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Studies on the effect of dietary supplementation of probiotics on proximate analysis and cost economics of crossbred pigs

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ABSTRACT

Pig farming is considered as an important component of the livestock sector and Pork is a major trade commodity globally. According to the Food and Agriculture Organization (FAO), global pork production reached 97 million metric tons in 2020. In India, an estimated half a million people are involved in Pig farming. It is more concentrated in certain states of the country, including Assam, Meghalaya, Nagaland, Manipur and Mizoram. As per 20 th Livestock census, the total pig population in the country is 9.06 million which accounts for 1.7% of the total livestock population. Several studies have been conducted to increase growth performance of grower pigs through various feed additives. The different feed additives added in feed of pig are like enzyme, *anti*-oxidant, antibiotic, prebiotic and probiotic. Probiotic is added to increase the population of beneficial microorganisms, such as Lactobacilli and Bifidobacteria. These healthy bacterial colonies then inhibit the growth of harmful microorganisms by producing substances (e.g., bacteriocins and/or organic acids). Probiotic feed additives stimulate antibody production and consequently boost the immune system naturally. So, probiotics are given in all different stages of growth of pigs (Pre-weaning, post –weaning and in Reproduction). It boosted immune response, antioxidant enzyme activities, and nutrient digestibility, while reducing lipid peroxidation. Economic analysis showed greater body weight, profit, and benefit-to-cost ratios, especially with moderate supplementation.

Keywords: Probiotics, Crossbred pigs, Proximate analysis, Cost economics, Feed additives

1 Introduction

Pig farming plays a vital role in the livestock industry, with pork ranking among the most widely traded meat products worldwide. Data from the Food and Agriculture Organization (FAO) indicates that global pork production stood at around 97 million metric tons in 2020. China emerged as the dominant producer, contributing more than half of the total output. To meet the rising demand for pork, major exporting nations rely on large-scale, intensive production systems designed to optimize efficiency (Bhaduaria *et al.*, 2023)¹. In India, pig farming is largely unorganized, with minimal use of additional nutrient supplements. However, over the past few decades, this sector has gained greater acceptance due to several factors, including the rising demand for pork products, shifts in dietary habits, rapid urbanization, increasing disposable income among the middle class, and the entry of international food chains that use pork for items such as bacon and sausages (Shastry *et al.*, 2021)². Nevertheless, pigs compete directly with humans for conventional feed resources, which has led to the exploration of alternative feed options aimed at lowering costs and improving feed conversion efficiency (Shastry *et al.*, 2021)². Various feed additives such as enzymes, antioxidants, antibiotics, prebiotics, and probiotics are commonly incorporated into pig diets to enhance growth and health (Al-Jaf *et al.*, 2019)³. Likewise, probiotics help maintain a healthy gut microbiota by enhancing populations of beneficial microorganisms like Lactobacillus and Bifidobacterium, which in turn suppress harmful microbes through the production of bacteriocins and organic acids (Al-Jaf *et al.*, 2019)³. Probiotics are described as live microbial feed additives that exert beneficial effects on the host by enhancing growth performance, strengthening immunity, and maintaining intestinal microbial equilibrium (Fuller, 1989)⁴. Similarly, yeast-based products such as yeast culture, yeast extract, and yeast hydrolysates (YH) act as effective probiotics because they are rich in nucleotides, B-complex vitamins, amino acids, and cell wall polysaccharides like β -glucans and mannans. These bioactive components contribute to enhanced growth, immune regulation, gut development, and tissue repair in animals (Sauer, 2010)⁵.

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2 Materials and Methods

2.1 Place of the experiment

The present work is carried out at Instructional Piggery Unit, Department of Livestock Production and Management, College of Veterinary Science and Animal Husbandry, Rewa (M.P.)

2.2 Management of pigs

The experimental pens were prepared as per standard practice before separation of weaned piglets. All healthy experimental piglets were taken and kept in similar managerial condition and provided with nor-

mal routine health care and vaccination. The experiment was conducted in 40 weaned crossbred piglets (Large white Yorkshire x Desi pigs) weaned at 60 days of age, born in same season (± 2 months) from different sows and were randomly divided into 4 experimental groups, each containing 10 piglets. The experimental groups consist of one control group (only basal diet given) and three treatment groups (Basal + probiotics) with varying degree of probiotics along with basal diet.

