**RESULTS OF INVESTIGATIONS ON CASSAVA AS POSSIBLE ALTERNATIVE TO MAIZE IN POULTRY DIETS**

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**Abstract**

Research activities were carried out aimed at developing appropriate method(s) of processing cassava tubers to serve as alternative to maize in poultry diets. The first trial demonstrated that fermentation in water is superior to just sun-drying as the product so produced could completely replace maize in broiler and layers diets although it tends to make feed dusty. The second trial showed that fermented cassava, palm kernel cake and brewers’ dried grains can be used to produce a maize-free low-cost diet for laying hens if they form 35%, 15% and 20% respectively, of the feed. The third trial demonstrated that if sun-dried cassava tuber meal is mixed with water at the rate of 5 parts of water to 4 parts of the meal and spread thinly on the floor for 5 hours and then dried and milled, the HCN is almost eliminated. The resultant product, called wetted sun-dried cassava tuber meal, can completely replace maize in broiler and layers diets. The fourth trial demonstrated that if sun-dried cassava tuber meal, brewers’ dried grains and palm oil are mixed at the rate of 6:3:1, a product named CBP-mix, is produced which looks like yellow maize and has similar proximate composition. When used to simulate maize in layers diets, the performance of the laying hens compared favourably with the control birds. The fifth trial was conducted to determine the efficacy of fermentation followed by gelatinization as a method of processing cassava tubers for use as alternative to maize in poultry diets. Fermented and gelatinized cassava tuber, peeled and unpeeled, is non-dusty and can completely replace maize in both broiler and layers diets. Unpeeled product is preferable in view of the fact that the peeled product promoted accumulation of abdominal fat in the birds. Fermentation followed by gelatinization is considered as the most appropriate method of processing cassava tubers as the products so produced is devoid of limitations of cassava as feed.

**Keyword:** Cassava, Processing, Feeds, Broilers, Layers

**Introduction**

Maize has been playing key role as source of energy in poultry feeds in Nigeria. However, because it is a major human food and also used as raw material for various industries, its demand outstrips its supply, leading to more than 2000% increase in its price within the last 25 years (Udedibie, 2003). This has contributed to the very high cost of poultry feeds with the concomitant increase in the prices of poultry products. There is the need therefore to search for other sources of energy that could be used in poultry feeds in the country to reduce the pressure on maize.

Cassava which is a source of calories for Nigerians could also serve as alternative to maize in poultry feeds. FAO (2005) estimated cassava production in Nigeria in 2004 at 38.2 million metric tons. By that figure, Nigeria became the largest producer of cassava in the world. The figure is expected to possibly double within the next few years as a result of the current emphasis on its production in the country by the Federal Government.

Earlier attempts to use cassava as a source of energy in poultry feeds as replacement for maize ended in conflicting results (Obioha *et al*., 1984; Odukwe, 1994; Ayasan, 2010). This was so because cassava tuber contains potentially toxic levels of cyanogenic glucoside, linamarin. Linamarine is deglycosylated by the enzyme, linamarase (also in the tuber), yielding acetone cyanohydrin, which spontaneously converts into deadly hydrogen cyanide (HCN) once it is ingested (Sayre, 2007) (fig 1)

Another draw-back in the use of cassava tuber as a feedstuff is the powdery nature of the meal and its short shelf-life. The powdery nature of the meal renders poultry feeds very dusty, making feed intake of young birds difficult (Tewe and Bokanga, 2011). The powdery meal easily gets infested with weevils that render it useless, unless it is sealed in polyethylene bags. Cassava is also very low in crude protein content (about 3%) but this could be taken care of in feed formulation by increasing protein supplements in the feed.

This paper summarizes some of the experiments which the author and his students and colleagues have conducted in the last 12 years at the Federal University of Technology, Owerri, aimed at rendering cassava tuber meal utilizable as alternative to maize in poultry feeds.

CH2OH

O

OH

OH

OH

O

C

N

CH3

H2O

Linamarase

CH3

**Linamarin**

C

CH3

CH3

O

HC

OH

**D-Glucose**

**Acetone**

**Hydrogen Cyanide**

***Fig. 1: Hydrolysis of linamarin to glucose, acetone and HCN***

C

N

CH2OH

O

OH

OH

OH

 COOH

NH2 C H

 H C H

 H C H + HCN

 S

 CH3

 COOH

NH2 C H

 H C H + SCN

 H C H

 COOH

Rhodanase

H2O

Glutamate Thiocyanate

Methionine

***Fig. 2: Conversion of Hydrogen Cyanide (HCN) to Thiocyanate (SCN) in the body***

**EXPERIMENT ONE**

**Comparative Evaluation of Fermented and Unfermented Cassava Tuber Meals as Source of Energy In Broiler Diets**

**Preamble**

The purpose of this work was to determine the effect of sun-drying alone as compared to fermentation followed by sun-drying on HCN content of cassava and to observe the effect of the cassava so processed as source of dietary energy for broilers.

**Materials and Methods**

A batch of fresh bitter cassava tubers was cut into pieces, dried in the sun and milled to produce unfermented cassava tuber meal (UFC). Another batch was cut into pieces, fermented in water for four days, dried in the sun and milled to produce fermented cassava tuber meal (FC). Both fresh cassava tuber and the processed meals were subjected to proximate and HCN analysis using standard methods (AOAC, 1995).

In the first feeding trial, the meals were used to make 7 iso-nitrogenous broiler starter diets (Table 1) such that diet 1 (the control) contained maize as source of energy while in diets 2, 3 and 4, 50%, 75% and 100% of the maize was replaced with UFC; in diets 5, 6 and 7, 50% 75% and 100% of the maize was replaced with FC. Each diet was fed to a group of 24 broiler chicks for 4 weeks. In the second feeding trial, the meals were used to make 7 iso-nitrogenous broiler finisher diets (Table 2), using the same replacement levels as in the starter trial and each diet fed to a group of 22 broiler chicks from 5 weeks old to 9 weeks old. Data collected were subject to one-way analysis of variance (Snedecor and Cochan, 1978).

**Table 1: Ingredient and nutrient composition of the experimental broiler starter diets**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Ingredients %** | **Control** | **50% UFC** | **75% UFC** | **100% UFC** | **50%** **FC** | **75%** **FC** | **100% FC** |
| Maize  | 50.0 | 25.0 | 12.5 | 0.0 | 25.0 | 12.5 | 0.0 |
| FC  | 0.0 | 0.0 | 0.0 | 0.0 | 25.0 | 37.5 | 50.0 |
| UFC | 0.0 | 25.0 | 37.5 | 50.0 | 0.0 | 0.0 | 0.0 |
| SBM | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| PKC | 6.0 | 4.5 | 4.0 | 3.0 | 4.5 | 4.0 | 3.0 |
| Blood meal | 2.5 | 4.0 | 4.5 | 5.5 | 4.0 | 4.5 | 5.5 |
| Wheat offal | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 |
| Bone meal | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 |
| Common salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| TM/Vit. Premix**\*** | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-Lysine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| **Chemical composition (Calculated) (% DM)** |
| Crude protein  | 22.82 | 22.78 | 22.78 | 22.80 | 22.79 | 22.81 | 22.81 |
| Crude Fibre  | 4.57 | 6.13 | 6.66 | 7.31 | 6.33 | 6.89 | 7.34 |
| Ether Extract  | 3.83 | 3.01 | 2.82 | 2.34 | 2.82 | 2.33 | 2.24 |
| Total Ash | 2.85 | 2.96 | 3.93 | 4.14 | 2.96 | 3.93 | 4.14 |
| ME (Kcal/g) | 2.77 | 2.83 | 2.83 | 2.83 | 2.84 | 2.90 | 2.91 |

FC = Fermented cassava; UFC = Unfermented cassava; SBM = Soybean meal; PKC = Palm kernel cake

\* Each kg feed contained: Vit. A, 2000,000iu; Vit D3, 400iu; Vit. E, 8.0g; Vit. K, 0.4g; Vit B1, 0.3g; Vit B2, 1.0g; Vit B6, 0.6g, Vit. C, 24.0g; Vit. B12, 4.0g; Folic acid, 0.2g; Biotin, 8.0g; Choline, 48.0g; BHT, 32.0g; Mn, 16.0g; Fe, 8.0g; Zn, 7.2g9; Cu, 0.32g; Iodine, 0.25g; Co, 36.0mg; Se, 16.0mg.

