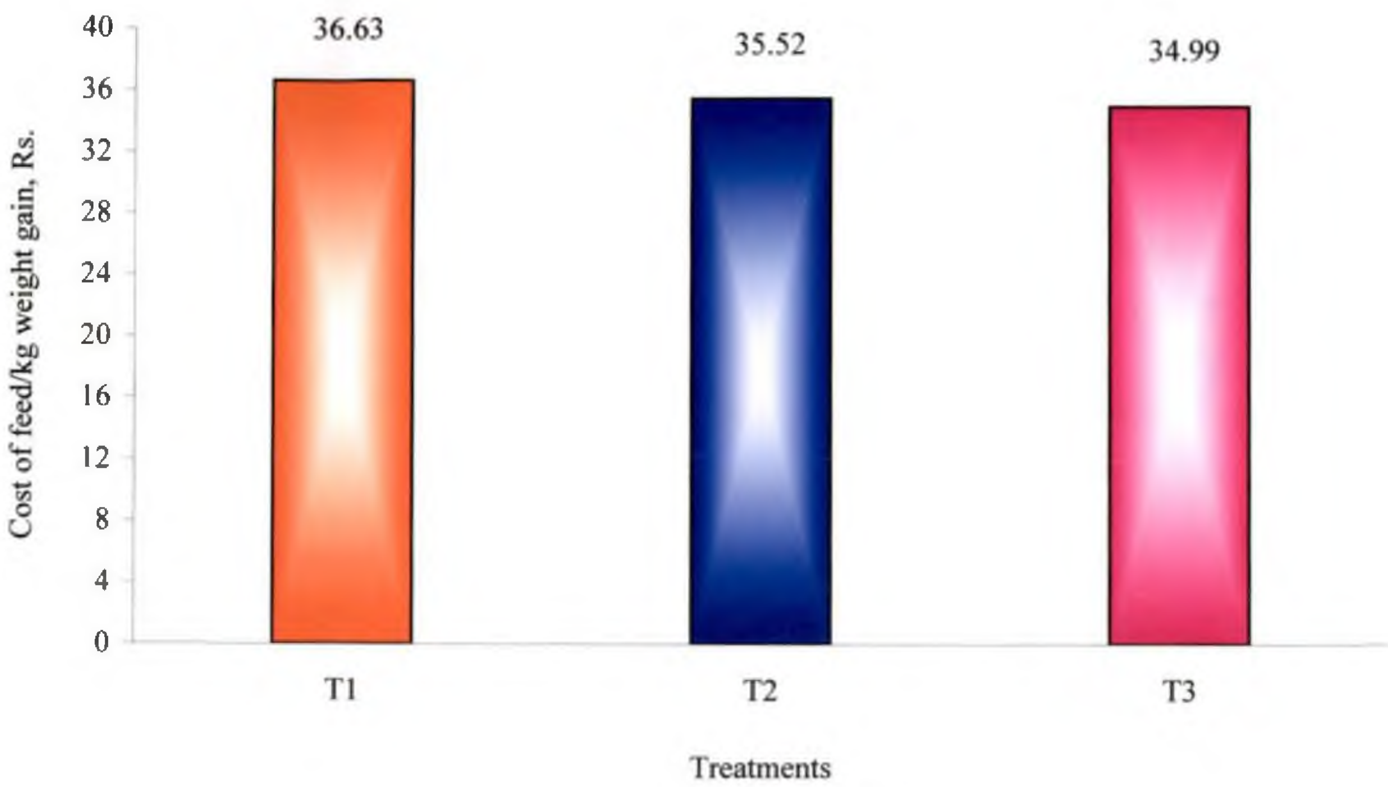

Fig. 6. Cost of feed per kg weight gain of pigs maintained on different experimental diets

Discussion

DISCUSSION

5.1 ANALYSIS OF YEAST CULTURE

5.1.1 Proximate Composition

Crude protein and crude fibre content of baker's yeast were 31.2 and 1.5 per cent, respectively (Table 4), which were higher than the corresponding values of 14 and <0.80 per cent reported by Arambel and Kent (1990). Natarajan (1999) reported almost similar values of 26.8 and 1.3 per cent for crude protein and crude fibre, respectively. The estimated ether extract content of baker's yeast was 5.2 per cent which was similar to the value of 5.6 per cent reported by Natarajan (1999). The total ash and nitrogen free extract contents were 7.1 and 55.1 per cent, respectively.

