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Cassava and sweet potato are effective energy sources for finishing broiler chickens in the Papua New Guinea Highlands

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Abstract

The rising cost of grain-based poultry feed highlights the need for alternative energy sources in broiler nutrition. Cassava (*Manihot esculenta* Crantz) and sweet potato (*Ipomoea batatas L.*) are common tropical staples and offer energy-dense, starch-rich options for partially replacing conventional grains. This study evaluated two finisher diets: one incorporating 57% cassava with a universal protein concentrate (UC+Cas), and another using 25% sweetpotato with a low-energy broiler (protein) concentrate (LEBC+SP), compared against a commercial grain-based diet. 364 mixed-sex Ross 308 broilers were assigned to the dietary treatments from 21 to 42 days of age across seven broiler farms. Birds were housed in floor-pens within naturally ventilated, locally constructed sheds. There were no significant differences ($p>0.05$) in broiler growth parameters (feed intake, daily weight gain, feed conversion ratio, final body weight) between the feed treatments. Compared to the control, grain-based ration, UC+Cas was 14% cheaper and LEBC+SP was 24% cheaper. These findings indicate that cassava and sweetpotato can be effectively used as energy sources in broiler finisher diets in the Papua New Guinea highlands without compromising growth performance. However, for optimal utilisation of cassava or sweetpotato, future research and development efforts should focus on processing and storage costs of any feed used.

Keywords: cassava, sweetpotato, protein concentrate, broiler, growth response, benefit-cost

Introduction

Cereal grains such as maize and sorghum are the primary energy sources in commercial poultry diets. However, increasing demand for these grains for human consumption and industrial uses has contributed to rising feed costs in many countries (Adeniji & Balogun, 2003; Mmereole, 2009; Slama et al., 2021). Feed typically accounts for 50-70% of total poultry production costs, wit cereal-based energy ingredients comprising approximately 50-55% of poultry diets (Midau et al., 2011; Okereke, 2012; Tesfaye et al., 2013). Consequently, identifying alternative, locally available energy sources that reduce feed costs without compromising productivity has become a priority for sustainable poultry production (Novel et al., 2009).

In Papua New Guinea (PNG), this challenge is compounded by the country's dependence on imported cereal grains for commercial feed manufacture, despite the widespread availability of locally produced root and tuber crops. Sweetpotato (*Ipomoea batatas* L.) is the country's principal staple food, particularly in the highlands, while cassava (*Manihot esculenta* Crantz) is widely cultivated in the lowlands and drought-prone regions. Their high carbohydrate content, widespread cultivation, and adaptability to local farming systems make these crops attractive alternative energy sources for poultry diets. When adequately supplemented with protein, often from locally available ago-industrial by-products, cassava and sweetpotato can partially or substantially replace cereal grains in monogastric diets (Ravindran, 1993; Broch et al., 2017). Previous studies have shown that incorporating either crop into poultry diets can reduce feed costs without adversely affecting bird performance (Anaeto & Adighibe, 2011). Glatz et al. (2013) assessed broiler performance on diets containing 50 – 70% cassava or sweetpotato. Ahizo et al. (2015) evaluated a diet containing 40% cassava, while Nano (2015) investigated free-choice feeding using cassava chips and copra meal. Additional on-farm and on-station studies by Pandi et al. (2017) and Ayalew et al. (2017) examined the growth and economic performance of broilers fed diets containing up to 70% cassava or sweetpotato. Collectively, these studies demonstrate that locally available root crops can effectively replace a substantial proportion of conventional cereal grains, although outcomes vary with diet formulation and production conditions. However, these studies were conducted in the lower highlands (<1,700 m above sea level) and the lowlands of Morobe Province (<500 m above sea level), and their applicability to higher-altitude production systems remains uncertain.

This study builds on that body of research by evaluating cassava and sweetpotato-based finisher diets under high-altitude conditions (>1,700m above sea level) in PNG. The objective was to determine their effects on broiler growth performance and farm profitability. The null hypothesis is that cassava and sweetpotato-based finisher diets would not significantly affect broiler growth performance or economic returns when compared with a commercial finisher diet at high altitudes.

Table 1. Nutrient specification of the diets expressed as percentage of DM and metabolizable energy.

