Full length article

Effects of Different Feeds on Body Weight Gain and Profitability of Pig Production in Subtropical Bhutan

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ABSTRACT

A feeding trial was conducted with the objectives to evaluate the body weight gain of improved pigs fed with three different feeds and determine the cost of production for each feed. The feeds were commercial feed, thin stillage of the Army Welfare Project and locally formulated feed. Twenty-four weaners, each weighing 8.21 kg with an average age of 40.17 days were used for the study. The weaners were divided into three groups [group A, B and C]. Each group was allotted eight weaners with uniform breed and sex ratio. Pigs in group A, B and C were fed with commercial feed, formulated feed and thin stillage, respectively. Pigs were weighed individually using digital weighing scale and a crate once every Monday for 30 times in seven months study period. The amount of feed fed to each group and the leftover feed were recorded daily during the entire study period. The Average Daily Gain [ADG] of pigs in group A, B and C were 0.518 kg, 0.118 kg and 0.299 kg, respectively. The average final weight of group A, B and C were 117.27 kg, 32.45 kg and 70.86 kg, respectively. Differences in both ADG and final weight gain between group A, B and C were highly significant. The costs incurred to produce a kilogram of pork were Nu. 180.93, Nu. 324.97 and Nu. 169.63 for group A, B and C, respectively. The cost of producing one-kilogram pork was cheaper by Nu.11.30 for group C than A. The study concluded that the high body weight gain in pigs does not necessarily lead to high income.

1. INTRODUCTION

Livestock production is an important component of the agricultural economy of developing countries. According to World Bank [2009], livestock contributes about 40% to agricultural gross domestic product in the world. In Bhutan, livestock farming is also an integral component of agriculture system and contributes 24% to the Renewable Natural Resources Gross Domestic Product [MoAF 2013]. According to FAO [2011], pig farming is a viable and profitable enterprise that can be easily taken up by poor farmers. Pig farming requires a small initial investment as pigs are good feed to meat converter, compared to other livestock [FAO 2011].

Pigs in South East Asia constitute 48% of the total livestock population [FAO2011]. In Bhutan, pig constitutes about 1% of the total livestock population, and the domestic pork production is about 25% of the total meat consumption in the country [DoL 2016]. Within 11th plan period, about 63 farms were established across the country through piggery stimulus support package [DoL 2016]. Market weight of pigs is considered as an important economic factor in pig farming, as it influences profit [Kim et al. 2005]. Although, pigs are good converter of feeds, about 60-80% of the total costs are incurred in feeds [ITCPH 2005]. Feed costs can be reduced if locally available feed resources are used. However, it is important to understand the types of feeds to be fed to the animals for optimum result. Beside commercial feeds, pigs are also fed with various available feedstuffs such as kitchen wastes, distiller's thin stillage liquid waste, agricultural residues, vegetables wastes, wild weeds etc. [Nidup et al. 2011; Tenzin et al. 2017]. Although, pig production efficiency could be enhanced through improved feeding management, most pig farmers in Bhutan cannot afford commercial feeds or are not willing to invest in pig feeds. Instead, farmers overcome feed shortage by feeding pigs with locally available feed resources and supplement by collecting feeds from nearby forest. These locally available feedstuffs appear not to meet the nutritional requirements for proper and timely growth of pigs. Therefore, it is important to improve the quality of local feed resources, which could help pig farmers to earn more income. Hence, there is a need to understand the types of feeds fed to the animals, currently.

As pigs are raised under different feed resources, there is a need to understand the average weight gain [ADG] of pigs fed with different feeds. Therefore, this study was conducted to understand the growth performance of improved pigs fed with commercial feed, distillery wastes and locally formulated feed. The study objectives were to evaluate the effects of three different feeds on bodyweight gain of improved pigs and determine the cost of pig production under three different feeding practices.

2. MATERIALS AND METHOD

2.1 Study area

The on-farm feeding trial was carried out in government farm of National Piggery Research and Development Centre [NPiRDC] in Gelephu, Sarpang *Dzongkhag* [District]. The study was conducted for seven months from 25th September 2017 to 23rd April 2018. NPiRDC lies between 26˚ 52' N and 90˚ 29'E [Google Earth 2017], and located at an altitude of 300 m [984.25 ft.] above sea level [NSB 2016]. The climate is characterized by warm and wet summer and cold and dry winter. The total annual rainfall in Gelephu is 5930.3 mm [WCSD 2017].

