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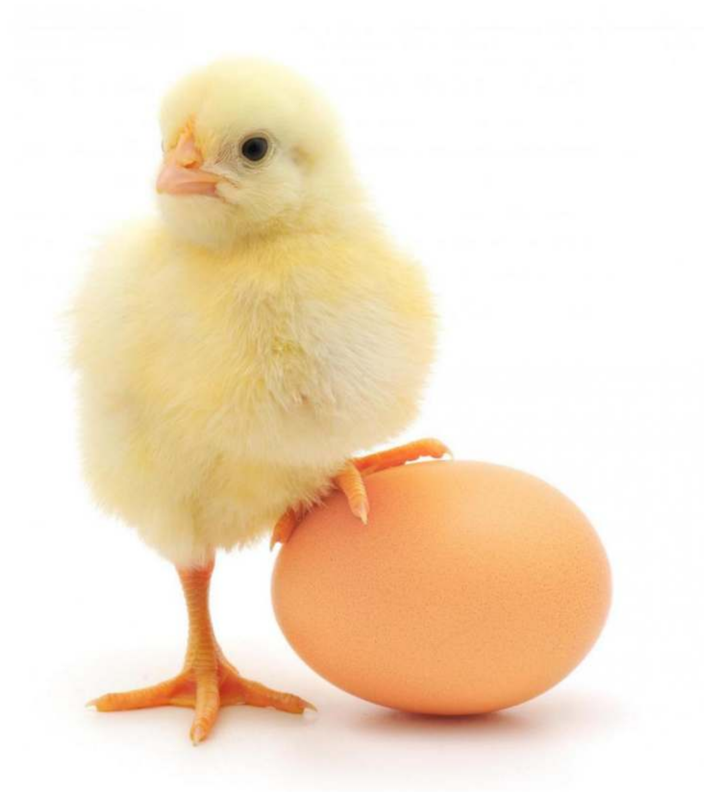

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Effect of Corn Substitution by Sorghum Grain with Low Tannin Content on Broilers Production: Animal Performance, Nutrient Digestibility and Carcass Characteristics

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Abstract: The effect of substituting corn with sorghum grains with low tannin content (LTC) on broilers performances was investigated in a 6-week feeding trial. Seven hundred fifty 1-day old chicks and not sexed Coob 500 were used in this test. These animals were separated into five groups with three replicates of 50 birds for each one. A control diet with 50% of corn was used in the control group. Three other diets where corn was substituted by conventional sorghum in 1/3, 2/3 and 3/3 were given respectively to the G1/3, G2/3 and G3/3 groups. The GLTC groups received diets with total substitution of maize by sorghum with LTC. No significant difference was shown for the body weight between the control and the GLTC groups (respectively 1303 and 1418 g). But the use of conventional sorghum decreases significantly the broilers weight live ($p>0.05$) with the lower weight performances (1128 to 1225 g). Mortalities were similar for the different groups. It's always results to climatic environment which was identical for the different group. No difference has been observed for the carcass dressing percentage (68 to 76%). For the nutrients digestibility, except the fat matter which was difference and higher (more than 92%), dry matter, ash and then metabolizable energy were similar ($p>0.05$) in the starting and growing diets.

Key words: Sorghum, tannin, broiler, digestibility, carcass

INTRODUCTION

Corn is the main cereal used for poultry diets in Africa (Abdoulaye, 2006). Because this feedstuff is imported, high production costs are the main constraint to poultry production in West Africa (Ayssiwede *et al.*, 2009). However it's necessary to identify some alternative feed ingredient for corn.