5.1.2 Mineral Composition

Calcium, phosphorus and magnesium contents of baker's yeast culture were 0.78, 0.32 and 0.13 per cent, respectively (Table 4). Arambel and Kent (1990) reported slightly higher values for calcium (1.80 per cent) and phosphorus (0.70 per cent) and similar value for magnesium (0.01 per cent), whereas Natarajan (1999) reported 0.40 per cent calcium, 0.18 per cent phosphorus and 0.53 per cent magnesium. Trace mineral contents of yeast culture were 232.0, 142.7 and 35.7 mg/kg for iron, zinc and manganese, respectively.

5.1.3 Viability of Yeast Culture

The estimated viability of baker's yeast used in the trial varied from 0.9×10^8 to 1.2×10^9 cfu/g. However, this viability was higher than the values of 1.6×10^5 cfu/g (Kamalamma *et al.*, 1996) and 0.7×10^8 cfu/g (Natarajan, 1999). But, Dawson *et al.* (1990) reported a value of 2.04×10^9 live yeast cells/g of yeast culture.

Moore (1993) reported that metabolic activity rather than reproductive ability was the important factor for the success of yeast culture as a feed additive. In her opinion, total cell count including dead cells should be considered while expressing the yeast cell count. The live and dead cell count per g was 18.7 to 23.1 x 10^9 cells in the present study.

5.2 FINAL BODY WEIGHT AND BODY WEIGHT GAIN

The average final body weight (kg) recorded in pigs of the three treatments T_1, T_2 and T_3 were 66.4, 71.0 and 74.4, respectively. Body weight gain (kg) of pigs during the experimental period was 52.8, 57.4 and 60.8 for T_1, T_2 and T_3, respectively (Table 8).

Statistical analysis of data revealed that pigs fed with diet containing 0.5 per cent baker's yeast (T_3) recorded significantly higher ($P<0.05$) body weight and body weight gain when compared to that of control (T_1). There was no significant difference between 0 and 0.25 per cent as well as 0.25 and 0.5 per cent baker's yeast fed groups. There was a trend for improved growth performance in baker's yeast fed groups than that of control. The higher body weight gain has been reported by Kronka *et al.* (1991) which ranged from 69.0 to 83.5 kg when varying levels of dried sugarcane distillers yeast was included in the diet of crossbred (Landrace x Wessex x Duroc) pigs. Final body weight of pigs ranged from 93.8 to 107.1 kg was obtained when *Saccharomyces cerevisiae* yeast was used as a protein supplement (Gutierrez *et al.*, 1999). These values were higher than those obtained in the present study.

Jurgens (1995), Mathew *et al.* (1998), Naskar *et al.* (2000) and Heugten and Dorton (2001) reported higher body weight and body weight gain in yeast culture supplemented groups and are in agreement with the present results. Contrary to above findings, Ravi *et al.* (2000) and Harper (2002) reported no effect of yeast culture on body weight and body weight gain in pigs.

The results of the present study revealed that the 0.5 per cent baker's yeast is more effective in improving body weight. Yeast culture in the diet nurtures the entire microflora of the gut helping to maintain a vigorous and balanced bacterial population and checks the bacterial diarrhoea by suppressing growth and proliferation of pathogenic organisms. Further, it also contains unidentified growth factors which are useful in improving the body weight gain. Thus, it acts as a promotent of digestion and assimilation of the entire feed and thereby it may improve the weight gain.

