THE USE OF BLENDS OF CASSAVA FLOUR AND EXTRUDED FULL-FAT SOYBEANS IN DIETS FOR BROILER CHICKENS

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SUMMARY

A study was conducted to determine the effects of blending different levels of a low-prussic acid cassava flour with extruded full-fat soybeans in diets for growing broiler chickens. The full-fat soybeans contribute oil which increases the energy content of the diet, aids in overcoming the dusty nature of cassava, and provide high-quality protein. One-third. two-thirds, and all of the maize was replaced by cassava in diets with none, 12.5 and 25o/o extruded full-fat soybeans. Diets were fed in pelleted form to broiler chickens for a 47-day feeding trial.

Replacement of one-third of the maize with cassava had no adverse effects on body weight gains in this study with a reduction in weight at higher levels at the conclusion of the study. Feed utilization was reduced more severely than was anticipated. However, growth rate on the higher levels of cassava was reasonably good, indicating that producers might feed these diets for a slightly longer period of time and produce chickens more economically if cassava meal were available at a cost significantly less than that of maize.

INTRODUCTION

Poultry production in tropical and semitropical areas is often impaired by lack of indigenous supplies of traditional cereal grains. Production costs could probably be reduced, especially for the small-scale or backyard producer, if locally produced ingredients could be substituted for imported grains while maintaining an adequate (but not necessarily maximum) gain.

Manuscrito modificado recibido: 11—4—84.

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Published with the approval of the Director, Arkansas Agricultural Experiment Station.

Cassava (*Manihot esculenta*) is widely grown in tropical and semitropical areas and is adaptable to large-scale production. Many feeding trials indicate that cassava may be used to supply a portion of the energy needs of chickens. Vogt (1) extensively reviewed earlier studies and presented results from his own work which indicated that diets with 10% cassava meal gave performance equal to that of the control diet. Levels of 20 and 30% cassava meal gave diminished gains, which Vogt attributed to the residual prussic acid and possibly to a phosphorylase inhibitor in the rind.

Enríquez and Ross (2) fed chickens a dried cassava root meal that tested only slightly positive for cyanide. Poor growth and feed conversion were observed with increasing levels of cassava. Adding molasses or soybean oil to the diets had no beneficial effect, indicating that palatability or lack of an essential fatty acid was not the factor responsible for the poor results. Nevertheless, supplementation with methionine largely overcame the depressing effect. When the ration was balanced with respect to protein and methionine, 50% of the corn in the ration was satisfactorily replaced by cassava. Olson, Sunde and Bird (3) also noted that the performance of chicks fed cassava could be improved by the addition of methionine or cystine to the ration.

The same authors (4) concluded that cassava meal could be included in chick rations at levels up to 30% without sacrificing gains if the rations were balanced with respect to energy and protein content. Enríquez, Ortega and Avila (5) also indicated that performance of chickens fed diets with 50% cassava meal compared favorably with that of chickens fed maize or guinea corn. However, their data –which indicate significant differences between these treatments– do not support their conclusions.

Gerpacio (6) reported that performance of chickens fed 25 and 37.5% cassava meal was equal to that of the control group, but there was a significant depression when 50% cassava meal was fed. When data were corrected for differences in feed intake, performance of chicks on the 50% level of cassava was equal to that of chicks fed the control diet, suggesting that reduced feed intake was the major reason for this growth depression. He suggested that at higher levels of cassava feeding, the nutrient density should be increased, or the diets pelleted to increase feed intake.

Ademosun and Eshiett (7) concluded that diets fed to young chickens should not contain more than 30% cassava root meal. They suggested that the absence of added fat and the dusty nature of the cassava diets might have limited the utilization of the diets containing the higher levels of cassava. Zumbado and Murillo (8) also reported that 30% cassava was acceptable in chick diets. On the other hand, Chih and Muller (9) have indicated that cassava meal could be used successfully to replace all of the maize in broiler diets.

Several studies (10-12) state that the starch of cassava meal is highly digestible and is generally nutritionally equal to that of maize and other well-digested starches. Therefore, it should be possible to utilize high levels of cassava meal in poultry feeds if the physical and nutritional deficiencies can be minimized.

