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Evaluation of the fertility of broiler breeder cocks fed on diets containing differently processed sweet potato tuber in a humid tropical environment

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The high cost of poultry feedstuffs has led to the use of tropical root and tuber crops to formulate the balanced and low cost poultry diets. However, utilization of feeds compounded from roots and tubers has been low due to some identified anti-nutritional factors such as cyanide in cassava and high sugar levels in sweet potato which cause diarrhea in chicken. Furthermore, the few studies done on them have been on animals' performance in terms of feed intake/weight gain, with little or no emphasis on the effect of such feeds on the animals' reproductive performance. A completely randomized block experimental design was carried out to evaluate the effect of diets containing differently processed sweet potato tuber on the fertility and reproductive performance of broiler breeder cocks. Though, the values for semen characteristics were lower in sweet potato-based diets than the maize-based diet, they fell within the recommended levels for the tropics. Grated sweet potato (GP25) had the least semen volume (0.16 ± 0.04 cm^3) while least sperm concentration (2.68 ± 0.44 × $10^9/cm^3$) and sperm output (0.44 ± 0.14 × 10^9/ml) were obtained in thinly sliced sweet potato (SP_{25}). Percentage of eggs fertilized was highest in GP_{25} and least in Fermented sweet potato (FP_{25}). Thus, breeder cocks are potentially fertile when fed on diets formulated with sweet potato tuber and that sweet potato tubers may be used as a good substitute for maize in poultry feed when grated or when fermented.

Key words: Breeder cocks, fertility, semen characteristics, sweet potato.

INTRODUCTION

Livestock feeds contribute about 75 to 80% of the total cost of producing poultry to market (Tewe, 1996). Chicken production in Cameroon, like other Sub-Saharan African countries, has not kept pace with the demand due to high feed costs and feed ingredients, leading to the importation of frozen chicken from Western Europe to the tune of 24,478 tons per year (Anon, 2004). This has a direct consequence on the indigenous farms, for instance in Cameroon, where 92% of small scale producers (farms with less than 500 chicks) identified in 1996, had ceased activity in 2002 (Anon, 2004). To sustain local production, there is need to look for local and readily available alternatives to substitute maize which is the major energy source in poultry feed. This problem could be solved by introducing less expensive local feed ingredients like cassava and sweet potato in poultry feed formulations to

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Table 1. Proximate analysis of processed sweet potato.

Treatment	Total sugar (%, w/w)	Dry matter (%, w/w)	Crude protein (%, w/w)	Crude fibre (%, w/w)	Ether extract (%, w/w)	Ash (%, w/w)	Gross energy (Kcal/g)
Fermented – 1 day, F_1	11.70	90.23	4.02	0.73	0.52	4.00	3.598
Fermented – 2 days, F_2	7.13	87.84	3.94	0.74	0.54	4.06	3.578
Fermented – 3 days, F_3	4.91	89.93	4.07	0.77	0.54	4.16	3.548
Grated form, GR	9.93	90.41	4.85	0.75	0.52	4.36	3.592
Thinly sliced form, SL	10.24	89.54	3.89	0.70	0.48	3.98	3.609

Table 2. Ingredient composition of experimental diet.

Ingredient	Control, 100% maize (%, w/w)	Fermented potatoes, FP_{25} (%, w/w)	Sliced potatoes, SP_{25} (%, w/w)	Grated otatoes, GP_{25} (%, w/w)
Maize	44.0	33.0	33.0	33.0
Sweet potato	-	11.0	11.0	11.0
Fish meal	0.50	0.50	0.50	0.50
Soya bean cake	4.00	4.00	4.00	4.00
Groundnut cake	2.00	2.00	2.00	2.00
Wheat offal	45.25	45.25	45.25	45.25
Oyster shell	1.50	1.50	1.50	1.50
Bone meal	1.50	1.50	1.50	1.50
Vit./Min. premix	0.75	0.75	0.75	0.75
Common salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
C.P.(%)	14.96	14.31	14.28	14.39
M.E. (Kcal /g)	2.528	2.540	2.547	2.545

reduce the overall cost of production. Sweet potato, like cassava, is one of the staple food crops grown in Cameroon. It plays a major role in efforts to alleviate the African food crisis because of its efficient production of energy, year round availability, tolerance to extreme stress conditions and suitability to present farming and food systems in Africa (Hahn, 1992).