5.3 AVERAGE DAILY GAIN

The cumulative average daily gain of pigs maintained on three experimental rations T_1, T_2 and T_3 were 352, 383 and 405 g, respectively (Table 8).

Data on average daily gain indicated that the pigs belonging to T_3 had significantly higher ($P<0.05$) daily gain than that of T_1. Though the T_2 had numerically higher average daily gain, there was no significant difference between T_2 and T_1. Yeast culture at higher level (0.5 per cent) in the diet of growing-finishing pigs improved the average daily gain by six per cent over 0.25 per cent yeast culture group and 15 per cent over 0 per cent yeast culture group.

Mean daily gain ranging from 624 to 649 g was recorded in pigs when yeast culture grown on a substrate containing chromium was included in the diet (Savoini *et al.*, 1996). Gutierrez *et al.* (1999) recorded an average daily gain of 700 to 980 g when yeast was included in the diets of pigs as protein source. The values reported by the above researchers were higher than those obtained in the present study.

Veum *et al.* (1988) reported that the average daily gain of pigs receiving 1.75 per cent yeast culture diet was higher than those pigs fed with 0.75 per cent yeast culture and control diet. Naskar *et al.* (2000) reported 37.7 per cent increase in average daily gain in probiotic supplemented group. Similarly, Heugten *et al.* (2003) found enhanced daily weight gain when pigs fed yeast supplemented diet along with growth promoting levels of antimicrobials. These findings are in line with the present results. Contrary to above findings, Kornegay *et al.* (1995) and Bekaert *et al.* (1996) did not find any significant effect of yeast culture on average daily gain of pigs.

The improvement in average daily gain may be due to improved feed utilization since feed intake was not significantly affected. Yeast culture contains significant amount of essential amino acids, vitamin B complex, trace minerals and beneficial metabolic products of the fermentation process. These would have aided to increase the average daily gain in yeast supplemented groups.

5.4 FEED CONVERSION EFFICIENCY

Pigs maintained on diet containing 0.25 and 0.5 per cent baker's yeast culture recorded better ($P<0.01$) feed conversion efficiency than those fed unsupplemented diet. There was no significant difference between T_2 and T_3. The values were 4.36, 4.05 and 3.83 for T_1, T_2 and T_3, respectively (Table 8). Baker's yeast at 0.5 per cent level in the diet of growing-finishing pigs improved the feed efficiency by five per cent over 0.25 per cent yeast culture group and 12 per cent over control group.

Bonomi *et al.* (1978) recorded 6.5 per cent greater feed efficiency in 0.2 per cent yeast supplemented group than control pigs. Veum *et al.* (1988) observed significantly higher feed conversion efficiency in the yeast culture supplemented group. Caleffi and Broccaioli (1991) reported a value of 3.8 to 4.2 for the fattening pigs fed with various levels of fresh brewer's yeast. Similarly, Jurgens *et al.* (1997) observed significant ($P<0.05$) improvement in feed efficiency. Growing pigs fed diet containing yeast culture converted feed 9.6 per cent more efficiently than that of control pigs (Reddy, 2001). The above findings are in agreement with the present results. In contradiction to this, Kronka *et al.* (1991), Kornegay *et al.* (1995), Bekaert *et al.* (1996) and Savoini *et al.* (1996) reported no significant effect of yeast culture on feed conversion ratio.

Feed efficiency tended to be improved in pigs fed diets containing baker's yeast because of improved daily gain and digestibility of nutrients. The probiotics would have been efficient in converting feed into body mass only during the latter stages of growth which led to better feed efficiency at that period. Yeast cell wall contains mannan oligosaccharides and fructan oligosaccharides which are also known as prebiotics. These substances usually bind with pathogenic bacteria and toxic substances and aid in their excretion. This might have helped to maintain hygienic environment in the gut and thereby improved feed conversion efficiency (Reddy, 2001).

