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ORIGINAL PAPER

Effect of commercial diets quality on bio-economic performances of broilers in Benin

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Abstract The objective of this study was to assess the quality of commercial poultry feeds in Benin. The performances of 396 unsexed broilers chickens Ross 308 fed with a control diet (R1) and five commercial diets (R2 to R6) were evaluated. Broilers fed commercial diets showed significantly low ($P<0.001$) body weight gain (BWG) and economic feed efficiency (EFE) and significantly high ($P<0.001$) mortality rate, feed conversion ratio and feed cost (FC). At 42 days of age, the body weight of broilers fed control diet was 1662 g versus 838 to 1041 g for broilers fed commercial diets. In R1 diet, overall FC was 388 Fcfa/kg BWG, and EFE was 2.7 Fcfa BWG/Fcfa feed. These values represented respectively 50 to 64% and 1.6 to 2.0 times the FC and the EFE recorded in commercial diets. A deficiency in crude protein and metabolisable energy, combined with high contents of crude fibre and total ash was found in some commercial diets. These results suggest the necessity to organize the market of poultry feed in Benin in the perspective to reduce the production cost by using more efficient and cheap commercial diets.

Keywords Benin · Body weight gain · Broilers · Commercial diets · Economic feed efficiency · Feed cost

Abbreviations

BW	body weight
BWG	body weight gain
CF	crude fibre
CP	crude protein
d 21	21 days of age
EFE	economic feed efficiency
FC	feed cost
Fcfa	currency of Benin 1€=655.9 Fcfa
FCR	feed conversion ratio
GE	gross energy
ME	metabolisable energy

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Introduction

Despite the intensification of the poultry production system, feed continues to account for 54 to 64% of the total production cost and 39 to 53% of total revenue in South Africa (Madiya 2005). It is therefore essential to have a market of efficient and cheap feeds. In developing countries where the import of poultry meat constitutes a constraint for the development of domestic production, the reduction of the production cost should be a prior objective.

Unfortunately, in some of those countries, the lack of control of commercial feeds allows companies to sell any quality of feeds. Studying 200 poultry feeds from eight countries in East Africa, Bastianelli et al. (2005) stated that, in most of cases, the diets analyzed might not allow satisfactory performances. Similar result was found in Senegal, where an addition of lysine to commercial diet resulted in a significant improvement of broilers performance (Cissé et al. 2001). According to Apantaku et al. (2006), in Oyo state of Nigeria, 84% of poultry farmers prefer and use self-compounded feeds instead of commercially compounded feeds.

The higher production performance and feed conversion efficiency make today's chickens more susceptible to heat stress than before (Lin et al. 2006). A decrease of feed intake, growth and protein deposition combined with an increase of fat retentions in broiler was recorded, when in chronic heat cases, ambient temperatures were above 30°C in poultry houses (Geraert 1991). To deal with high temperatures constraints on poultry performance, National Research Council (1994) suggested an increase of the requirements in protein and amino acids in warmer environment in accordance with expected differences in feed intake. To increase feed intake, Jensen (2000) suggested the pelleting of diet, while Larbier and Leclercq (1994) proposed an increase of dietary fat in order to reduce heat increment of nutrient metabolism. To exteriorize their full growth potentiality, broilers require very high quality of diet. Francesch et al. (2002) reported a decrease of the digestibility of dry matter and energy when cellulose level increased in broiler diet.

Many dietary factors affect broilers' performances and should to be considered when formulating and processing diets for poultry in warm and humid environment. The objective of this study was to investigate the relationship between the quality of commercial feeds, broilers growth performances and some economic variables of feeding.

Materials and methods

Diet and sampling

In Southern and Centre of Benin, 30 commercial companies producing feeds for monogastric animals were identified by a survey. They were categorized according to their processing equipments and the region. Then, 5 companies having similar equipments were sampled randomly from the 5 regions for feed purchase.

Six dietary treatments were used in the experiment; a control diet (R1) and 5 diets (R2 to R6) purchased in commercial companies. All diets were in mashed form. The control diets (starter and grower) were processed in a commercial company and their ingredients were purchased at the market prices. Thus, these prices included the benefit of the company.