Sorghum (*Sorghum bicolor* L. Monch) is the fifth most important crop in the world after wheat, rice, corn and barley (Bryden *et al.*, 2009). In west Africa, Issa *et al.* (2007) reported that is the second most important cereal grain after millet and just before corn. Moreover, it is produced extensively in sahelian countries like Burkina Faso, Mali, Senegal, Niger and Nigeria and could play an important role in feeding poultry (Issa *et al.*, 2007; Kwari *et al.*, 2011). Indeed, many Poultry nutritionists would typically discount the nutritional value of sorghum grain compared to corn or wheat. The nutritional value is usually considered to have about 5% less feeding value than corn (Dowling *et al.*, 2002; Leeson and Summers, 2005).

Literature reporting that the old varieties of sorghum grain contained relatively high amount of an anti nutritional compound called tannin (Hancock, 2000; Ravindran *et al.*, 2005; Sell *et al.*, 2010). Many studies have demonstrated an array of deleterious influences to tannin including: (i) depressed feed intake, (ii) increased endogenous protein secretion, (iii) formation of less digestible tannin-dietary protein complex, (iv) inhibition of digestive enzymes, (v) toxicity of absorbed tannin or its metabolites (Sell *et al.*, 2010). It's appeared that these negative effects resulted from the ability of tannins and specially condensed tannins, to bind and precipitate proteins including grain proteins and digestive enzymes (Butler and Rogler, 1992).

Therefore, to use sorghum in animal's diets and specially broilers productions, authors develop some technology like a supplementation of sodium bicarbonate (Drinah *et al.*, 1990) or methionine (Armstrong *et al.*, 1973). Kyarisiim *et al.* (2004) using ash from wood reduces up to 62% the level of tannin in the sorghum grain. Staying the grain of sorghum in acetic and propionic acid in 60/40 volume ratio during 10 to 20 days and conserving same under high humidity protect against fungus aggression and reduce significantly tannin content in sorghum (Mitaru *et al.*, 1985). But all these diet processing present some limits like the cost and use of methionine or sodium bicarbonate and the complicity of the process.

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Table 1: Composition of the diets offered to control groups (CG) and of the experimental diets in which maize was substituted by conventional sorghum at levels of 1/3 (G1/3), 2/3 (G2/3) or 3/3 (G3/3) and totally (3/3) by sorghum LTC (GLTC)

	Starting period					Growing period				
	CG	G1/3	G2/3	G3/3	GLTC	CG	G1/3	G2/3	G3/3	GLTC
Ingredients (g/kg)										
Maize	500.0	333.3	166.7	0	0	500.0	333.3	166.7	0	0
Sorghum	0	166.7	333.3	500.0	0	0	166.7	333.3	500.0	0
Sorghum LTC	0	166.7	333.3	0	500.0	0	166.7	333.3	0	5000
Millet	85.0	85.0	85.0	85.0	85.0	175.0	175.0	175.0	175.0	1750
Groundnut cake	210.0	210.0	210.0	210.0	210.0	190.0	190.0	190.0	190.0	1900
Fish by-product meal	105.0	105.0	105.0	105.0	105.0	5.0	5.0	5.0	5.0	50
Groundnut oil	40.0	40.0	40.0	40.0	40.0	3.5	3.5	3.5	3.5	35
$CaCO_3$ (lime)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	50
Tricalcium phosphate	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	60
L-Lysine HCl	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
DL-Methionine	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15
Vitamin-mineral premix[1]	45.0	45.0	45.0	45.0	45.0	35.0	35.0	35.0	35.0	350
Chemical composition (g/kg)										
Dry matter	923.0	915.2	919.0	913.0	916.3	926.6	928.5	950.8	925.8	9185
Crude protein	221.0	238.8	209.8	239.5	223.3	204.6	207.2	185.0	199.0	2025
Ether extract	57.1	63.8	67.1	52.2	59.1	54.5	63.7	65.7	46.6	667
Crude fiber	35.2	32.1	30.3	29.5	29.3	37.6	33.6	28.8	25.0	318
Ash	113.3	104.7	107.0	96.4	98.1	73.8	67.1	64.1	84.4	735
Others										
ME, Kcal/kg	3219	3431	3318	3268	3310	3347	3459	3604	3368	3427
Condensed tannin, mg/kg	0	441.7	888.3	1325	0	0	441.7	888.3	1325	0