Table 1.

Details of experimental design			
Experimental Animals			
Group 1	Group 2	Group 3	Group 4
Control group (Basal diet)	Basal diet + Probiotic @ 200g/ tonne of feed [<i>Bacillus subtilis</i> and <i>B. lichenformis</i> @ 3×10^6 CFU per gram, <i>Saccharomyces cerevisiae</i> @ 6×10^6 CFU / gram]	Basal diet + Probiotic @ 400g/ tonne of feed [<i>Bacillus subtilis</i> and <i>B. lichenformis</i> @ 6×10^6 CFU per gram, <i>Saccharomyces cerevisiae</i> @ 12×10^6 CFU / gram]	Basal diet + Probiotic @ 600g/ tonne of feed [<i>Bacillus subtilis</i> and <i>B. lichenformis</i> @ 9×10^6 CFU per gram, <i>Saccharomyces cerevisiae</i> @ 18×10^6 CFU / gram]
NRC (1980) feeding standard with CP 22% and 18%	(from 60 days of age to upto 120 days)	(from 60 days of age to upto 120 days)	(from 60 days of age to upto 120 days)
10 piglets	10 piglets	10 piglets	10 piglets

2.3 Proximate Analysis

2.3.1 Moisture

A sample of the feed and faecal was weighed into a dried aluminium disc and heated to 100 ± 2 °C in a hot air oven without a lid for 16–18 hours. Loss in weight (moisture of the sample) was calculated after cooling the sample in desiccator. The difference in weight is expressed as moisture percent from which DM° can be calculated.

$$\text{Moisture}\% = \frac{\text{Weight of sample after drying in hot air oven}}{\text{Weight of sample before drying in hot air oven}} \times 100$$

Reagents-

1. Commercial sulphuric acid
2. Digestion mixture {1-part CuSO_4 (act as catalyst): 10 parts NaSO_4 or K_2SO_4 (raises boiling point)}
3. 40% NaOH
4. Tashiro's indicator
5. N/7 H_2SO_4

For crude protein estimation, 3 steps required –

Digestion

Distillation

Titration

Twenty millilitres of concentrated H_2SO_4 and five grams of sample were added to a Kjeldahl flask. After adding 5 grams of the digestion mixture, the mixture was further broken down until a blue-green coloured solution appeared. The final volume (aliquot) was obtained by mixing with distilled water after cooling. After mixing 10 ml of the aliquot with 15 ml of the 40% NaOH solution, it was made alkaline and then distilled. After distillation, ammonia that had been freed was collected in a conical flask with two to three drops of Tarshiro's indicator and ten millilitres of boric acid solution. The boric acid-containing flask's contents were titrated against N/7 H_2SO_4 .

$$\text{Protein} = \frac{\text{Amount of N/7 H}_2\text{SO}_4 \text{ used} \times 0.00014 \times 100 \times 6.25 \times 100}{\text{Weight of sample} \times \text{ml of aliquot}}$$

2.3.3 Crude fibre-

Reagents-

- 1) H_2SO_4
- 2) NaOH
- 3) Ethyl alcohol

In a spoutless beaker on a hot plate, measured amounts of moisture- and fat-free feed and faecal samples were refluxed with diluted sulphuric acid (2.05N) and sodium hydroxide (2.05N) for 30 minutes each, after which each was filtered and repeatedly washed with hot water. The leftover residue was weighed and then quantitatively moved to a silica basin. It was then oven dried and ash-treated in a muffle furnace for two to three hours at 550 °C. By dividing the sample weight on a dry matter basis by the weight loss resulting from ashing the residue, crude fibre was computed.

The calculation was as follows:

$$\% \text{ CF} = (a-b) \times 100/w$$

Where,

a = weight (g) of silica basin plus oven dried sample

b = weight (g) of silica basin plus ash

w = weight of sample

2. Total Ash-

Five grams of the feed and faecal sample were placed in a silica crucible that had been dried and weighed. The sample was cooked on a hot plate until the smoking stopped and it was completely blackened. The burned sample was then maintained for 2.5 hours at 600 °C in a muffle furnace. The crucible was weighed after being cooled in a desiccator. The weight difference between the empty crucible and the weight after ashing was used to calculate the amount of ash.