Several reports suggest that various mixtures of cassava with other ingredients might aid in improving performance. Manjarrez *et al.* (13) used a mixture of cassava meal and rice polishings for partial (50%) and total substitution for corn in broiler rations. Body weight gains were not significantly affected, but feed consumption and feed utilization were linearly affected due to the lower metabolizable energy of the cassava-rice polish mixture. Greater success has been observed when cassava meal was mixed with high-protein feeds such as cowpeas, soybeans, and cottonseed meal (14-17). Physically altering the texture of cassava-cowpea diets by extruding has also been found to be effective (15).

Considerable interest in utilizing whole soybeans has developed in tropical and semitropical areas. Whole soybeans offer many potential advantages that suggest that they might be used effectively in blends to overcome some of the physical and nutritional deficiencies of cassava meal. When properly processed to destroy the trypsin inhibitor, they provide a good-quality protein, especially when fortified with methionine. Soybeans contain large amounts of a highly digestible oil which can supply essential fatty acids, aid in overcoming dustiness, and provide an energy source for the chick. Whole soybeans are perhaps best processed by extrusion, and machines that process up to 1,000 kg/hour have been developed. The processing and usage of full-fat soybeans in poultry diets has been reviewed in detail (18).

MATERIALS AND METHODS

A study was carried out in our laboratory in a attempt to improve the utilization of cassava meal in broiler diets. Computer formulation was utilized to provide a well-balanced diet that met all known nutritional requirements. Extruded full-fat soybeans were utilized at various levels, and the diets were pelleted to reduce dustiness.

A sample of cassava flour obtained from Ecuador contained (as per cent of sample) 14.19 moisture, 1.7 crude protein, 3.1 crude fiber and 1.19 ether extract. Averages of values reported in the literature (1, 3, 4, 6, 8, 11, 19-22) were used in assigning this sample a metabolizable energy value of 3.5 kcal/g and nutrient values (as per cent of sample) of 0.05 inorganic phosphorus, 0.29 calcium, 0.098 arginine, 0.04 lysine, 0.01 methionine, and 0.01 cystine. A sample was sent to the Tropical Products Institute in London, England, for cyanide assay and was found to be negative.

Whole soybeans were extruded using the Brady Crop Cooker (Koehring Farm Equipment Co., Des Moines, Iowa, USA). The resulting product contained (as per cent of sample) 38.1 crude protein, 17.6 ether extract, and 5.3 crude fiber. Diets were formulated for three age periods (0 to 21 days, 21 to 42 days, and 42 to 47 days) using the requirements suggested by the National Research Council (23). The nutrient requirements were expressed as quantity per 1,000 kcal of metabolizable energy. Diets were formulated using linear programming to provide optimum energy levels; therefore, within each age period there were small differences in the energy content of the diets. All diets, however, had equal energy:protein ratios and met or exceeded the desired ratio of energy to amino acids and essential minerals.

Four basal diets were formulated within each age period. These were: A) All maize with no full-fat soybeans; B) All maize with 25o/o full-fat soybeans; C) Cassava replacing all the maize with no full-fat soybeans; D) Cassava replacing all the maize with 25o/o full-fat soybeans. After mixing these four basal diets, blends were made so that a 3 x 4 factorial arrangement of levels of full-fat soybeans (0, 12.5 and 25o/o of the diet) and cassava (0, 33, 66, and 100o/o replacement of maize) were made. This gave a total of 12 final experimental diets. The composition of the basal mixtures is given in Tables 1, 2, and 3 for the different age periods. The blending schedule used to provide the final diets is shown in Table 4. All diets were supplemented with 0.2o/o sodium sulfate as a potential detoxifying agent for cyanide (24) although analysis of the cassava flour indicated no residual toxins. After blending, the diets were pelleted using a California Pellet Mill Laboratory Model (California Pellet Mill Co., Crawfordsville, Indiana, USA).