Previous studies on the performance of broilers and layer birds fed on sweet potato-based diets indicate that, if well processed to reduce the sugar content (cause of diarrhea in animals), and used at the recommended levels (25 to 50%), sweet potato can conveniently substitute for maize in livestock feeds (Oboh, 1986; Tewe, 1996; Abu, 1997; Etchu and Egbunike, 2002). However, information on the processing of sweet potato and its utilization in livestock feeds is scanty. It is therefore necessary to evaluate the effect of feed containing processed sweet potato on the fertility and reproductive potentials of broiler breeder cocks.

The objectives of this study were to reduce the sugar content of sweet potato using standard processing techniques (fermenting, grating or slicing), and to formulate breeder cock diets based on the processed sweet potato, evaluate the fertility and semen characteristics of the breeder cocks fed on the sweet potato-based diets.

MATERIALS AND METHODS

Study site

The study was carried out at the Teaching and Research Farm of the University of Ibadan (Nigeria) with a humid and semi-hot climate. During the duration of the study, weekly weather data were as follows; temperatures ranged from 21° to 31°C, rainfall from 13 to 27 mm and relative humidity from 43 to 75%.

Processing of sweet potato and formulation of experimental diets

Freshly harvested sweet potato *(Ipomoea batatas*) was procured and processed into the following forms: (a) Fermentation in water for 1, 2 and 3 days, (b) Grated – using a milling machine. The paste was put in a sack and water squeezed out and (c) Thinly sliced form using a knife. They were separately sun-dried to a maximum moisture content of less than 10%. The processed sweet potato tubers were characterized for their proximate composition (Table 1). Based on their proximate analyses, experimental breeder cock diets were formulated (Table 2). Four dietary treatments, notably the control diet (maize as the major energy source), and three

Table 3. Chemical analysis of the experimental diets.

Nutrient	Treatment			
	Control	FP_{25}	SP_{25}	GP_{25}
Dry matter (%)	90.26	92.95	93.96	93.89
Crude fibre (%)	3.12	7.01	8.25	5.41
Ether extract (%)	4.29	3.89	6.01	5.81
Ash (%)	6.12	5.69	9.82	6.84
Crude protein (%)	19.51	20.08	19.69	20.25
Metabolizable energy (kcal/g)	2.624	2.758	2.720	2.734

processed forms of sweet potato substituting maize at 25% level each that is, FP_{25}, GP_{25} and SP_{25}. The chemical analysis of the four diets was equally carried out (Table 3).

Experimental animals

Forty parent broiler breeder cocks aged 12 weeks were procured from S & D Farms – Abeokuta, Nigeria and randomly assigned to 4 dietary treatments each having 10 animals, serially tagged to represent replicates. The birds were housed in previously sanitized battery cage compartments in an open-sided building, fed standard breeders' diet containing about 15 % crude protein (CP) and 2,500 kcal/g metabolizable energy and given fresh cool clean water each morning *ad libitum*. The cocks were fed with the experimental diets for 10 weeks and then subjected to a semen collection exercise for another 3 weeks. The cocks were weighed on weekly basis.

