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Effect of feeding banana pseudostem (*Musa* spp.) and cassava tubers (*Manihot esculenta*) on the growth performance and nutrient utilization of cross-bred (Lumsniang) pigs in Mizoram

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Abstract
The study was to evaluate the effect of cooked banana pseudostem and cassava tubers (1:1) on eighteen (18) numbers of cross-bred grower pigs (Lumsniang) in Mizoram which was a common practice among the farmers. The experimental pigs were divided into 3 treatment groups, which consists of 6 pigs in each group (Av. 10.87±0.65 kg, 10.20±0.48 kg and 10.91±0.60 kg body weight respectively) and allotted in individual pen with the provision of feeding and watering. A feeding trial was conducted incorporating cooked banana pseudostem (*Musa* spp.) and cassava tubers (*Manihot esculenta*) (1:1 on DM basis) as a replacement to the standard commercial grower pig ration at 0% (G1), 15% (G2) and 25% (G3) for 154 days. A digestibility trial was carried out for 7 days during the last week of the trial. The present study observed that the average body weight gain was highest (45.49±1.32) in G1 and lowest in G2 (42.91±0.98) for the experimental period of 154 days with non-significant differences. The ration incorporated with banana pseudostem and cassava tubers (1:1) reduced the feed cost even though there were no significant differences. Considering the non-significant effect of banana pseudostem and cassava tubers (1:1) on overall body weight gain, FCR and nutrient utilization, it was drawn to the reference that the same could be incorporated up to 25% level for economic small scale pig production system in Mizoram.

Keywords: Crossbred pig, banana pseudostem, cassava tubers, nutrient digestibility, growth, feed conversion efficiency

Introduction
Piggery farming, is the approved economic activity all throughout the state and is one of the main sources of income for subsistence of the rural farmers amongst the livestock farming. As per the 20th livestock census of India, the total Pigs in the country are 9.06 Million in the current Census, declined by 12.03% over the previous Census. Out of these the total population of pigs in Mizoram is 0.29 million (20th livestock census) and it shows an increase in the population by 19.26% from previous census (19th livestock census) (Lalmuansangi *et al*, 2021) [1]. In Mizoram, majority of the farmers follow backyard system of rearing pigs mainly in the rural areas, and is entirely different from other states of India. Pigs are fed using local vegetations, agro-wastes, and household and kitchen wastes (Kumaresan *et al*., 2006) [2]. Due to the high cost of transportation, compounded feeds becomes very high in the local markets of Mizoram, which leads to high feeding cost for nearly 70-80% of total production cost of pig rearing so, the farmers are compelled to utilize the locally available unconventional feed-stuffs to reduce production cost and increase profit margin (Lalhuthangi and Buragohain, 2020) [3]. Several non-conventional plant sources for example sweet potato leaves and stem (*Ipomoea batatas*) with high crude protein have been identified for incorporation in pig ration which could be cultivated in large scale for meeting the protein deficiency in pig ration.
Cassava (*Manihot esculenta*) also known commonly as Tapioca, continues to be a food of certainty for the millions of people especially in the developing countries of the globe and is an substitute source of energy to meet the demands of increasing population. This crop has the potential to produce more food per unit area, ability to withstand adverse biotic and abiotic stresses and adaptability to the conditions of drought and marginal lands. There are some cassava varieties suited for pig feed and has been cultivated in India for more than a century. Cassava chips is a product of cassava tubers which can be dried and stored and can be utilized

for human consumption and feeds for pigs as well. The vegetative parts can be made into silage which could be preserved and stored for lean season.

Bananas and plantains are mostly grown in every humid tropical region and constitute the fourth-largest fruit crop of the world. The time between planting and the harvest of a bunch of bananas is between 9 and 12 months (DuPonte *et al*., 2016) [4]. Bananas do not have a growing season, a flower appears in the sixth or seventh month after planting, making bananas potentially available throughout the year through staggered planting times. The current importance of banana and plantain product use in livestock feeding varies considerably from country to country. Every part of the banana and plantain plant (except the roots and suckers) can be and has been used to feed livestock in various parts of the world. Furthermore, banana waste components are said to be high in vitamins and nutrients, particularly dietary fibre (Mydhili *et al*., 2022) [5].