**Table 2: Ingredient and nutrient composition of the experimental broiler finisher diets**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Ingredients (%)** | **Control** | **50% UFC** | **75% UFC** | **100% UFC** | **50%** **FC** | **75%** **FC** | **100% FC** |
| Maize  | 60.00 | 30.00 | 15.00 | 0.00 | 30.00 | 15.00 | 0.00 |
| FC  | 0.00 | 30.00 | 45.00 | 60.00 | 0.00 | 0.00 | 0.00 |
| UFC | 0.00 | 0.00 | 0.00 | 0.00 | 30.00 | 45.00 | 60.00 |
| SBM | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| PKC | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Blood meal | 3.00 | 4.50 | 4.50 | 4.50 | 5.00 | 4.00 | 5.00 |
| Local Fish meal | 1.00 | 2.00 | 2.50 | 3.00 | 2.00 | 2.50 | 3.00 |
| Wheat offal | 8.00 | 6.00 | 5.00 | 4.00 | 6.00 | 5.00 | 4.00 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Common salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| TM/Vit. premix**\*** | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-Lysine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| **Chemical composition (Calculated) (% of DM))** |
| Crude protein  | 19.10 | 19.10 | 19.10 | 19.10 | 19.10 | 19.10 | 19.10 |
| Crude Fibre  | 4.57 | 5.92 | 6.50 | 6.81 | 5.90 | 6.52 | 6.83 |
| Ether Extract  | 3.83 | 3.02 | 2.82 | 2.56 | 3.10 | 2.81 | 2.60 |
| Total ash | 2.96 | 3.32 | 3.60 | 3.82 | 3.36 | 3.64 | 5.80 |
| ME (Kcal/g) | 3.12 | 3.08 | 3.02 | 3.10 | 3.02 | 3.04 | 3.02 |

\* Each kg feed contained nutrients as in Table 1

**Results**

**HCN and Proximate Composition of the Test Materials**

Fresh cassava tuber meal contained 0.44mg/gm HCN while unfermented cassava tuber and fermented cassava tuber meals contained 0.15mg/gm and 0.08mg/gm HCN, respectively. It therefore follows that fermentation in water can render cassava tubers almost HCN-free. There were no significant differences (P>0.05) in proximate composition of the 2 processed samples (Table 3).

**Table 3: Cyanide and proximate composition of Fresh, Fermented and Unfermented Sun-dried Cassava Tuber Meals (DM basis)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameters** | **FUC\*** | **FC\*\*** | **UFC\*\*\*** | **SEM** |
| Cyanide (mg HCN/g) | 0.44a | 0.08b | 0.15b | 0.016 |
| Crude protein  | 2.51a | 2.46a | 2.38a | 0.13 |
| Crude fibre  | 2.31a | 2.06a | 2.42a | 0.001 |
| Total ash  | 1.62b | 2.11a | 2.16a | 0.03 |
| Ether extract  | 0.84b | 1.20a | 1.32a | 0.02 |
| Nitrogen free extract  | 92.72 | 92.17 | 91.72 | 1.38 |

\* Fresh unprocessed Cassava; \*\*Fermented Cassava; \*\*\* Unfermented Cassava

ab Means within a row with different superscripts are significantly different (P<0.05)

**Performance of the Experimental Broilers**

The performance of the broilers are summarized in Table 4. In the starter trial, the group that received the diet in which 50% of maize was replaced with UFC compared favourably with the control in performance of the chicks. UFC resulted in severe stunted growth and ruffled feathers of the chicks (Plate 1A).

**A**

***Plate 1: Effect of 100% Replacement of Maize with Sun-Dried Cassava Meal on Starter Broilers***

**B**

In the finisher trial, replacement of maize up to 75% with FC produced no adverse effect (P>0.05). 100% replacement slightly depressed performance. For detailed information on this work, refer to Udedibie *et al* (2004).

**Table 4: Performance of the broilers fed Fermented and Unfermented Cassava Tuber Meals**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **Control** | **50% UFC** | **75% UFC** | **100% UFC** | **50% FC** | **75% FC** | **100% FC** | **SEM** |
| **Starter**  |  |  |  |  |  |  |  |  |
| Initial body wt. (g)  | 106.0 | 106.2 | 106.7 | 106.4 | 106.3 | 06.0 | 106.2 | 0.51 |
| Final body wt. (g) | 862.2a | 791.2a | 651.3b | 372.6b | 790.8a | 670.3b | 660.0b | 16.72 |
| Av. Daily wt. gain (g) | 27.0a | 24.5a | 19.5b | 9.5b | 24.8a | 20.2b | 19.9b | 1.33 |
| Av. Daily feed Intake(g) | 64.6a | 65.0a | 56.2b | 40.6b | 63.8a | 56.2b | 40.6b | 2.42 |
| Feed/gain ratio | 2.39a | 2.60a | 2.88a | 4.27b | 2.60a | 3.05b | 3.04b | 0.12 |
| Mortality (%) | - | 12.50 | 8.33 | 16.44 | 8.3 | 4.16 | 8.33 | - |
| **Finisher**  |  |  |  |  |  |  |  |  |
| Initial body wt. (g) | 540.0 | 560.0 | 560.8 | 558.4 | 540.6 | 560.0 | 562.2 | 1.72 |
| Final body wt. (kg) | 2.12a | 2.12a | 1.94b | 1.82b | 2.12a | 2.06a | 1.95b | 0.03 |
| Av. daily wt. gain (g) | 56.4a | 55.7a | 49.3b | 45.06 | 56.3a | 53.6a | 49.6b | 2.16 |
| Av. daily feed intake(g) | 170.0a | 167.1a | 161.7b | 161.7b | 163.8ab | 163.0ab | 161.3b | 1.72 |
| Feed/gain ratio | 3.18b | 3.00b | 3.28ab | 3.58a | 3.00b | 3.04ab | 3.25a | 0.08 |
| Mortality (%) | 4.55 | - | 9.10 | 9.10 | - | - | - | - |
| **Internal Organs (% of dressed wt)** |
| Liver | 2.29b | 2.27a | 2.92a | 2.73a | 2.82a | 2.85a | 3.12a | 0.04 |
| Gizzard  | 2.88a | 2.97a | 2.78a | 2.78a | 2.74a | 2.75a | 2.55a | 0.22 |
| Kidney  | 0.20a | 0.19a | 0.21a | 0.22a | 0.24a | 0.22a | 0.24a | 0.01 |
| Abdominal fat | 1.44a | 0.86b | 0.96b | 0.91b | 2.29a | 1.73a | 0.99b | 0.08 |

ab Means within a row with different superscripts are significantly different (P < 0.05)

**Conclusion**

The results of the study demonstrated that fermentation is a very effective method of processing cassava tubers for dietary inclusion for broilers. The results also demonstrated that broilers can perform optimally if 50% of dietary maize is replaced with cassava tuber meal, fermented or unfermented.

**EXPERIMENT TWO**

**Use of Fermented Cassava, Palm Kernel Cake and Dried Brewers’ Grains to Produce Maize-Free Low-Cost Diets for Laying Hens**

**Preamble**

In view of the rising cost of maize and its negative effect on poultry industry in the country, we felt that appropriate combinations of such readily available and cheap materials like cassava, palm kernel cake and dried brewers’ grains could be used in place of maize to produce relatively cheap and effective diets for poultry, particularly laying hens.

