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Utilization Potentials of Cassava Starch (*Manihot esculenta*) as Micro-Livestock Feed Binder

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ABSTRACT

The investigation was conducted to study the suitability of cassava starch as a binder in grasscutter feed, which is effective. With respect to pellet forming ability, maximum value were obtained at 10, 15, 20 and 25% levels of cassava starch inclusion for diets 1, 2, 3 and 4, respectively. In terms of pellet forming index and dust level generated, the binding characteristic of the cassava starch in the pelleted feed diets increased as the level of inclusion increases and decreases with increase in the level of grass meal inclusion with values specific to a particular diet sample, while the level of inclusion have significant effect ($p<0.05$) of the densities (loose and bulk) of the diet samples. This study shows that 20% level of cassava starch inclusion would ensure a desirable pellet as it gives the maximum least value of pellet forming ability value when compared with the least values of other levels of starch inclusion.

Key words: Cassava starch, binding agent, feed pellet

INTRODUCTION

It is very evident today in the developing countries of the world including Nigeria that the average citizen does not meet their daily protein requirement (Chupin, 1992; Sodeinde *et al.*, 2007) due to deficit in the supply of meat and other animal products and this has led to widespread increase in prices of these products. Therefore in a bid to increase animal protein availability and consumption, farming wildlife species (like grasscutter) for their meat as being proposed (Ajayi, 1971; Cicogna, 1992; Fonweban and Njwe, 1990).

Micro-livestock (grasscutter) rearing has a huge potential in developing countries like Nigeria in supplying the much needed animals protein in the diet of the citizen (Adu *et al.*, 2000; Mensah and Okeyo, 2005). However, one of the major challenges confronting an average grasscutter farmer is the provision of balanced diet (Annor *et al.*, 2008) and adequate feeding to the animals that would meet their nutritional and physiological needs (Opara *et al.*, 2006) and at a reduced cost (Vietmeyer, 1991; Annor *et al.*, 2008). The pivotal position of feed in the correction of deficit in livestock production generally cannot be over emphasized as availability of these feeds will lead to increase in the level of grasscutter meat available for local consumption (there by playing an important role in reducing Africa's chronic protein shortage by increasing the average protein intake of the poor) and for the export market (Mensah and Okeyo, 2005).

The characteristics (physical and chemical) of the feed have a profound effect on the utilization of the feed by the animal (Khajarern and Khajarern, 1991). Physical properties such as dustiness and bulkiness are closely related to palatability and feed intake of the animals (Khajarern and Khajarern, 1991), hence the suitability of the feed in providing the necessary function in the body of the animals. Therefore for animal to fully utilize the feed such physical characteristic should be taken into consideration.

In recent years, the utilization of pelleted animal feed in the feeding of animal has increased among farmers because of its numerous advantages which include wholesome delivery and increase nutritional utilization of the feed components among others (Tiamiyu *et al.*, 2003).

The physical quality of pellets is largely affected by raw material quality and with the increasing trend towards bulk delivery and automated handling systems; pellet quality has now become an important factor in feed marketing.

Binders are now been increasingly used by feed millers and compounders to produce good quality pellets that do not crumble upon handling and this has increase role of feed binder in animal feed significantly. However, the high cost of conventional synthetic binders make pellet feed production a difficult exercise especially for small and medium scale farmers, so the utilization of cassava which is abundant in sub-Saharan Africa (Nweke *et al.*, 2002; Dufour *et al.*, 2002) will provide an appropriate local alternative to feed millers and farmers as this would enhance micro-livestock feed production by rendering feed production affordable and attainable.

Therefore this study aims at establishing the range of natural binders (cassava starch) in micro-livestock feed i.e the binder level that will give desirable pellets (Hastings and Higgs, 1980) as well as that will ensure wholesome delivery of nutrients to the animals with minimum wastage (Natividad, 1994).

MATERIALS AND METHODS

Materials: The materials used in the project work include cassava and grasses (obtained from a private farm in Oshodi, Lagos, Nigeria) while soybean meal, fish meal, bone meal and vitamin supplements were obtained from a reputable animal feed shop at Abattoir, Oko-Oba, Agege, Lagos, Nigeria.