5.5 DIGESTIBILITY COEFFICIENT OF NUTRIENTS

5.5.1 Dry Matter

The digestibility coefficient of dry matter of the three experimental diets T_1, T_2 and T_3 were 58.4, 59.2 and 63.5, respectively (Table 10 and Fig. 5). Pigs fed with 0.5 per cent yeast culture had higher ($P<0.05$) dry matter digestibility than those fed with unsupplemented diet. There was no significant difference between pigs belonging to T_1 and T_2 as well as T_2 and T_3. Pigs belonging to T_3 had 8.7 and 7.2 per cent higher dry matter digestibility than T_1 and T_2, respectively.

Veum *et al.* (1995) obtained dry matter digestibility coefficient ranging from 73.5 to 75.0 for sow diets supplemented with different levels of yeast culture. Heugten *et al.* (2003) reported higher values (82 to 83.5) for weanling pigs fed diet containing yeast culture. The above values were higher than those obtained in the present study. Similary, Reyes *et al.* (1991) and Kornegay *et al.* (1995) also reported non-significant effect of yeast culture on digestibility of dry matter.

The improved dry matter digestibility in baker's yeast fed group may be due to the enzymes present in the culture medium and increased hindgut fermentation due to the action of yeast.

5.5.2 Crude Protein

A perusal of the data in Table 10 further indicates that the digestibility coefficient of crude protein in the experimental diets T_1, T_2 and T_3 were 68.9, 70.0 and 73.3, respectively. There was no significant difference among the three treatments. However, pigs belonging to the group T_3 digested crude protein 6.4 and 4.7 per cent more efficiently than those of T_1 and T_2, respectively.

The present finding that the nitrogen digestibility was not affected by baker's yeast supplementation is in agreement with the findings of Reyes *et al.* (1991) who reported non-significant effect of yeast culture supplementation on nitrogen digestibility in gestation and lactating sows. The same effect was reported by Kornegay *et al.* (1995) and Veum *et al.* (1995) in growing-finishing pigs. In opposition to this, Park *et al.* (2003) reported improved crude protein digestibility in the 0.1 and 0.2 per cent yeast culture supplemented groups than in control group.

The effect of nutrient digestibility may be species related. Glade and Biesik (1986) reported improved nitrogen metabolism in horses fed diets with added yeast culture. In the present study, a trend for better nitrogen digestibility may be due to different protein digesting enzymes present in the yeast culture.

5.5.3 Ether Extract

The average ether extract digestibility was 53.0, 57.0 and 61.2 per cent for the three treatments T_1, T_2 and T_3, respectively (Table 10). Pigs fed diet containing 0.5 per cent yeast had a higher ($P<0.05$) digestibility of ether extract than those fed with the control diet. There was no significant difference between pigs belonging to T_1 and T_2 as well as T_2 and T_3. Pigs belonging to T_3 had 15.4 and 7.3 per cent higher ether extract digestibility than T_1 and T_2, respectively.

Live yeast culture such as *Saccharomyces cerevisiae* contain enzymes such as lipase, lecithinase and phospholipase that could be released into the intestine and aid in the digestion of fat. This might be the reason for improved digestibility of fat obtained in the present study.

The similar findings were also reported in broilers (Saha *et al.*, 1999b). However, Reyes *et al.* (1991) and Murry and Dawe (1996) reported non-significant action of yeast culture on crude fat digestibility in pigs.

5.5.4 Crude Fibre

The digestibility coefficient of crude fibre for the three experimental diets T_1, T_2 and T_3 were 22.3, 25.5 and 32.8, respectively (Table 10). Pigs fed diet containing 0.5 per cent baker's yeast had higher ($P<0.05$) fibre digestibility than those fed with the diets containing 0 and 0.25 per cent yeast culture.

Yeast can ferment wide variety of feed stuffs including those rich in fibre both in ruminants and non ruminants. The addition of yeast culture had positive effect on fibre digestibility due to the fact that addition of yeast culture would increase ruminal cellulolytic bacterial populations as reported by Harrison *et al.* (1988) and Dawson *et al.* (1990). Similarly, addition of yeast culture to growing-finishing pigs diet might have increased the cellulolytic bacterial counts in large intestine. Yeast cells can not colonize in the gut but it moves freely and helps in fermentation process. The improved digestibility in yeast supplemented groups in the present study confirm the above facts.