**Materials and Methods**

Six experimental diets were produced such that diet 1 (the control) contained maize as the main source of energy while diets 2, 3, 4, 5 and 6 contained fermented cassava tuber meal (FCTM), palm kernel cake (PKC) and dried brewers’ grains (DBG) at percentages of 30, 20, 20; 35, 15, 20; 35, 20, 15; 25, 20, 25 and 25, 25, 20, respectively, completely eliminating maize (Table 1). Each diet was fed to a group of 24 laying hens for 12 weeks, using completely randomized design (CRD). The birds were weighed at the beginning and end of the experiment to determine their body weight changes. At the end of the experiment, 6 eggs from each group were randomly selected and used to determine egg quality.

**Table 1: Ingredient Composition of the Layer Experimental Diets**

|  |  |
| --- | --- |
|  | **Experimental Diets** |
| **Ingredients (%)** | **Diet 1 (control)** | **Diet 2** | **Diet 3** | **Diet 4** | **Diet 5** | **Diet 6** |
| Maize  | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| FCTM\* | 0.00 | 30.00 | 35.00 | 35.00 | 25.00 | 25.00 |
| Palm kernel cake | 15.00 | 20.00 | 15.00 | 20.00 | 20.00 | 25.00 |
| Brewers’ dried grains  | 5.00 | 20.00 | 20.00 | 15.00 | 25.00 | 20.00 |
| Soyabean meal | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Wheat offal | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Fish meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Blood meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Bone meal | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| Vit./TM premix\*\* | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Common salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-lysine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Total  | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| **Calculated Nutrient Composition of the Experimental Layer Diets (% of DM)**  |
| Crude protein | 17.45 | 17.05 | 17.25 | 16.15 | 17.95 | 17.85 |
| Crude fibre | 4.41 | 7.59 | 7.97 | 8.93 | 7.80 | 7.76 |
| Ether extract  | 3.89 | 3.55 | 2.45 | 2.42 | 2.46 | 2.77 |
| Ash  | 3.11 | 4.05 | 3.92 | 3.69 | 4.19 | 4.19 |
| Calcium | 3.43 | 3.54 | 3.53 | 3.51 | 3.53 | 2.53 |
| phosphorus | 1.99 | 2.04 | 2.04 | 1.99 | 2.08 | 2.07 |
| Metabolizable energy (Kcal/g) | 2.67 | 2.64 | 2.62 | 2.63 | 2.55 | 2.58 |

\*Fermented cassava tuber meal

\*\*To provide the following per kg of diet: Vit. A, 2000,000iu; Vit. D3 100iu, Vit. E; 8g; Vit. K, 0.4g; B1, 0.3g; Vit. B2, 1.0g; Vit. B6, 0.6g; Folic acid, 0.2g; Biotin, 8.0mg; Choline, 48.0g; BHT 32.0g; Iodine, 2.5mg; Cobalt, 3.6mg; Vit. C, 2.4mg; Vit. B12, 4.0mg; Mn, 1.6mg; Fe, 8.0mg; Zn, 7.2mg; Copper, 3.2mg; Selenium 1.6mg.

**Results**

The performance of the experimental laying hens is summarized in Table 2. The layers on the maize-free diets tended to consume more feed than those on the control diet. The group on diet 3 (35%: 15%: 20%) recorded significantly (P < 0.05) higher hen-day egg production (69.50%) than those on the other diets. There were no significant differences (P>0.05) in egg weight. The group on the control diet and that on diet 3 recorded significantly (P < 0.05) superior feed conversion ratios (g feed/g egg). Haugh unit of the eggs from diet 4 was significantly (P < 0.05) higher than the others. Diet 3 recorded the lowest feed cost of egg production with the value of N178.67 per kg eggs as against N210.25 per kg eggs from the control.

**Table 2: Performance of the Experimental Laying Hens**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **Diet 1****(control)** | **Diet 2** | **Diet 3** | **Diet 4** | **Diet 5** | **Diet 6** | **SEM** |
| Av. Initial body wt. (kg) | 1.32 | 1.38 | 1.27 | 1.32 | 1.37 | 1.35 | 0.02 |
| Av. final body wt. (kg) | 1.52 | 1.58 | 1.49 | 1.60 | 1.55 | 1.47 | 0.05 |
| Av. body wt. gain (kg) | 0.19ab | 0.20ab | 0.22ab | 0.28a | 0.18b | 0.12b | 0.008 |
| Hen-day egg prod. (%) | 64.40ab | 65.08ab | 69.50a | 67.05ab | 63.04b | 64.79ab | 1.85 |
| Av. daily feed intake (g) | 110.23b | 137.14ab | 120.26b | 140.04a | 140.13a | 140.17a | 6.51 |
| Av. egg wt. (g) | 63.27 | 59.66 | 58.66 | 58.44 | 59.67 | 59.64 | 1.85 |
| Feed conversion ratio (kg feed/kg eggs) | 3.24b | 4.12a | 3.46b | 4.21a | 4.42a | 3.97a | 0.12 |
| Cost of feed (N/kg) | 64.89 | 50.14 | 51.64 | 50.89 | 49.39 | 45.64 | 0.12 |
| Cost of production (N/kg eggs) | 210.25 | 206.58 | 178.67 | 214.25 | 218.30 | 181.19 | - |
| Mortality  | 1 | 2 | 1 | - | 1 | - | - |
| **Egg Quality Indices** |  |  |  |  |  |  |  |
| Egg weight  | 62.12 | 62.71 | 57.47 | 59.51 | 60.85 | 59.66 | 1.61 |
| Egg shell thickness (mm) | 0.43 | 0.47 | 0.46 | 0.43 | 0.42 | 0.44 | 0.01 |
| Yolk index | 0.47 | 0.41 | 0.42 | 0.44 | 0.41 | 0.43 | 0.03 |
| Albumen index | 0.13 | 0.13 | 0.12 | 0.14 | 0.12 | 0.10 | 0.02 |
| Haugh unit | 92.15b | 93.29ab | 89.74bc | 97.96a | 88.23bc | 85.36c | 1.64 |

abc Means within a row with different superscripts are significantly different (P<0.05)

**Conclusion**

The results of the trial showed that fermented cassava tuber meal, palm kernel cake and dried brewers’ grains can be used to produce low-cost maize-free diets for laying hens if appropriately combined and the most efficient combination from this study is 35%, 15% and 20%.

It is therefore recommended that in the event of scarcity and/or high cost of maize, the three products can be used to completely replace maize in the diets of laying hens, using the combination.

**EXPERIMENT THREE**

**Wetting Method as a Means of Improving the Nutritive Value of Cassava for Broilers and Laying Hens**

**Preamble**

Studies conducted in Australia (Bradbury, 2004) showed that wetting sun-dried cassava tuber meal and thinly spreading it on a clean floor for 5 hours before cooking reduces the cyanide content of the meal to about one third of its previous level thereby rendering the meal very safe for human consumption. We therefore decided to test the efficacy of this so-called wetting method as a means of processing cassava tubers for inclusion in broiler and layers diets as a source of energy.

**Materials and Methods**

Cassava tubers were peeled, chopped into pieces, sun-dried and then milled. Part of the sun-dried cassava tuber meal was soaked in water at the rate of 5 parts of water to 4 parts of the meal, thinly spread on the floor for 5 hours and then taken out and spread by the side of the tarred road and sun-dried again. The raw cassava tuber meal (RCTM), sun-dried cassava tuber meal (SCTM) and wetted sun-dried cassava tuber meal (WSCTM) were analysed for cyanide content, using the picrate paper method of Bradbury *et al.* (1999). For broiler feeding trial, five fairly iso-nitrogenous diets were made such that diet 1 (control) contained no cassava tuber meal; in diets 2 and 3, 75% of the maize in diet 1 was replaced with SCTM and WSCTM, respectively, while in diets 4 and 5, 100% of the maize was replaced with SCTM and WSCTM, respectively. Each diet was fed to a group of 30 one-week old broiler chicks for 4 weeks. At the end of the 4 weeks, blood was collected from 4 birds in each group and analyzed for haematological constituents. The birds were weighed at the beginning of the trial to obtain their initial body weights and weekly thereafter. Feed and water were provided *ad* *libitum*.

