Production dynamics and cost-benefit analysis of cross bred grower piglets under kitchen and chicken wastes management

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Abstract

Feed cost itself claims 70-75% of the total cost of pork production which strongly suggests alternate low-cost feeding strategy for the overall production, reproduction and rural livelihood. Aiming to this fact, the present study was conducted to assess the production dynamics and cost-benefit effect of cross-bred grower piglets under different feeding regime. Twenty-seven cross bred *i.e.* F_1 progeny (white Yorkshire x Ghungroo) as sire X pure Ghungroo as dam, growing piglets (60±3days) were considered for this study and randomly divided into three dietary treatments *i.e.* T_1, T_2 and T_3. Each treatment was comprising of 9 animals and had three replicates of 3 animals. The T_1 served as control was fed *ad libitum* Soya-mustard rich farm-based ration (FBR). T_2 and T_3 were offered FBR replacing 25% each kitchen wastes (KW) and chicken wastes (CW) respectively. Animals under different feeding regime were managed comfortably in the Institute IFS model farm under uniform husbandry condition. Average daily gain (ADG), FCR, haematological & biochemical parameters and production economics were assessed using statistical software package. The highest body weight (kg) was recorded in T_2 (43.68±1.09) and differed significantly *($p<0.05$)* from rest of the treatments. Since, FCR was changed invariably, the ADG (g) was significantly *($p<0.05$)* higher (290.64±8.61) in kitchen waste management compared to T_1 (223.57±8.58) and T_3 (220.25±6.48). Results indicated that the haematological parameters were statistically at par to all the treatments under different feeding regimes. The KW management revealed the highest magnitude of total serum protein (63.71±2.95) when the CW highlighted significantly ($p<0.05$) higher levels of serum cholesterol (81.27±2.79mg/dl) and major minerals *i.e.* calcium (7.96±0.49mg/dl) and phosphorus (5.87±0.95). The feed cost per kg live weight gain was satisfactorily lower in T_2 (₹ 98.57) with the highest B:C ratio (1.54) as compared to T_3 and T_1. This result concludes that substitution of low-cost kitchen and chicken wastes in grower pig can reduce the cost of pork production without any negative impacts. It is also presumed that utilization of kitchen or chicken waste renders equal importance in restoring the balance of nature's eco-system.

Key words: Production, Kitchen waste, Chicken waste, Production economics, CB piglets

Introduction

Pork, a significant source of animal protein, accounts for over 30% of global meat production annually (FAO, 2022). As demand for animal products increases, pig production will continue to be a major farm animal in Asia, with Asia accounting for 74.0% (Wang and Li, 2024). India contributes nearly 1% of the total pig population (Wang and Li, 2024) of Asia. It contributes significantly to food system, household food and nutritional security, cash income, and acts as a safety net during periods of financial distress (Das et al., 2021). The pig population in West Bengal has concentrated mostly in northern districts of the state.

Traditional or backyard production system in general suffers from many inherent challenges, including shortage of quality germplasm, low plane of nutrition, insufficient knowledge of scientific pig farming practices (Roy, 2014; Das et al., 2021; Mondal, 2023). Inbreeding is an unavoidable phenomenon in the local pig farming community due to the use of breeding male for a long time in the same herd and that is gaining more importance of cross breeding to explore better heterozygosity and vigour. Exorbitant feed costs strongly suggest alternate sources *i.e.* residues of agro-animal-poultry-domestic industrial wastes which could partially or totally replace costly protein sources *i.e.* SBM, GNC, rapeseed meal, fish meals etc. thus enabling low-cost pork production. The increased costs for the disposal of organic waste products in landfills and governmental restrictions on such disposal, have led to growing interest in using food waste products (FWP) in diets for animals. Kitchen wastes are nutrient rich surplus materials, which have higher CP and energy value and can be used as regular feeds for pigs. These nutrient dense surplus bio wastes fed to the growing pigs favours positive effect on overall production, reproduction and carcass quality. According to Schanes et al. (2018), 20-33% of total human food is spilled out as kitchen wastes owing to increase financial power and urbanization. The use of leftovers kitchen waste from private households in diets for pigs has been limited because of concerns over the hygienic quality of the raw material.