2.2 Animal selection and housing

Twenty-four weanlings of *Large black* and *Saddleback* were used for the study. Weanlings had an initial mean body weight of 8.21±1.37 kg and were uniform in age, breed and sex ratios, as recommended by Reese et al. [2010]. The animals were selected using simple random sampling and lottery technique to avoid bias. Weanlings were divided into three groups and each group was randomly allotted eight weanlings, similar to Handle et al. [2002] and Smith et al. [2014]. The initial stocking density for the study was 1.29 pigs m^{-2} whereas the minimum number of pigs recommended for confined fattening pigs kept in a group is 1 pig m^{-2} [Dietze 2011]. Although, Reese and Stroup [2010] recommend a minimum of two groups for one feed type to ensure accuracy of the results, one pen of pigs per feed type was maintained in this study, due to inadequate research facility.

2.3 Feed treatment and management

The three different types of feed used were as follows.

[i] Concentrate feed from BMG: The commercial grower feed formulated by BMG Feeds had 88.06% Dry Matter [DM], 18.95% Crude Protein [CP], 64.48% Nitrogen Free Extract [NFE] and 7.80% Crude Fibre [CF].

[ii] Improvised feed as recommended by National Research Center for Animal Nutrition [NRCAN]: The ingredients of improvised feed consisted of 45% maize crush, 10% rice bran, 4% molasses, 40% thin stillage liquid waste and 1% salt. The feed ingredients were collected from markets, which were from old stocks.

[iii] Distiller Dried Grain [DDG] waste [Thin stillage] from AWPL, Samtenling: The thin stillage waste contained 2.5 to 3% solid with specific gravity of 1.002 to 1.004. Nutrient analysis of this feed could not be carried out due to lack of laboratory facilities. Each group of pigs was allotted only one type of feed.

During the first two weeks, to reduce nutritional stress besides weaning, pigs in all three groups were fed with starter at the rate of 0.5 kg pig^{-1} day^{-1}. From third week onwards, pigs in group B and C were subjected to gradual feed change to adapt to their respective assigned feed [FAO 2009]. The feeding regime followed for group B and C was 30:70 traps in 3rd week, 50:50 trap in 4th week, and 100% assigned feed from 5th week onwards until the end of study period. The concentrate feeds such as grower and finisher rations were fed to pigs, depending on their age and weight, as followed in the farm. Pigs in group C were fed with thin stillage liquid only, with addition of about 100 grams of salt during each feeding, as followed by fattening farms. Pigs in all three groups were fed two times a day at around 9:00 AM and 4:00 PM. Water was provided *ad libitum*. Although, the selection and stocking of weanlings began on 25th September 2017, the data for analysis were considered from the fifth body weight measurement [23rd October, 2017] onwards. All male pigs were castrated at an average age of 92.17±2.66 days, as advised by AARD [2010] to avoid boar taint in pork.

2.4 Measurements and data collection

The direct method of weight measurement was employed as it was found to provide precise estimates of weight [Zaragoza 2009]. Pigs were weighed individually with electronic weighing scale. A weigh crate was used to hold pigs during weight measurement. Body weight measurement was carried out before morning feeding to avoid possible error from feeding. The live body weight measurement was recorded every Monday, with seven days interval between two measurements. The number of measurements was 30 [seven months] during the entire research period. The linear body measurements such as body length and girth were not used. This is because, misreading of girth measurement by one inch would result in an error of ± 10 pounds. Ear notching was done to identify pigs. The initial measurement and record of body weight was taken on the first day of the trial. Data on feed amount consumed, feed leftover and treatment details were also recorded daily. The Feed Conversion Ratio [FCR] was computed by dividing the total feed consumed during the study period by average weight gain of pig during the study period, as suggested by Acero et al. [2013]. FCR was computed using the equation of Dan et al. [2015] as mentioned below.

$$FCR = \frac{Xq_1 - q_0}{q_1 - q_0}$$

Where Xq_1-q_0= quantity of total feed consumed during the study period; q_0 = starting weight; and q_1= is the market live weight of pig.

2.5 Economic analysis

The cost of production was estimated by adding all costs [variable and fixed] involved in rearing animals. The net return per pig produced was computed by subtracting the total expenses from estimated sales value of pork. Equation 1 of Obayelo et al. [2017] was used for calculating net returns. Equation 2 was used to calculate the cost of production.

Equation 1: Profit [Net Returns] = Total Revenue [TR] − Total Cost [TC]
Where: Total Revenue [TR] = Output [Q] × Unit price [P]; Total Cost [TC] = Total Variable Cost [TVC] + Total Fixed Cost [TFC]; Gross Margin = Total Revenue [TR] – Total Variable Cost [TVC]; Gross Income [Net Profit] = Gross Margin [GM] – Total Fixed Cost [TFC]. Likewise, the cost of production was estimated using the Equation 2 as stated below.