 **Table 1: Ingredient composition of the experimental broiler diets**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Ingredients (%)** | **Control** | **75%** **SCTM\*** | **75% WSCTM** | **100% CTM** | **100% WSCTM** |
| Maize | 50.00 | 12.50 | 12.50 | 0.00 | 0.00 |
| SCTM | 0.00 | 37.50 | 0.00 | 50.00 | 0.00 |
| WSCTM | 0.00 | 0.00 | 37.50 | 0.00 | 50.00 |
| Soybean meal  | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 |
| Fish meal | 2.00 | 3.50 | 3.50 | 4.50 | 4.50 |
| Blood meal | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| Palm kernel cake | 6.00 | 4.50 | 4.50 | 3.50 | 3.50 |
| Wheat offal | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Bone meal | 3.50 | 3.50 | 3.50 | 3.50 | 3.50 |
| Common salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Vit./TM premix\*\* | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-Lysine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-Methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| **Calculated Chemical Composition** |
| Crude protein, % | 23.81 | 23.11 | 23.11 | 23.23 | 23.23 |
| Crude fibre, %  | 4.22 | 4.49 | 4.49 | 4.58 | 4.58 |
| Ether extract, % | 4.72 | 4.37 | 4.37 | 4.18 | 4.18 |
| Calcium, % | 1.51 | 1.73 | 1.73 | 1.75 | 1.75 |
| Phosphorus, % | 0.84 | 0.89 | 0.89 | 0.88 | 0.88 |

\* SCTM = Sun-dried cassava tuber meal

\*\* WSCTM = Wetted sun-dried cassava tuber meal

\*\*\* To provide the following per kg of feed: Vit. A, 10.000iu; Vit. D1, 2000iu;

 Vit. B1, 0.75 mg; Nicotinic acid, 2.5mg; Calcium panthothenate, 50mg;

Vit. B12, 2.5mg; Vit. K3, 2.50mg; Folic acid, 1.00mg; Choline chloride, 25mg; copper, 8.00mg; Manganese, 64mg; Fe, 32mg; Zn, 40mg; 1, 0.8mg, Se, 0.16mg

In the layer feeding trial, five diets (Table 2) were made such that diet 1 (control) contained no cassava tuber meal; in diets 2 and 3, 50% of the maize in diet 1 was replaced with SCTM and WSCTM, respectively, while in diets 4 and 5, 100% of the maize was replaced with SCTM and WSTM, respectively. Each diet was fed to a group of 24 laying hens for 12 weeks. The layers were weighed at the beginning and the end of the trial to determine their body weight changes. Feed and water were offered *ad libitum*. At the end of the trial, 4 birds were randomly selected from each group and used for determination of internal organ weights and haematological indices.

**Table 2: Ingredient composition of the experimental layer diets**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Ingredients (%)** | **Control** | **50%****SCTM** | **50%****WSCTM** | **100%****SCTM** | **100%****WSCTM** |
| Yellow maize | 50.00 | 0.25 | 0.25 | 0.00 | 0.00 |
| Cassava tuber meal | 0.00 | 0.25 | 0.25 | 50.00 | 50.00 |
| Soybean meal | 16.00 | 17.00 | 17.00 | 18.00 | 18.00 |
| Fish meal | 2.50 | 4.00 | 4.00 | 5.00 | 5.00 |
| Blood meal | 1.50 | 2.00 | 2.00 | 2.00 | 2.00 |
| Palm kernel cake | 7.00 | 5.50 | 5.50 | 4.50 | 4.50 |
| Wheat offal | 12.00 | 11.00 | 11.00 | 10.00 | 10.00 |
| Bone meal  | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |
| Oyster shell | 4.50 | 4.50 | 4.50 | 4.50 | 4.50 |
| Common salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Tm/ViL Premix\* | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-lysine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| **Calculated chemical composition (% DM)** |
| Crude protein | 17.57 | 17.63 | 17.63 | 17.24 | 17.24 |
| Ether extract | 3.53 | 2.91 | 2.91 | 1.97 | 1.97 |
| Crude fibre | 4.63 | 5.41 | 5.41 | 5.46 | 5.46 |
| Ash  | 6.19 | 6.83 | 6.83 | 6.37 | 6.37 |
| NFE | 69.84 | 69.72 | 69.72 | 69.96 | 69.96 |
| Calcium | 3.71 | 3.93 | 3.93 | 4.00 | 4.00 |
| Phosphorus | 1.35 | 2.34 | 2.34 | 2.56 | 2.56 |
| ME (Kcal g-1) | 2.76 | 2.71 | 2.71 | 2.82 | 2.82 |

\* To provide the following per kg of feed; Vitamin A: 10,000iu; Vitamin D3: 1500 iu; Vitamin E: 3 iu; Vitamin K: 2 mg; Riboflavin: 3 mg; Pathothanic acid; 6 mg; Niacin 15 mg; Vitamin B12; 8mg; Choline: 350 mg: Folic acid: 4 mg; Mg: 56 mg; Iodine: 1.0mg: Iron: 20 mg; Cu: 10 mg; Zn: 0.5 mg

**Results**

**Hydrogen Cyanide Content**

Raw cassava tuber meal contained 800 ppm HCN, sun-dried cassava tuber meal (SCTM) contained 50 ppm HCN while the wetted sun-dried cassava tuber meal (WSCTM) contained 10 ppm HCN. This meant about 94% reduction in HCN by sun-drying alone and about 99% reduction when wetting process was applied.

**Performance of the Experimental Broilers**

Data on the performance of the broilers are presented in Tables 3. At 100% replacement of dietary maize with SCTM, growth performance of the birds was significantly (P < 0.05) depressed. Similarly, haematological indices (Hb, PCV, RBC and WBC) were also depressed at that level.

**Table 3: Performance of the experimental broiler birds**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **Control** | **75% SCTM** | **75% WSCTM** | **100% WSCTM** | **100% WSCTM** | **SEM** |
| Av. initial body wt. (g) | 95.00 | 97.00 | 96.50 | 98.00 | 95.60 | 1.17 |
| Av. final body wt. (g) | 994.40 | 970.50 | 1004.80 | 997.50 | 997.10 | 13.16 |
| Av. body wt. gain (g) | 899.40a | 873.5ab | 908.30a | 864.50b | 901.60a | 9.64 |
| Av. daily wt. gain (g) | 32.12a | 31.20ab | 32.44a | 30.88b | 32.20a | 0.74 |
| Av. daily feed intake (g) | 54.77b | 59.13ab | 62.62a | 58.26ab | 60.60a | 1.55 |
| Feed/gain Ratio  | 1.71 | 1.92 | 1.93 | 1.89 | 1.85 | 0.06 |
| Mortality (%) | 3.33 | 0.00 | 3.33 | 3.33 | 0.00 | - |
| **Blood Indices** |  |  |  |  |  |  |
| Haemoglobin (HB) (g/100ml) | 10.80a | 10.35a | 9.90ab | 9.40b | 9.95ab | 0.35 |
| PCV (%) | 35.45a | 34.15ab | 32.70ab | 31.40b | 32.85ab | 1.08 |
| RBC (x 106/ul) | 4.23a | 4.12a | 3.98ab | 3.70b | 9.95ab | 0.18 |
| WBC (103/ul) | 30.80a | 29.40ab | 28.15ab | 27.55b | 29.20ab | 0.57 |
| MCV (%) | 84.10 | 83.07 | 83.63 | 84.88 | 83.51 | 1.19 |
| MCH (%) | 25.61 | 25.17 | 25.01 | 25.400 | 25.28 | 0.32 |
| MCHC (%) | 30.46 | 30.30 | 30.28 | 29.93 | 30.27 | 0.18 |
| Neutrophils (%) | 55.50 | 56.00 | 57.50 | 59.50 | 58.50 | 1.81 |
| Eosinophils (%) | 2.50 | 2.50 | 2.50 | 1.00 | 1.00 | 0.02 |
| Basophils (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lymphocytes (%) | 39.00 | 39.50 | 39.00 | 37.00 | 37.50 | 1.67 |

ab Means within a row with different superscripts are significantly different (P<0.05)

**Performance of the Laying Hens**

Data on the performance of the laying hens are presented in Table 5. The group on 100% WSCTM diet consumed significantly (P < 0.05) less feed, gained least body weight and recorded least hen-day egg production, possibly due to very dusty nature of the diet. Egg weight and feed conversion ratios were not affected by the treatments (P > 0.05). Egg quality indices were also not affected by the treatments (P > 0.05). Internal organ weights were also not affected by the treatments but the layers on cassava diets accumulated significantly (P < 0.05) more abdominal fat. They also recorded significantly (P < 0.05) less WBC and PCV values relative to the control group.