Semen collection and ejaculate assessment

Cocks for each treatment were subjected to a training period of 3 weeks using the double hand Lumber massage method (Burrow and Quinn, 1937). They were then accorded a resting period of 1 week after which they were ejaculated at 72 h intervals. Altogether, 5 ejaculations were made for each animal. A ll he ejaculations were done between the hours of 7: 45 a.m. to 10 a.m. during the collection period. Upon collection, semen volume was read directly on the micro syringe to the nearest 0.01 ml. Semen color was also read directly while sperm progressive motility, sperm concentration, semen pH and sperm abnormality were estimated using methods described elsewhere (Etchu and Egbunike, 2002). The ratio of live to dead sperms was estimated using the eosin/nigrosine stain, where dead sperm cells pick up the stain and appear blue black on a pink background while live sperm cells did not pick up the stain and appeared shiny.

Mating plan and egg collection for incubation

This was accessed by natural mating of the cocks with 60 hens, randomly assigned to the 4 treatments. 3 cocks from each treatment were introduced to the 15 hens, giving a ratio of 1 cock to 5 hens. Egg collection started following 1 week adaptation of the cocks to the hens. Mating was allowed for 5 days. Eggs were collected daily for 6 days, marked according to the treatment and day of collection, graded and incubated. 2 batches of eggs were incubated. The sex ratio (cockerel/pullets) was determined after brooding the hatched chicks for 2 weeks.

Proximate analysis

Proximate analysis for the feed ingredients and the feeds was carried out according to standardized techniques (AOAC, 1985). Processed sweet potato and experimental diets were characterized for their total sugar, dry matter, crude protein, crude fibre, ash contents as well as for their ether extract (extractable fats) and gross energy levels. 2 samples of each potato type as well as the feed were used to run the proximate analysis.

Statistical analysis

Data on semen characteristics, fertility and hatchability were analyzed using Analyses of Variance (ANOVA). Separation of means between dietary treatments was done using the Duncan's multiple range tests (SAS, 1999).

RESULTS

Nutrient composition of processed sweet potato

Values on proximate analysis for crude protein, crude fibre, ether extract, ash and gross energy as well as total sugar and dry matter contents are presented on Table 1. The concentration of the total sugars in the processed sweet potato reduced considerably as the duration of fermentation increased. Meanwhile, total sugar content reduced more in the grated form (9.90%) than in the sliced form (10.24%). The dry matter was relatively higher in day one of fermentation while crude protein appeared highest (4.07%) in day 3 of fermentation. Gross energy reduced with increasing number of days of fermentation.

Semen characteristics

Results on the body weight of cocks fed with potato-substituted diets as well as the semen characteristics (pH, ratio of live-to-dead sperms, semen volume, sperm concentration, sperm motility, sperm output and abnormal sperm cells are presented in Table 4. The body weights of cocks fed with potato-substituted diets (grated, fermented and sliced) were similar to those fed with

Table 4. Body weight and semen characteristics of breeder cocks fed processed sweet potato-based diets (Mean ± SEM).

Parameter	Control, 100% maize (%, w/w)	Fermented potatoes, FP_{25} (%, w/w)	Sliced potatoes, SP_{25} (%, w/w)	Grated potatoes, GP_{25} (%, w/w)
Body weight (kg)	2.83 ± 0.23	2.87 ± 0.14	2.83 ± 0.22	2.85 ± 0.26
Semen volume (cm^3)	0.19 ± 0.05^{a}	0.16 ± 0.03^{b}	0.17 ± 0.03^{b}	0.16 ± 0.03^{b}
Sperm conc.(10^9/ cm^3)	3.66 ± 0.48^{a}	3.37 ± 0.62^{ab}	3.02 ± 0.50^{bc}	$2.68 \pm 0.44c^{b}$
Sperm motility (%)	71.3 ± 10.4^{a}	60.7 ± 6.3^{b}	62.2 ± 7.6^{b}	62.7 ± 11.3
Live/Dead ratio (%)	92.4 ± 2.7	90.3 ± 7.6	92.0 ± 1.9	91.9 ± 2.2
Sperm output (10^9 /cm^3)	0.73 ± 0.21^{a}	0.53 ± 0.14^{b}	0.51 ± 0.17^{b}	0.44 ± 0.14^{b}
Abnormal sperm cells (%)	16.7 ± 7.1^{a}	12.9 ± 7.8^{b}	13.6 ± 5.5^{b}	25.9 ± 7.5^{b}
Semen pH	7.19 ± 0.04	7.17 ± 0.03	7.18 ± 0.03	7.19 ± 0.04

^{abc}Means with different superscripts along the same row are significantly different ($P < 0.05$).

