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Research article

Effect of sorghum varieties on bioeconomic performance of broiler in Niger

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Abstract

The effect of sorghum varieties on bioeconomic performances of broiler has been evaluated in Cobb 500 chicks. The chicks were randomly divided into five treatments and four replications (per treatments) of 18 chicks each. Five dietary treatments based on Mota Maradi, IRAT 204, Janjaré, white Kaoura and yellow Kaoura sorghum varieties. Feed intake and growth performance of broilers were significantly affected ($P<0.05$) by the varieties of sorghum used in the diet. Broilers fed with Janjaré sorghum treatment had the highest growth performance and those fed with Mota Maradi, the lowest. Feed conversion ratio, feed cost and economic feed efficiency were statistically different at the starter phase ($P<0.05$), but not at the grower phase and for the overall phases ($P>0.05$). White Kaoura and Janjaré sorghum varieties were the more efficient. The varieties of sorghum used in broiler diet did not have a statistically significant effect on carcass yield, feathers, empty gizzard and liver yields ($P>0.05$). It appears that White Kaoura and Janjaré sorghum varieties are more appropriate than the three other varieties in broiler feed.

Keywords: Bioeconomic performances; broiler; Niger; sorghum variety

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Introduction

Sorghum bicolor L. Moench is the second cereal produced in Niger after millet (Issa et al., 2010). In terms of nutritive value, cost and availability, sorghum grain may be the alternative to maize in poultry feeding (Etuk et al., 2012), but tannin content limits the use of sorghum grain in poultry feeding. Tannin affects the digestibility of feeds and limit the activities of some enzymes and microorganisms by forming complexes with nutrients and prevent their dissolution in the digestion system (Imik, 2009), which reduced feed intake, weight gain and feed conversion efficiency (kumar et al., 2005). Some tests of substitution in West Africa (Kwari et al., 2012; Diaw et al., 2014; Issa et al., 2015) have revealed the good potential of low tannin sorghum to replace maize in broiler diets.

However, tannin content is not the only one parameter that influences nutritive value of sorghum grain. Variety, climate, soils (Ebadi et al., 2005), proportion of kafirin (Sonia et al., 2015), physical structure (Kim et al., 2000) also influence the chemical composition and nutritive value of sorghum. Kaijage et al. (2014) found that the chemical composition of 12 sorghum varieties expressed in percentage of dry matter gave 10.4 to 12.7% of crude protein, 2.66 to 4.05% of ether extract, 1.79 to 6.43% of ash and 1.14 to 2.18% of tannin. Metabolisable energy varied from 12.7 to 13.8

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MJ/kg of dry matter. It appears that the content of crude protein, crude fiber, ether extract, ash and tannin had an effect on metabolisable energy of sorghum grain (Sedghi et al., 2011), while variation in metabolisable energy of feed affect broiler performance (Lee and Leson, 2001).

In Niger, several varieties and hybrids of sorghum are produced (Abdoulaye et al., 2006). It is therefore crucial to evaluate the effect of these varieties on bioeconomic performance of broiler.

Materials and Methods

Ingredients and diets

Sorghum varieties used in poultry feeding by farmers were identified through an investigation. After that, Mota Maradi (MM), IRAT 204 (IRAT), Janjaré (JJ), White Kaoura (WK) and Yellow Kaoura (YK) varieties were selected. IRAT 204 is an improved variety, while others are local varieties. So MM, IRAT, JJ, WK and YK feeds were formulated corresponding to the diets containing Mota Maradi, IRAT 204, Janjaré, White Kaoura and Yellow Kaoura varieties respctively. All of the five sorghums varieties were incorporated at the same ratio in the diets. Formulation has been done according to the nutritional recommendation of National Research Council (NRC) (1994). The ingredients composition and nutritive value of starter and grower diet were reported in Table 1.