Preparation of cassava starch: The cassava starch was produced according to the method described by Kordylas (1990) with little modification. The raw cassava tubers (*Manihot esculenta*) was peeled, washed and grated with electrically powered mechanical grater. The pulp obtained was then mixed with sufficient quantity of water to allow for proper exudation of the starch from the fiber. The solute was the poured into a muslin cloth and squeezed to obtain the starch solution filtrate. The filtrate was allowed to settle for about 6-8 h and the supernatant poured away. The thick starch remaining was washed again by re-suspending in water and left to settle for overnight for thorough separation. The supernatant was decanted to obtain the thick starch cake at the bottom of the bowl which was packed and pressed in a sack to remove water. The dewatered cake was then dried in a Cabinet dryer at 65°C for 6 h, milled and packaged in polyethylene bag prior to usage.

Preparation of grass meal: The grass (Guinea grass (*Panicum maximum*)-chosen because of its relative abundance and it is also relish by grasscutters) was collected from farm around Oshodi, Lagos, Nigeria. They were washed, sized reduced, dried (first air-dried (35-37°C) for about 3 days before drying in the cabinet drier at 60°C for 3 h, milled and packaged for usage.

Preparation of pelleted feed: The cold starch gel prepared by mixing the required quantity of starch powder with water in ratio (1:1) and heated on fire with constant stirring was thoroughly mixed other feed ingredients (which have been previously milled separately using hammer milling machine and mixed together) to form a dough. The dough was then divided into smaller quantity and fed into locally fabricated hand-driven cold pelletizing machine which consists of an inlet trough through which the dough is being fed into the machine. With the aid of a pestle the dough was press into the action zone (screw conveyor) in which feed is compressed and worked upon. It also helps to further mix the dough and move it towards the die (6 mm) where it is forced through a restricted opening to the discharge end of the screw as the handle of the machine is being turn. The pellet was then dried at 65℃ for 6 h in a cabinet dryer. Flow chart for the production of starch gel and feed pellets is shown in Fig. 1.

Evaluation of physical properties of the pellets

Pellet forming ability: The pelleted feed was sifted to separate the well formed from the unformed. The percentage pellet ability was obtained by expressing the pellet weight to the total weight.

Pellet durability Index: This was performed using ASAE (2004) modified method. One hundred grams (100 g) of pellet sample was put in a container and attached to mechanical test sieve shaker (Serial No: 9166, Volt: 220/240, Endecotts, England) for 20 min. The loose particles generated from the agitated pellets were then collected, weighed and expressed as a percentage of the sample weight.

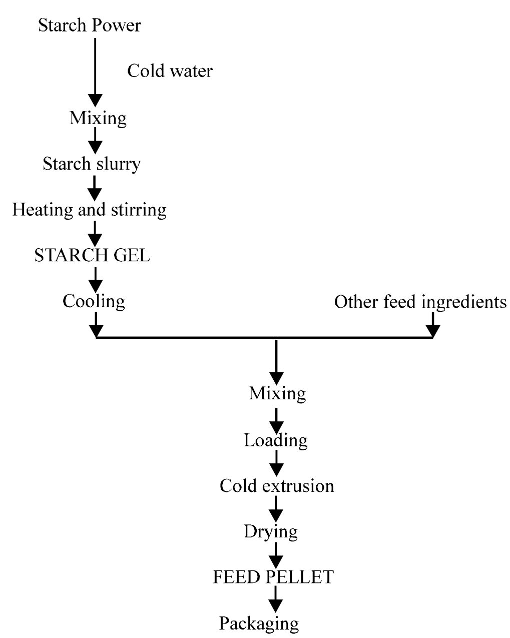

Fig. 1: Flow chart for the production of starch gel and feed pellets

Dust level: Sample pellets of one hundred grams (100 g) by weight were placed under normal stress-condition, such as handling, packaging and transportation for a period of two (2) weeks. The dust particles produced was collected through a 2 mm sieve and was measured as a percentage of the original weight.