Considering the huge availabilities of banana pseudostem and cassava tubers in Mizoram, and viewing into the importance of economic feeding in the area, the present study was conducted to evaluate the effect of cooked banana pseudostem and cassava tubers to be incorporated in different levels replacing the standard concentrate mixture in crossbred (Lumsniang) pigs in Mizoram.

Materials and Method

The present study was taken up at Piggery Unit, ICAR, Mizoram Centre, Kolasib, Mizoram during January, 2021 to June, 2021. Eighteen crossbred (Lumsniang) pigs aged 3 months old of similar average body weights (10.87±0.65 kg, 10.20±0.48 kg and 10.91±0.60 kg, respectively) were divided randomly into 3 experimental groups (G1, G2 and G3) where 6 pigs were kept in each group. The experimental animals are housed individually with a well-ventilated environment in the farm. For this study, fresh banana pseudostem and cassava tubers samples were initially harvested, chopped, and analyzed for their proximate nutrient content to gather nutritional baseline data. The banana pseudo stem and cassava tubers collected from nearby areas were chopped by using a cutting knife. The chopped materials were stored indoors under normal room temperature. For preparing of feed to the pigs, the chopped materials were cooked in a traditional way by using big cooking pot and firewoods and let it boiled for 10 minutes at 100 °C. Cooked banana pseudostem and cassava tubers were incorporated in the feeds in 1:1 ratio. The samples were analysed for their proximate nutrient content after cooking on DM basis. The experimental animals were provided with an individual feeding trough with a provision fresh drinking water. A standard Grower and Finisher Ration was procured from MODUFER, Department of Animal Husbandry and Veterinary, Mizoram which was formulated as per NRC (1998) [6]. This mixture procured was considered as a Standard Concentrate mixture. Two types of rations was prepared from the Standard Concentrate Mixture which were iso-caloric and iso-nitrogenous by replacing it with banana pseudo stem and cassava tuber meal (1:1) at 15% (for G2) and 25% (for G3). G1 group was given 100% concentrate feed as control feed.

The experiment was conducted within a period of 154 days with additional 10 days adaptation period. During the feeding trial, daily dry matter intake was recorded and calculated by recording the daily feed offered and the residual feed. Grower ration was provided for 3 months (approx. 94 days) which was continued with finisher ration for 2 months (approx. 60 days). The amount of feed intake by the pigs was recorded throughout the experiment individually and weekly body weight gain was recorded. Average daily gain (ADG) (g/day) during the trial period was calculated by dividing the body weight gain by the number of days in a time. The weekly feed conversion ratio (FCR) was calculated by dividing the weekly total feed consumption (kg) by weekly gain in body weight (kg). At the end of the feeding trial, digestion trial which will reflect the digestibility coefficient of the feeds and faces was conducted for a period of 7 days. For these trial 3 animals from each group was studied. Representative samples of each of the concentrate feed ingredients, banana pseudo stem and cassava tubers used in the experiment, residual feeds and fecal matter were analysed. The amount of feces was weighed daily, and 5% of the total amount was sampled and then stored at – 4 °C until the end of the experiment. The sampled feces from every replicate was mixed together thoroughly by hand, before analysis for DM, crude protein (CP), and crude fiber (CF) were analyzed in the Central laboratory (ICAR, Mizoram Centre, Kolasib). Proximate principles of all the feed ingredients separately and as a ration in each group has been analysed as per the method described by AOAC (2000) [7], Fibre fractions like Neutral Detergent Fibers and Acid Detergent Fibers were analysed as per the method described by Goering and Van Soest (1970) [8]. Calcium and Phosphorus were analysed as per the method described by Talapatra *et al*. (1940) [9]. The data observed were subjected and put through to standard statistical analysis as per the method described by Snedecor and Cochran, 1994 [10] for discussion and interpretation of results.