**Table 4: Performance of the experimental laying birds**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **Experimental Diets** |  |  |
| **Parameters** | **Control** | **75% SCTM** | **75% WSCTM** | **100% WSCTM** | **100% WSCTM** | **SEM** |
| Av. initial body wt. (kg) | 1.51 | 1.52 | 1.50 | 1.52 | 1.52 | 0.02 |
| Av. final body wt. (kg) | 1.58 | 1.58 | 1.56 | 1.56 | 1.51 | 0.02 |
| Av. body wt. change (kg) | 0.07a | 0.06a | 0.06a | 0.04b | 0.02b | 0.006 |
| Av. feed intake (g/day) | 114.6 | 116.2 | 115.7 | 113.9 | 107.9 | 1.56 |
| Av. hen-day egg prod (%) | 78.7ab | 82.1a | 80.6a | 76.6b | 75.6b | 2.09 |
| Av. egg wt. (g) | 56.9 | 54.0 | 55.3 | 54.5 | 55.1 | 0.80 |
| Feed conversion ratio (kg feed/kg eggs) | 2.02 | 2.11 | 2.09 | 2.09 | 1.96 | 0.05 |
| **Egg quality indices**  |  |  |  |  |  |  |
| Haugh unit | 26.40b | 50.12a | 39.20a | 52.16a | 50.42a | 4.02 |
| Albumen index | 0.07 | 0.08 | 0.07 | 0.12 | 0.10 | 0.016 |
| Yolk index | 0.47 | 0.40 | 0.42 | 0.44 | 0.44 | 0.10 |
| **Internal organ wts. (% of dressed wt.)** |
| Liver  | 4.20 | 3.86 | 4.48 | 4.02 | 4.53 | 0.45 |
| Heart  | 0.70 | 0.80 | 0.80 | 0.71 | 0.83 | 0.06 |
| Gizzard  | 3.47 | 3.77 | 3.25 | 3.19 | 3.31 | 0.20 |
| Kidney  | 0.15 | 0.12 | 0.13 | 0.15 | 0.16 | 0.03 |
| Abdominal fat | 1.71b | 2.71a | 2.27a | 2.15a | 2.15a | 0.09 |
| **Haematological Indices**  |  |  |  |  |  |  |
| Hb (g/100ml) | 7.88 | 8.15 | 8.23 | 8.50 | 8.38 | 0.21 |
| RBC (mm3) | 20.30a | 21.70ab | 20.40ab | 17.70b | 20.60b | 130.3 |
| WBC (x10/g) | 3.72a | 2.48b | 2.50b | 2.61b | 2.58b | 0.08x10 |
| PCV (%) | 37.00a | 24.75b | 25.00b | 25.50b | 25.75b | 3.01 |
| MCV (n) | 0.011b | 0.011b | 0.012ab | 0.015a | 0.013ab | 0.001 |
| MCH (pg) | 35.00b | 38.06b | 41.20ab | 50.16a | 41.11ab | 3.01 |

Means within a row with different superscripts are significantly different (P<0.05)

**Conclusion**

It is concluded that dietary maize could be completely replaced with wetted sun-dried cassava tuber meal in broiler and layer diets provided that the diets are balanced for crude protein in view of the disparity in crude protein content between maize and cassava. However, the dusty (powdery) nature of the cassava diets remains a problem.

**EXPERIMENT FOUR**

**Use of Sun-Dried Cassava Tuber Meal, Brewers’ Dried Grains and Palm Oil to Simulate Maize in the Diet of Laying Hens**

**Preamble**

Sun-dried cassava tuber meal is a good source of carbohydrates but its use as feedstuff is limited by the fact that it is dusty, contains very low crude proteins and is high in HCN which is highly toxic. Brewers’ dried grains, the by-product of the brewing industry, is relatively high in crude protein (about 28%) and crude fibre but low in digestible carbohydrates (Udedibie, 1984; Uchegbu and Udedibie, 1998). Palm oil is very rich in energy (about 8.0 Mcal/kg ME) and can serve as stabilizing agent to reduce dustiness of feeds. With the characteristics of sun-dried cassava tuber meal, brewers’ dried grains and palm oil described above, it was felt that it might be possible to develop a product that could simulate maize in poultry diet based on their appropriate proportions.

**Materials and Methods**

Sun-dried cassava tube meal, dried brewers’ grains and palm oil were weighed out and thoroughly mixed at the ratio of 6:3:1 to produce an energy product that somehow looked like yellow maize and referred to as CBP-mix. In other words, to produce 100kg of the product, the three items were mixed at the rate of 60kg sundried cassava tuber meal, 30kg brewers’ dried grains and 10 litres of palm oil. The product so produced was subjected to proximate analysis according to AOAC (1995) and HCN analysis according to Bradbury *et al.* (1999).

Two layers diets (Table 1) were made such that diet 1 (control) contained yellow maize as the source of energy while in diet 2, CBP-mix was used to completely replace maize. Each diet was fed to a group of 40 laying hens for 12 weeks. Data were collected on body weight changes, egg production, egg weight, feed conversion ratio and cost of egg production as well as egg quality and internal organ weights.

**Table 1: Ingredient and chemical composition of the experimental diets**

|  |  |  |
| --- | --- | --- |
| **Ingredients (%)** | **Diet 1 (Control)** | **Diet 2 (CBP-mix)** |
| Yellow Maize | 50.00 | 0.00 |
| CBP-mix | 0.00 | 50.00 |
| Soyabean meal | 15.00 | 15.00 |
| Fish meal | 2.00 | 2.00 |
| Blood meal | 2.00 | 2.00 |
| Palm kernel meal | 5.00 | 5.0 |
| Wheat offal | 15.00 | 15.00 |
| Bone meal | 10.00 | 10.00 |
| Vit./Trace mineral premix\* | 0.25 | 0.25 |
| Salt | 0.25 | 0.25 |
| **Chemical Composition (% dm)** |
| Crude protein | 18.32 | 18.46 |
| Crude fiber | 5.06 | 8.14 |
| Ether extract | 4.82 | 7.43 |
| Ash | 4.62 | 4.76 |
| Nitrogen-free extract | 67.18 | 61.34 |
| ME (Mcal/kg) (Calculated) | 2.76 | 2.84 |

To provide the following per kg of feed: Vit. A, 10,000iu, Vit. D3,1500iu; Vit. E, 3iu; Vit. K, 2mg; Riboflavin, 3mg; Panthothenic acid, 6mg; Niacin, 15mg; Vit. B12, 8mg; Choline, 350mg; Folic acid, 4mg; Mg, 56mg; Iodine, 1.0mg; Fe, 20mg; Cu, mg; Zn, 0.5mg.

**Results**

The fresh cassava tubers used for the study contained 800 ppm HCN. After drying, it dropped to 50 ppm. It therefore followed that the CBP­-mix used for the study contained 30 ppm HCN since the sun dried cassava tuber meal constituted 60% of the product. Therefore, the CBP-mix diet which contained 50% CBP-mix should contain 15 ppm HCN. The WHO safe level of HCN is 10 ppm (Udedibie, 2007). CBP-mix contained 10.20% crude protein, 5.26 crude fibre, 12.12% ether extract, 4.36% ash and 68.06% nitrogen-free extract. It was therefore similar to maize in crude protein and energy but higher in crude fibre and ether extract.