Densities (Loose and Bulk): Both Loose and Bulk density was determined by the method of Okaka and Potter (1979) with little modification. About 20 g of the samples were grounded using laboratory mortar and pestle into a fine powder. For Loose density, the of sample was poured into a 100 mL measuring cylinder and the volume occupied by the sample was recorded; whereas for the bulk density the measuring cylinder containing the sample was subject to constant tapping on a flat wooden platform until there was no further change in volume. The volume occupied by the sample was recorded.

$$\text{Density (g mL}^{-1}\text{)} = \text{Weight of sample/Volume occupied}$$

Experimental design: A 4×6 factorial design consisting of 4 diet levels (0, 10, 20 and 30 percent of grass meal inclusion) and 6 levels (5, 10, 15, 20, 25 and 30 %) of starch inclusion in the diets was adopted for the pellet feed production.

Statistical analysis: All data collected during the experiment was subjected to a one-way Analysis Of Variance (ANOVA) procedure. Treatment means were statistically tested using SPSS statistical package (15.0 Version) for significance ($p<0.05$).

Table 1 show the formulation used in the production of different diet samples. The table reveals the ranges of various compositions of the diets per 100 g. Maize ranges from 28 to 40, wheat offal

Table 1: Formulation used for the production of feed

	Composition per 100 g			
Ingredient	Diet 1	Diet 2	Diet 3	Diet 4
Maize	40	36	32	28
Wheat offal	30	24	18	12
Grass meal	0	10	20	30
Soybeans meal	22	22	22	22
Fish meal	5	5	5	5
Bone meal	2	2	2	2
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Vitamin and mineral premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Calculated Chemical Composition (%)				
Protein	24.98	24.74	24.51	24.27
Fibre	5.41	12.81	20.53	27.64

Note: 2.5 kg Premix used contains Vitamin A (12,500000 IU), Vitamin D (2500000 IU), Vitamin E (40,000 mg), Vitamin K3 (2000 mg), Vitamin B1 (3000 mg), Vitamin B2 (5500 mg), Niacin (55000 mg), Calcium Pantothenate (11500 mg), Vitamin B6 (5000 mg), Vitamin B12 (25 mg), Folic acid (1000 mg), Biotin (80 mg), Choline Chloride (500000 mg), Manganese (120000 mg), Iron (100,000 mg), Zinc (80000 mg), Copper (8500 mg), Iodine (1500 mg), Cobalt (3000 mg), Selenium (120 mg) and Anti-oxidant (120,000 mg)

12 to 30, grass meal 0 to 30, with soybean, fish meal and bone meal constituting 22, 5 and 2 g, respectively while methionine, lysine, vitamin and mineral premix and salt constitute 0.25 g per 100 g of the diets.

The calculated proximate composition (%) shows that protein and fibre content ranged from 24.27 to 24.98 and 5.41 to 27.64, respectively.

RESULTS AND DISCUSSION

Figure 2 reveals that the pellet forming ability values for diet 1, 2, 3 and 4 with 5% starch inclusion ranged from 54.44 to 85.75%; with 10% starch inclusion the values ranged from 61.53 to 94.16%; at 15% starch inclusion the values ranged from 76.58 to 92.19%; at 20% starch inclusion the values ranged from 78.21 to 89.22%; while at 25 and 30% starch inclusions the values ranged from 74.48 to 90.37% and 67.76 to 86.78%, respectively.

The pellet forming index (Fig. 3) for Diets 1, 2, 3 and 4 ranged from 1.67 to 5.12, 1.24 to 4.87, 1.16 to 4.03, 1.05 to 3.94, 0.86 to 3.55 and 0.24 to 2.25 at 5, 10, 15, 20, 25 and 30% levels of starch inclusion respectively. Figure 4 shows that dust level values for Diets 1, 2, 3 and 4 ranged from 0.48 to 1.22, 0.41 to 0.91, 0.32 to 0.75, 0.20 to 0.54, 0.11 to 0.49 and 0.08 to 0.30 at 5, 10, 15, 20, 25 and 30% levels of starch inclusion, respectively.

Table 2 revealed that both loose and bulk densities values ranged from 0.25 to 0.58 (g mL^{-1}) and 0.31 to 0.67 (g mL^{-1}), respectively for the diet samples at different levels of starch inclusion.