The findings of Eggum *et al.* (1982) on digestibility coefficient of crude fibre which ranged from 24.0 to 31.2 in pigs fed on diets containing 13 per cent crude protein and varying levels of crude fibre which is in accordance with results obtained in the present study. In contradiction to this, Reyes *et al.* (1991) and

Kornegay *et al.* (1995) reported no effect of yeast culture on the digestibility of fibre rich diets.

5.5.5 Nitrogen Free Extract

The digestibility coefficient of nitrogen free extract for the three experimental diets T_1, T_2 and T_3 were 73.4, 75.0 and 76.3, respectively. The analysis of data revealed no significant difference between the treatments.

The nitrogen free extract portion of feed is highly digestible. So the enzymes present in the yeast culture had only little effect on digestibility of nitrogen free extract. Similar results indicating non-significant effect of yeast on nitrogen free extract digestibility were reported by Bowman and Veum (1973) and Kornegay *et al.* (1994).

5.6 CARCASS CHARACTERISTICS

5.6.1 Dressing Percentage

The average dressing percentage of pigs slaughtered from three dietary treatments T_1, T_2 and T_3 were 71.7, 72.0 and 72.4, respectively (Table 11). Analysis of data revealed no significant difference between the treatments.

Anjaneyulu *et al.* (1984) reported values ranging between 70.9 to 71.4 for dressing percentage of pigs slaughtered at the age of 191 to 290 days. Kronka *et al.* (1991) also reported values ranging from 75 to 78.5 for dressing percentage of pigs fed with diets containing distiller's yeast (*Saccharomyces cerevisiae*). Gutierrez *et al.* (1999) reported non-significant effect of yeast feeding on dressing percentage. The results of the present study are in line with the above findings. In contrary, Moreira *et al.* (1998) reported that 7 per cent dried yeast in the diets of growing-finishing pigs improved the dressing percentage.

5.6.2 Back Fat Thickness

The mean back fat thickness of pigs maintained on the three dietary treatments T_1, T_2 and T_3 were 33.5, 32.8 and 33.2 mm, respectively (Table 11). There was no significant difference among the treatments.

Baird *et al.* (1975) and Seerley *et al.* (1978) obtained values ranging from 34 to 36 mm in pigs fed on rations containing varying levels of crude fibre, crude protein and dietary energy. The fact that the back fat thickness did not differ significantly due to yeast feeding was reported by Bowman and Veum (1973), Murry (1994) and Gutierrez *et al.* (1999). These results were similar to those obtained in the present study.

5.6.3 Loin Eye Area

The average value for loin eye muscle area of pigs on the three dietary treatments T_1, T_2 and T_3 were 22.0, 22.6 and 23.7 cm^2, respectively. There was no significant difference among the three dietary treatments.

Filho *et al.* (1993) recorded loin eye area that ranged from 28.5 to 31.8 cm^2 when pigs were fed diets containing different levels of *Saccharomyces cerevisiae* yeast which were higher than the values obtained in the present study.

Bonomi *et al.* (1978), Mazzocco and Bolla (1989), Murry (1994) and Gutierrez *et al.* (1999) reported non-significant effect of yeast feeding on loin eye area. These findings are in accordance with the results obtained in the present study. But, Caleffi and Broccaioli (1991), Savoini *et al.* (1996) and Moreira *et al.* (1998) obtained higher *Longissimus dorsi* muscle area in yeast supplemented group.

5.6.4 Carcass Length

The mean carcass length of pigs in the three dietary treatments T_1, T_2 and T_3 (Table 11) were 60.1, 61.2 and 61.9 cm, respectively and they did not differ significantly. Bowman and Veum (1973) and Caleffi and Broccaioli (1991) had obtained similar values for yeast supplemented and control groups.

