High-Quality Cassava Peel® (HQCP®) mash as a feed ingredient for livestock – a review of feeding trials

ILRI PROJECT REPORT

High-Quality Cassava Peel® (HQCP®) mash as a feed ingredient for livestock – a review of feeding trials

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1. Introduction

The livestock sector makes an important contribution to human nutrition through the provision of animal-sourced foods and provides an important source of livelihood to rural households (Enahoro et al. 2018; Randolph et al. 2007). However, livestock production consumes natural resources, therefore new ways of feeding animals more sustainably are needed to reduce the environmental impact of livestock production and improve profitability (Rojas-Downing et al. 2017). From the livestock nutrition point of view, there is a need to evaluate a range of new and novel feed ingredients for use in poultry, pig, aquaculture, and ruminant livestock rations and to assess the economic impact of their use on livestock production.

Poultry diets are constituted primarily of cereal grains, soya bean meal, animal by-products, fats, and vitamin and mineral premixes (Alimon and Hair-Bejo 1995). Energy sources, particularly maize, contribute the largest portion of poultry rations. Also, although ruminant diets are largely dependent on natural pastures and crop residues in developing countries, supplementation with commercially available concentrate feeds, consisting of feedstuffs such as maize grains, palm kernel, fish meal etc. is common (Akinmutimi 2004). However, the cost of livestock feed ingredients, especially maize and soya beans, is continually increasing and the scarcity of high quality feeds necessitates feed importation to developing countries; the United States Department of Agriculture (USDA) estimated about 1 million metric tonnes of maize were imported into Nigeria between 2019 and 2020, and annual soya bean imports are set to reach 100,000 tonnes by 2022. According to Food and Agriculture Organization of the United Nations (FAO), the cost of feed also led to a reduction in global aquaculture production between 2016 and 2018. Global demand has forced many livestock farmers to explore viable alternatives that can replace these ingredients at a lower cost without significant deleterious impacts on the production and performance of their livestock (Chauynarong et al. 2009).

The International Livestock Research Institute (ILRI) has developed innovative patented methods of processing cassava peels into feed products, namely High-Quality Cassava Peel (HQCP®) mash (Okike et al. 2015). These methods involve a combination of different physical processes such as grating, dewatering, pulverizing, and sun-drying or drying by toasting on a fire-heated pan or flash dryer in the case of commercial production (Amole et al. 2019). The processing of cassava peel into HQCP® mash and its utilization as a partial replacement for more conventional energy sources aims at delivering an environmentally friendly low-cost feed ingredient that promises to increase both the productivity and profitability of livestock enterprises and ultimately increase the accessibility of animal-sourced foods.

Several investigations into the inclusion of HQCP® mash at varying levels into poultry, fish, and ruminant diets have been conducted, all aimed at understanding the level at which the inclusion of HQCP® mash will support the best performance while examining the economic implications of the inclusion of this ingredient. This document is designed to evaluate and provide an overview of the results of a number of feeding trials with HQCP® mash, the purpose of which is to assist in developing standard protocols for the optimal level of inclusion in livestock diets.

Nutrient composition of HQCP® mash

Samples from three HQCP® mash processing factories were collected during five production cycles in 2016 and three production cycles in 2022. These were analysed at the ILRI feed analysis laboratory using near-infrared reflectance spectroscopy (NIRS). Samples were processed on a FOSS DS2500 Analyzer equipped with WinISI II software and calibration equations developed at ILRI. Proximate composition, hydrocyanic acid (HCN) concentrations, and aflatoxin concentrations were determined at the International Institute of Tropical Agriculture (IITA) analytical lab and at MasterLab (https://www.masterlab.nl/), the Netherlands. The nutritive value of the various constituents analysed is presented in Table 1. Importantly, concentrations of the various aflatoxins produced by Aspergillus flavus and Aspergillus parasiticus were not detectable in any of the samples. Variations in results, especially the crude protein and fibre, could be due to handling of products during processing.