The compositions of the control diets as formulated are presented in Table 1. The formulation of diets was

Table 1 Ingredients and chemical composition of control diets (R1) as formulated and fed

Ingredients /Nutrient	Starter diet	Grower diet
Ingredients (in 100 kg diet)[1]		
Maize	60	60
Soybean meal	30	20
Fish meal	5	3
Wheat Bran	2	4.5
Oyster Shell	1.75	1.40
Cotton seed meal	–	8
Palm oil	–	1
Lysine	0.10	0.10
Methionine	0.30	0.30
NaCl	0.30	0.30
Bi-calcium Phosphate	0.30	1.15
Premix[2]	0.25	0.25
Nutrients/Energy		
Crude Protein (%)	21.2	19.0
Crude fat (%)	3.83	5.10
Crude Fibre (%)	3.52	3.82
Lysine (%)	1.29	1.06
Methionine (%)	0.62	0.53
Methionine + Cystine (%)	0.77	0.67
Calcium (%)	1.14	1.28
Total Phosphorus (%)	0.76	0.87
Phosphorus available (%)	0.43	0.51
ME (MJ/kg diet)	12.4	12.5

[1] Ingredients were not analyzed; the compositions used were from Institut National de la Recherche Agricole (1989)

[2] Premix contained per kg:

Vitamins: A 4000000 UI; D3 800000 UI; E 2000 mg; K 800 mg; B1 600 mg; B2 2000 mg; niacin 3600 mg; B6 1200 mg; B12 4 mg; choline chloride 80000 mg

Minerals: Cu 8000 mg; Mn 64000 mg; Zn 40 000 mg; Fe 32000 mg; Se 160 mg.

done in solver of Excel software (Thomson and Nolan 2001) using the chemical composition of feedstuffs from Institut National de la Recherche Agricole (1989).

Feeding

Diets were assigned to repetitions by random. From first day of experiment (d 1), chickens in 3 repetitions were fed the same diet. At grower phase, the starter diet was progressively substituted by the grower diet from the same origin (control or commercial) at the respective daily rate of 33, 67, and 100% on the third day. Exceptionally, starter and grower diets were identical in treatment R4 according to the prescriptions of the company. Birds were fed *ad-libitum* and they had free access to drinking water. Feed delivered and feed residue, were recorded daily per repetition.

Animals and housing

396 broilers chickens (Ross 308) were used. They were day-old chickens of both sexes transported by car from Ghana to Cotonou in Benin (about 350 km). At their arrival a day after hatching, they were divided in 18 repetitions of 22 chicks each. In repetitions, the average weights per chicken varied from 29.9±0.85 to 30.9±0.43 g.

During the first 3 weeks, chickens were kept on deep litter in a starter room provided with heating and lighting systems. The heating was stopped at the end of week 2. In the room, the average temperatures (minimum and maximum) measured during the starter phase varied from 27.5 and 33.2°C, while the relative humidity varied from 62.2 to 79.7%.

At day 22 of age (d 22), birds were moved during nighttime to pens under natural light for the grower phase. During 3 weeks, birds were maintained in 18 pens until d 42. In pens, the average temperatures and relative humidity varied, respectively, from 26 to 32°C, and from 73 to 88%. Densities of animal on litter were respectively 15 and 6 birds/m^2 at starter and grower phases. During the experiment, birds were weighted weekly.

At d 45, 7 broilers per treatment were slaughtered for carcass study. In each treatment, the body weights of animals sampled in the 3 repetitions were similar to the average weight of the treatment. The throat of each bird was cut, and birds were hanged during 20 minutes for bleeding. Then, each bird was weighted before and after removing feathers using hot water. After that, head and feet, heart and spleen, empty gizzard, liver, and carcass, were weighted separately. The experimental design is summarized in Table 2.

Laboratory analyses

Experimental feeds were analyzed at the Faculty of Life Sciences, University of Copenhagen in Denmark. Dry matter (DM) was obtained by evaporation of water at 105°C. Ash was determined after burning the material at 525°C. Nitrogen (N) content was estimated by the technique of Kjeldahl. The percentage of crude protein (CP) was determined as N×6.25.