Equation 2: Cost of Production = Total expenses – Revenue generated by sale of fatteners

2.6 Data analysis

Pigs from group B and C died during the trial period and their weight gain data were excluded for the analysis as advised by Reese and Stroup [1992]. Data were compiled in Microsoft Excel Program and analyzed with the statistical tool SPSS version 23. Data were analyzed with One-Way ANOVA. Bonferroni Post Hoc test was performed to determine differences in weight gain. Feed conversion efficiency and cost of pig production were analyzed manually in Microsoft Excel program. Feed conversion efficiency was computed by dividing the total feed consumed per group by its mean weight of the pigs per group. The cost of production per group was computed by subtracting the total expenses from the estimated sales of fatteners per group.

2.7 Ethical consideration

For the entire trial period, all aspects of welfare issues related to animal, housing, feeds and overall management were considered for better result. As far as possible, gentle handling of research pigs was ensured during feeding and weight measurement to reduce handling stress. Animals were monitored routinely for clinical signs of any illness and feeding complications.

3. RESULTS AND DISCUSSION

3.1 Body weight gain

The results of body weight before and after feeding are presented in Table 1. There was no significant difference among three groups in the initial body weight, but the final body weights of pigs differed significantly [$p<0.05$] among the groups. Pigs in group A, fed with control diet [concentrates — balanced diet], gained more weight compared with pigs in group B and C that received formulated feed [improvised] and thin stillage waste, respectively. The average weekly weight gain of pigs in group A, B and C were 3.63±0.42 kg, 0.83±0.32 kg and 2.09±0.34 kg, respectively. The ADGs were 0.518±0.06 kg for group A, 0.118±0.05 kg for group B, and 0.299±0.05 kg for group C. Growth rate ranging from 0.300 to 0.500 kg was reported in pigs by Arganoza [2002]. Carter et al. [2017] found growth rate of 0.355 kg, 0.184 kg and 0.289 kg in pigs fed with commercial, forage-based and silage-based diets, respectively. The differences in weight gain showed the different effects of feeds. It also indicates difference in feed quality among three feed types. A significantly heavier body weight [117 kg] in group A, fed with commercial feeds indicates the high nutritional quality of commercial feed, which may have met the nutritional requirements of pigs. The final body weight in group A was higher than the ideal body weight of 60-90 kg for fattened pig at the time of slaughter [APCARRD 2005]. On the contrary, pigs in group B, fed with formulated feed, had the lowest body weight. It indicates the poor quality of formulated feed. It supports the fact that the nutrient content of pig diet, formulated with local feedstuffs, is usually less optimal for pig requirement [Wallenbeck 2011]. Moreover, the laboratory test results of formulated feed were positive to aflatoxin in two different batches of feed samples. Consumption of mycotoxins contaminated feeds by livestock leads to reduced feed intake, feed refusal, poor feed conversion, reduced weight gain and suppression of immune system [Gashaw 2015]. Pigs are more susceptible to mycotoxins and suffer from chronic syndromes affecting animal performance [Li et al. 2014]. Aflatoxins could be the possible reasons for lower growth performance of pigs in group B.

3.2 Feed Conversion Ratio [FCR]

FCR of pigs in group A, B and C are presented in Table 2. A single pig in group A needed 4.74 kg of commercial feeds to gain a kilogram of body weight, which shows that commercial feed is far more efficient than the improvised feed and thin stillage. A pig in group B and C needed 13.45 kg and 58.52 liters of improvised feed and thin stillage, respectively, to gain a kilogram of body weight. Thin stillage liquid waste contained only 2.5-3% solid. As per Dan et al. [2015], the FCR of pigs reared under commercial, specialized, smallholder and backyard farms in China were 2.73, 2.90, 3.03 and

3.99, respectively, and FCR of 3.03 is considered as world average feed efficiency. The level of feed intake also determines growth rate and feed conversion of fattening pigs receiving balanced diets [Verstegen et al. 1978].

Pigs eat more of less nutrient dense feed to meet requirements for growth [Bakere et al. 2014]. In general, FCR declines as farm size increases, thereby larger farms are more efficient at converting feed to meat than smaller farms [Wang et al. 2015]. However, factors such as management, diet, genetics, age and disease affect FCR [Varley 2009]. According to Arganoza [2002], FCR of pigs can be improved by adding succulent feeds to rations. Nevertheless, succulents were not provided in this study. Better growth was also observed due to supplementary effect of one feed over another[Samala 1984; Acero et al. 2013]. Moon et al. [2004] found pigs fed with wet feed growing faster than those fed with dry feed, due to higher feed intake when fed wet. Better growth rates, attributed to greater feed intake, were also reported by Augspurger and Ellis [2002].

Table 1: Mean initial body weight, final body weight and actual body weight gain of pigs in group A, B and Cfrom 25th September 2017 to 23rd April 2018.Values with different superscripts [a, b, c] within columns are significantly different [p<0.05] at 95% confidence interval.