[1]Macro-vetamix 5% (Vetagropharma technology) which provided (per kg of premix):

Ca, 280 g	P, 37 g	NaCl, 33 g	Mn, 1.4 mg
Zn, 1.2 mg	Fe, 1.4 mg	Cu 0.2 mg	I, 8 mg
Co, 2 mg	Se, 2.8 mg	vitamin A, 250,000 IU	vitamin D_3, 50,000 IU
vitamin E, 290 mg	vitamin B_1, 55 mg	vitamin B_2, 100 mg	vitamin B_3, 480 mg
vitamin B_5, 195 mg	vitamin B_6, 55 mg	vitamin B_{12}, 600 µg	vitamin K_3, 50 mg
folic acid vitamin, 27 mg	vitamin C, 175 mg	H biotin vitamin, 600 µg	Lysine HCl, 5%
Methionine, 3%			

Nowadays, some news varieties of sorghum with low tannin content (LTC) have been created and homologous (CE 151-262, CE 196-7-2, F-2-20, ...) in Senegal by the Senegalese Institute of Agricultural Research (ISRA) (Ba *et al.*, 2010). However a few studies have been done in these varieties and, anyone in a similar condition of West Africa's poultry. The aim of this experiment was to study, in broiler, the effects of the replacement of corn by sorghum with LTC on animal performance, nutrient digestibility and carcass characteristics in comparison with conventional sorghum in an increasing level of incorporation in diets.

MATERIALS AND METHODS

The experiment was planned at the end of the rainy season 2013, at the experimental station of ENSA (high school in University of Thies, Senegal). During the experiment, temperature and moisture were daily recorded at 07.00 a.m., 01.00 p.m. and 06.00 p.m. The mean temperature was 32.7°C, with minima (28 to 30°C) and maxima (35 to 37°C) measured respectively at 07.00 a.m. and 01.00 p.m. and the average moisture was 57.9%, comprised between 30.0±7.9% and 75.1±7.5%.

Seven hundred and fifty 1-d-old unsexed and unidentified Cobb 500 broilers were used in this experiment. They were randomly assigned to five groups. The control group (CG) that receive a diet containing 50% of corn as main source of energy and in conformity with the principal diets use in poultry production. The three other groups received diets in which corn was substituted with increasing levels of conventional sorghum grain (1/3, 2/3 and 3/3 substitution for G1/3, G2/3 and G3/3 groups respectively). The fifth group was the GLTC in which bird received diets with the total substitution of corn by the sorghum LTC produced from *Sorghum vulgar* var. *bicolor* cultivar Faourou in the National Center of Agronomic Research (CNRA) of ISRA (Bambey, Senegal) (Table 1). Each group was divided in three homogenous blocks of 50 birds.

A starting diet was used until 21 days old and a growing diet was offered afterwards until slaughter at d43 (Table 1). The different diets were formulated to present theoretical iso-proteic and iso-energetic characteristics. Iso-EE diets levels were ensured by the use of groundnut oil addition, with respect to the levels of substitution. Consequently, levels of nutrients were that recommended by the National Research Council (NRC, 1994). Feed and water were provided on a marginal *ad libitum* basis for the duration of the experiment.

Individual body weights (BW) were obtained on d1 and once a week thereafter. Birds were observed twice daily to assess healthiness and death occurrence. Feed intake (FI) was recorded weekly.

At the end of the experiment, 5 animals per group were randomly chosen and killed by cervical rupture. They were eviscerated for carcass characteristics determination. Individual weights of carcass were measured.