Animals, housing and design

The experimentation was conducted at the poultry house of the Faculty of Agronomy in Niamey, Republic of Niger. A total of three hundred and sixty (360) day old broilers (Cobb 500), weighting 42±2g were used for a total of 42 days experimental period. Birds were randomly allotted in 20 pens of 3 m x 0.9 m with 18 chicks each. Temperature and hygrometry varied respectively from 25 to 38°C and from 20 to 67%. Chicks were vaccinated against Newcastle and Gumboro diseases and prevented against coccidiosis. Anti-stress was giving during vaccination and weighting period. The five dietary treatments (MM, IRAT, JJ, WK and YK) were randomly distributed in the 20 pens with 4 replications per treatment.

Laboratory analyses

Raw materials were analyzed in the "Laboratoire d'Alimentation et de Nutrition Animale (LANA)" of "Institut National de la Recherche Agronomique du Niger (INRAN)" for dry matter (DM), Ash, crude protein (CP), ether extract (EE) and crude fiber (CF). Contents of DM and ash samples were determined by the standard method of Association of Official Analytical Chemists (AOAC, 1995). Crude protein (CP) was determined according to the Kjeldhal (N×6.25) method and ether extract (EE) by the method of petroleum ether extraction using Soxhlet machine. The crude fat (CF) content has been determined by the method of (A.O.A.C., 1990).

Table 1: Ingredients and nutritionals compositions of broiler diets used

Ingredients (%)	Starter diet*					Grower diet*				
	MM	IRAT	JJ	WK	YK	MM	IRAT	JJ	WK	YK
Sorghum	59.40	59.40	59.40	59.40	59.40	63.00	63.00	63.00	63.00	63.00
Wheat bran	8.00	8.00	8.00	8.00	8.00	8.50	8.50	8.50	8.50	8.50
Peanut meal	12.00	12.00	12.00	12.00	12.00	11.00	11.00	11.00	11.00	11.00
Fish meal	14.00	14.00	14.00	14.00	14.00	11.55	11.55	11.55	11.55	11.55
Methionine	0.15	0.15	0.15	0.15	0.15	0.10	0.10	0.10	0.10	0.10
Lysine HCl	0.20	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10	0.10
Bone meal	4.50	4.50	4.50	4.50	4.50	4.00	4.00	4.00	4.00	4.00
Peanut oil[1]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Premix[2]	0.25	0.25	0.25	0.25	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	100.00	100.00	100.00	100.00
Calculated nutritional composition										
ME (Kcal/kg MS) [3]	2814	2815	2830	2850	2827	2837	2839	2854	2826	2875
Crude fiber (%)	4.84	4.10	4.10	4.25	4.63	4.83	4.02	3.97	4.20	4.64
Crude protein (%)	22.17	22.66	23.15	23.42	22.36	19.99	20.50	21.02	21.31	20.16
Lysine (%)	1.23	1.23	1.23	1.23	1.23	1.02	1.02	1.02	1.02	1.02
Methionine (%)	0.60	0.60	0.60	0.60	0.60	0.50	0.50	0.50	0.50	0.50
Calcium (Ca) (%)	1.64	1.64	1.64	1.64	1.64	1.44	1.44	1.44	1.44	1.44
NPP (%) [4]	0.60	0.60	0.60	0.60	0.60	0.47	0.47	0.47	0.47	0.47
Ca/NPP	2.73	2.73	2.73	2.73	2.73	3.08	3.08	3.08	3.08	3.08

(*) Diets who contain Mota Maradi (MM), IRAT 204 (IRAT), Janjaré (JJ), White Kaoura (WK) and Yellow Kaoura (YK)sorghum varieties. **(1)** Non refined peanut oil. **(2)** Premix containing per Kg : 220 mg of Mg; 220 mg of Zn; 110 mg of Fe; 248 mg of Cu; 33 mg of I; 77,105 IU of Vit A; 27.538 IU of Vit D; 165 IU of Vit E; 0,11 mg of Vit B12; 8 mg of menadion; 66 mg of riboflavin; 11 mg of thiamin; 66 mg of pantothenic acid ; 275 mg of niacin; 14 mg of Vit B6; 7 mg of folic acid; 3,855 of choline; and 0,33 mg of biotin. **(3)** Metabolisable energy in kilocalorie per kilogram of dry matter. **(4)** Non Pythic Phosphorus.