Table 1: Nutrient profiles of HQCP® mash from five factories located in two agroecological zones in Nigeria

Nutrient profile	Oyo		Ogbomosho		ILRI	
Parameters	Fine	Coarse	Fine	Coarse	Fine	Coarse
Crude protein (%)	5.2	5.1	4.9	3.3	3.6	4.8
Fat (%)	2.8	4.1	7.4	8.6	2.8	2.4
Ash (%)	6.3	6.0	6.2	4.9	3.8	5.5
Starch (%)	66.2	43.8	61.2	58.1	66.6	46.9
	Ojapata		ILRI		IITA	
*Aflatoxin concentrations (ppb)						
B1	-	-	-	-	-	-
B2	-	-	-	-	-	-
G1	-	-	-	-	-	-
G2	-	-	-	-	-	-
HCN mg/100g						
a	0.82	0.24	0.33	2.76	1.37	1.34
b	0.7	0.24	0.13	2.17	1.34	1.42

*For all the samples, aflatoxin analysis was conducted using thin-layer chromatography (TLC) by scanning densitometry. (Camag TLC Scanner 3, ISO 9001, Reg. No. 11668-01). B1, B2, G1, and G2 are the four main types of aflatoxins; a and b are the two main groupings of HCN.

2. High-Quality Cassava Peel® mash utilization in livestock feed

Pig production

Empirical research has been carried out to investigate the amount of HQCP® mash that can be incorporated in pig feed without detriment to the growth and performance of the pigs. Adesehinwa et al. (2016) conducted research with the objective of determining the effect of partial replacement of maize with graded levels of HQCP® mash on growth performance and hematological and serum biochemical responses of 45 growing pigs randomly assigned to five dietary treatments for 56 days (Table 2).

Data from the trial showed a uniform daily weight gain and feed conversion ratio across the dietary treatments. Pigs on the diet containing 38% replacement level of maize with HQCP® mash recorded the least daily feed intake while those on the diet containing 56% HQCP® mash recorded the highest daily feed intake (Table 2). There were no differences (P>0.05) in the hematological and serum biochemical parameters among treatments. The authors concluded that HQCP® fine mash can be used to replace up to 75% of the maize in the diet of growing pigs without adverse effects on the growth performance and blood biochemical indices. A cost-benefit analysis showed that the inclusion of HQCP® mash at up to 38% of the diet was most financially beneficial.

Table 2: Formulated ration and gross composition

Ingredients (%)	Level of replacement of maize with HQCP® mash (%)					SEM
	0	19	38	56	75	
Maize	40.0	32.5	25.0	17.5	10.0	
HQCP® mash	-	7.5	15.0	22.5	30.0	
Corn bran	10.0	10.0	10.0	10.0	10.0	
Groundnut cake	15.0	15.0	15.0	15.0	15.0	
**Others	35.0	35.0	35.0	35.0	35.0	
Total	100	100	100	100	100	
Performance						
Daily weight gain (g)	409	395	399	361	353	0.01
Daily feed intake (g)	2035b	1935d	1850e	2043a	1995c	10.8
Feed cost/kg weight gain (N/kg)	359	342	322	377	345	9.87
Calculated analysis						
Crude fibre (%)	6.06	6.17	6.28	6.39	6.51	
Metabolizable energy (MJ/kg)	11.59	11.52	11.44	11.37	11.29	
Crude protein (%)	18.4	18.0	17.5	17.0	16.4	

[a,b,c,d,e]: means on the same row with different superscripts are significantly different (P < 0.05)

SEM = Standard error of mean

Source - Adesehinwa et al. (2016), ** - premixes

The cost was based on the market price of ingredients, USD1 ≙ N360, at the time of study

Fatufe et al. (2017) conducted a total tract digestibility trial to determine the effect of partial replacement of maize with graded levels of HQCP® mash on the nutrient digestibility and fibre fraction digestibility of growing pigs. The trial used similar dietary treatments, ingredients and levels of replacement as reported above. There was a significant increase in the amount of acid detergent fibre ($P<0.05$) with the inclusion of HQCP® mash. There was also an increase in the apparent digestibility of crude protein ($P<0.05$) with increasing levels of HQCP® mash inclusion from 19 to 75% replacement level of maize. Therefore, Fatufe et al. (2017) also concluded that HQCP® mash can be included at up to 75% replacement of maize in the diet of growing pigs.