Data on the performance of the layers are summarized in Table 2. The layers on CBP-mix diet performed significantly (P<0.05) better than those on control diet in terms of egg production, feed conversion ratio and cost of egg production. Egg quality indices (albumen index, yolk index and Haugh unit) as well as egg shell thickness were not affected by the treatments (P>0.05). Egg yolks of both treatments had scores of 6 and 5, respectively, on Roche egg yolk colour chart (Plate 3).

The weights of the internal organs (liver, heart, gizzard and kidney) were not affected by the treatments (P > 0.05) but the birds on CBP-mix diet developed significantly (P < 0.05) more abdominal fat. Haematrological indices were not affected by the treatments (P > 0.05).

***Plate 2: Egg Yolk Color of the Experimental Laying Hens***



**Table 2: Performance of the Experimental Laying Birds**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Control** | **CBP-mix** | **SEM** |
| Av. initial body wt. (kg) | 1.78 | 1.73 | 0.04 |
| Av. final body wt. (kg) | 1.87 | 1.92 | 0.07 |
| Av. body wt. change (kg) | 0.09b | 0.19a | 0.002 |
| Av. feed intake (g/day) | 115.73 | 112.08 | 2.14 |
| Feed conversion ratio (kg feed/kg eggs) | 3.76b | 3.22a | 0.03 |
| Av. hen-day egg prod. (%) | 62.76b | 70.86a | 1.46 |
| Av. egg wt. (g) | 58.02 | 58.03 | 0.02 |
| Cost of feed (N/kg) | 74.90 | 72.10 |  |
| Cost of prod. (N/kg eggs) | 281.16 | 232.16 |  |
| **Egg Quality Indices** |  |  |  |
| Haugh unit | 52.42 | 52.65 | 1.03 |
| Albumen index | 0.20 | 0.19 | 0.014 |
| Yolk index | 0.65 | 0.67 | 0.002 |
| Egg shell thickness (mm) | 0.38 | 0.36 | 0.001 |
| Yolk color | 6.0 | 5.0 |  |
| **Internal Organ Weights** |  |  |  |
| Liver | 1.73 | 1.78 | 0.02 |
| Gizzard | 1.92 | 2.12 | 0.08 |
| Kidney | 1.14 | 0.12 | 0.014 |
| Heart | 0.51 | 0.56 | 0.041 |
| Abdominal fat | 1.16b | 1.41a | 0.02 |
| **Haematological Indices**  |  |  |  |
| Hb (g/dl) | 12.14 | 11.74 | 0.17 |
| RBC (x1012) | 3.92 | 3.56 | 0.1 x 106 |
| PVC (%) | 31.21 | 29.35 | 1.22 |
| MCV (%) | 81.32 | 82.61 | 4.31 |
| MCHC (%) | 32.43 | 33.08 | 1.26 |
| WBC (mm3) | 3476.00 | 3282.00 | 122.3 |
| Heterophils (%) | 42.62 | 45.15 | 2.33 |
| Lymphocytes (%) | 44.72 | 46.24 | 1.92 |
| Eosinophils (%) | 22.30 | 26.44 | 1.06 |

abMeans within a row with different superscripts are significantly different (P < 0.05)

**EXPERIMENT FIVE**

**Gelatinization of Fermented Cassave Tuber Meal and its Nutritive Value for Broilers and Laying Hens**

**Preamble**

Traditionally, fermentation has remained the best way to eliminate HCN from cassava (Udedibie *et al.* 2004). However, fermented cassava flour still has the limitation of dustiness and short shelf-life. Chukwuemeka (2009) and Emeh (2009) have demonstrated that when fresh cassava tubers are boiled for an hour, they gelatinize and yield non-dusty cassava tuber meal when dried and milled. However, when used in place of maize in balanced broiler diets, it depressed growth performance of broilers. Analysis of the meal for HCN using picrate paper method of Bradbury *et al.* (1999) showed that the product still contained up to 50 ppm HCN, which is still considered high in broiler diets. It could therefore follow that gelatinization of fermented cassava tuber, which is already HCN-free could be the solution to limitations of cassava tuber as feedstuff in poultry diets.

The following study was therefore conducted to determine the efficacy of fermentation followed by gelatinization as a method of processing cassava tubers for use as alternative to maize in the diets of broilers and laying hens.

**Materials and Methods**

Peeled and unpeeled cassava tubers were separately fermented in water for four days, dried in the sun and then milled to produce fermented peeled and unpeeled cassava tuber meals, respectively. The dusty meals were then gelatinized by mixing with water in pots seated over fire at the rate of 1kg of the cassava tuber meal to one litre of water and stirred until they gelatinized into fufu. The gelatinized pastes were then taken, bit by bit and flattened on polyethelene sheets and dried in the sun. The resultant fermented and gelatinized peeled and unpeeled cassava tuber cakes were then milled to produce fermented and gelatinized unpeeled cassava tuber meal (UFGC), a brownish looking non-dusty product and fermented and gelatinized peeled cassava tuber meal (PFGC), an ash-looking non-dusty product. Both were analysed for proximate and HCN composition.

**Broiler Feeding Trial**

Three broiler diets (Table 1) were made such that diet 1 (control) contained maize as source of energy, while in diets 2 and 3, the maize in the control diet was completely replaced with UFGC and PFGC, respectively, both in the starter and finisher diets. One hundred and twenty (120) one-week old broiler chicks were divided into 3 groups of 40 birds each and each group randomly assigned to one of the diets, using completely randomized design (CDR), and fed for 4 weeks with the starter diets and then finisher diets for another 4 weeks. Data were collected on growth performance and internal organ weights.

**Table 1: Ingredients and nutrient composition of the experimental starter and finisher broiler diets**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Ingredients (%)** | **Control** | **Starter PFGC diet\*** | **UFGC diet \*\*** | **Control** | **Finishers PFGC diet\*** | **UFGC diet\*\*** |
| Yellow maize | 50.00 | 0.00 | 0.00 | 60.00 | 0.00 | 0.00 |
| Cassava tuber meal | 0.00 | 50.00 | 50.00 | 0.00 | 55.00 | 55.00 |
| Fishmeal (65% CP) | 2.00 | 2.50 | 2.50 | 2.00 | 3.00 | 3.00 |
| Blood meal (80% CP) | 3.00 | 3.50 | 2.00 | 4.00 | 4.00 | 4.00 |
| Palm kernel cake | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Wheat offal  | 9.00 | 6.00 | 6.00 | 10.00 | 8.00 | 8.00 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Common salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| TM/Vit. Premix\*\*\* | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-Lysine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| L-Methionine | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 |
| **Calculated chemical composition (% DM)** |
| Crude protein | 22.54 | 22.62 | 22.62 | 18.95 | 18.87 | 18.92 |
| Ether extract | 4.37 | 7.05 | 7.05 | 3.48 | 6.53 | 6.53 |
| Crude fibre | 3.78 | 2.86 | 3.46 | 3.95 | 2.92 | 3.46 |
| Ash | 3.40 | 4.67 | 4.67 | 3.04 | 4.30 | 4.36 |
| NFE | 65.91 | 63.50 | 62.20 | 70.55 | 68.13 | 66.73 |
| Calcium  | 1.31 | 1.40 | 1.40 | 1.86 | 1.78 | 1.78 |
| Phosphorus | 1.03 | 0.82 | 0.82 | 1.10 | 1.18 | 1.18 |
| ME (Mcal/kg) | 2.70 | 2.84 | 2.74 | 2.94 | 2.98 | 2.98 |

\*PFGC = peeled, fermented and gelatinized cassava tuber meal.

\*\*UFGC = unpeeled, fermented and gelantinized cassava tube meal

\*\*\*Provide the following per kg of feed: Vitamin A, 12,000iu; vitamin D3, 2500iu; Vitamin E, 8mg; Vitamin K3, 2mg; Vitamin B1, 23mg; Vitamin B2, 5mg; Vitamin B12, 8mg; Niacin, 15mg; Pantothenic acid, 6mg; Folic acid, 4mg; Manganese, 8mg; Zinc, 0.05mg, iron, 20mg; Copper, 3mg; Iodine, 1.2mg; Selenium, 0.16mg; Cobalt, 2mg.