Treatments	Initial Body Weight [kg]	Final Body Weight [kg]	Body Weight gain [kg]
Group A [control —fed with commercial feed]	8.47±1.00[a]	117.28±13.08[a]	108.81±12.54[a]
Group B [fed with improvised feed]	8.07±1.44[a]	32.45±10.34[b]	24.83±10.34[b]
Group C [fed with thin stillage distillers' liquid]	8.11±1.71[a]	70.86±11.38[c]	62.81±10.06[c]

Table 2: Average FCR of pigs in group A, B and C.

Treatment Group	Average weight gain	Average feed consumption	Feed conversion efficiency
Group A [fed with Concentrate feed]	108.81 kg	4119.03 kg	4.74
Group B [fed with locally formulated feed]	24.83 kg	2004.13 kg	13.45
Group C [fed with thin stillage]	62.81 kg	25733.09 liter	58.52

3.3 Cost and return analysis

The expenditure, costs and returns of pig production are presented in Table 3. A higher net income was obtained from pigs in group C, fed with thin stillage of AWPL, followed by pigs in group A, fed with commercial feed. The lower cost of production per pig could be due to low investment on thin stillage. The high expenditure was in group A, which is due to huge investment in commercial feed. However, this study shows that high expenditure and high weight gain of pigs did not necessarily result in more income. This is evident from the net income that was higher for group C, which had lower investment and weight gain. Low weight gain in pigs are often compensated by low investment in feed, as seen in pigs of group C, fed with thin stillage. Group C had a minimal investment in feed, despite high amount of thin stillage required to produce a kilogram of pork [1:58.52]. The main cost incurred for group C was in transportation of thin stillage and purchase of salt only.

According to Dietze [2011], production cost includes cost of capital, housing cost, equipment cost, and cost on labor, feed, medicines and veterinary services, including other operation costs and marketing expenses. However, in this study, only specific costs such as cost of feeds, piglets and labor were taken into account to determine the cost of production. Carter et al. [2017] used the cost incurred in each kilogram of diet to determine the cost of one-kilogram weight gain in pigs. This study showed that the cost of producing one-kilogram pork is cheaper by Nu.11.30 for group C when compared with group A.

3.5 Limitation of the study

This research had limitations that hindered the smooth conduct of the study. Occasional cessation of AWPL plant at Samtenling affected the continuity of feeding thin stillage to the pigs in group C. Besides, change in feed supplier as per government procurement procedure led to a shift from BMG formulated commercial feed to Karma feeds formulated commercial feed for pigs in group A. Difficulty in getting the animals of same weight, age and size is another limitation. Nevertheless, the research was conducted according to the research protocol as far as possible.

4. CONCLUSIONS AND RECOMMENDATIONS

The high weight gain of pigs is directly related to high quality diets. However, the study indicated that the greater weight gain does not necessarily lead to high income, due to high investment mainly in feed. The feeding of quality commercial feeds involves high investment due to high feed price. On the other hand, the low weight gains of fattening pigs are often compensated by low investment. Therefore, based on the findings of the on-farm feeding trial, following recommendations were deduced.

- Feeding thin stillage to fattening pigs can be economically rewarding, as the cost of production of one-kilogram pork is cheaper for pigs fed with thin stillage, compared to pigs fed with commercial feeds. Thus, the use of thin stillage from the nearby Army Welfare Project distillery plants is recommended for fattening farms across the country. However, feeding of fresh thin stillage is preferably recommended than fermented thin stillage.
- Feeding of pigs with locally formulated diets using old stock maize crush, rice bran, molasses and salt is not recommended, especially in warm and humid regions. Feeding of such diet increases the risk of feed contamination with mycotoxins. Mycotoxins infection negatively affects pig performance. Formulated feed, piled up without proper ventilation for longer duration, could cause aflatoxicosis.

Table 3: Cost and return analysis for group A, B and C

Parameters	Treatment Group		
	Group A	Group B	Group C
A. Production cost			
Piglets	16000.00	16000.00	16000.00
Feedstuffs	103589.14	24691.78	40130.97
Labor	6123.60	6123.60	6123.60
Medicines	0.00	0.00	0.00
Depreciation of sheds	0.00	0.00	0.00
Transportation of feeds	0.00	0.00	0.00
Total Expenses [Nu.]	125712.74	46815.38	62254.57
B. Returns			
Estimated carcass yield [26% KO]	86.85	24.01	52.43
Sales from fatteners [Nu.]	132012.00	27371.40	69731.90
Net Income [Nu.]	6299.26	-19443.98	7477.33
Cost per pig production [Nu.]	15714.09	7802.56	8893.51
Cost per kg pork meat production [Nu.]	180.93	324.97	169.63

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