Table 5. Effect of sweet potato-based diets on fertility and hatchability of eggs.

Parameter	Control, 100% maize (%, w/w)	Fermented potatoes, FP_{25} (%, w/w)	Sliced potatoes, SP_{25} (%, w/w)	Grated potatoes, GP_{25} (%, w/w)
No. of eggs collected	45^{ns}	43^{ns}	45^{ns}	46^{ns}
No. of eggs fertilized	35^{ns}	38^{ns}	32^{ns}	30^{ns}
Average weight of eggs (g)	61.5^{b}	63.7^{a}	65.0^{a}	62.0^{b}
Fertility (%)	77.8^{b}	88.4^{a}	71.1^{bc}	65.2^{c}
Hatchability (%)	85.7^{b}	92.1^{a}	93.8^{a}	90.0^{ab}
Sex ratio (cockerel/ pullets)	1.5^{ns}	1.7^{ns}	$2.0n^{s}$	2.0^{ns}

Treatment means with different superscripts (a,b,c, ...) along the same row are significantly different ($P < 0.05$); ^{ns}, not significant.

standard maize diets. Similarly, the semen pH and ratio of live-to-dead sperms were not affected by the substitution of dietary maize by differently processed sweet potato tuber. However, the semen volume, sperm concentration, sperm motility, sperm output and abnormal sperm cells seemed to have been adversely affected by the partial substitution of maize in the formulated diets. The control diet had the highest semen volume (0.19 ± 0.05 ml) while the least semen volume (0.16 ± 0.03 ml) was recorded in diets (GP_{25}) and (FP_{25}).

Fertility and hatchability of eggs

Results on the fertility and hatchability of eggs were presented in Table 5. Substitution of dietary maize with differently processed sweet potato tubers in the diets of broiler cocks had no significant effect on the number of eggs collected, the number of eggs fertilized and the ratio of cockerel-to-pullets (Table 5). This was not the case for average weight, fertility and hatchability of eggs as the diet formulated with 25% substitution with GP_{25} produced systematically higher values than the diet with no maize substitution The 25% of FP_{25} substituted diet equally gave eggs of higher hatchability and average egg weight than the non-potato substituted diet. The 25% of SP_{25} substituted diet was only better than the control diet in terms of the hatchability of the eggs obtained.

DISCUSSION

Nutrient composition of processed sweet potato

Sweet potato is made up of mostly soluble sugars, which dissolve into the surrounding water reason why their concentrations reduced with increasing number of days of fermentation. This same reason on the water solubility of sweet potato also explains why the gross energy reduced with increasing duration of fermentation. No particular trend was observed for the dry matter and crude protein contents as fermentation varied from day 1 to day 3. The high values of dry matter were apparently due to the level of drying which reduced the moisture content of the processed sweet potato resulting to the observed dry matter. Day 3 of fermentation had a relatively higher value for crude protein than days 1 and 2. This is probably due to the accumulation of micro organisms forming single cell protein which added to the crude protein of sweet potato resulting to the higher crude protein values observed in day 3 of fermentation.