**Layers Feeding Trial**

Three diets (Table 2) were made such that diet 1 (control) contained maize as the main source of energy, while in diets 2 and 3, the maize was completely replaced with PFGC and UFGC, respectively. Each diet was fed to a group of 40 laying hens for 12 weeks, using completely randomized design. Data were collected on body weight changes, egg production and quality, weight of internal organs and haematological indices.

**Table 2: Ingredient and Nutrient Composition of the Experimental layers Diets**

|  |  |  |
| --- | --- | --- |
|  | **Experimental diets** |  |
| **Ingredients(%)** | **T1****(Control)** | **T2****(PFGC diet)\*** | **T3****(UFGC diet)\*\*\*** |
| Yellow maize | 50.00 | 0.00 | 0.00 |
| Cassava tuber meal | 0.00 | 50.00 | 50.00 |
| Soyabean meal | 16.00 | 18.00 | 18.00 |
| Fishmeal (65%CP) | 3.00 | 3.00 | 3.00 |
| Blood meal (80%CP) | 2.00 | 4.00 | 4.00 |
| Palm kernel cake | 7.00 | 4.50 | 4.50 |
| Wheat offal 922%CP) | 11.50 | 10.00 | 10.00 |
| Bone meal | 5.00 | 5.00 | 5.00 |
| Oyster shell | 4.50 | 4.50 | 4.50 |
| Common salt | 0.25 | 0.25 | 0.25 |
| TM/Vit. Premix\*\*\* | 0.25 | 0.25 | 0.25 |
| L-Lysine | 0.25 | 0.25 | 0.25 |
| L-Methionine | 0.25 | 0.25 | 0.25 |
| Total | 100 | 100 | 100 |
| **Calculated chemical composition (% DM)** |
| Crude protein | 17.57 | 17.24 | 17.24 |
| Ether extract | 3.53 | 2.97 | 2.97 |
| Crude fibre | 4.63 | 5.46 | 5.96 |
| Ash | 6.19 | 6.37 | 6.37 |
| NFE | 68.08 | 67.96 | 67.46 |
| Calcium  | 3.71 | 4.00 | 4.00 |
| Phosphorus | 1.35 | 2.56 | 2.56 |
| ME (Mcal/kg) | 2.76 | 2.82 | 2.82 |

\* PFGC = peeled, fermented and gelatinized cassava tuber meal

\*\* UFGC = unpeeled, fermented and gelatinized cassava tuber meal

\*\*\* To provide the following per kg of feed: Vitamin A, 10,000,000iu; Vitamin D3, 2,000,000iu; Vitamin E, 12,000iu, Vitamin K, 2,000mg; Niacin, 15,000mg; Riboflavin B2, 4,000mg; Pyridoxine B6, 1,500mg; Niacin, 15,000mg; Vitamin B12, 10mg; Pantothenic Acid, 5,000mg; Folic Acid, 500mg; Biotin, 20mg; Choline Chloride, 100,000mg; Maganese, 75,000mg; Zinc, 50,000mg; Iron, 20,000mg; Copper, 5,000mg; Iodine, 1,000mg, Selenium, 200mg; Cobalt, 500mg; Antioxidant, 125,000mg.

**Results**

PFGC contained no HCN while UFGC contained 50 ppm HCN and more crude fibre (Table 3). This is due to the fact that cassava peel is much higher in HCN and crude fibre than the pulp.

**Table 3: Proximate and HCN composition of fermented and gelatinized peeled and unpeeled cassava tuber meals**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameters(%)** | **RPCT\*** | **PFGC** | **RUCT\***  | **UFGC** |
| Moisture (%) | 75.22 | 9.84 | 75.81 | 9.72 |
| Crude protein (% DM) | 2.78 | 2.82 | 3.62 | 3.78 |
| Ash (% DM) | 3.14 | 3.26 | 4.34 | 4.40 |
| Ether extract (% DM) | 1.06 | 1.08 | 1.25 | 1.22 |
| Nitrogen free extract (% DM) | 89.59 | 88.88 | 85.96 | 87.18 |
| HCN (ppm) | 800.00 | 0.00 | 800.00 | 50.00 |

\* Raw peeled cassava tuber meal

\*\*Raw unpeeled cassava tuber meal

**Broiler Trial**

The performance of the experimental broiler birds is summarized in Table 4. At the starter phase, the birds on UFGC diet consumed less feed and gained significantly (P < 0.05) less body weight and consequently had poor feed conversion ratio, possibly because of the HCN content of the diet. There were no significant differences in feed intake (P < 0.05) at the finisher phase. The group on UFGC diet gained significantly (P < 0.05) more body weight, a case of compensatory growth. The groups on cassava diets tended to consume less feed and so had better feed conversion ratio. There were no differences (P > 0.05) in dressed weights and weights of internal organs but the group on PFGC diet accumulated significantly (P < 0.05) more abdominal fat.

**Table 4: Effects of the experimental diets on the performance of the experimental broilers**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Experimental diets** |  |
| **Ingredients(%)** | **Control**  |  **PFGC diet\*** | **UFGC diet\*\*** | **SEM** |
| **Starter phase** |  |  |  |  |
| Av. initial body wt. (g) | 169.48 | 161.77 | 169.75 | 9.78 |
| Av. final body wt. (g) | 1141.25 | 1096.25 | 928.75 | 33.89 |
| Av. body wt. gain (g) | 971.77a | 934.18a | 759.00b | 27.32 |
| Av. daily wt. gain (g) | 34.71a | 33.73a | 27.73b | 0.98 |
| Av. feed intake (g/day) | 81.87 | 83.15 | 82.73 | 1.03 |
| Feed conversion ratio (g feed/g gain) | 2.36a | 2.47a | 3.05b | 0.09 |
| Mortality | 0.00 | 0.00 | 0.00 | 0.00 |
| **Finisher Phase** |  |  |  |  |
| Av. initial body wt. (g) | 1141.25 | 1096.25 | 928.75 | 33.89 |
| Av. final body wt. (g) | 2348.28 | 2378.08 | 2407.25 | 22.03 |
| Av. body wt. gain (g) | 1206.65b | 1281.75b | 1478.25a | 33.09 |
| Av. daily wt. gain (g) | 43.10b | 45.78ab | 52.79a | 1.18 |
| Av. feed intake (g/day) | 160.65 | 158.85 | 154.90 | 2.99 |
| Feed conversion ratio (g feed/g gain) | 3.73a | 3.47a | 2.96b | 0.09 |
| **Carcass and Internal Organs weight (% LW)** |  |
| Dressing percentage | 59.38 | 62.46 | 60.31 | 1.64 |
| Liver | 3.78 | 3.90 | 3.53 | 0.34 |
| Gizzard  | 4.04 | 2.80 | 2.47 | 0.86 |
| Heart | 1.14a | 0.93a | 0.69b | 0.11 |
| Kidney | 0.71a | 0.59a | 0.44b | 0.065 |
| Abdominal fat | 2.56b | 4.18a | 2.99b | 0.062 |

ab Means within a row with different superscripts significantly different ( P < 0.05)

\* PFGC = peeled, fermented and gelatinized cassava tuber meal

\*\*UFGC = unpeeled, fermented and gelatinized cassava tuber meal

LW = live-weight.

**Layer Trial**

Data on the performance of the experimental laying hens are summarized in Table 5. There were no significant differences in body weight changes and hen-day egg production (P > 0.05) among the groups. The group on UFGC diet consumed significantly (P < 0.05) less feed, laid heavier eggs and had superior feed conversion ratio. Egg quality was not affected by the treatments (P > 0.05), although the group on PFGC diet recorded significantly (P < 0.05) thicker egg shell. Dressed weights, weights of the livers and hearts were not affected by the treatments (P > 0.05) but the group on PFGC developed significantly (P < 0.05) more abdominal fat as in broiler trial and less gizzard weights. Almost all the haematological and serum biochemical indices were not affected by the treatments. Total bilirubin and albumin were, however, reduced by the cassava diets.