Poultry production – broiler birds

In the study by Adekeye et al. (2021), a feeding trial was conducted involving 400 21-day-old Arbor Acres broiler chickens, fed for 21 days with isonitrogenous and isocaloric diets containing varying levels of HQCP® fine mash. The study aimed at evaluating the effect of inclusion of HQCP® mash on the performance and cost of feeding the broilers. The birds were assigned a dietary treatment regime that included varying quantities of HQCP® mash (0, 150, 200, 250 and 300 kg/t) as shown in Table 3. The results showed that birds fed diets containing 28 and 48% replacement levels of maize with HQCP® mash recorded the highest body weight and live weight gain while feed intake was uniform across the diets. The feed conversion ratio (FCR) was highest amongst birds on the diet containing 28% maize replacement level with HQCP® mash. The authors concluded that the inclusion of HQCP® mash in broiler finisher diets at up to 28% replacement of maize (corresponding to 150kg/tonne) conferred the best cost-saving and most improved production performance.

Oladimeji et al. (2020) investigated the effect of feeding four HQCP® mash-based diets on carcass characteristics and organ weights of broiler chickens. In this trial, 455 10-day-old Ross 308 broiler chickens were randomly divided into 13 groups of 35 birds, with each group consisting of five replicates with seven chicks in each replicate. The diet included three levels of replacement of maize (20, 40 and 60%) with HQCP® mash. The results of this trial showed no effect ($p>0.05$) of feeding chickens with the cassava peel-based diets on carcass primal cuts and internal offal, except for breast meat and the spleen. The breast meat yield of chickens on a maize-based diet was 25% higher ($p<0.05$) than that of chickens fed the other diets. In conclusion, the replacement of up to 60% dietary maize with cassava peel products had a similar effect on broiler carcass yield and productivity with the exception of breast meat yield.

In all the trials, soya oil, full-fat soya and D-L methionine were the major ingredients used to improve the nutritional quality of HQCP® mash-based diets at a viable cost level.

Table 3: Dietary composition (kg/tonne) of broiler finisher diets containing HQCP® mash

	Quantity of HQCP® mash/tonne					
	0	150	200	250	300	
Soya oil	24	25	25	25	25	
White maize	522	372	322	272	222	
Wheat bran	70.4	35	23.2	12.5	0.7	
45% soya bean meal	172	172	172	172	172	
Full fat soya	172	207	219	230	242	
Limestone 35%	2.6	2.6	2.6	2.6	2.6	
Bone meal	25.6	25.6	25.6	25.6	25.6	
Salt	3.7	3.7	3.7	3.7	3.7	
Lysine HCL	1.8	1.2	1	0.7	0.5	
DL-Methionine	1.9	1.9	1.9	1.9	1.9	
Toxin binder	1	1	1	1	1	
Cibenza	0.5	0.5	0.5	0.5	0.5	
Broiler premix .25%	2.5	2.5	2.5	2.5	2.5	
HQCP® fine mash	0	150	200	250	300	
Total	1,000	1,000	1,000	1,000	1,000	
***Calculated analysis**						
Crude protein (%)	19.5	19.5	19.5	19.5	19.5	
Metabolizable. energy(MJ)	13.00	12.99	12.99	12.98	12.98	
Ether extract (%)	7.64	7.75	7.79	8.03	8.06	
Crude fibre (%)	3.23	3.61	3.73	3.92	4.04	
Calcium (%)	0.91	0.9	0.9	0.9	0.9	
Av. phosphorus (%)	0.458	0.47	0.46	0.46	0.45	
Lysine (%)	1.16	1.16	1.16	1.16	1.16	
Methionine (%)	0.47	0.47	0.467	0.463	0.47	
Performance and economics of production						**±SEM**
Total feed intake, kg	2.36a	2.36a	2.40a	2.40a	2.17b	0.003
Total feed cost, USD/kg	0.8a	0.79a	0.8a	0.8a	0.72b	0.02
Total weight gain, kg	1.11ab	1.42a	1.13ab	1.33a	0.95b	0.029
Feed cost per kg gain, USD	0.96ab	0.74b	0.93ab	0.80ab	1.05a	0.07
Cost savings, USD	-	0.22	0.02	0.15	-0.09	-

a,b : means on the same row with different superscripts are significantly different (P < 0.05)

SEM = Standard error of mean

Note: The cost was based on the market price of ingredients, 1USD ♎ N510, at the time of study