Semen characteristics

The values obtained for semen characteristics were comparable to those recommended for the breeding of broiler cocks in humid tropics; 3.80×10^9 per ml for sperm

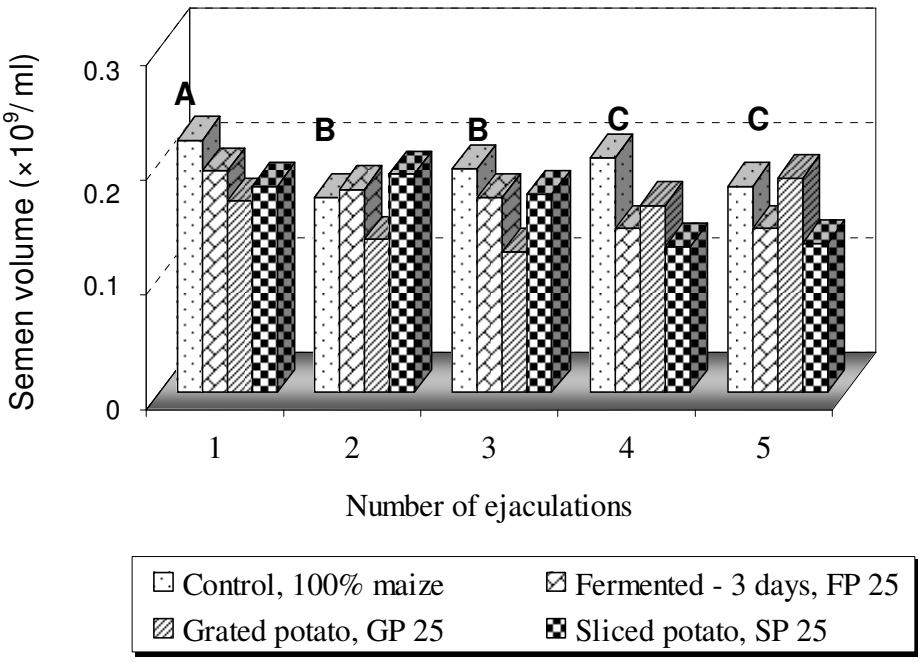

Figure 1. Effect of feed and ejaculation frequency on semen volume. Frequencies of ejaculation with different superscripts (A, B, C or D) were significantly different ($P < 0.05$).

concentration and 0.25 to 2.00 ml for volume (Cerolini et al., 2003). Semen volume, sperm concentration and sperm output are functions of the animals' efficiency in feed utilisation. Birds on the control diet had better feed utilisation efficiency than those on sweet potato-based diets as reflected in the observed semen characteristics. Birds on 25% of GP_{25} substituted diets had higher sperm concentration followed by those on 25% of FP_{25} substituted diet with the least sperm concentration recorded for birds on 25% of SP_{25} substituted diet which had a relatively higher total sugar content than GP_{25} and FP_{25}. This sugar has an influence on the animals' performance. These results further confirm the need to reduce the sugar content of sweet potato meant for poultryfeeds as earlier recommended by Tewe (1996) and Etchu and Egbunike (2002). This is because the α-bonds binding simple sugars in sweet potato are not susceptible to α-amylase activity in monogastric animals. Sperm motility is a function of the seminal fluid, pH and energy sources for the spermatozoa to metabolize. However, fertility is not an entity on its own, as it is influenced by semen volume, sperm concentration, sperm Live/Dead ratio, sperm motility and semen pH. Motility must be progressive and unidirectional for effective fertilization of an egg to take place unlike the tactile, static with a wavy tail-type of motility, which yields no fertility. The fact that a spermatozoon may be alive is not a guarantee that it can fertilize an egg except by chance. Thus, spermatozoa abnormality, be it primary (inherent) or secondary (mechanical damage or injury), adds to other semen characteristics to influence the animal's fertility. The study equally reveals that frequent ejaculation, time of sperm collection, and method of handling the cocks affect the overall semen quality and quantity (Figures 1 and 2).