TABLE 1

COMPOSITION OF STARTER DIETS (0 TO 21 DAYS)

Ingredient	Per cent of diet			
	A	B	C	D
Yellow corn	62.65	53.48	0.00	0.00
Soybean meal	33.15	17.22	42.20	24.95
Cassava meal	0.00	0.00	54.02	46.11
Extruded soybeans	0.00	25.00	0.00	25.00
Limestone	1.32	1.34	0.80	0.90
Dicalcium phosphate	1.61	1.68	1.64	1.70
Salt	0.50	0.50	0.50	0.50
DL-methionine	0.17	0.18	0.24	0.24
Trace minerals[1]	0.10	0.10	0.10	0.10
Vitamin premix[2]	0.50	0.50	0.50	0.50
	100.00	100.00	100.00	100.00
Calculated analysis				
M. E. (kcal/g)	2.93	3.06	2.89	3.03
Protein (o/o)	21.09	22.04	20.78	21.78
Lysine (o/o)	1.17	1.35	1.32	1.48
Methionine (o/o)	0.52	0.53	0.53	0.54
Met + Cys (o/o)	0.85	0.93	0.84	0.94

1 Supplies as mg/kg of diet: iron 100; zinc 100; manganese 100; copper 10 and iodine 1.

2 Supplies per kg of diet: 6,612 IU vit. A; 2,204 IU vit. D_3; 6.6 IU vit. E; 3.3 mg menadione; 5.5 mg riboflavin; 33 mg niacin; 8.8 mg pantothenic acid; 495 mg choline; 1.1 mg thiamine; 1.1 mg pyridoxine; 9.9 mcg vit. B_{12}; 0.11 mg biotin; 0.66 mg folic acid; 62.5 mg ethoxyquin, and 1 mg selenium.

TABLE 2

COMPOSITION OF GROWER DIETS (21 TO 42 DAYS)

Ingredient	Per cent of diet			
	A	B	C	D
Yellow corn	68.78	59.89	0.00	0.00
Soybean meal	27.00	10.79	37.02	19.52
Cassava meal	0.00	0.00	59.20	51.55
Extruded soybeans	0.00	25.00	0.00	25.00
Limestone	1.37	1.40	0.74	0.87
Dicalcium phosphate	1.69	1.76	1.81	1.83
Salt	0.50	0.50	0.50	0.50
DL-methionine	0.06	0.06	0.13	0.13
Trace minerals[1]	0.10	0.10	0.10	0.10
Vitamin premix[1]	0.50	0.50	0.50	0.50
	100.00	100.00	100.00	100.00
Calculated analysis				
M. E. (kcal/g)	3.00	3.14	2.95	3.09
Protein (%)	18.74	19.59	18.43	19.33
Lysine (%)	1.00	1.13	1.16	1.28
Methionine (%)	0.38	0.38	0.40	0.39
Met + Cys (%)	0.67	0.73	0.66	0.73

1 As given in Table 1.

Because of the method of formulation used (to optimum nutrient density rather than to a constant energy level) the amount of cassava flour was not constant in all diets within a series. The actual quantity of cassava flour used in each of the test diets is given in Table 5. Over all age periods and levels of full-fat soybeans, diets with 33% replacement contained an average of 17.4% cassava flour while diets with 66 and 100% replacement contained an average of 36.5 and 54.8% cassava flour, respectively.

Each of the 12 experimental diets was fed to two replicate groups of chikens in battery cages. Day-old chicks of a commercial broiler strain (average weight 44 g) were obtained from a local hatchery, and within six hours of hatching were randomly distributed into pens with five male and five female chicks per pen. Pen group weights by sex and pen feed consumption were obtained at 21, 42, and 47 days of age. Any bird that died or which was removed due to leg disorders was weighed, and the pen given credit for the weight for purposes of calculating feed utilization. The incidence of mortality or leg disorders was low in this study and evenly distributed among the dietary treatments. The data were subjected to the analysis of variance as outlined by Steel and Torrie (25) with significant

TABLE 3

COMPOSITION OF FINISHER DIETS (42 TO 47 DAYS)