Source - Adekeye et al. (2021)

Ruminant production – sheep

At ILRI Ibadan, a sheep fattening trial was performed on rams for 60 days. The trial was conducted to evaluate the performance and economics of production when offering rams a concentrate supplement with different inclusion levels of HQCP® mash. Three dietary inclusion levels in a concentrate diet were tested: no HQCP® mash (control diet), 25% HQCP® mash, and 50% HQCP® mash. To balance the N-concentration of the diets, the inclusion levels of brewer's dried grain (BDG), palm kernel cake (PKC) and urea were also adjusted (Table 4). The diet with the inclusion of 50% HQCP® mash and the addition of urea had the highest measured crude protein (16%), metabolizable energy (12.8 MJ) daily weight gain (133.5g/day), and the highest final body weight of the rams (33 kg). The economics of production revealed that the highest feed cost/kg weight gain (Naira (N)/kg) was recorded for the control (602.5) and the lowest in the diet with 50% HQCP® mash inclusion (364.2). Therefore, it was concluded that the inclusion of HQCP® mash at up to 50% with supplemental urea in a ram concentrate diet not only increased body weight gain but also reduced the unit cost of feeding by nearly 40%, hence increasing profit during ram fattening.

Table 4: Composition of the experimental diets

	Inclusion level			
Ingredients (kg)	0	25	50	Prices (N)/kg
Wheat offal	50	25	-	60
HQCP® mash	-	25	50	50
BDG	19.5	34.5	29.5	30
PKC	15	15	19	50
P. maximum wilted	15	-	-	10
**Grower premix	0.5	0.5	0.5	600
Urea	-	-	1	120
Total	100	100	100	
Performance				SEM
Av. Initial weight (kg)	20.18	25.73	24.63	0.00
Av. Final weight (kg)	25.25	31.73	32.64	0.00
Av. Weight gain (kg)	5.08c	6.01b	8.03a	0.00
Av. Daily weight gain (g/day)	84.83c	99.85b	133.55a	0.23
Feed cost /kg weight gain (N/kg)	602.5a	523.7b	364.2c	10.9
Calculated composition				
Crude protein (%)	15.19	15.34	16.27	
Metabolizable. energy (MJ)	11.00	11.49	12.75	

[a,b,c] : means on the same row with different superscripts are significantly different ($P < 0.05$)

BDG: brewer's dried grains; PKC: palm kernel cake.

** Each 2.5 kg contains: vitamin A =12,000,000i.u, vitamin D3 =2,500,000i.u, vitamin E =30,000 mg, vitamin K3 =2,000 mg, vitamin B1 =2,250 mg, vitamin B2 =6,000 mg, vitamin B6 =4,500 mg, vitamin B12 =15 mcg, niacin =40,000 mg, pantothenic acid =15,000 mg, folic acid =1,500 mg, biotin =50 mcg, choline chloride =300,000 mg, manganese =80,000 mg, zinc =50,000 mg, iron =20,000 mg, copper =5,000 mg, iodine =1000mg, selenium =200 mg, cobalt =500 mg, antioxidant =125,00 0mg

Note: The cost was based on the market price of ingredients, USD1 ≙ N360, at the time of study

In another study, 20 West African Dwarf (WAD) rams were assigned four dietary treatments consisting of HQCP® mash as a sole diet offered ad libitum or supplemented with dried Ficus thonningii (DFT) foliage at 20, 40 and 60% (Bakare et al. 2019). Feed intake and apparent digestibility coefficients of dry matter, crude protein, ether extracts, neutral detergent fibre, and acid detergent fibre were highest ($P < 0.05$) in rams fed 60% DFT foliage. The study concluded that DFT foliage fed at up to 60% inclusion level of HQCP® mash improved the total dry matter intake, nutrient digestibility, body weight, and blood parameters of the WAD rams.

Aquaculture production

In a search for the least expensive, most accessible, and most readily available non-conventional nutrient sources to mitigate the high cost of feed, especially maize, for aquafeed production, Orisasona et al. (2019) investigated the growth response and economics of production using HQCP® mash as a replacement for maize in the diet of juvenile African sharptooth catfish (Clarias gariepinus) for a period of 84 days. Five diets were formulated with HQCP® mash replacing maize at 0%, 25%, 50%, 75% and 100% inclusion levels, respectively (Table 5). The outcome of the trial showed that, based on growth parameters, the value of fish produced and the cost aspects, HQCP® mash can be successfully used to completely replace maize in the diets of Clarias gariepinus.