The method of petroleum ether extraction after HCl hydrolysis was used to determine fat content. Gross energy (GE) was measured in an adiabatic bomb calorimeter (IKA® calorimeter system, IKA® GmbH & Co. KG, Staufen, Germany).

Crude fibre (CF) was determined using the Fibertec FiberCap 2021/2023 system (FOSS Tecator AB, SE-263 21 Hoganas Sweden). In that method, petroleum ether 40–60°, sulphuric acid 1.25% and sodium hydroxide 1.25% were used to isolate the crude fibre.

Calculations

The metabolisable energy in balanced feeds was estimated from the laboratory results by the following

Table 2 Experimental design

Dietary treatments	R1	R2	R3	R4	R5	R6
Number of starter + grower diets	1+1	1+1	1+1	1[a]	1+1	1+1
Number of animals at start (repetitions)	66 (3)	66 (3)	66 (3)	66 (3)	66 (3)	66 (3)
Number of animals for carcass study	7	7	7	7	7	7

[a] The starter and grower diets R4 were the same.

equation of Sibbald (1980) in Larbier and Leclercq (1994):

$$\mathrm{AMEn\,(kcal/kg)} = 3951 + 54.4\,\mathrm{EE} - 88.7\,\mathrm{CF} - 40.8\,\mathrm{ASH}$$

where, AMEn is apparent metabolisable energy corrected to zero nitrogen retention;

EE crude fat (% of dry matter);

CF crude fibre (% of dry matter);

ASH ash (% of dry matter).

The costs of metabolisable energy (ME) and of crude protein (CP) were calculated by using the feed price, ME and CP per kg of feed:

$$\mathrm{Energy\ cost\,(Fcfa/MJ\ ME)} = \mathrm{Feed\ price/ME}$$
$$\mathrm{Protein\ cost\,(Fcfa/g\ CP)} = \mathrm{Feed\ price/CP}$$

For a given phase, the economic feed efficiency (EFE) was calculated as following:

$$\mathrm{EFE\,(Fcfa\ BWG/Fcfa\ feed)} = \mathrm{Revenue\ BWG/Feed\ cost}$$

where, BWG is the body weight gain and feed cost is the amount invested in feeding.

The formula of EFE integrates the feed intake (kg), the feed price, the body weight gain (kg) and the price (per kg) of live body weight. It can therefore allow having an economic view of the productivity in a specific market.

Statistical analyses

Data were analyzed using GLM procedure in SAS Institute Inc. (2004), version 9.1.2. The effect of pen (repetitions) and the interaction between diet and pen were not significant (P>0.05). Hence, analyses were performed according to the following model:

$$\mathrm{Y_i} = \mu + \mathrm{D_i} + \varepsilon_i$$

where, Y_i is the observation for dependent variables, μ is the general mean, D_i is the fixed effect of the diet and ε_i is the residual error.

The significance effect of diets on variables was stated when P<0.05. Regression analysis was performed in Microsoft Excel 2000.

Results

Diets composition, feed intake and feed efficiency

The chemical composition of diets from laboratory analyses is presented in Table 3. In control diets, data showed some differences between ME, CP, fat, crude fiber (CF) from laboratory analyses (Table 3) and the calculated values during the formulation of diets (Table 1). CF in both R5 diets was very high compared to that in other diets.

Furthermore, starter R2, R4 and R5 diets were particularly poor in CP. In addition, ME in starter R5

Table 3 Chemical composition of diets as fed, calculated metabolisable energy (ME); Cost of crude protein (CCP) and of metabolisable energy (CME)