Chicken offal business is developed due to a higher demand for quality, healthy, and inexpensive protein sources. It is worthy to consider that pig due to omnivores nature can make use of poultry offals as un-conventional foods in order to reduce the production cost. It is hypothesized that India is producing about 1.3-1.5 million tonnes/annum poultry offals pretending each bird contributing @25-30% of live body weight. However, un-scientific disposal of poultry offals and kitchen wastes lead to serious environmental pollution and health hazards. Considering the overall shortage of protein rich feeds and their relative costs, locally available poultry offals could be the alternate protein source not only can easily convert to ration also mitigate the possibilities of bio-hazards and environmental pollution. So, the current research has been taken to address the low-production efficiency of the local pigs by using feasible options to get benefit of crossbreeding and also to provide best solution for providing better nutrition by using available feed resources.

Materials and Methods

Experimental design and animals

The protocols involving the care and use of animals for these experiments were in accordance with the rules of the 'Institutional Animal Ethics Committee (IAEC) of Uttar Banga Krishi Viswavidyalaya, Pundibari. As the experimental animals crossbred piglets with 25% Yorkshire and 75% Ghungroo genes were produced in the farm by crossing male pigs born out of Ghungroo X Large White Yorkshire (LWY) and the female of purebred Ghungroo. Twenty-seven progenies of such cross were used in the study to assess their growth performance under different plane of nutrition provided through locally available feed materials. Growing piglets immediately after weaning at 60 days available in the IFS model farm of the University were used for this study. The piglets were randomly divided into three dietary treatments *i.e.* T_1, T_2 and T_3 comprising of nine animals in each treatment. Each treatment further comprises of three replicates having three piglets per replicate. The experimental animals were housed in concrete pens provided with separate feeder, water trough and a run behind. They were closely monitored regarding their diet, water intake, behaviour and physical characteristics. The piglets on attaining 2 months of age were dewormed with Albendazole and vaccinated against swine fever. All subjects were apparently healthy in this study.

Feed offered to the animals upon 2.5% of body weight on DM basis. Animals from T_1 served as the control group and received farm-based ration (FBR) formulated with locally available ingredients *i.e.* crushed maize, de-oiled mustard cake, wheat bran, Fish meal, mineral mixture and common salt at the rate of 35, 10, 47, 6, 1.5 and 0.5 percent respectively (Table 1). 25% of the total required feed was replaced with kitchen wastes (KW) directly collected from the hostels within campus and get available to the piglets of second group (T_2). The main components in kitchen wastes were residues of rice, wheat chapattis/bread, dal, rarely egg, bones, butter raw and cooked vegetables etc. The chicken wastes (CW) received from the retail chicken suppliers were used to replace the FBR by 25% in T_3 group after through washing and boiling at 100^{o}C for 10min. Samples of feeds and residues were analysed for proximate principles as per standard methods. The cost of different treatment was evaluated @ Rs. 27.53, 8.5 and 5.0 per kg for FBR, KW and CW respectively and calculated to draw the cost-benefit analysis. Feed and potable drinking water supply was *Ad libitum* to all the treatment groups for a period of 16weeks. The experimental animals were housed in concrete pens provided with separate feeder, water trough and a run behind. The healthy piglets on attaining 2 months of age were dewormed with Albendazole and were vaccinated subsequently against Classical Swine Fever (CSF).

Sample collection and assessment

Body weight (BW) was recorded at every 4weeks interval using electronic balance (with 0.00g accuracy) from starting in all the groups to assess the effect of treatment on growth performance till end of the evaluation. Feed consumption was calculated measuring left-over feed on daily-basis and residual amount was subtracted for feed conversion ratio (FCR) analysis. The average daily gain (ADG) was calculated considering the difference between final and initial weight divided by the days of the experiment.

Blood samples (5ml) were taken from the jugular vein of six randomly selected cross-bred piglets of each treatment. 2ml was anticoagulated with 1% ethylene diamine tetra acetic acid (EDTA) for complete blood counts (CBC) and 3ml was placed in centrifuge tubes for serum extraction to measure blood glucose, total protein, cholesterol, calcium and phosphorus following manufacturer's guideline. Samples were spinned at 5000xg for 10min at low-temperature and serum was carefully transferred to 1.5 ml plastic tubes (Tarson Pvt. Ltd.) and stored at –20°C until analysis.

The cost benefit analysis (B:C) was performed based on the feed cost / kg of BW gain on local prices of feed ingredients during experiment and the demand of pork in the local market.

Statistical analysis

The data generated during the course of study were assessed applying the system of statistical one-way analysis of variance (SPSS v.24) and means were compared using Duncan's multiple range test.