Calculation of bioeconomics variables and statistical analyses

Feed offered and refusals were recorded daily per pen. Live body weight was collected on day 1, 21 and 42 days old. The cost (in the local markets) of the different feed ingredients and the chicks live weight price were used to determine the economic parameters. The following variables including daily feed intake, daily weight gain, feed conversion ratio, feeding cost (FC) and economic feed efficiency (EFE) were determined (Houndonougbou et al. (2009a).

$$FC = \frac{FI * FP}{WG}$$

And

$$EFE = \frac{WG \times WGC}{FI \times FP}$$

FI: Feed Intake (kg); FP: Feed Price (FCFA/kg); WG: Weight Gain (kg); WGC: Weight Gain Cost (FCFA/kg);

Carcass characteristics were evaluated using 20 chickens per diet. Carcass weight, carcass yield, feathers yield, head and leg yield, empty gizzard yield and liver yield were determined.

The Statistical analysis of variables was performed in R software version 3.4 (R, 2016) via ANOVA, using the General Linear Model (GLM) procedures. The model used was:

$Y_i = \mu + A_i + \varepsilon_i$ with:

Y_i = dependent variable observed;

μ = general mean;

A_i = fixe effect of diet;

ε_i = residual error.

The mean of variables were showed in tables with standard error (SE) and probability (P). The effect of sorghum varieties is stated significant if $P<0.05$.

Results

Chemical composition

Chemical composition of the five sorghum varieties and calculated metabolisable energy were reported in Table 2. The content of dry matter (DM) varied from 91 to 94.16%. White Kaoura sorghum variety has the highest CP content (13.03%), followed by Janjaré. Mota Maradi variety showed the lower CP content (10.93%). For CF, Janjaré, IRAT 204 and White Kaoura sorghum varieties had the lower rate (2.55 to 2.90%), whereas Mota Maradi and Yellow Kaoura had the higher CF (3.90 and 3.54%). The percentage of EE of varieties varied from 2.15 to 4.25, where IRAT 204 variety had the lowest and White Kaoura had the highest rate (Table 2). IRAT 204 showed more ashes (2.9%) than Janjaré (0.20%), Yellow Kaoura (0.30%), Mota Maradi (0.31%) and White Kaoura (1.23%). The content of nitrogen free extract (NFE) of IRAT 204 sorghum variety was the highest and White Kaoura the lowest. Mota Maradi, Janjaré and Yellow Kaoura had similar NFE content. The concentration of metabolisable energy (ME) varied from 3230 to 3290 kcal/kg. White Kaoura variety contained more ME followed by Janjaré. Mota Maradi contained less ME (Table 2).

Feed intake

The varieties of sorghum used in diet significantly influenced broiler feed intake ($P = 0.001$) at starter phase. Broilers consumed more diet containing Janjaré sorghum variety and less Mota Maradi sorghum variety. However, the difference of feed intake was not statistically significant for broilers fed with diets containing IRAT 204, Janjaré and White Kaoura sorghum varieties (Table 3). At grower phase, feed intake of sorghum was not statistically significant ($P>0.05$) in broiler. The MM based diet was less consumed by broilers comparatively to the others diets.

For the overall experimental phase (42 days), feed intake was statistically influenced ($P<0.05$) by the sorghum varieties used in the diet. Broiler fed with JJ had the highest average daily feed intake (84 g/d). They consumed more than those fed with MM, Yellow Kaoura (YK), IRAT and WK based diet respectively.

Growth performance

The live body weight (LBW) of broiler was reported in Table 4. The difference of initial broiler LBW was statistically non-significant ($P = 0.774$). But at the end of starter phase, the LBW is significantly affected by the sorghum varieties ($P<0.05$). However, this difference was not significant ($P>0.05$) for broiler fed with IRAT, WK and YK treatments (Table 4).

The varieties of sorghum used in diet also significantly influenced ($P<0.05$) broiler LBW at the end of grower phase. Broilers fed with MM had the lowest final LBW (990 g). They had a growth retardation of about 78, 77, 58 and 53% compared to broiler fed with JJ, WK, IRAT and YK respectively. Broiler LBW was not statistically significant for those fed with IRAT and YK on the one hand, and for those fed with JJ and WK on the other hand (Table 4).