Feed Type	DM	Ash	CF	Fat	CP	Ca	P	NFE	ME (MJ/kg)
Starter	89.8	9.81	4.1	7.70	21.0	1.26	0.70	47.19	12.13
Finisher	89.7	5.89	5.0	7.50	19.0	1.28	0.71	52.31	12.20
UC+Cas	90.1	7.80	4.2	8.30	22.4	1.23	0.92	47.40	12.44
LEBC+SP**	-	-	1.4	1.93	15.1	-	-	-	14.93

DM= Dry Matter, Ash= mineral content estimate, CF=Crude Fibre, CP=Crude Protein, Ca=Calcium, P=Phosphorus, NFE= Nitrogen Free Extracts, ME=Metabolizable Energy. Source: specifications from LFM and Carey Nutrition.
***No feed sample analysis was made for the LEBC+SP ration.*

Materials and Methods

Study site and description

The study was conducted in 2016 in the Alkena and Kiripia communities of the Tambul-Nebilyer (5.9250° S, 144.0110° E) district of Western Highlands province of PNG. The region's altitude ranges from 800 m in the lower Kaguel Valley to over 4,000 m on the upper slopes of Mt. Giluwe. Annual rainfall, temperature and humidity ranges from 2,300 – 4,000 mm, 18-20°C and 65 – 75% respectively (Hanson et al., 2001).

Stock distribution and housing of broilers

A total of seven batches of mixed-sex Ross 308 one-day-old broiler chicks (52 birds per batch and 364 in all) were sourced from the hatchery at the Christian Leaders Training College, Banz, Jiwaka Province and distributed among seven smallholder households participating in the study. Each household received one batch of chicks for rearing. Broiler sheds on each farm were constructed using locally available materials, comprising timber frames, roofs thatched with *Miscanthus floridulus* reeds, and walls made tightly woven split reeds. All sheds were naturally ventilated and divided into two 2m^2 pens, each assigned to one of two dietary treatments. Each pen housed 25 birds, accordingly, allocated either to LEBC+SP or the UC+Cas, with the corresponding commercial finisher diet serving as the control. There were four replicate farms for the LEBC+SP treatment and three replicate farms for the UC+Cas treatment.

Dietary treatments

The experimental diets (see) consist of three treatment groups:

- LEBC+SP: a low energy broiler (protein) concentrate mixed with boiled and mashed sweetpotato in a 1:3 ratio.
- UC+Cas: a universal protein concentrate blended with cassava flour.
- Control: a standard commercial broiler finisher ration (Flame Brand®).

All diets were provided ad libitum, with feed allocated at 200 g per bird daily to ensure continuous availability throughout the experimental period. The protein concentrates and cassava-based feeds were sourced from Lae Feed Mills and Labu Mini-Feed Mill respectively. The commercial broiler starter and finisher rations were obtained from Farmset Ltd. The starter diet was administered ad libitum to all birds from day 1 – 21 while the dietary treatments were introduced from day 22 onwards.

Statistical analysis

Feed intake and body weight data were collected over a 42-day experimental period. Daily feed offered and refusals were recorded using a kitchen-scale (10 kg ±0.025 kg), while individual bird weights were recorded weekly using the same scale. Feed conversion ratio (FCR) was calculated as the ratio of feed intake to total weight gain. Daily feed intake (DFI) was determined by subtracting feed refusal from the quantity of feed offered. Average daily gain (ADG) was calculated as the difference in bird weight between day 42 and day 22, divided by the number of trial days. All data were organised in Microsoft Excel and analysed using the Statistical Package for Social Sciences (SPSS version 17.0). Levene's test was used to assess the homogeneity of variances between groups. Statistical significance was set at $p<0.05$. Where the assumption of equal variances was met, differences between treatment groups were analysed using Student's independent-samples t-Test.

Table 2. Comparative analysis of mean values for DFI, FCR, FBW and ADG of broilers subjected to different dietary treatments (n=25).

UC+Cas				**Levene's Test**		**Student's T-Test**	
Parameter	Diet	Mean	S.E.M	F-value	P-value	t-value	P-value
DFI (g/bird)	UC+Cas	139.97	9.14	0.077	0.786	0.575	0.576
	STD_BR	132.47	9.30				
FCR	UC+Cas	1.79	0.18	0.006	0.937	0.016	0.987
	STD_BR	1.80	0.19				
FBW (kg/bird)	UC+Cas	2.22	0.07	1.021	0.332	0.604	0.557
	STD_BR	2.15	0.09				
ADG (g/bird)	UC+Cas	26.53	2.73	1.284	0.279	0.78	0.451
	STD_BR	25.20	3.58				
LEBC+SP							
DFI (g/bird)	LEBC+SP	106.73	5.76	0.258	0.619	0.351	0.731
	STD_BR	103.03	8.84				
FCR	LEBC+SP	3.11	0.28	0.035	0.854	0.751	0.465
	STD_BR	2.80	0.29				
FBW (kg/bird)	LEBC+SP	2.68	0.22	2.007	0.178	0.508	0.619
	STD_BR	2.81	0.16				
ADG (g/bird)	LEBC+SP	24.52	3.34	1.064	0.320	0.519	0.612
	STD_BR	26.76	2.67				

S.E.M = standard error of means. UC+Cas = 40% universal concentrate blended with 50% cassava flour and 10% micro-ingredients. LEBC+SP = 25% low energy broiler concentrate blended with 75% boiled and mashed sweetpotato. STD_BR = commercial broiler finisher.