Treatment 1 (T-1) **Treatment 2 (T-2)** **Treatment 3 (T-3)**

Fig. 1 Experimental animals: Cross-bred grower piglets under different feeding regimes, T-1: FBR, T-2: 75%FBR + 25% KW, T-3: 75% FBR + 25% CW.

Results and Discussion

Body weight gain

The pork industry is scientifically calibrated with body weight that significantly changes throughout their lifespan. Similar to other creatures, pigs attain early rapid growth which is gradually levelling off as they reach towards maturity. In this study, the monthly appraised mean body weight of the cross-breed grower piglets is presented in Table 2. Among the treatments (T-$_1$, T-$_2$ & T-$_3$), piglets from T-$_2$ received 75% FBR and 25% Kitchen wastes sensed better at any point of time and gained numerically the highest body weight (43.67±1.09) over to the control (35.34±1.54) and T-$_3$ (36.04±0.66). Comparatively, the weight gain in T-$_2$ was drastic and revealed a significant difference ($p<0.05$) meanwhile value of T-$_1$ and T-$_3$ varied insignificantly throughout the study period. Kitchen waste is very rich in nutrient contents; however, they are variable within and/or between sources from place to place due to different food habits of peoples. This result agrees with other findings who concluded that CP, TDN and GE intake were significantly ($P<0.05$) higher than farm-based ration. In some cases, kitchen waste has been shown to improve feed conversion efficiency and can gain more weight from the same amount of feed. Our findings are supported by other workers who observed faster growth in pig maintained on kitchen waste as compared to concentrate diets. Since, weaning age, environmental cues and feeding composition & strategies affects weight gain, birth weight noticeably influences subsequent growth and performance, with heavier piglets at birth generally reaching heavier slaughter weights.

Average Daily Gain

The average daily gain (ADG) refers to the weight gain per day. Incorporating kitchen waste, either dried or fermented, can accelerate growth rate because kitchen waste, despite being a by-product, can be a valuable source of nutrients like protein, fat, carbohydrates, and minerals. The ADG recorded in different treatments of this study is presented in Table 3. Based on the data assessed, animals with KW (T_{-2}) revealed the highest ADG (232.52±8.62) and differed significantly ($P<0.05$) from T_{-1} (176.20±6.47) and T-3 (178.86±8.58). However, the changes of average daily gain in T_{-1} and T_{-3} were insignificant throughout the study period. The higher magnitude of T_{-2} might be due to better digestibility of KW and favourable rations with optimum nutritional value. The proportional availability of amino acids, energy, different trace elements and vitamins in KW may be high and that could favour the synthesis of body protein, fat and bones, ultimately accelerates better ADG. Further, the energy loss due to heat production might be less in T_{-2} because of relatively lower CF percent in the KW which coupled with favourable energy protein ratio. Contrary to this finding, Ramírez-Zúñiga et al. (2014) reported that dining and kitchen wastes did not affect daily weight gain.

Feed Conversion ratio (FCR)

The feed conversion ratio (FCR) is the amount of feed consumed by an individual which can be converted into one kilo of live weight. Several strategies i.e. optimizing feed formulation, effective management practices, friendly environmental cues etc. can improve FCR and subsequently reduce the production cost. The assessment of feed conversion ratio (FCR) among the treatments ranged between 3.48 – 4.26 and is presented in Figure 2. The observation logged in this study revealed that T_{-3} substituted with 25% CW consumed significantly ($p<0.05$) more feed for a unit of body weight gain compared to T_{-1} and T_{-2}. However, FCR did not differ statistically among the T_{-1} and T_{-2} groups. According to Enwerem et al. (2013), replacing brewer's spent grains with fish meal at different level in growing pigs recorded better FCR which may be correlated and in close agreement with the above result. Kumar et al. (2016) concluded better FCR in growing pig supplemented with 5% rice gluten meal which could be correlated with the above findings may due to palatability, low fibre content and good balance of essential amino acids in KW. The present finding is supported by Nguyen et al. (2024) who reported higher FCR in pig fed poultry by-product meal which could be due to concentrated source of protein, minerals and energy for animals (Kerr et al., 2017).