Ingredient	Per cent of diet			
	A	B	C	D
Yellow corn	73.00	64.28	0.00	0.00
Soybean meal	22.75	6.34	33.43	15.76
Cassava meal	0.00	0.00	62.75	55.25
Extruded soybeans	0.00	25.00	0.00	25.00
Limestone	1.40	1.44	0.69	0.82
Dicalcium phosphate	1.75	1.82	1.95	1.99
Salt	0.50	0.50	0.50	0.50
DL-methionine	0.00	0.02	0.08	0.08
Trace minerals[1]	0.10	0.10	0.10	0.10
Vitamin premix[1]	0.50	0.50	0.50	0.50
	100.00	100.00	100.00	100.00
Calculated analysis				
M. E. (kcal/g)	3.04	3.18	2.99	3.13
Protein (%)	17.12	17.89	16.81	17.62
Lysine (%)	0.88	0.98	1.06	1.15
Methionine (%)	0.30	0.32	0.32	0.33
Met + Cys (%)	0.58	0.64	0.56	0.63

1 As given in Table 1.

differences between treatment means determined by the multiple range test of Duncan (26).

RESULTS AND DISCUSSION

Body weights of broiler chickens at various age intervals throughout the study were significantly affected by the addition of cassava flour to the diet (Tables 6, 7, and 8). At all ages, the body weight of chickens fed diets in which 33% of the maize was replaced by cassava flour was equal to that of chickens fed the diets containing all maize. At 21 and 47 days of age, a further increase in the amount of cassava in the diets resulted in a significant reduction in body weight; however, the chickens still grew at a reasonably good rate.

The addition of up to 25% of extruded full-fat soybeans to the diets had no adverse effects on body weight gains at any age. Nevertheless, there was no interaction of levels of cassava flour in the diet and levels of full-fat soybeans, suggesting that there was no favorable effect of the inclusion of the extruded soybeans on the response of the chickens to the

TABLE 4

BLENDING SCHEDULES FOR BASAL DIETS TO PRODUCE FINAL TEST DIETS

Per cent of maize replaced by cassava	Per cent full-fat soybeans in diet		
	0	12.5	25
		Amount of each basal diet (%)[1]	
0	100%A	50 %A 50 %B	100%B
33	67%A 33%C	33.5%A 33.5%B 16.5%C 16.5%D	67%B 33%D
66	33%A 67%C	16.5%A 16.5%B 33.5% C 33.5%C	33%B 67%D
100	100%C	50 %C 50 %D	100%C

1 See Tables 1, 2, and 3 for composition of basal diets A, B, C and D.

TABLE 5

ACTUAL QUANTITIES OF CASSAVA FLOUR UTILIZED IN TEST DIETS FOR BROILERS AT DIFFERENT AGES

Per cent of maize replaced by cassava	Feeding period[1]	Per cent full-fat soybeans		
		0	12.5	25
			Per cent cassava flour	
	S	17.82	16.52	15.22
33	G	19.54	18.28	17.01
	F	20.70	19.47	12.22
	S	35.65	33.02	30.43
66	G	39.66	37.10	34.54
	F	42.04	39.53	37.02
	S	54.02	50.06	46.11
100	G	59.20	55.37	51.55
	F	62.75	59.00	55.25

1 S = 0 to 21 days; G = 21 to 42 days; F = 42 to 47 days.

TABLE 6

TWENTY-ONE-DAY BODY WEIGHT OF CHICKENS FED COMBINATIONS OF CASSAVA FLOUR AND FULL-FAT EXTRUDED SOYBEANS

Per cent of corn replaced by cassava	Sex	Per cent full-fat soybeans			
		0	12.5	25	Mean
		Body weight (g)			
0	M	450	526	463	479
	F	425	429	427	427
	Ave.	437	478	445	453[a]
33	M	445	441	448	445
	F	417	404	421	414
	Ave.	431	423	434	429[a]
66	M	404	432	417	417
	F	373	389	391	384
	Ave.	388	410	404	401[b]
100	M	416	382	401	400
	F	373	338	361	357
	Ave.	394	360	381	378[b]
Mean	M	429	445	432	435
	F	397	390	400	396
	Ave.	413	418	416	415

[a,b] Means having the same superscripts do not differ significantly ($p < 0.05$).

cassava flour, as was anticipated. The soybeans used in this study were extruded prior to their incorporation in the diets containing cassava. According to the studies of Jorge João, Elías and Bressani (15), it might be advantageous to extrude the entire mixture of soybeans and cassava flour rather than just the soybeans alone.