At the starter and grower phases, sorghum variety used in diet affected ($P<0.05$) broilers average daily weight gain (ADWG). If JJ allowed the higher ADWG in starter phase, WK induced more weight gain in grower phase. However, MM gave the lowest growth performance on broiler in both starter and grower phases (Table 5).

Broiler ADWG was about 38 g/d during the 42 experimental days. It was influenced by the sorghum varieties in diet ($P<0.05$). JJ had induced the better ADWG which was about 49, 16, 13 and 2% higher compared to the ADWG induced by MM, YK, IRAT and WK respectively.

Table 2: Nutritional value of sorghum varieties used

Varieties	DM (%)	CP (%)	CF (%)	EE (%)	Ash (%)	NFE (%)	ME (kcal/kgDM)
Mota Maradi	91.00	10.93	3.90	3.22	1.98	79.97	3230
IRAT 204	91.33	11.75	2.62	2.15	2.29	81.19	3232
Janjaré	91.04	12.58	2.55	3.44	2.09	79.34	3256
Yellow Kaoura	92.88	11.24	3.54	3.95	1.99	79.28	3252
White Kaoura	94.16	13.03	2.90	4.25	1.06	78.76	3290

DM: Dry Matter; **CP**: Crude Protein; **CF**: Crude Fiber; **EE**: Ether Extract; **NFE**: Nitrogen Free Extract; **ME:** Metabolisable Energy: ME (Kcal/kg) = 21.98×CP + 54.75×EE + 35.18×NFE, Janssen (1989) cited by NRC (1994).

Table 3: Daily feed intake (g/d) of broilers fed with diet containing different variety of sorghum

Phases	MM	IRAT	JJ	WK	YK	SE	P
Starter	37^{c}	51^{a}	53^{a}	52^{a}	46^{b}	2,77	0.001
Grower	69	107	116	111	103	21,49	0.055
Overall	53^{b}	79^{a}	84^{a}	82^{a}	75^{a}	11,88	0.010

^{a,b,c} Means with unlike superscripts in the same row differ significantly (P<0.05).

Table 4: Effect of sorghum varieties on broilers live body weight (g) at the end of each rearing phase

Phases	MM	IRAT	JJ	WK	YK	SE	P
Initial BW	41	41	42	41	41	1.62	0.774
Starter end BW	436^{c}	657^{b}	811^{a}	734^{ab}	644^{b}	74.75	0.001
Grower end BW	990^{c}	1567^{b}	1765^{a}	1749^{a}	1518^{b}	87.75	0.000

^{a,b,c} Means with unlike superscripts in the same row differ significantly (P<0.05)

Table 5: Effect of sorghum varieties on broiler Average Daily Weight Gain (ADWG) (g/d)

Phases	MM	IRAT	JJ	WK	YK	SE	P
Starter	20^{c}	44^{a}	45^{a}	39^{ab}	33^{b}	4.85	0.001
Grower	26^{c}	44^{ab}	46^{ab}	49^{a}	42^{b}	2.79	0.000
Overall	23^{c}	39^{b}	45^{a}	44^{a}	38^{b}	2.54	0.000

a,b,c Means with unlike superscripts in the same row differ significantly (P<0.05)

Table 6: Effect of sorghum varieties on feed conversion ratio (FCR: kg feed/kg body weight gain) of broiler

Phases	MM	IRAT	JJ	WK	YK	SE	P
Starter	1.87^{a}	1.50^{b}	1.22^{b}	1.33^{b}	1.38^{b}	0.18	0.010
Grower	2.64	2.46	2.51	2.30	2.48	0.39	0.822
Overall	2.25	1.98	1.86	1.82	1.93	0.27	0.233

^{a,b} Means with unlike superscripts in the same row differ significantly (P<0.05)

Table 7: Effect of sorghum varieties on feeding cost (FC: FCFA[1] feed/Kg weigh gain) of broiler

Phases	MM	IRAT	JJ	WK	YK	SE	P
Starter	606^{a}	485^{ab}	396^{b}	434^{b}	449^{b}	61	0.002
Grower	790	736	750	689	741	118	0.821
Overall	698	610	573	561	595	83	0.204

^{a,b} Means with unlike superscripts in the same row differ significantly (P<0.05). [1]FCFA: Republic of Niger currency: 1€ = 655.96 FCA at 2016-10-22.