**Table 5: Performance of Experimental laying Hens**

|  |  |  |
| --- | --- | --- |
|  | **Experimental diets** |  |
| **Parameters**  | **T1****(Control)** | **T2****(PFGC diet)\*** | **T3****(UFGC diet)\*\*** | **SEM** |
| Initial body wt. (kg) | 1.59 | 1.58 | 1.57 | 0.008 |
| Final body wt. (kg) | 1.66 | 1.65 | 1.65 | 0.018 |
| Av. body wt. change (kg) | 0.07 | 0.07 | 0.08 | 0.017 |
| Av. feed intake (g/day) | 142.94a | 140.82a | 133.51b | 1.90 |
| Av. Hen-day egg production (%) | 68.44 | 69.33 | 68.90 | 0.64 |
| Av. Egg weight (g) | 59.82b | 63.97ab | 67.88a | 2.48 |
| Feed conversion ratio (g feed/g eggs) | 2.40a | 2.21ab | 1.97b | 0.87 |
| **Dressed and internal organ Weights**  |  |  |  |
| Live weight (kg) | 1.83 | 2.04 | 1.94 | 0.096 |
| Dressed weight (kg) | 1.00 | 1.08 | 1.00 | 0.053 |
| Dressing percentage (%) | 54.62 | 52.90 | 51.56 | 2.02 |
| Gizzard % of DW | 3.14a | 1.90b | 2.39ab | 0.21 |
| Heart, % of DW | 0.88 | 0.83 | 0.59 | 0.13 |
| Kidney, % of DW | 0.50a | 0.47a | 0.35b | 0.023 |
| Abdominal fat, % of DW | 2.00b | 6.65a | 2.03b | 0.66 |
| Crop, % of DW | 0.63 | 0.43 | 0.49 | 0.089 |
| Intestinal weight % of DW | 3.04 | 3.15 | 2.78 | 0.18 |
| Intestinal length(cm) | 161.00 | 166.25 | 155.00 | 6.20 |

ab Means within a row with different superscripts are significantly different ( P < 0.05)

\* PFGC = peeled, fermented and gelatinized cassava

\*\*UFGC = unpeeled, fermented and gelatinized cassava

**Conclusion and Recommendation**

The results of these trials have shown that 4 days of fermentation followed by gelatinization of cassava tubers resulted in non-dusty product that was HCN-free if peeled and about 50 ppm HCN if unpeeled. Both PFGC and UFGC could completely replace maize in both broiler and layer diets but PFGC promoted development of abdominal fat which is not desirable, particularly for laying hens.

It is therefore recommended that both PFGC and UFGC can be used to completely replace maize in the diets of laying hens but UFGC is preferable because it promoted more egg production and egg weight and reduced abdominal fat.

The process appears laborious and therefore needs to be mechanized to make it commercializable. A prototype machine (cassava gelatinizing machine) had been fabricated by the Department of Agricultural Engineering, Federal University of Technology, Owerri, for that purpose (Plate 4). However, since this processing method appears to be the best option for development of cassava as alternative to maize in poultry diets, a more sophisticated machine that can also handle drying will be needed.



***Plate 3: Cassava Gelatinizing Machine***

**References**

A.O.A.C. 1995. Association of Official Analytical Chemists. Official Methods of Analysis, 17th ed., Washington DC.

Ayasan, T. 2010. Use of cassava and products in Animal nutrition. *Gaziosmanpasa University Ziraal Fakultesi Desgisi,* 27(1):73 – 83.

Bradbury, J.H. 2004. Wetting method to reduce cyanide content of cassava flour. *Cassava Cyanide Diseases Network News,* 4: 3 - 4.

Bradbury, M.E., Egan, S.V. and Bradbury, J.H. 1999. Picrate paper kit for determination of total cyanogens in cassava roots and all cyanogens in cassava products. *J. Sci. Fd. Agric.,* 79: 595 – 601.

Chukwuemeka, C.M. 2009. Effect of cooking as a method of improving the nutritive value of cassava for starter broilers. B. Agric. Tech. Project Report, Fed. Univ. of Tech., Owerri-Nigeria.

Emeh, O.T. 2009. Effect of cooking as a method of improving the nutritive value of cassava for finisher broilers. B. Agric. Tech. Project Report, Fed. Univ. of Tech., Owerri-Nigeria.

Enyenihi, G.E., Udedibie, A.B.I., Akpan, M.J., Obasi, O.L. and Solomon, I.P. 2009. Effects of 5-hour wetting of sun-dried cassava tuber meal on HCN content and dietary value of the meal for laying hens. *Asian J. Anim. and Vet. Adv.,* 4(6): 326 – 331.

FAO. 2005. Food and Agricultural Organization of the United Nations Statistics (FAOSTAT database P. ID 567).

Obioha, F.C., Ngoka, D.A., Alozie, S. and Okpokiri, A. 1984. The value of methionine and palm oil supplementation in cassava-based layer diet. (unpublished data).

Odukwe, C.A. 1994. The Feeding Value of Composite Cassava Root Meal for Broiler Chickens. Unpublished PhD Thesis submitted to the Department of Animal Science, Univ. of Nigeria, Nsukka-Nigeria. 182p.

Okere, P.C. 2011. Evaluation of Sun-dried Cassava *Fufu* Meal as a source of Dietary Energy for Broilers. Unpublished M.Sc. Thesis submitted to the Department of Animal Science and Technology, Fed. Univ. of Tech., Owerri – Nigeria. 87p.

Sayre, R. 2007. Transgenic strategies for reducing cyanogens levels in cassava foods. *Cassava Cyanide Diseases Network News,* 7: 1 – 2.

Snedecor, G.W. and Cochran, W.G. 1978. *Statistical Methods,* 6th ed., Iowa State Univ. Press, Ames – Iowa.

Tewe, O.O. and Bokanga, M. 2001. Cost – effect cassava plant-based relations for poultry and pigs. Proc. of the ISTRC. African branch (IITA), 10 – 11 Nov., 2001, Ibadan, Nigeria

Uchegbu, M.C. and Udedibie, A.B.I. (1998). Maize/sorghum-based dried brewers’ grains in broiler finisher diets. Nig. J. Anim. Prod., 26: 110 – 118.

Udedibie, A.B.I. (1984). Brewers’ grains as feedstuff for milk production. A review. J. Anim. Prod. Res., 4 (1): 43 – 55.

Udedibie, A.B.I. 2003. *In Search of Food: FUTO and the Nutritional Challenge of Canavalia Seeds.* 6th Inaugural Lecture, Fed. Univ. of Tech., Owerri – Nigeria.

Udedibie, A.B.I. and Asoluka, C.O. 2008. Effects of 5-hour wetting of sun-dried cassava tuber meal on the HCN content and dietary value of the meal for young broiler chicks. *Nig. J. Anim. Prod.,* 35: 25 – 31.

Udedibie, A.B.I. Chukwurah, O.J., Enyenihi, G.E., Obikaonu, H.O. and Okoli, I.C. (2012). The use of sun-dried cassava tuber meal, brewers’ dried grains and palm oil to simulate maize in the diet of laying hens. J. Agric. Tech., 8(4): 1269 - 1276.

Udedibie, A.B.I., Anyaegbu, B.C., Onyechekwe, G.C. and Ogbukporo, O.C. 2004. Effects of feeding different levels of fermented and unfermented cassava tuber meals on performance of broilers. *Nig. J. Anim. Prod.,* 31: 211 – 219.

Udedibie, A.B.I., Enang, M.T., Enyenihi, G.E. and Obikaonu, H.O. (2009). The use of sun-dried cassava tuber meal, dried brewers’ grains and palm oil to simulate maize in broiler diets. Proc., Intl Conf. on Global Food Crisis, held at Owerri – Nigeria, April 19 – 24, 2009. Pp. 56 – 58.

Udedibie, A.B.I., Enyenihi, G.E., Akpan, M.J., Obasi, O.L. and Solomon, I.P. 2008. Physiochemical nature and nutritive value of dried cassava *fufu* meal for laying hens. *Nig. Agric. J.,* 39: 44 – 49.