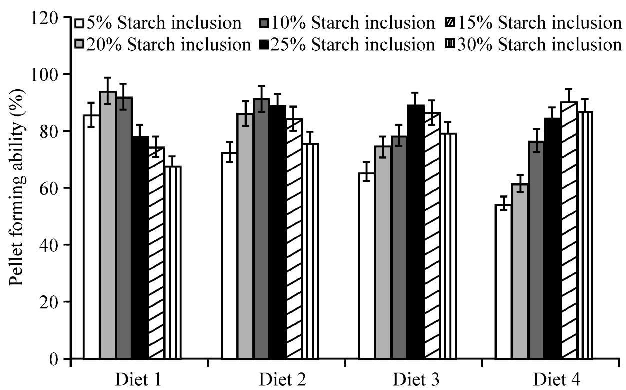

Fig. 2: Pellet forming ability of the developed grasscutter feed pellets

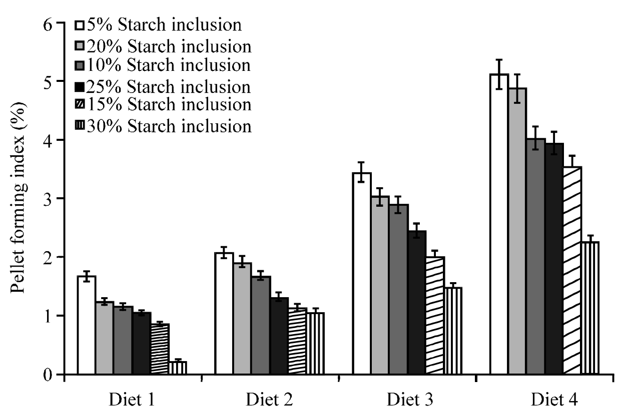

Fig. 3: Pellet forming index values of the developed grasscutter feed pellets

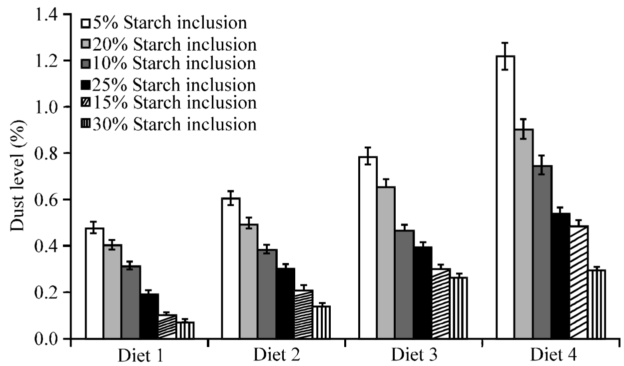

Fig. 4: Dust level values of the developed grasscutter feed pellets

Table 2: Densities of the developed grasscutter feed pellets

	Level of starch inclusion (%)					
Sample	5	10	15	20	25	30
Diet 1	0.35±0.05^{a}	0.39±0.06^{b}	0.43±0.01^{c}	0.49±0.06^{d}	0.52±0.06^{e}	0.58±0.06^{f}
	0.44±0.04^{a}	0.49±0.02^{b}	0.54±0.02^{c}	0.58±0.02^{b}	0.62±0.02^{b}	0.67±0.01^{c}
Diet 2	0.32±0.06^{a}	0.34±0.06^{a}	0.38±0.01^{b}	0.43±0.01^{c}	0.49±0.01^{d}	0.52±0.01^{d}
	0.39±0.02^{a}	0.42±0.02^{a}	0.48±0.07^{b}	0.53±0.02^{c}	0.57±0.01^{d}	0.62±0.01^{d}
Diet 3	0.27±0.01^{a}	0.29±0.01^{a}	0.33±0.01^{b}	0.37±0.06^{c}	0.42±0.01^{d}	0.49±0.01^{e}
	0.34±0.06^{a}	0.38±0.01^{b}	0.41±0.06^{c}	0.48±0.06^{d}	0.51±0.06^{e}	0.58±0.01^{f}
Diet 4	0.25±0.01^{a}	0.28±0.06^{b}	0.31±0.06^{b}	0.35±0.06^{c}	0.40±0.06^{d}	0.46±0.01^{c}
	0.31±0.01^{a}	0.35±0.06^{b}	0.39±0.01^{c}	0.44±0.06^{d}	0.49±0.01^{e}	0.53±0.01^{f}