Table 8: Effect of sorghum varieties of on economic feed efficiency (EFE: FCFA weight gain/FCFA feed) of broiler

Phases	MM	IRAT	JJ	WK	YK	SE	P
Starter	1.67^{b}	2.06^{ab}	2.71^{a}	2.32^{ab}	2.24^{ab}	0.43	0.047
Grower	1.27	1.36	1.44	1.46	1.35	0.20	0.707
Overall	1.47	1.71	2.07	1.89	1.79	0.30	0.122

^{a,b}Means with unlike superscripts in the same row differ significantly (P<0.05).

Table 9: Effect of sorghums varieties on broiler carcass characteristics

Parameters	MM	IRAT	JJ	WK	YK	SE	P
Carcass weight (g)	1138^{b}	1699^{ab}	1801^{a}	1909^{a}	1667^{ab}	162.21	0.012
Carcass yield (%)	71.37	74.23	75.25	75.63	73.08	16.22	0.079
Feather yield (%)	4.96	5.20	4.93	5.61	5.39	0.81	0.731
Head and leg yield (%)	6.65	6.83	6.38	6.02	6.81	0.61	0.333
Empty gizzard yield (%)	1.62	2.00	1.71	1.59	1.76	0.29	0.324
Liver yield (%)	1.98	1.90	2.23	1.85	2.34	0.34	0.215

^{a,b}Means with unlike superscripts in the same row differ significantly (P<0.05).

Feed efficacy and efficiency

For the 42 days, FCR of broiler was not statistically influenced (P>0.05) by the sorghum variety in diet. Nevertheless, broiler fed with WK had the lowest and those fed with MM had the highest FCR. During the starter phase, FCR was significantly affected (P<0.05) by the sorghum varieties in broiler diet. JJ sorghum produced the lowest FCR at that phase (Table 6).

Broiler feeding cost in MM diet was more expensive at starter phase (P = 0.002) compared to those in IRAT, JJ, WK and YK diets (Table 7). But, at grower phase and for the overall phases, feeding cost (FC) of broiler was not significantly influenced (P>0.05) by the sorghum varieties used in diet. For the 42 trial days, the average cost of feed to produce 1 kg of live weight was 607 FCFA.

Economic feed efficiency (EFE) was also statistically influenced (P<0.05) by sorghum varieties in broiler diet at starter phase (Table 8). However, EFE was not statistically influenced by sorghum varieties (P>0.05) at grower phase and for the overall experiment. JJ and WK allowed the best financial gains and MM diet produced the lowest one. In general, investment of 1 FCFA in feeding generated 1.79 FCFA by selling live broiler.

Carcass characteristics

The carcass weight was significantly affected by the sorghum varieties used in broiler diet (P<0.05). In general, broiler fed with MM diet presented the lowest carcass and giblets (feather, head and leg, empty gizzard and liver) yields with no statistical difference (P>0.05) compared to the broilers fed with others feeds (Table 9).

Discussion

Chemical composition of sorghum varieties

The varieties of sorghum used have been characterized by variations in their chemical compositions. Indeed, the genetic factors (Gelata et al. 2013), climate, soils (Ebadi et al. 2005) are mentioned as factors that influence the chemical composition of sorghum varieties. These variations influence consequently the content in crude protein, crude fiber and metabolisable energy of diets formulated. The chemicals compositions and concentration of metabolisable energy obtained in this study are in agreement with those reported by Sedghi et al. (2011) on chemical composition of 36 varieties of sorghum and by Kaijage et al. (2014) on 12 varieties of sorghum.