Nutrient digestibility was evaluated with five additional 6-w-old Cobb 500 broilers, mean BW of 1200 g, for each of the 10 diets (5 starting and 5 growing diets). They were penned in individual metabolism cages and, after an adaptation period (7 days), feed intakes, refusals and faeces were obtained once a day and dehydrated at 60°C, over a period of 7 days. At the end of the trial, faeces were gathered by animal and sample was taken for analyses to evaluate the faecal nutrient. Apparent nutrient digestibility (AND) was calculated as the ratio (nutrient intake-faecal nutrient)/nutrient intake.

The prophylactic program was the one used in poultry production in Senegal and during the experimental period no sanitary trouble was identified.

Aflatoxins levels (B1, B2, G1 and G2) were determined in groundnut cake and in the control diets by liquid chromatography according to the 92/95 and 94/14 directives of the European Commission. This process was used to evaluate the condensed and hydrolyzable tannin in the sorghum.

It's important to note that the levels of tannin in the sorghum grain were 2.69 and 0.03% respectively for the conventional sorghum (brown colour) and the sorghum LTC (white colour).

Dry matter (DM), ash, crude fiber (CF) and ether extract (EE) were analyzed according to AOAC (1990) procedures. Crude protein (CP) was determined by the Kjedahl method, as nitrogen (N) x 6.25. Nitrogen non-extract (NNE) was calculated as:

NNE = 1,000-CP-CF-Ash-EE, fractions being expressed as g/kg (NRC, 1994)

Metabolizable Energy (ME) was calculated by an indirect method, using the INRA equation (INRA, 2004) where True ME (Mj/kg DM) = (3951+54.4 EE-88.7 CF-40.8 ash) *0.004184, where nutrient contents are expressed in % DM.

The non individualizable date like ADG, FI and FCR were analysis with a descriptive statistical model. For BW, nutrients digestibility and carcass components the data were analyzed according to General Linear Models (Proc GLM, SAS, 2003). The model initially used included the main effect of the substitution level of corn by sorghum (conventional sorghum and sorghum LTC), the repetitions effect and the interaction between the level of substitution and the repetition. The final model was thus:

$$Y = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \varepsilon_{ijk}$$

where,

μ = Overall mean

α_i = effect of the substition level i of corn by sorghum

β_j = effect of the repetition j

$\alpha\beta_{ij}$ = effect of interaction between the substition level i and the repetition

ε_{ijk} = random residual effect (N[0,1])

A 1 autoregressive covariance structure (AR1) was done. The repetition effect was considered as random. For the mortality, a survival analysis (Proc LifeReg, SAS) was done to compare the groups.

RESULTS

The BW was significantly affected by the level of substitution, the kind of sorghum (conventional and LTC sorghum) and the date or time. In the same group, no difference has been observed for the repetitions (p = 0.477). The substitution of corn by Sorghum LTC increase significantly broilers performances. With the conventional sorghum, the BW decrease proportionally to the level of corn's substitution (Table 2).

However, significant difference has been observed from the end of the starting period and then therefore. At the end of the experimentation, bird fed diets with sorghum LTC realize the best performance with 1418 g versus 1303 g for the control group (Table 2). But no difference has been observed by the statistical analysis between the two groups (p = 0.129).

The lower performances has been observed with animal fed by diet with total substitution and 2/3 of conventional sorghum with respectively 1128 and 1220 g (p = 0.221) for the BW.

Significant difference has been observed for the average daily gain (ADG) during the starting and growing period ($p<0.05$). The higher ADG was given by the control diets and the diet with the sorghum LTC (respectively, 26.4 and 28.5 g). During the starting period the lower ADG was 23.2 g for the total substitution by conventional sorghum (Table 2). The G1/3 and G2/3 has similar ADG (about 25 g). Similar result has been observed during the growing period with the higher ADG for the control and the GLTC groups (respectively, 48 and 47 g; $p<0.05$).

No difference has been observed for the feed intake (FI) during the starting (p = 0.741) and the growing (p = 0.218) period. The FI ranged between 286 and 316 g/bird/week during the starting period and 730 and 870 g/bird/week during the growing period (Table 2).