Results and Discussion

Chemical composition of Banana pseudostem and Cassava tubers

In this study it was observed that the chemical composition on DM basis (as shown in Table 1) (DM, CP, CF, EE, TA, AIA and Ca) for banana pseudostem were 8.9, 7.2, 27.9, 1.8, 21.4, 8.20 and 4 percent respectively, which was in concordance with the findings of Sokchea *et al.* (2018) [11] where CP%, Lipid%, Ash% and Ca% were 6.5, 1.5, 14 and 7.5% respectively. The same was supported by Du Ponte *et al* (2016) [4] where the chemical composition for banana stem were 8.25, 2.08, 2.13, 0.50, 56.83 and 26.8 percent respectively for DM, CP, EE, Ash, NDF and ADF. Arjin *et al* (2022) [12]. Similarly, Wang *et al.* (2016) [13] also reported similar observation regarding the chemical composition of banana pseudostem. Chemical composition of Cassava tubers in the present study were 39.2, 2.6, 3.5, 0.92, 2.9, 0.23, 84.35, 36.02, 23.5, 0.2 and 0.16 percent respectively which was consistent with Emmanuel *et al.* (2012) [14] who reported that cassava tubers contained 2.93% CP, 3.20% CF, 1.07% EE, 2.26% TA, 0.91% Ca and 1.26% P. Lukuyu *et al.* (2014) [15] also reported a similar chemical composition for cassava roots in DM, CP, CF,EE and TA whereas the NDF and ADF percentage were 7.8 and 5.3% respectively which was in contrary to the present findings of 36.02 and 23.5 percent respectively for NDF and ADF.

Table 1: Chemical composition of Banana pseudostem and Cassava tubers (% Dry Matter basis)

Particulars (%)	Banana pseudostem (%)	Cassava tubers (%)
Dry Matter (DM)	8.9	39.2
Crude Protein (CP)	7.2	2.6
Crude Fibre (CF)	27.9	3.5
Ether Extract (EE)	1.8	0.92
Total Ash (TA)	21.4	2.9
Acid Insoluble Ash (AIA)	8.20	0.23
Nitrogen Free Extract (NFE)	47.21	84.35
Neutral Detergent Fibre (NDF)	67.2	36.02
Acid Detergent Fibre (ADF)	45.3	23.5
Calcium (Ca)	4	0.2
Phosphorus (P)	0.03	0.16

Chemical composition of the rations and Digestibility of Nutrients

The CP% was comparable for all the groups (18, 17.99, and 17.85 for G1, G2 and G3 respectively) suggesting that all the rations were iso-nitrogenous (Table 2). At the end of the feeding trial, three animals from each group were selected randomly and used to determine the digestibility of feed by the animals. Statistically there was a non-significant difference (p>0.05) (Table 2) among the groups in respect to digestibility of nutrients. DM digestibility coefficient (56.58±0.45, 56.95±0.24 and 57.32±0.32) (for G1, 0% Banana stem and cassava tubers, G2, 15% banana stem and cassava tubers and G3, 25% banana stem and cassava tubers)respectively shows no significant differences, however, they increased as the level of banana pseudostem and cassava tubers increased. The present observation was supported by Malsawmthangi *et al.* (2016) [16] whom in particular used Sweet Potato meal (SPM) to replace the standard concentrate mixture and observed that the level of DM digestibility increased as the level of SPM increased. The CP digestibility also showed no significant differences (p>0.05) but showed a gradual decrease with increasing level banana pseudostem and cassava roots which was also supported by Malsawmthangi *et al.* (2016) [16] who used SPM as a replacement of standard concentrate mixture. Lalhuthangi and Buragohain (2020) [3] also supported these results where *Mikania micrantha* meal was used as a replacement of protein source in large white Yorkshire pigs in Mizoram.