Nutrients/Energy	Starter diet (0–3 weeks)						Grower diet (4–6 weeks)					
	R1	R2	R3	R4	R5	R6	R1	R2	R3	R4	R5	R6
Dry matter (%)	80.6	81.1	82.1	78.1	81.7	80.3	83.6	84.3	81.0	78.1	78.9	74.8
Total ash (%)	7.1	11.6	8.6	6.2	10.7	9.4	6.3	14.9	7.9	6.2	10.2	6.7
Crude Protein (%)	21.9	16.3	18.3	16.0	15.1	19.1	18.1	17.0	19.9	16.0	17.3	17.9
Crude Fat (%)	1.0	3.3	3.1	3.7	2.5	4.1	5.4	5.8	1.3	3.7	1.2	1.4
Crude Fiber (%)	5.0	3.2	3.7	3.3	10.5	4.9	3.0	2.4	3.9	3.3	9.6	5.4
ME (MJ/kg diet)	10.9	11.2	11.7	11.7	9.07	11.2	13.0	11.9	11.2	11.7	8.71	9.99
ME/GE (%)	76.4	81.7	80.9	81.3	63.4	76.6	83.4	84.0	78.7	81.3	66.2	75.5
ME/CP (kJ/g)	49.5	68.7	63.8	73.3	60.2	58.4	72.0	70.3	56.0	73.3	50.4	55.7
CCP (Fcfa[a]/g CP)	0.91	1.38	1.20	1.40	1.16	1.26	1.05	1.32	1.15	1.40	1.01	1.23
CME (Fcfa /MJ ME)	18	20	19	19	19	22	15	19	21	19	20	22

[a] 1 €=655.9 Fcfa

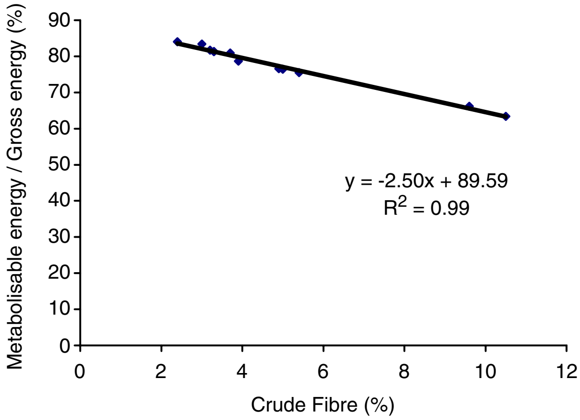

Fig. 1 Relationship between metabolisability of energy and crude fibre in diets of broilers

diet and grower R5 and R6 diets were the lowest; while in R2 and R5, both starter and grower diets were rich in total ash (minerals). Economically, ME cost at grower phase and mainly CP cost at starter phase were low in the control diet.

A negative relationship was established between the metabolisability of energy and the CF in diets (Fig. 1). In that figure, the increase of CF resulted in the decrease of the metabolisability of energy.

Feed intake and feed conversion ratio (FCR) are presented in Table 4, while Fig. 2 shows the pattern of the daily feed intake. At starter phase, and for overall phases, feed intakes were similar. However, at grower phase, the feed intake of broilers fed with control diet was significantly higher ($P<0.001$) than the feed intakes in R2, R3 and R4 diets. The switch of diet at 3 weeks of age and probably the change of environment affected negatively in week 5 the feed intake of broilers fed with R2 and R3 (Fig. 2).

During the whole experimental period, and particularly at starter phase, feed conversion ratio (FCR) in control diet (R1) was significantly lower ($P<0.001$) than that in commercial diets (1.9 versus 2.7 to 4.5, and 1.7 versus 2.5 to 3.9, respectively). Within commercial diets, the FCR was high in R2, R5 and R6 diets having lower CP and/or ME.

Growth and mortality

As consequence of the disparities in feed intake and feed efficiency, the body weight gain, the final body weight and the carcass weight of broilers fed with the control diet were significantly higher than those of broilers fed with commercial diets (Table 5). Thus, the broilers fed with less efficient diets (R2, R5 and R6) had the lowest final and carcass weights. At d 42, the final average body weight of broilers fed with the control diet was about the double of the weights of broilers fed with R2, R5 and R6 diets. At that age, 38% of birds in control diet had a final body weight of about 1700 g and the highest weight was 2260 g, whereas in commercial diets only 32% of birds had above 1000 g with 1590 g as the highest weight.