Feed utilization, expressed as grams of gain per gram of feed consumed, is shown in Tables 9, 10, and 11 for the different age periods. In general, there was a reduction in utilization of feed as the amount of cassava flour was increased in the diet. Since the diets were not formulated to be isocaloric, a small reduction would have been anticipated but

TABLE 7

FORTY-TWO-DAY BODY WEIGHT OF CHICKENS FED COMBINATIONS OF CASSAVA FLOUR AND FULL-FAT EXTRUDED SOYBEANS

Per cent of corn replaced by cassava	Sex	Per cent full-fat soybeans			
		0	12.5	25	Mean
		Body weight (g)			
0	M	1,331	1,321	1,295	1,315
	F	1,138	1,210	1,106	1,151
	Ave.	1,234	1,265	1,200	1,233[a]
33	M	1,253	1,343	1,257	1,284
	F	1,168	1,115	1,132	1,139
	Ave.	1,211	1,229	1,195	1,212[a]
66	M	1,197	1,218	1,307	1,240
	F	1,012	1,093	1,091	1,065
	Ave.	1,105	1,155	1,198	1,152[a]
100	M	1,390	1,068	1,115	1,201
	F	1,112	1,000	1,025	1,046
	Ave.	1,251	1,034	1,085	1,124[b]
Mean	M	1,293	1,238	1,251	1,260
	F	1,108	1,105	1,089	1,100
	Ave.	1,200	1,171	1,170	1,180

[a,b] Means having the same superscript do not differ significantly ($p < 0.05$).

not one of this magnitude. It is possible that the metabolizable energy value assigned to the sample of cassava flour in this study overestimated its energy value. The assigned value, however, was in good agreement with that of many published reports, including a recent estimate by Ravindran *et al.* (27) using the True Metabolizable Energy system. All diets pelleted well and produced firm, dust-free pellets which should have minimized any effects of diet texture. Since the sample used in this study was tested to be negative for prussic acid, it must be concluded that some other factor(s) were responsible for the lower rate of growth observed in this study. Although formulated to meet the minimum requirements for sulfur amino acids suggested by the National Research Council, it is possible that diets containing cassava might require ad-

TABLE 8

FORTY-SEVEN-DAY BODY WEIGHT OF CHICKENS FED COMBINATIONS OF CASSAVA FLOUR AND FULL-FAT EXTRUDED SOYBEANS

Per cent of corn replaced by cassava	Sex	Per cent full-fat soybeans			
		0	12.5	25	Mean
		Body weight (g)			
0	M	1,553	1,532	1,474	1,520
	F	1,305	1,366	1,268	1,313
	Ave.	1,429	1,449	1,371	1,415[a]
33	M	1,476	1,570	1,483	1,510
	F	1,360	1,312	1,302	1,325
	Ave.	1,418	1,440	1,392	1,417[a]
66	M	1,428	1,440	1,554	1,474
	F	1,197	1,298	1,265	1,253
	Ave.	1,312	1,369	1,410	1,364[b]
100	M	1,483	1,264	1,364	1,370
	F	1,344	1,154	1,207	1,235
	Ave.	1,414	1,209	1,285	1,303[b]
Mean	M	1,485	1,451	1,469	1,468
	F	1,301	1,282	1,261	1,281
	Ave.	1,393	1,367	1,365	1,375

[a, b] Means having the same superscript do not differ significantly ($p < 0.05$).

ditional methionine supplementation for maximum performance.

Although the overall performance of broiler chickens fed the diets with cassava flour was reduced as compared to that of chickens fed diets containing maize, growth rates were still reasonably good. These data indicate that cassava meal of high quality, low in prussic acid content, can be effectively used to replace at least one-third of the maize in mixtures with extruded full-fat soybeans in diets for growing broiler chickens. Both of these ingredients have potential benefits for use in tropical and semitropical areas of the world. Depending upon the relative costs of maize and cassava, it might be more economically advantageous to make use of locally-produced cassava meal and, if necessary, grow the chickens for a slightly longer period of time to attain the desired market weight.