However, CF digestibility was highest in G3 (58.97±0.35) and lowest in G2 (56.92±0.16) but there was no significant differences between the groups. The observed value in CF digestibility were in agreement with the value (54.5) reported by Totsuka *et al.* (1978) [17] in growing-finishing pigs by feeding cassava as an alternative to standard CM. The dietary fiber components are poorly digested in the small intestine of pigs and provide a substrate for microbial fermentation in the large intestine. Noblet and Perez (1993) [18] reported that the amount of digestible EE content was linearly and positively related to the dietary EE content and negatively affected by the dietary NDF content. The trend toward reduced EE digestibility in the present study could be attributed to the CF content of the experimental feed which is in contrast with the findings of Dominquez (1991) [19] and Malsawmthangi *et al.* (2016) [16] who observed an increase in the value as sweet potato foliage and SPM level increased explaining that the reduced digestibility of EE could be due to high crude fibre content with the inflated conclusion of sweet potato foliage and SPM in the diets.

Table 2: Chemical composition and fibre fractions (%DM) and digestibility coefficient (%) of rations in different groups of pigs

Parameters	G1 (control)	G2 (15% replacement)	G3 (25% replacement)
Dry Matter (DM)	88.43	85.93	85.83
Crude Protein (CP)	18	17.99	17.91
Crude Fibre (CF)	5.3	5.9	6.3
Ether Extract (EE)	2.28	2.51	3.18
Total Ash (TA)	6.5	6.77	6.53
Acid Insoluble Ash (AIA)	1.32	1.22	1.54
Nitrogen Free Extract (NFE)	57.92	55.64	60.01
Nitrogen Detergent Fibre	26.04	29.53	22.60
Acid Detergent Fibre	8.54	9.16	8.90
ME (Kcal/kg)	3134	3095	3038
Digestibility of Nutrients			
Dry Matter	56.58±0.45	56.95±0.24	57.32±0.32
Crude Protein	58.47±0.32	57.34±0.50	57.02±0.29
Crude Fibre	57.59±0.40	56.92±0.16	58.97±0.35
Ether Extract	57.92±0.39	56.38±0.31	55.68±0.40

Growth performance and Economic production

The final live weight was 56.26±4.87 kg, 53.11±4.42 kg and 53.91±3.22 kg respectively for G1, G2 and G3. Statistical analysis revealed no significant effect of unconventional feeding on the overall body weight gain of pig of different groups. Weekly body weight gain also shows no significant differences between the groups. This study was supported by Lallo *et al.* (2016) [20] where there was no significant differences observed in all the treatment group with cassava chips for 40 days.

The present study observed that the mean body weight gain was highest (45.49±1.32) in G1 and lowest in G2 (42.91±0.98) during the experimental period of 154 days (Table 3). No significant difference (p>0.05) was observed for the average daily gain (ADG), average feed intake and the feed conversion efficiency (FCR). Feed conversion efficiency can be defined as unit of feed (on DM basis) required per unit gain of body weight. It is often used as an index to determine

the production efficiency in the case of meat animals. The observed FCR valuesin the present study were4.45±0.18, 4.96±0.22 and 5.02±0.11 for G1, G2 and G3 respectively. The present study is in agreement with the results observed by Lalthansanga and Samanta (2015) [21] which specifically observed no significant difference when replacing the standard concentrate mixture with chayote (*Sechiumedule*) at 20, 30 and 40% replacement respectively. The present research was also comparable to observation showed by Lallo *et al.* (2016) [20] in which the lowest FCR was observed in treatment T60with highest cassava chips diet (562g/kg dried cassava by-products). Oke (1978) [22] showed that cassava root meal or cassava peel should be supplemented with rich sources of protein and oil in order to improve their palatability and digestibility due to low energy content, dustiness and low protein content.