3. Ether extract

In a thimble with a boiling flask that had been previously weighted, three grams of sample were taken. In Soxhlet's extraction apparatus, the sample was extracted using petroleum ether (which has a boiling point between 60 and 80 °C) for a duration of 6 to 8 hours. Following extraction, the boiling flask was removed, allowed to dry outside and then placed in a hot air oven set at approximately 100 °C for one hour. The percentage of ether extract was computed and the weight gain of the boiling flask was noted.

3. To assess the cost economics of feeding probiotics in pigs.

Calculation of cost economics –

$$\text{Profit (Rs.)} = \text{Income} - \text{Expenditure}$$

$$\text{Benefit: cost ratio} = \frac{\text{Benefit (Income)}}{\text{Cost (expenditure)}}$$

3 Result and discussion

3.1. Proximate analysis of feed and feces

The results of proximate analysis as proximate values of Feed and Feces are reported as follows-

In the present study, the proximate values of the feed remained relatively similar across groups, as expected, since the basal diet formulation was constant and only probiotics were supplemented. However, variations were observed in the proximate values of feces, suggesting differences in nutrient absorption and digestive efficiency among the groups. Moisture content in feces was highest in groups supplemented with probiotics compared to the control, which could be linked to improved gut microbial activity and modulation of intestinal fermentation, thereby influencing water retention and consistency of fecal matter.

Previous studies have reported that probiotics supplementation enhances gut microbial balance, which promotes better nutrient breakdown and intestinal health (Datt *et al.*, 2011⁶; Cai *et al.*, 2015⁷) [6, 7]. Crude protein levels in feces were relatively low across all groups, but pigs fed probiotics diets showed slightly reduced protein excretion compared to controls, indicating improved protein utilization.

The present research findings agree with earlier findings that probiotics enhance protein digestibility by stimulating enzymatic activity and microbial fermentation in the gut (Giang *et al.*, 2011⁸; Wang *et al.*, 2019⁹) [8, 9]. Similarly, fecal crude fiber levels were lower in probiotics-fed groups, reflecting enhanced fiber degradation, which is consistent with reports that certain probiotics strains, such as *Lactobacillus* and *Bacillus*, possess cellulolytic activity that aids in fiber breakdown (Datt *et al.*, 2011⁶) [6]. Ether extract values showed some variation, with probiotics groups generally demonstrating improved lipid utilization, as evidenced by lower fecal fat in certain treatments. This observation supports earlier studies suggesting that probiotics promote bile salt hydrolase activity and fat metabolism in pigs (Upadhaya *et al.*, 2015¹⁰) [10]. Fecal ash content varied considerably among groups, with lower values in probiotic-supplemented pigs, implying better mineral absorption and retention (Upadhaya *et al.*, 2015¹⁰) [10].

3.2. Cost economics

The result of effect of probiotics supplementation at different doses in treatment groups (Group 1 to 4) at the end of the trial on Cost economics of crossbred pigs was evaluated. The result of Cost economics is presented below in Table 3.

Table 2. The Proximate analysis of feed samples, the values recorded for moisture content were 9.6%, 7.2%, and 6.8%. The crude protein levels were 21%, 22%, and 21.2%, while crude fiber content was observed at 4.2%, 4.8%, and 3.5%. Ether extract values were 5.5%, 4.0%, and 6.0%, and the total ash content measured 8.3%, 9.6%, and 8.4%. The result of fecal samples, the moisture content was 64.5% in Group 1, 69.2% in Group 2, 73.3% in Group 3, and 74.2% in Group 4. The crude protein values were 4.0%, 3.8%, 4.3%, and 4.1% for Groups 1, 2, 3, and 4, respectively. Crude fiber levels were 1.0%, 0.89%, 0.75%, and 1.2% across the same groups. Ether extract was recorded at 8%, 7.5%, 10%, and 6%, while total ash values stood at 16%, 33%, 16%, and 11% in Groups 1, 2, 3, and 4, respectively