The overall data on carcass characteristics presented in Table 11 reveal that there was no significant difference between dietary treatments in any of the parameters studied. Bowman and Veum (1973) concluded that supplementation of swine diets with 2.0 or 1.5 per cent yeast culture from 14 to 34 kg or 34 to 100 kg, respectively did not significantly affect the carcass characteristics such as back fat thickness, loin eye area and carcass length. Similarly, Murry (1994) reported that carcass characteristics were not significantly affected due to supplementation of yeast culture in the diet or because of sex. The overall results of carcass characteristics obtained in the present study are in line with the above findings.

5.7 Economics of Gain

The cost of feed per kg body weight gain of pigs maintained on the three dietary treatments T_1, T_2 and T_3 were Rs.36.63, 35.52 and 34.99, respectively (Table 12 and Fig.6). The cost of feed per kg of body weight gain was slightly lower for T_3 than those for T_1 and T_2. The approximate increase in cost per kg of feed due to addition of yeast culture at 0.25 per cent and 0.50 per cent levels were Rs.0.38 and 0.75, respectively. Even though the cost per kg of feed was higher in T_2 and T_3 due to yeast culture addition, cost per kg of live weight gain was lower in these groups compared to T_1. Improved average daily gain and feed conversion efficiency of pigs in T_2 and T_3 contributed for reduced cost of production.

Hence, it is concluded that baker's yeast can be economically included at 0.5 per cent level in the diet for better growth and feed conversion efficiency in crossbred pigs.

Summary

6. SUMMARY

An investigation was carried out to evaluate the effect of baker's yeast on growth and nutrient utilization in Large White Yorkshire x Desi (75:25) crossbred pigs. Thirty weaned piglets (15 barrows and 15 gilts) with an average body weight of 13.5 kg were selected from the Centre for Pig Production and Research, Mannuthy and divided into three homogeneous groups of ten each with regard to age, sex and body weight. Ten piglets in each group were randomly distributed into five replicates of two piglets each. The three groups were randomly allotted to three dietary treatments viz., T_1- control (standard ration), T_2- control diet supplemented with 0.25 per cent baker's yeast culture and T_3- control diet supplemented with 0.5 per cent baker's yeast culture.

The experiment was conducted for five months. The pigs were fed twice daily. The piglets were fed on grower ration having 18 per cent protein and 3200 kcal digestible energy per kg until they reached an average body weight of 50 kg and then with finisher ration having 14 per cent protein and 3100 kcal digestible energy per kg till slaughter. Each replicate was housed in separate pen and maintained under identical managemental conditions. Digestibility trial was carried out towards the end of the experiment using chromic oxide as external indicator. On completion of seven months of age, six pigs from each treatment were randomly selected and slaughtered to obtain data on carcass characteristics.

The average daily gain was 352, 383 and 405 g and the feed conversion efficiency was 4.36, 4.05 and 3.83 for the three groups T_1, T_2 and T_3, respectively. The pigs fed diet supplemented with 0.5 per cent baker's yeast (T_3) had higher ($P<0.05$) daily gain than those fed with unsupplemented (T_1) diet. There was no significant difference between T_1 and T_2 as well as T_2 and T_3. However, there was a trend for higher daily gain in those fed 0.25 per cent baker's yeast (T_2) than those fed with unsupplemented diet (T_1). Pigs maintained on diet containing 0.25 and 0.5 per cent baker's yeast culture recorded better ($P<0.01$) feed conversion

efficiency than those fed unsupplemented diet. There was no significant difference between T_2 and T_3. Baker's yeast supplementation at 0.5 per cent level in the diet of growing-finishing pigs improved average daily gain and feed conversion efficiency by 6 and 5 per cent over 0.25 per cent baker's yeast group and by 15 and 12 per cent over control group, respectively.