The Feed conversion ratio was affected by the treatment ($p<0.05$). The control diet and the diet with sorghum LTC was more efficiency than the others (Table 2). The higher FCR was observed with the G2/3 and G3/3 groups about 2.12 during the starting period and respectively 3.28 and 3.17 during the growing period.

Table 2: Animal performance of Cobb 500 broilers that received either a control diet (CG) or diets in which maize was substituted by conventional sorghum at levels of 1/3 (G1/3), 2/3 (G2/3) or 3/3 (G3/3) and totally (3/3) by sorghum LTC (GLTC)

	CG	G1/3	G2/3	G3/3	GLTC	SEM	P>F
Initial weight, g	44.4	44.0	44.8	44.5	45.0	0.32	Ns
Weight at d22, g	527.5[ab]	506.3[b]	461.7[c]	464.5b[c]	597.3[a]	9.29	***
Final weight, g	1303.4[a]	1224.7[b]	1128.7[c]	1220.2[c]	1418.0[a]	25.1	**
ADG starting period, g/d	26.4[ab]	25.4[ab]	25.1[ab]	23.2[b]	28.5[a]	-	-
ADG growing period, g/d	48.4[a]	43.8[ab]	37.3[b]	39.6[b]	47.0[a]	-	-
Feed intake starting period, g	287.0	287.3	320.7	303.8	314.4	-	-
Feed intake growing period, g	810.5	734.7	730.4	754.9	786.2	-	-
Feed conversion ratio starting period	1.76	1.9	2.12	2.12	1.80	-	-
Feed conversion ratio growing period	2.79[b]	2.80[b]	3.28[a]	3.17[a]	2.79[b]	-	-

Values on the same line with no common letter are significantly different at p<0.05

Table 3: Animal performance and carcass characteristics of broilers that received either a control diet (CG) or diets in which maize was substituted by conventional sorghum at levels of 1/3 (G1/3), 2/3 (G2/3) or 3/3 (G3/3) and totally (3/3) by sorghum LTC (GLTC)

	CG	G1/3	G2/3	G3/3	GLTC	SEM	P>F
Live weight (g)	1100[c]	1201[bc]	1295[c]	1432[ab]	1545[a]	20.19	**
Carcass weight (g)	749[c]	883[bc]	947b[c]	1056[ab]	1067[a]	26.95	***
Dressing (%)	68.55	73.24	73.76	73.89	75.64	1.81	Ns

On a line, means with no common letter are significantly different at p>0.05

Table 4: Nutrients digestibility (%) of Cobb 500 broilers that received either a control diet (CG) or diets in which maize was substituted by conventional sorghum at levels of 1/3 (G1/3), 2/3 (G2/3) or 3/3 (G3/3) and totally (3/3) by sorghum LTC (GLTC)

Items	CG	G1/3	G2/3	G3/3	GLTC	SEM	P>F
Starting diets							
Dry matter	76.15	78.97	79.15	75.9	79.43	1.81	0.063
Organic matter	81.93[b]	83.55[ab]	83.91[ab]	81.45[b]	84.37[a]	1.42	0.037
Fat matter	92.37[b]	93.32[a]	93.12[a]	92.27[b]	93.46[a]	0.55	0.006
Ash	38.67	49.48	48.09	39.24	46.75	5.80	0.213
EM	87.08	87.87	88.45	86.46	88.71	1.28	0.097
Growing diets							
Dry matter	78.07	79.35	82.91	81.77	77.54	1.80	0.273
Organic matter	83.11[b]	84.42[ab]	87.29[a]	86.18[a]	82.9[b]	1.42	0.048
Fat matter	90.74[b]	91.19[ab]	92.83[a]	92.09[ab]	90.72[b]	0.67	p<0.001
Ash	25.80	26.43	37.40	38.03	23.12	6.50	0.439
EM	87.32	88.44	90.51	89.64	87.48	1.02	0.109

Values on the same line with no common letter are significantly different at p<0.05

At the end of the experimentation, mortality was average 7%. High mortality was observed at the beginning of this work. For the survival life, no difference has been observed by the analysis; its border on quarter life (25%) except the control and the G2/3 groups.