The ADG ranges from 0.30±0.01 to 0.27±0.02 from G1 to G3, where 0.27±0.03 was the ADG for G2. In the current study, while no significant difference in ADG was found, which is supported by the result observed by Arjin *et al.* (2022) [12] where non-significant difference was observed when fed with Fresh Banana stem, Fermented Banana stem and concentrate diet. The trend for the present study for ADG to decrease with increasing banana stem and cassava inclusion in the diet which was supported by Lallo *et al.* (2016) [20], where they also observed a trend of ADG decreasing with increasing inclusion of cassava chips in the diet. Baruah *et al* (2022) [23] reported a significant difference (p<0.05) of improvement in the final body weight gain and ADG of crossbred female pigs in treatment T_2 (20% replacement of dietary maize with sun dried banana pseudostem).

Table 3: Growth performance of pigs fed rations with 0%, 15% and 25% banana pseudostem and cassava tubers (1:1)

Parameters	G1 (control)	G2 (15% replacement)	G3 (25% replacement)
Initial body weight (kg)	10.77±0.65	10.20±0.48	10.91±0.60
Final body weight (kg)	56.26±4.87	53.11±4.42	53.91±3.22
Overall body weight gain (kg)	45.49±1.32	42.91±0.98	43.00±1.06
Average daily gain (kg)	0.30±0.01	0.27±0.03	0.27±0.02
Average feed intake (g/day)	1350.85±83.94	1425.15±140.45	1443.75±133.61
Feed Conversion Ratio (kg/kg wt.gain)	4.45±0.18	4.96±0.22	5.02±0.11
Total Feed Intake (kg)	202.50±12.91	213.00±13.36	216.00±13.01
Feed cost/kg gain (Rs.)	122.86	116.45	103.98

Economic production shows that by replacing concentrate feed upto 25% with the use of banana pseudostem and cassava tubers has been shown to be economical for the small scale farmers in Mizoram. The feed cost/kg live weight gain decreased with increased incorporation of banana pseudostem and cassava tubers (1:1) (Table 3). Baruah *et al.* (2022) [23] also observed the feed cost/kg live weight gain decreased by inclusion of banana pseudostem at 20%. But due to their low protein content, banana and cassava meal-based diets require higher amounts of protein-supplying ingredients such as soybean meal to obtain an adequate balance of protein and amino acids. Therefore, the economic feasibility of using banana stem cassava roots as an alternative for conventional energy sources would depend not only on the relative price of banana pseudostem and cassava root but also on the price of protein supplements needed to balance banana and cassava-based diets. Harikumar *et al.* (2016) [24] also highlighted on the main limitation in swill feeding which is the highly variable nutrient content, and may be due to the variation in the composition and source of feed. He also suggests that this problem can be compensated by supplementing with protein, minerals, vitamins and amino acids. Similarly, to the present study and observation of other unconventional feeds in pig, crop/vegetable residues and agricultural by products are also used as pig feed. Performance of gestating and lactating gilts, their litters, and growing-finishing pigs fed least-cost diets containing cassava meal were also similar to that obtained with practical commercial diets based on sorghum (Gomez *et al.* 1984) [25]. Therefore, although banana stem and cassava roots can be satisfactorily used as the energy supplying ingredients, especially when combined with other good protein source, least cost diet formulation will take into account the nutrient supply as well as the cost of available feedstuffs, and the total income from live weight gain.

Conclusion

It can be concluded that feeding of banana pseudostem and cassava tubers (meal) upto 25% by replacing standard grower ration did not have any adverse effect on the growth performance and nutrient utilization of the pig. In addition, banana pseudostem and cassava tubers are easily available in the locality. Therefore, banana pseudostem and cassava tubers can economically be incorporated upto 25% by replacing the standard concentrate grower pig ration.

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Conflict of Interest

Authors declare that they have no conflict of interests arising from this study.

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