The digestibility coefficient of dry matter and ether extract were higher ($P<0.05$) for pigs fed diet containing 0.5 per cent baker's yeast (T_3) than those fed with unsupplemented diet (T_1) and there was no significant difference between T_1 and T_2 or T_2 and T_3. Pigs fed diet containing 0.5 per cent baker's yeast had higher ($P<0.05$) crude fibre digestibility than those fed with the diets containing 0 and 0.25 per cent yeast culture.

Carcass characteristics such as dressing percentage, hot carcass weight, meat yield percentage, meat bone ratio, carcass length, back fat thickness and loin eye area were not significantly influenced by the inclusion of baker's yeast at different levels in the diet. The cost of production per kg live weight gain of pigs maintained on three dietary treatments T_1, T_2 and T_3 were found to be Rs.36.63, 35.52 and 34.99, respectively.

From the present investigation it is concluded that baker's yeast can be economically included at 0.5 per cent level in the diet for better growth and feed conversion efficiency in crossbred pigs. Thus, live yeast culture can be used as an alternative feed additive to antibiotics in swine production.

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EFFECT OF BAKER'S YEAST ON GROWTH AND NUTRIENT UTILIZATION IN CROSSBRED (LARGE WHITE YORKSHIRE X DESI) PIGS

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ABSTRACT

A study was carried out to assess the influence of baker's yeast culture on growth performance, digestibility of nutrients and carcass characteristics in Large White Yorkshire x Desi (75:25) crossbred pigs. Thirty weaned piglets (15 barrows and 15 gilts) with an average body weight of 13.5 kg were divided into three homogeneous groups with regard to age, sex and body weight. Ten piglets in each group were randomly distributed into five replicates of two piglets each. The three groups were randomly allotted to three dietary treatments viz., T_1- control (standard ration), T_2- control diet supplemented with 0.25 per cent baker's yeast culture and T_3- control diet supplemented with 0.5 per cent baker's yeast culture. The piglets were fed on their respective grower rations which contained 18 per cent crude protein and 3200 kcal digestible energy per kg until they attained an average body weight of 50 kg and thereafter changed to finisher rations which contained 14 per cent crude protein and 3100 kcal digestible energy per kg until the pigs were slaughtered. A digestibility trial was conducted towards the end of the experiment using chromic oxide as external indicator. On completion of seven months of age six pigs from each treatment were slaughtered to study the carcass characteristics.

Average daily gain of 352, 383 and 405 g were recorded for the groups T_1, T_2 and T_3, respectively. The pigs fed with diet containing 0.5 per cent baker's yeast (T_3) had higher ($P<0.05$) average daily gain than those fed with unsupplemented diet (T_1). But, there was no significant difference between T_1 and T_2 as well as T_2 and T_3. However, there was a trend for a higher average daily gain for those fed 0.25 per cent yeast culture (T_2) over those fed control diet (T_1). Feed conversion efficiency was 4.36, 4.05 and 3.83 for the groups T_1, T_2 and T_3, respectively. The pigs fed with diets containing 0.25 (T_2) and 0.5 per cent baker's yeast (T_3) had higher ($P<0.01$) feed conversion efficiency than those fed with unsupplemented diet (T_1). The digestibility coefficient for dry matter and ether extract were significantly higher ($P<0.05$) for pigs fed 0.5 per cent yeast

culture than those fed with unsupplemented diet and there was no significant difference between T_1 and T_2 or T_2 and T_3. Pigs fed diet containing 0.5 per cent baker's yeast had higher ($P<0.05$) crude fibre digestibility than those fed with the diets containing 0 and 0.25 per cent yeast culture. Study of the carcass characteristics revealed that the dressing percentage, carcass length, back fat thickness and loin eye area were not significantly influenced by the inclusion of yeast culture at different levels. The cost of feed per kg live weight gain was Rs.36.63, 35.52 and 34.99, respectively for the treatments T_1, T_2 and T_3. Feed cost per kg live weight gain was lower in T_3 compared to other treatments.

It is concluded that baker's yeast can be economically included at 0.5 per cent level in the diet for better growth and feed conversion efficiency in crossbred pigs.