Feed intake

The contents in crude protein, lysine and methionine of diets formulated are in agreement with the nutritional recommendation of National Research Council (1994) for broilers. Also, crude fiber did not exceed 5%. However, MM was less consumed diet for all experimental phases. This variety could have more starch and antinutritional factors than other sorghums. Indeed, starch structure influences broiler feed intake from 9 to 18 day old (Weurding et al. 2003), because non-waxy starch decreased broiler feed intake (Sonia et al. 2015). Antinutritional factors reduce the palatability of diet and depress broiler feed intake (Ferket and Gernat, 2006). Average daily feed intake (47g/d) of broiler in this experiment is superior to reported by Issa et al. (2010) in Niger on broiler Arbor Acre strain from 1 to 42 days in maize replacement by two varieties of sorghum (47 g/d). This could be related to the broiler strain, because one of the varieties used by these authors was IRAT 204.

Growth performance

The varieties of sorghum used in diet influenced broiler performances where, those fed with MM presented the lower performance. Torres et al. (2013) observed the same tendency while using two varieties of sorghum to replace maize in broiler diet. The growth performances of broilers are influenced by chemical composition and physical property of sorghum grain (Kim et al., 2000). Also, the nutritive value of sorghum grain is affected by starch structure, protein (Salinas et al., 2006), proportion of kafirin and antinutritional factors (Sonia et al., 2015). The starch digestibility depends on wax or non-wax of grains of sorghum (Wang et al., 2009). Starch from waxy sorghum was more rapidly digested than non-waxy sorghum (Kim et al., 2000). Kafirin, a part of protein, influences the nutritive value of sorghum grain (Sonia et al., 2015). The height concentration of kafirin in sorghum grain induces a low digestibility of protein, metabolisable energy (Salinas et al., 2006) and amino acids such as lysine (Sonia et al., 2015). But also starch protein interaction affects the nutritive value of sorghum grain. A low starch digestibility is associated with a high protein digestibility, which favors higher broiler growth (Weurding et al., 2003). The antinutritionnal factors also act on the nutritional quality of the variety. Protein phytate interaction decreases arginine, proline and lysine availability (Sonia et al., 2015). The tannin has the capacity to reduce metabolisable energy (Sedghi et al., 2011) and amino acids digestibility (Duoda et al., 2003; Ebadi et al., 2005), which accordingly reduces poultry growth (kumar et al., 2005).

Final body weight, in this study, is superior to that reported by Diaw et al. (2014) and Issa et al. (2015) in Cobb 500 and Arbor acre broiler in gradual substitution of maize by sorghum in broiler diet.

Feed efficacy and efficiency

Feed efficacy was affected in starter phase, but not in grower phase with age due to the antinutritional factors tolerance by broiler with age and the phenomenon of the compensatory growth after nutritional stress. Indeed, Lee and Leeson (2001) observed that diet or nutriment reduction provokes a weight gain reduction, but broiler growth accelerates after the period of restriction especially from 35 to 49 days old. Feed conversion ratio of broiler is lower than the one observed by Kwari et al. (2012) in gradual replacement of maize by sorghum in broiler diet. The feeding cost recorded is higher and the economic feed efficiency is lower than those reported by Houndonougbo et al. (2009b) in broiler using two varieties of maize probably, due to the price of feed. The local sorghum varieties of Janjaré and White Kaoura of Niger are better valorized than the IRAT 204 improved variety by broilers contrary to the result of Diaw et al. (2014) in which, local sorghum was badly valorized by broiler in Senegal.

Carcass Characteristics

The influence of the sorghum variety used in diet on broilers body weight generated a significant effect on the carcass weight. The carcass yield has not been influenced by the sorghum variety (Torres et al., 2013) because broiler which had higher body weight developed more giblet weight. The broiler carcass yield is slightly different than reported by Diaw et al. (2014) with the same broiler strain. Broiler empty gizzard and liver yields are inferior than those reported by Issa et al. (2010), but similar to those observed by Ahmed et al. (2013) in substitution of maize with low tannin sorghum in broiler diet.

Conclusion

The sorghum variety used in diet significantly influenced broiler feed intake and growth performance. It affected carcass weight. However, sorghum variety had a significant effect on feed conversion ratio, feeding cost and economic feed efficiency for starter phase only. Diet containing Mota Maradi sorghum variety (MM) caused a lower growth performance. All other varieties produced similar results.

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