Parameters	Group 1		Group 2		Group 3		Group 4	
	Feed	Feces	Feed	Feces	Feed	Feces	Feed	Feces
Moisture(%)	9.6	64.5	6.6	69.2	6.8	73.3	7.2	74.2
Dry Matter(%)	90.4	35.5	93.4	30.8	93.2	26.7	92.8	25.8
Crude Fiber(%)	4.22	1	4.86	0.89	3.52	0.75	6.46	1.2
Crude Protein(%)	21.2	4	21.7	3.8	22	4.3	21.9	4.1
Fat(%)	5.5	8	9	7.5	4	10	6	6
Ash(%)	8.3	16	9.09	33	9.09	16	8.4	11

The economic evaluation of feeding probiotics to crossbred pigs revealed noticeable improvements in cost efficiency and profitability compared to the control group in Table 10. The cost economics of probiotics supplementation in crossbred pigs revealed clear advantages over the control group. The rearing cost per pig was highest in Group 2 (₹10,722.5) and Group 4 (₹10,697), while it was lowest in Group 1 (control, ₹10,410). Despite higher feed and supplement costs, probiotics-fed groups achieved improved body weights and higher returns. The selling price per pig was maximum in Group 2 (₹12,800) followed by Group 4 (₹12,600), Group 3 (₹12,400), and

Group 1 (₹12,000). Consequently, profit per pig increased in all probiotics-supplemented groups compared to control, with Group 2 recording the highest profit (₹2077.5), closely followed by Group 3 (₹2040.4) and Group 4 (₹1903), against only ₹1590 in Group 1. The benefit-cost ratio (B:C) further supported the economic advantage, being highest in Group 3 (1.20) and Group 2 (1.19), 1.18 in Group 4 compared to the lowest 1.15 in the control. These results indicate that probiotics supplementation, particularly at moderate levels, improves profitability and efficiency of production in crossbred pigs.

Table 3. Effect of probiotics supplemented diet on Cost economics

Parameters	Group 1	Group 2	Group 3	Group 4
Cost of feed /kg (Rs)	52	52	52	52
Total feed consumed per pig (kg)	180	182.5	172.4	175.4
Total cost of feed consumed per pig(Rs)	9360	9490	8964.8	9120.8

(continued on next page)

Parameters	Group 1	Group 2	Group 3	Group 4
Cost of supplement (Rs/kg of feed)	0	1	2	3
Total cost of supplement (Rs)	0	182.5	344.8	526.2
Labour, treatment and other expenses/pig	1050	1050	1050	1050
Total cost per pig (Rs)	10410	10722.5	10359.6	10697
Selling price per kg body weight of pig (Rs)	50 kg @ Rs.200/kgwt			
Average body weight per pig (kg)	60	64	62	63
Selling price per pig (Rs/kg)	12000	12800	12400	12600
Profit per pig	1590	2077.5	2040.4	1903
Benefit:cost ratio	1.15	1.19	1.20	1.18

The results of the present study clearly demonstrate that probiotics supplementation improved profitability and cost-benefit ratios in crossbred pig production, particularly at the T2 level. These findings are consistent with earlier reports where probiotics-fed pigs exhibited superior feed conversion efficiency, weight gain, and economic returns compared to controls (Kumar *et al.*, 2012^[11]). Similarly, Giang *et al.* (2011^[8]) and Rai *et al.* (2013)^[12] reported that probiotics supplementation in weaned pig diets enhanced growth rate and reduced feed cost per kilogram of weight gain, thereby improving overall profitability. The benefit/cost (B/C) ratio further highlighted the economic advantage of probiotics supplementation, with the highest values recorded in Group 3 (1.20) and Group 2 (1.19), compared to 1.15 in the control. These findings corroborate earlier reports that dietary supplementation of probiotics enhances feed efficiency, growth, and net economic returns in swine production (Cai *et al.*, 2015^[7]). Similar studies by Datt *et al.* (2011^[6]) and Justino *et al.* (2024^[13]) have also shown that probiotics reduce feed cost per unit gain by improving nutrient utilization and gut health, thereby translating into higher profitability. Thus, while the inclusion of probiotics marginally increased feed cost, the overall economic returns improved, demonstrating probiotics as a cost-effective and sustainable feed additive strategy for crossbred pig production.

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