Haematological attributes

Haematological parameters in animal i.e. RBCs count, WBCs count, haemoglobin (Hb), platelets etc are important indicators of overall health and can be affected by factors like age, breed, disease, seasonal changes and nutritional status. These attributes were assessed at every 8-weeks interval and no significant difference ($p<0.05$) was evident in the parameters studied. The present finding was at par with Rui et al. (2019) who reported non-significant changes of haematologic parameters in Yorkshire and Yorkshire-Landrace cross-bred pigs. The ratio of neutrophil and lymphocyte is a simple blood test marker that reflects the body's inflammatory state. The present N:L ratio has reflected a non-significant inflammation irrespective of the treatments in cross-bred piglets.

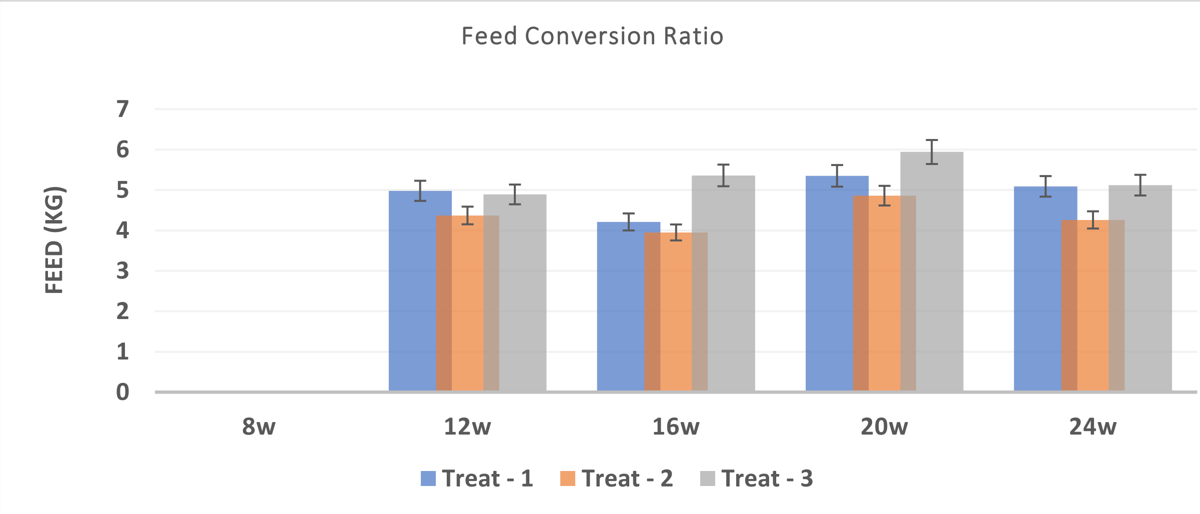

Fig. 2 Effect of different feeding strategy on the feed conversion ratio (FCR) in cross-bred grower piglets under intensive management system (mean ± SE; N = 9)

T-1: FBR, T-2: 75%FBR + 25% KW, T-3: 75% FBR + 25% CW, Means bearing different superscripts in column[abc] differ significantly ($p<0.05$)

Table 1 Chemical composition of experimental ration fed to the cross-bred grower piglets under intensive management system.

Attributes	Farm Based Ration (FBR)	Kitchen Wastes (KW)	Chicken Wastes (CW)
Crude protein (%)	16.82	41.58	37.13
Crude fibre (%)	7.15	4.5	4.17
Ether Extract (%)	4.65	1.31	8.64
Total Ash (%)	6.02	6.8	7.35
Acid insoluble Ash (%)	1.53	1.86	4.33
Total carbohydrate (%)	64.30	57.63	43.61
Gross energy (kcal/g)	4.35	4.43	3.48

Table 2 Effect of different feeding strategy on the body weight gain in cross-bred grower piglets under intensive management system (mean ± SE; N = 9)

Duration	Treatment 1	Treatment 2	Treatment 3
8th Week	10.68±0.38	11.15±0.49	10.95±0.67
12th Week	15.35±0.98^{a}	18.20±0.16^{b}	16.22±1.10^{ab}
16th Week	22.51±1.74^{a}	26.41±1.22^{b}	22.67±1.51^{a}
20th Week	29.66±1.14^{a}	35.65±2.09^{c}	31.23±1.35^{b}
24th Week	35.34±1.54^{a}	43.67±1.09^{b}	36.04±0.66^{a}

T-1: FBR, T-2: 75%FBR + 25% KW, T-3: 75% FBR + 25% CW
Means bearing different superscripts in row^{abc} differ significantly (p<0.05)

Table 3 Effect of different feeding strategy on the average daily gain (ADG) in cross-bred grower piglets under intensive management system (mean ± SE; N = 9)