Table 3. Feed cost (PGK)* of broilers under various dietary regimes during the finisher phase.

Feed type	Cost/bird Starter	Cost/bird Finisher	Total cost/bird	Selling price/bird	Profit	Benefit-cost ratio
BR_STD	3.00	6.15	9.15	30.00	20.85	3.28
UC+Cas	3.00	5.00	8.00	30.00	22.00	3.75
LEBC+SP	3.00	4.00	7	30.00	23.00	4.28

*These are based solely on feed costs and are exclusive of *other* fixed or variable costs. PGK = PNG Kina.

Results

Feed conversion and weight gain

The mean values of all measured performance parameters are presented in Table 2. No significant differences were found among the dietary treatments for any parameter measured. Across all treatments, broilers achieved marketable body weights (≥ 2.0 kg) by day 42, with no recorded mortality.

Cost analysis

The cost analyses for the three rations are presented in Table 3. The LEBC+SP ration emerged as the most economically favourable option for smallholder households, largely due to the low cost and local availability of sweetpotato. The higher cost per bird associated with the commercial finisher reflects its elevated unit price, making it the least cost-effective of the three. Finishing off broiler chickens with UC+Cas proved to be the next-best option available for farmers. Using the UC+cas diet resulted in a 14% increase in profit margin compared to the commercial diet, while LEBC+SP diet achieved a 24% increase – nearly doubling profitability. However, it is important to note that the sweetpotato-based diet required additional resources, including fuel and labour for boiling and preparation, and had a shorter shelf life than the cassava-based and commercial rations.

Discussion

This on-farm study evaluated the performance of broiler chickens fed cassava- and sweetpotato-based finisher diets under high-altitude village farming conditions. The results demonstrated no significant differences in feed consumption, weight, gain, final body weights, and FCR between the dietary treatments (UC+Cas and LEBC+SP) and the commercial finisher ration. These findings support the hypothesis that cassava and sweetpotato, when supplemented with appropriate protein concentrates, can effectively replace conventional cereal-based finisher diets under high-altitude production conditions.

These results are consistent with earlier studies. Pandi et al. (2017) found similar performance outcomes in broilers fed 50% cassava or sweetpotato with protein concentrate. Ahizo et al. (2015) also reported no significant differences in performance when broilers were fed a 40% cassava-based diet. Tesfaye et al. (2013) likewise observed no variation in growth rates across diets containing 25-75% cassava. Consistent with the sentiments of Babatunde (2013), these studies collectively support the view that cassava and sweetpotato are nutritionally viable energy sources in broiler diets.

However, previous research has also reported mixed results. Conversely, Agwunobi (1999) and Afolayan et al. (2012) observed lower body weights with broilers fed sweetpotato-based diets. Ayalew et al. (2017) and Pandi & Glatz (2017) reported improvements in FCR but lower final weights with higher inclusion levels (50-70%) of root-tuber meals. Similarly, Set'le et al. (2012) found significant variations in feed intake when using 20-80% sweetpotato-based diets, while Udedibie (2004) and Broch et al. (2017) noted a linear decline in body weights with increasing cassava inclusion. These inconsistencies are likely due to variations in energy and protein content, processing methods, feed formulation, crop variety, and broiler genotype (Tesfaye et al., 2013; Pandi et al., 2017).

Beyond performance, economic analysis revealed that cassava- and sweetpotato-based diets reduced feed costs by 14% and 24%, accordingly, compared to the commercial finisher. These cost savings directly translated to higher profit margins, confirming the potential for greater farm profitability with locally available ingredients. Similar trends were reported by Ahizo et al. (2015), who observed a 13% reduction in production costs using cassava-based diets, and by Besari et al. (2017), who reported an 11.5% reduction with sweetpotato-based rations. Glatz et al. (2013) also reported no adverse performance impacts when using up to 70% sweetpotato or 50% cassava in finisher diets.

Subsequent studies by Ayalew et al. (2017) and Pandi et al. (2017) suggested cost savings of up to 20%, which could translate into 25-30% increases in farm profitability (Pandi, 2007). For smallholder broiler farmers in PNG, particularly in informal markets, the adoption of cassava and sweetpotato as dietary energy sources offers a practical strategy for reducing production costs. However, the economic viability depends on the farmer's ability to grow, process, and manage these ingredients efficiently.

This study demonstrates that cassava and sweetpotato are viable alternatives to conventional energy sources in broiler finisher diets, maintaining growth performances while reducing feed costs and improving farm profitability under high-altitude conditions. To enhance the practical use of these root crops, future work should focus on improving processing methods – including drying, milling, pelletising, and detoxification – to enhance feed quality, extend storage life, and reduce anti-nutritional compounds, particularly cyanogenic glycosides in cassava.

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Data availability. The data used to generate these results are available and can be accessed by liaising with the corresponding author.

Conflicts of interest. The authors declare that they have no conflicts of interest.

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