Values are the average of triplicate determinations; and values along the same row with the same superscript are not significantly different ($p<0.05$).± = S.D values

Table 3: Pearson's correlation matrix between level of starch inclusion, sample diets and test parameters

Parameter	Level of starch inclusion	Diet type	Pellet forming ability	Pellet forming index	Dust level	Loose density	Bulk density
Level of starch inclusion	1						
Diet type	0.000	1					
Pellet forming ability	0.261*	-0.259*	1				
Pellet forming Index	-0.454**	0.849**	-0.449**	1			
Dust level	-0.738**	0.603**	-0.539**	0.894**	1		
Loose density	0.009	-0.967**	0.251*	-0.825**	-0.581**	1	
Bulk density	-0.006	-0.960**	0.252*	-0.790**	-0.562**	0.937**	1

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed)

Correlation analysis (Table 3) on the data generated was performed to examine and understand the strength of relationship that existed between all measured parameters.

The results obtained clearly showed that there was high level of variability among the Test Diets in terms of the physical characteristics (pellet forming ability, pellet forming index, dust level and densities) with respect to the experimental variable i.e., level of starch inclusions.

The pellet forming ability values of the developed feed generally increases to certain value irrespective of the diet types as the level of starch inclusion increases before decreasing. This is probably due to gumming together of the pellets at a higher level of inclusion which is an indication of over binding. The gumming/sticking together of the pellet strands is a function of the adhesive property of the binder (Akiyama *et al.*, 1989; Somsveb, 1993; Lim and Dominy, 1991; Stivers, 1970). The optimum values of pellet forming ability for different diet sample is however a function of the level of grass meal inclusion in the diet.

The pellet forming index is often used to assess the mechanical strength (durability) of a pellet and is therefore an important quality parameter in feed (Rosentrater *et al.*, 2005). The values for the diet samples show that the value decreases as the level of starch inclusion in the diet sample increases. The value also increases as the level of grass meal inclusion in the diet increases. This shows that binding together of feed components during pelleting may be affected by their physical nature and composition.

The dust level value of the diet samples generally decreases as the level of starch in a diet type increases and increases as the level of grass meal in the diet increases. This follows the same trend with the results of Church and Pond (1988) which states that high dust level is an indication for insufficient binder in the feed that resulted in the softness of the pellets.

The density of product is an indication of how compressible or fluffy a product is (Sefa-Dedeh, 1989). The Bulk Density (BD) is a measure of packing characteristics of particulate solids. This is an important factor as it determines the inter-particulate bonding that facilitates closer packing. Bulk density of a feed ingredient is important for inventory control purposes and will determine how the ingredient will perform during batching and blending.

The result revealed that there is variation in both the loose and the bulk densities of the diet samples and also shows that both the loose and bulk density of the feed increases as the level of grass-meal inclusion in the diets decreases but increases with increase in the percentage of starch inclusion. The higher the density the better its ability in resisting outside forces that crumbles or breaks it. In most cases high quality pellets were the denser, which also corresponded to high durability (Payne, 1978). A higher bulk density also reduces shrinkage as less material is lost to dust and also improves handling in feeding equipments when compared to lower bulk density (Dozier, 2001).

There exist a positive correlation between level of starch inclusion and pellet forming ability at 0.05 probability level while there exist a negative correlation with pellet forming index and dust level at 0.01 probability level. Also, diet type shows a positive correlation toward pellet forming index and dust level at 0.05 probability level while it shows a negative correlation at 0.05 and 0.01 probability level to pellet forming ability and the densities (loose and bulk), respectively.

Generally, the quality of pellets is directly related to its density (the denser the better) and this also corresponds to their pellet forming index and durability (Wood, 1987).

CONCLUSION

The study reveals the possibility of the utilization of cassava starch as grasscutter feed binder. Good physical characteristics exhibit by some of the test diets is a pointer to this. It can be inferred that the pelleting properties of cassava starch is highly affected by differences in the constituents/composition (especially the level of the grass meal inclusion) of the developed pellet feed as well as the levels of starch inclusion. For this work it can be said that 20% level of cassava starch inclusion would ensure a desirable pellet as it gives the maximum least value of pellet forming ability value when compared with the least values of other levels of starch inclusion.

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