Table 5: Gross composition of experimental diets fed to ***Clarias gariepinus juveniles***

Ingredients	Level of replacement of maize (%)				
	0	25	50	75	100
Fish meal	31.4	31.4	31.4	31.4	31.4
Soya bean meal	31.4	31.4	31.4	31.4	31.4
Maize	32.2	24.18	16.11	8.06	0
HQCP® mash	0	8.1	16.1	24.2	32.2
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5
Salt	1.0	1.0	1.0	1.0	1.0
Vitamin premix	1.0	1.0	1.0	1.0	1.0
Starch	1.0	1.0	1.0	1.0	1.0
Lysine	1.0	1.0	1.0	1.0	1.0
Palm oil	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100
Calculated composition					
Crude protein (%)	39.3	39.0	38.7	38.5	38.2
Fibre (%)	2.9	3.1	3.2	3.4	3.5
Fat (%)	4.4	4.2	4.1	4.0	3.9
Energy (kcal/100g)	276.97	267.06	256.92	247.10	237.27
Performance and economics analysis					
Av. daily weight gain (g/day)	0.64±0.00	0.61±0.02	0.62±0.00	0.62±0.00	0.63±0.01
Feed intake (g/head)	65.3±0.94	59.4±3.98	59.5±4.83	59.1±4.53	61.2±3.41
Feed cost /kg weight gain (N/kg)	450.24	454.02	434.8	448.1	435

Source - Orisasona et al. (2019)
The cost was based on the market price of ingredients, USD1♎ N360, at the time of study

Potential constraints on the utilization of HQCP® Mash

Despite the positive results from HQCP® mash feeding trials, a few constraints remain. The low price of HQCP® mash can lead to perceptions of poor quality despite evidence to the contrary. HQCP® mash producers have not yet attained threshold production levels that might attract industrial feed millers. There is also a lack of awareness among industry players about the potential and indeed the existence of the innovation. In addition, poor quality HQCP® products, varying prices, cost of machines, drying difficulty (during the rainy season), and the fear of high levels of cyanide are all still barriers to the commercialization and scaling of this technology.

However, at the time of writing this manual, a scaling study was being undertaken to try to address these and other constraints in order to realize the scaling potential of the HQCP® mash product. The multi-stakeholder scaling study sets ambitions for increased transformation of fresh cassava peels and their use as HQCP® mash in animal feed from the current level of 30,000 tonnes per year by 200 small and medium scale enterprises (SMEs) in Nigeria to 500,000 tonnes per year by 500 SMEs in Nigeria, Ghana, Democratic Republic of Congo, Rwanda and Tanzania. This transformation would lead to additional income, create employment, mitigate feed scarcity, and protect the environment. The aspiration is to achieve this level of growth within five years with ongoing institutional support from all stakeholders and technical support from CGIAR centres.

Conclusion

For the livestock industry in sub-Saharan Africa to reach self-sufficiency, there is a need for low-cost and simple technologies for livestock feeding and product processing. The development, transfer and adaptation of technologies should focus on improving the efficiency of feed utilization and increasing animal productivity.

This document synthesized the results of several studies that tested different levels of inclusion and combination of HQCP® fine mash in livestock and aquaculture diets, all aimed at cost minimization and profit maximization. To meet the increasing demand for feed ingredients (especially energy-based ingredients), there is a need to strengthen the current production of HQCP® mash by increasing awareness of its potential, thereby capitalizing on cheap and high-quality alternative feed energy sources for commercialization.

Improved methods of processing and formulation will also go a long way in increasing the inclusion of HQCP® mash as a non-conventional ingredient in the production of livestock feed. To ensure the adoption and wider acceptability of HQCP® mash-based diets among livestock farmers, cost-effective fortification of HQCP® mash with other feed ingredients to meet the animals' nutritional requirements for optimum production and health is essential. This includes maize, full-fat soya, wheat bran, methionine, lysine, and other mineral and vitamin supplements.

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