The best dressing was observed by the animals received diets with sorghum (average 73% for the conventional sorghum) and particularly the sorghum LTC (75.6%) (Table 3). The control group has the lower dressing carcass (68.5%). No difference has been observed by the statistical analysis.

The organic matter (OM) and the ether extract (EE) digestibility were better in diets received by the control group during the starting and growing period (Table 4). Few variations were observed between diets nutrients digestibility.

DISCUSSION

The final BW of the control groups was weak when considering the standard values reported for Cobb (2004). In the same experimental local, Bulgen (1996) produce, after 43 days, broilers weight 1728 g (versus about 1259 g in this experiment). Groundnut cake which is well known to habitually have a high level of an anti-nutritional component called aflatoxins was incorporate in the experimental diets. But the chemical analysis of this feed ingredient showed that the total aflatoxins content in groundnut cake (AB1, AB2, AG1 and AG2) was very weak (less than 0.15 ppm). It means that, aflatoxins incidence could be neglected since their levels were largely lower than the levels of 1 mg/kg causing a 5% reduction in growth rate in poultry, as reported by Dersjant-Li *et al.* (2003). Moreover, Leeson and Summers (2005) reported that the critical level of poultry toxicity for Aflatoxin is 1.2 ppm.

Therefore, the low growth would probably due to the fact that the experiment was carried out at the end of the rainy season under hot and wet climate, i.e., suboptimal conditions for broiler production. Indeed, over 30°C, FI decreases drastically in order to limit endogenous heat production, reducing growth performances and thus final BW (Dale and Fuller, 1979). Cooper and Washburn (1998) yet shown that broilers exposed to 32°C expressed almost half the growth performed at 21°C. In similar condition (animals, ambient and prophylactic programs) Diaw *et al.* (2010) obtained weaker weight performances. Indeed, after 42 days, the control groups weight was less than 1 kg. It's important to note that the farinaceous form can reduce feed intake (Bulgen, 1996) and then, explain the relative weak performance obtained in this experiment. Several authors reported that physical kernel characteristics (e.g., seed size and texture), production environment and processing are factors recognized to induce variation in sorghum-based diets poultry (Wondra *et al*., 1992; Hancock, 2000; Oria *et al*., 2000).

Sorghum LTC gave similar result with the corn. This is in conformity with those reported by Rostagno *et al*. (1972), Armstrong *et al*. (1973) and Hulan and Proudfoot (1982) who doesn't observed any difference between broilers fed with diets where sorghum was detoxify to substitute corn. For these authors sorghum varieties without tannin can replace corn (Ayssiwede *et al*., 2009). Pour-Reza and Edriss (1997) confirm this result with similar BW for broilers fed by diets with corn and those where corn were partially substitute (50%) by sorghum. With the total substitution these authors reported that the weight life of the broiler was significantly lower than the either (respectively, 1866 g versus about 1962 g). In other words, birds fed low-tannin sorghum performed better than birds fed corn or high-tannin sorghum. In this study, it appears that, in a neglected level of tannin content, sorghum can substitute the corn and beyond give superior BW (about respectively 1418 g and 1303 g). In consequence sorghum can replace efficiently corn in broilers production. Indeed without tannin, sorghum and corn have approximately the same feed value (Hulan and Proudfoot, 1982).

The weaker BW observed to the animals fed diets where sorghum were highly incorporate resulted to the depressive effects for tannin in the BW. Indeed, the level of tannin in the conventional sorghum was relatively high (2.69%) and, this component have a negative effect on broilers performed. McKersie and Brown (1997) reported that the most widely recognized property of condensed tannins is their capacity to strongly and selectively bind to proteins and other macromolecules, such as cell wall carbohydrates and starch, due to their high level of phenolic hydroxyl groups. Because, it reduces the availability of proteins, the growth speed could be negatively affected. Similar results were reported by Armstrong *et al*. (1973) and Oduho and Baker (2005) and, point up the depressive effect of tannin in conventional sorghum incorporate in broilers diets. The least level of substitution of corn by conventional sorghum decrease the ADG.