Duration	Treatment 1 (T-1)	Treatment 2 (T-2)	Treatment 3 (T-3)
8th Week	0.00±0.00	0.00±0.00	0.00±0.00
12th Week	166.80±3.92^{a}	251.13±9.85^{b}	188.15±3.45^{a}
16th Week	255.13±6.29^{b}	293.81±4.77^{c}	230.07±3.22^{a}
20th Week	255.86±7.35^{a}	330.97±8.90^{b}	305.00±14.35^{ab}
24th Week	203.24±8.35^{b}	286.67±10.94^{c}	171.08±13.33^{a}
Average	176.20±6.47^{a}	232.52±8.62^{b}	178.86±8.58^{a}

T-1: FBR, T-2: 75%FBR + 25% KW, T-3: 75% FBR + 25% CW Means bearing different superscripts in row^{abc} differ significantly (p<0.05)

Table 4 Effect of different feeding strategy on the concentration of metabolites in serum of cross-bred grower piglets under intensive management system (mean ± SE; N = 9)

Parameters	8 weeks			16 weeks			24 weeks		
	T-1	T-2	T-3	T-1	T-2	T-3	T-1	T-2	T-3
Glucose (mg/dL)	89.04±3.96	91.54±3.29	80.71±4.56	92.04±3.47	89.03±2.91	76.38±2.54	90.01±2.87	86.21±1.69	83.56±2.09
Total protein (g/L)	56.96±3.69^{a}	63.32±4.15^{b}	58.11±0.73^{a}	59.09±3.95^{a}	63.97±4.11^{b}	58.95±0.71^{a}	53.04±3.24^{b}	63.85±3.12^{ab}	49.44±2.89^{a}
Cholesterol (mg/dL)	69.39±6.62	73.76±2.89	77.78±3.17	69.49±6.32	77.09±3.03	81.54±2.55	67.42±6.33	79.27±2.80	84.48±4.35
Calcium (mmol/L)	6.08±0.46	7.76±2.89	7.78±3.17	6.15±0.58	6.09±0.11	7.18±0.75	6.49±0.72	6.23±0.71	7.94±0.38
Phosphorus (mmol/L)	3.12±0.38	3.25±0.73	4.23±1.04	2.98±0.54^{a}	3.17±1.05^{ab}	5.06±0.78^{b}	4.13±1.10^{ab}	3.89±0.87^{a}	5.87±0.95^{b}

T-1: FBR, T-2: 75%FBR + 25% KW, T-3: 75% FBR + 25% CW Means bearing different superscripts in row^{abc} differ significantly (p<0.05)

Table 5 Assessment of cost benefit (B:C) valuation of cross-bred grower piglets with different feeding strategy under intensive management system

Criteria	Treatment 1	Treatment 2	Treatment 3
Feed Conversion Ratio (FCR)	3.93 ± 0.35	3.49 ± 0.14	4.26 ± 0.22
Average daily gain (g)	176.20 ± 6.48^{a}	232.52 ± 8.61^{b}	178.86 ± 8.58^{a}
Cost of feed (Rs)/kg weight gain	108.08 ± 9.63^{c}	79.45 ± 3.99^{a}	93.28 ± 6.12^{b}
Cost of production per animal (Rs)	2454.34 ± 124^{b}	2146.51 ± 80^{a}	2184.69 ± 98^{a}
Income per animal (Rs)	3973.90 ± 202^{b}	4728.15 ± 176^{c}	3360.77 ± 185^{a}
Net income per animal (Rs)	1519.56 ± 77^{b}	2581.64 ± 96^{c}	1176.07 ± 86^{a}
B:C (Cost Benefit ratio)	0.62	1.20	0.59

T-1: FBR, T-2: 75%FBR + 25% KW, T-3: 75% FBR + 25% CW, Means bearing different superscripts in row^{abc} differ significantly (p<0.05)

Biochemical parameters

Glucose concentration

The mean glucose concentration (mg/dl) varied between 73.56 ± 2.09 to 92.04 ± 3.47 among the studied groups (Table 4). It is reported that blood glucose concentration is closely related to the time between blood collection and the last meal. We found animals from T-$_1$ showed the highest magnitude of serum glucose compared to the rest treatments. The present findings are closely associated with the results of other researchers. Rui et al. (2019) presented lower blood glucose in Yorkshire and Yorkshire-Landrace growing pigs that could be due to fasting blood collection. However, various stress factors and different blood sampling methods also affect the blood glucose concentration (Özkan et al., 2012).