From week 2, the live weight of broilers fed with the control diets (R1) became higher than that of broilers fed with commercial diets. That pattern was maintained until the end of the experiment (Fig. 3).

The switch of diet from d 22, affected negatively the growth of broilers fed R2 diet, and increased their mortality rate from 0 to 6.9% during the grower

Table 4 Daily feed intake and feed conversion ratio (FCR) of broilers fed control (R1) and commercial diets

Diets	DFI (g)			FCR (g Feed/g BWG[1])		
	Starter	Grower	Overall	Starter	Grower	Overall
R1	39.4	120.0^{a}	79.7	1.74^{a}	2.16^{a}	1.95^{a}
R2	37.9	75.1^{c}	56.5	2.49^{b}	3.68^{b}	3.08^{be}
R3	33.6	94.2^{b}	63.9	2.57^{b}	2.76^{a}	2.67^{b}
R4	35.4	96.4^{b}	65.9	2.52^{b}	2.81^{a}	2.67^{b}
R5	37.9	113.0^{ab}	75.4	3.86^{c}	5.08^{c}	4.47^{c}
R6	29.4	102.3^{ab}	65.8	2.98^{b}	3.71^{b}	3.34^{de}
SE	6.7	6.7	9.3	0.19	0.24	0.18
P-value	>0.05	<0.001	>0.05	<0.001	<0.001	<0.001

$^{a\ b\ c\ d\ e}$ Means with unlike superscripts in the same column differ significantly ($P<0.05$);

[1] Body weight gain

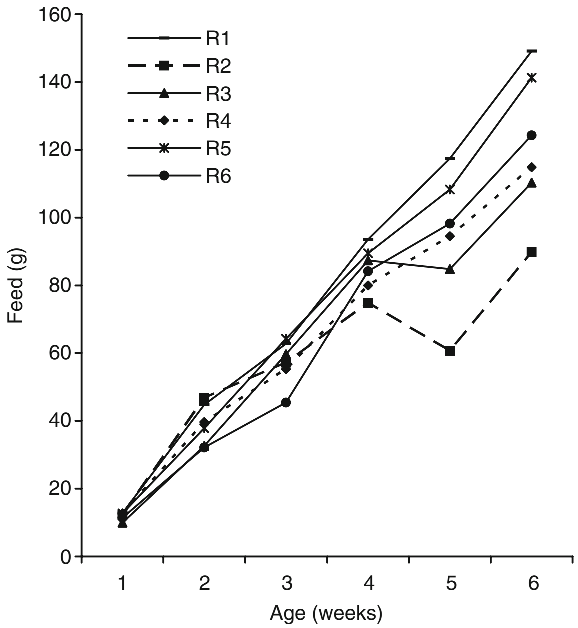

Fig. 2 Daily feed intake of broilers fed control (R1) and commercial diets

phase. Hence, a decrease of the slop of the growth curve of broiler in R2 occurred until 5 weeks of age (Fig. 3).

In general, mortality decreased from starter to grower phase. For the whole 6 weeks (Fig. 4), the lowest mortality rate (11.4%) was recorded in control diet and was significantly different ($P<0.001$) from those recorded in commercial diets (19.7 to 29.6%). Furthermore, in R1 diet, no mortality was recorded after two weeks of age, whereas in week 3 the weekly mortality rate in commercial diets varied from 2.1 to 4.2%.

Economics of feeding

In each treatment, the maximum difference in feed price between starter and grower feeds was 10 Fcfa per kg (Table 6). The overall feed cost per kg of body weight gain in control diet (388 Fcfa) was significantly lower than the costs (602 to 776 Fcfa) in commercial diets. Overall feed costs in commercial diets were 1.6 to 2.0 times the overall feed cost in the control diet. Furthermore, the economic feed efficiency (EFE) showed that, in control diet, feed cost represented only 38% of revenue when selling live broiler, while in commercial diets it was necessary to invest in feeding 60 to 78% of the revenue (Table 7).

Independently to the diet, feed cost and EFE were lower during the starter phase than the grower phase, indicating a better economic productivity in the earlier phase of broilers' growth.