Ingestion was similar and range between 730 and 810 g/bird/week. Subramanium *et al*. (2000) reported similar result. The FI was higher than those reported by Nyamambi *et al*. (2007) with 38.9 and 83.8 g/day/bird versus 43 and 109 g/day/bird for respectively the starting and growing period. During the starting period, the FI was similar with those obtained in optimal condition in the experimentation area (42 g/day/bird reported by Bulgen (1996), but this author reported a higher ingestion obtained in this study (116 g/day/bird). It's important to note that the relative weak FI could explain low BW. Experimental period (temperature and HR) should affect the ingestion and consequently the growth. Indeed, Pour-Reza realize broilers weight about 1914 g with 3834 g of ingestion diets.

For the FCR, they were better for the diets with corn and with sorghum LTC. Broilers from the G2/3 and G3/3 have the higher FCR, this prove that the conventional sorghum was badly valorise. In general, the FCR were high. It mind be caused by the ambient. Moreover, similar values were reported by Diaw *et al*. (2011) who obtained, in the same condition, FCR about 2.72. In contrary, Ayssiwede *et al*. (2009) reported a light deterioration for diets with sorghum (2.01 versus 2.18 respectively for 0 and 50% level of corn substitution by sorghum). However, the measure of tannin in sorghum used by this author wasn't reported. In other words, chemical analysis of tannin content wasn't done and, probably, sorghum content sufficiently tannin who must affect the FCR to decrease diets efficiency. Indeed, same result was obtained by Pour-Reza and Edriss (1997) who, substituting corn by sorghum with high tannin content in 0, 50 and 100% reported respectively 1.89, 1.96 and 2.04 for the FCR.

Statistical analysis doesn't show any difference for the mortality ratio. At the end of the experimentation, mortality was about 7% and in conformity with the standard reported by Bulgen (1996). Mortalities should be resulted to the ambient and the experimental period. Sorghum incorporate in the diet (conventional and LTC) hasn't affected the mortalities. However, internal lesion wasn't evaluate in this study because its finality was to substitute corn by sorghum LTC in the same way to shown how tannin could affect the performances.

Carcass yields were similar for the different groups. Kwari *et al*. (2011) who use many varieties of Sorghum with different level of tannin obtain, in same condition in Nigeria, similar result with 68.77%. It means that diets were converted in the same way to produce carcasses. In expect of the control group, the carcasses yields are in conformity with those reported by Issa *et al*. (2007) with about 75.76% (approximately equal to those obtained with the GLCT group). The carcass yields reported by Ayssiwede *et al*. (2009) were very high and more than the standard reported for Cobb (2004). However, it's important to note that sorghum did not depreciate the carcasses yield and better, it improve this.

Nutrients digestibility was higher than those reported by Diaw *et al*. (2011). The crude fiber and fat digestibility were lower than those reported by Adama *et al*. (2007) (between 60.28 and 74.28%). No difference has been observed for the metabolizable energy digestibility. Tannin doesn't reduce energy value of sorghum. The weaker performances for broilers fed with conventional sorghum wasn't resulted by the energy available. Many authors reported that was the linkage between tannin and protein (Price and Butler, 1980; Butler *et al.*, 1992; Hancock, 2000; Sell *et al.*, 2010).

Conclusion: These study shown that the news varieties of sorghum with low tannin content could be an alternative for corn. Its feed value is near to that for corn with a higher level of protein and a better feed efficiency. In the sahelian aerea where corn is produced difficultly, it constitutes the best response for boiler production and in a large way in poultry.

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