TABLE 9

TWENTY-ONE-DAY FEED UTILIZATION BY CHICKENS FED COMBINATIONS OF CASSAVA FLOUR AND FULL-FAT EXTRUDED SOYBEANS

Per cent of corn replaced by cassava	Per cent full-fat soybeans			
	0	12.5	25	Mean
	Grams gain per gram feed consumed			
0	0.688	0.783	0.755	0.743[a]
33	0.622	0.694	0.729	0.682[ab]
66	0.626	0.657	0.639	0.641[bc]
100	0.597	0.600	0.639	0.612[c]
Mean	0.633	0.683	0.691	0.670

a,b,c Means having the same superscript do not differ significantly ($p < 0.05$).

TABLE 10

FORTY-TWO-DAY CUMULATIVE FEED UTILIZATION BY CHICKENS FED COMBINATIONS OF CASSAVA FLOUR AND FULL-FAT EXTRUDED SOYBEANS

Per cent of corn replaced by cassava	Per cent full-fat soybeans			
	0	12.5	25	Mean
	Grams gain per gram feed consumed			
0	0.530	0.572	0.567	0.556[a]
33	0.505	0.551	0.555	0.536[ab]
66	0.504	0.504	0.515	0.508[b]
100	0.525	0.495	0.639	0.508[b]
Mean	0.576	0.531	0.535	0.527

a,b Means having the same superscript do not differ significantly ($p < 0.05$).

TABLE 11

FORTY-SEVEN-DAY CUMULATIVE FEED UTILIZATION BY CHICKENS FED COMBINATIONS OF CASSAVA FLOUR AND FULL-FAT EXTRUDED SOYBEANS

Per cent of corn replaced by cassava	Per cent full-fat soybeans			
	0	12.5	25	Mean
	Grams gain per gram feed consumed			
0	0.514	0.541	0.543	0.532[a]
33	0.486	0.535	0.533	0.578[a]
66	0.486	0.496	0.501	0.495[ab]
100	0.422	0.483	0.493	0.466[b]
Mean	0.477	0.514	0.518	0.503

[a,b] Means having the same superscript do not differ significantly ($p < 0.05$).

ACKNOWLEDGEMENTS

Appreciation is expressed to Dr. R. H. Houser, Allied Mills, Inc., Libertyville, Illinois, USA, for supplying the cassava flour, and to Brian Capper, Tropical Products Institute, London, England, for conducting the prussic acid assay.

RESUMEN

LA UTILIZACION DE MEZCLAS DE HARINAS DE YUCA Y DE SOYA INTEGRAL EXTRUIDA, EN DIETAS PARA POLLOS DE ENGORDE

Se llevó a cabo un estudio con miras a determinar los efectos resultantes de la administración, a pollos de engorde en proceso de crecimiento, de raciones elaboradas con diferentes niveles de harina de yuca de bajo contenido en ácido prúsico, y harina de soya integral extruida. Esta última aporta aceite, lo que incrementa el contenido energético de la dieta, ayuda a corregir la naturaleza pulverulenta de la yuca, y suministra proteína de alta calidad. Así, en dietas que contenían cero, 12.5 y 25o/o de soya integral extruida, se reemplazó por harina de yuca un tercio, dos tercios y el total del maíz de las mismas. Dichas raciones se suministraron en forma granulada a polluelos de engorde, en un ensayo alimenticio de 47 días de duración.

Según se observó en este estudio, el reemplazo de un tercio del maíz por yuca no tuvo ningún efecto adverso sobre las ganancias ponderales de las aves, constatándose al finalizar el ensayo, un descenso en su peso al administrarse las dietas a los niveles más altos de yuca. La utilización del alimento se redujo con mayor severidad de lo previsto. No obstante, a niveles más altos de yuca las tasas de crecimiento fueron razonablemente buenas, lo que indica que los productores pueden alimentar polluelos con estas dietas por un período de tiempo ligeramente más largo, y lograr su crianza en forma más económica, si se dispone localmente de harina de yuca a un costo significativamente más bajo que el del maíz.

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