Fertility and hatchability of eggs

The hatchability of chicken eggs is influenced by the age of the hen. The younger the hen, the higher the percentage hatchability of its eggs and vice versa. This is because older hens (> 48 weeks) have fewer viteline lining and pores on the surface of the egg which has a negative effect on the respiration of the developing embryo during incubation and a resultant poor hatchability. However, the hens used for the study were of the same age and still active and in their good state of performance in terms of egg production and hatchability. This explains why there was no significant treatment effect on the number of eggs collected and fertilized. For effective hatchability of eggs, the weight of the eggs is known to be incubated for hatching counts. The average weights of eggs for this study ranged from 61.2 to 65.0 g, which fall within the normal range of 60.6 to 67.0 g reported by (Reis et al., 1997). From the results, since the weight of the eggs of diet FP_{25} was highest (64.97 g) it followed that diet FP_{25} also had highest hatchability (93.75%). Generally the hatchability was appreciable and these results agree with those reported by (Reis et al., 1997) on a drop in hatchability with a decrease in egg weight. From this study more cockerels were obtained than pullets. The reason for this difference in sex ratio is

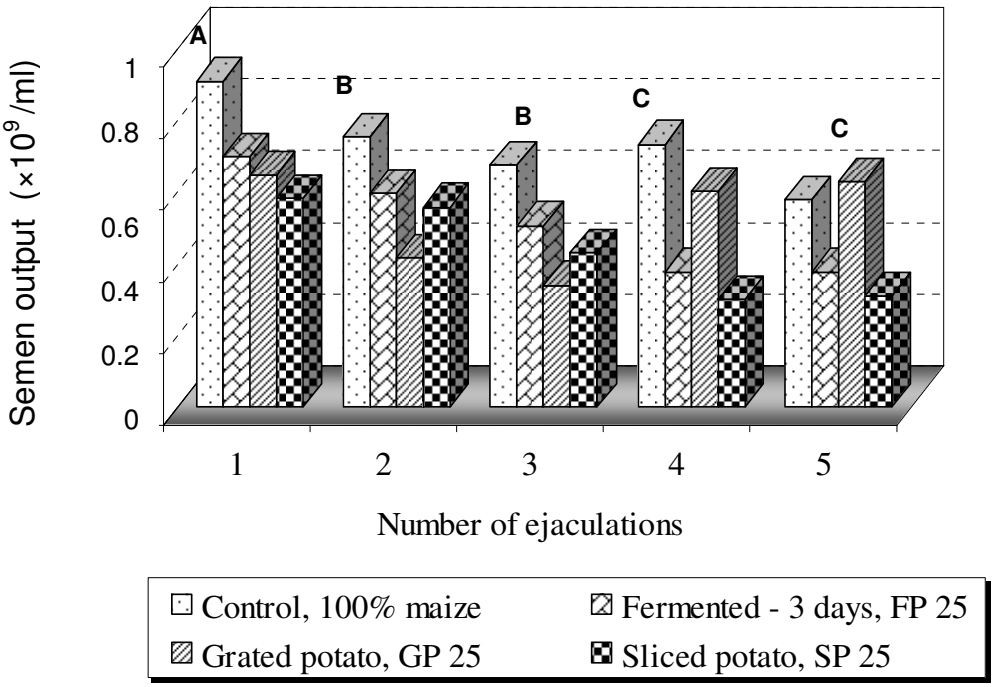

Figure 2. Effect of feed and ejaculation frequency on semen output, frequencies of ejaculation with different superscripts (A, B or C) were significantly different (P< 0.05).

not clear. But from this study the cocks used were younger (28 weeks) than the hens (38 weeks) so it is assumed that the age difference would have influenced the observed sex ratio.

Conclusion

Though cocks from maize-based diet (Control) had higher values for semen volume, sperm concentration and sperm output, they were not better than cocks from sweet potato-based diets in terms of egg fertility and hatchability. The short production period (90 to 120 days) of sweet potato and its tolerance to extreme drought conditions makes it readily available all year round. The new variety with low sugar and high protein content even offers more prospects. Hence, processed sweet potato can partially substitute for maize in poultry diets when adhere to recommended levels. Since the major problem with sweet potato is its high sugar content which causes diarrhea in chicken, and based on this study, farmers are advised to go in for the fermentation (for 2 to 3 days) and GP_{25} of processing which reduces the sugar levels making sweet potato a good feed ingredient to substitute for maize in poultry feed.

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