Concentration of total protein

Estimation of total protein in animals determines overall health, nutritional status and insights of various physiological processes. Piglets have lower serum protein concentrations at birth compared to adult pigs that gradually increases as they mature. The present study earmarked an average serum protein value fluctuated between 49.44 ± 2.89 to 63.97 ± 4.11 g/L (Table 4). The data recorded significantly ($P<0.05$) higher in T-$_2$ compared to counterparts which is assumed to be more protein percentage in kitchen wastes. This agrees with Bindas et al. (2019) who summarized the same range in the cross-bred pigs under different protein levels. Comparatively lower levels of serum protein (albumin & globulin) was observed in a study of Yorkshire pigs (Rui et al., 2019) which may be correlated with the different feeding regimes.

Serum cholesterol

Cholesterol, in spite of making hormones and coordinating biological functions, is essentially used as indicators of the level of lipid metabolism. Valuation of serum cholesterol (mg/dL) reached 67.42±6.33 84.48±4.35 is flashed in Table 4. Without statistical changes, the highest mean cholesterol value was recorded in T-$_3$ followed by T-$_2$ and T-$_1$ which may be ascribed by more fat percentage in feed composition. The present data revealed higher value of cholesterol compared to Rui et al. (2019) which may be clarified by breed difference and detection methods. Bindas et al. (2019) noted comparatively lower serum cholesterol in cross-bred pigs which could be due to varying composition of feed and nutrients availability.

Assessment of calcium and phosphorus

Adequate provision of calcium (Ca) and phosphorus (P) is essential for bone mineralization and high growth performance in pigs (Abeni et al., 2015). The mean serum values of both the major minerals were presented in Table 4. Data recorded significantly ($p<0.05$) higher in T-$_3$ for both Ca and P compared to other treatments which is hypothesized of direct association of chicken wastes comprising of feathers.

Economics of pork production

Economics of pork production involves understanding the costs, revenues and profitability that directly depends on the efficiency in feed conversion and genetic potential of performance. The economics of feeding cost, net income and cost-benefit ratio for each treatment is summarized in Table 5. The feed cost per kg of live weight gain was recorded significantly ($p<0.05$) lowest herein Rs. 79.45±3.99 in kitchen waste treatment followed by chicken wastes (93.28±6.12) and un-treated control (108.08±9.63). This present finding obliged to higher costs than reported by Deca et al. (2011) as waste food was available at the free of cost for their study. Ignoring the wages of labour, the actual cost of production worked out the lowest in T-$_2$ (2146.51±80) wherein T-$_1$ revealed the significantly ($p<0.05$) highest cost of production (2454.34±124) due to 100% supplement of concentrate feed. This agrees to Saskia and Bhar (2010) who reported that the feed cost per kg live weight gain was lower ($P<0.01$) when the piglets were fed on kitchen wastes-based diet. This finding indicates that the cost of feeding can be significantly minimized by substituting the costly concentrate feed with kitchen wastes and alternate unconventional source of chicken wastes. Considering the market sale price (Rs 250 per kg) and 70-percent of dressed weight, animals from T-$_2$ fetch nearly the highest net profit (Rs. 2581.64±96) per animal followed by T-$_1$ (1519.56± 77) and T-$_3$ (1176.07±86) which can be positively compared to Deca et al. (2011). The benefit-cost (B:C) ratio of this study ranged between the lowest 0.59 (T-$_3$) to the highest (1.20) shown in Table 6. It is common that B:C ratio is a financial metric that assess the profitability by comparing the present value of its benefits and costs. Further, B:C greater than 1 suggests that the benefits outweigh the costs and indicates economically viable and not worthwhile when the value goes reverse. However, based on this result, T-$_2$ substituting by 25% kitchen wastes exposed the best profitable nutritional combination over other treatments herein this study.

Conclusion

It is concluded from this study that kitchen waste supports the best body weight and average daily gain (ADG) in cross-bred piglets while chicken waste accelerates serum total cholesterol and major minerals i.e. calcium and phosphorus concentration. This study also determines the highest B:C ratio in kitchen waste (KW) group compared to CW and FBR. However, substitution of 25% kitchen wastes settled the best profitable nutritional combination for pork production.

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Conflict of interest

All the authors have no conflict of interest on this manuscript.

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