Carcass characteristics

The carcass yields and the relative weights of some organs are presented in Table 8. The carcass yields were similar, whereas the relative weights of some organs were significantly different between diets. Thus, broilers fed with the control diet had a significantly low relative weight of head and feet (6.2%) and of gizzard, including proventricule (2.3%) compare to those of broilers fed with commercial diets (7.8 to 8.3% and 3.0 to 3.8%, respectively). The richest diet (R5) in crude fiber had the highest relative weight of gizzard. The relative weight of liver and spleen seemed higher in commercial diets with high mortality rate (R3 and R4) than in control diet (R1). However,

Table 5 Body weight gain, final body weight and carcass weight of broilers fed control (R1) and commercial diets

Diets	Body weight gain (g/day)			Final body weight (g)		Carcass weight (g)
	Starter	Grower	Overall	d 21	d 42	
R1	21.6^{a}	56.0^{a}	38.9^{a}	485^{a}	1662^{a}	1105^{a}
R2	14.4^{b}	22.5^{b}	18.4^{b}	332^{b}	805^{b}	538^{b}
R3	12.3^{b}	34.4^{c}	23.4^{b}	289^{c}	1011^{c}	658^{c}
R4	13.7^{b}	34.4^{c}	24.1^{b}	318^{bc}	1041^{c}	659^{c}
R5	9.3^{b}	23.5^{b}	16.4^{b}	226^{d}	718^{b}	521^{b}
R6	9.7^{b}	28.8^{bc}	19.2^{b}	233^{d}	838^{b}	582^{bc}
SE	2.2	2.8	3.1	12	45	37
P-value	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001

a b c d Means with unlike superscripts in the same column differ significantly ($P<0.05$)

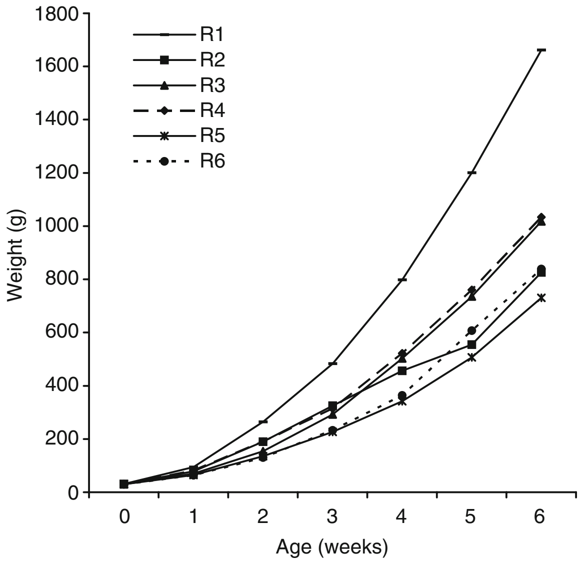

Fig. 3 Growth curves of broilers fed control (R1) and commercial diets

the difference was not significant. When comparing the control diet with commercial diets, no significant difference was found in the relative weight of feather.

Discussion

Diet composition, feed intake and feed efficiency

The content in ME, CP, fat and CF of all diets (Table 3) was different from the allowances recommended by National Research Council (1994). Consequently, the ratio ME/CP instead of being higher in grower diets compared to starters diets, was lower in some commercial grower diets (R3, R5, R6) and similar in others (R2, R4). In control diets, the differences in ME, CP (at grower phase mainly), fat and crude fiber between data calculated (Table 1) and those from chemical analyses (Table 3) could be linked to the chemical composition of feedstuffs used. Such differences confirm the variation of feedstuffs' composition according to their origin. Comparing corn and soybean meal imported in Lebanon from different origins, Barbour et al. (2008) found lower CP, fat and fiber in corn compared to the values of the premium corn reported by NRC (1994). They recommended to feed importers the re-evaluation of the corn grain in order to preserve the quality. Harvesting conditions may have a small influence on energy content in maize with a difference of about 200 kJ/kg on dry matter basis when maize is harvested too early with 40% of moisture (Larbier and Leclecq 1994). Furthermore, the energy content of by-products depends on the processing methods. Solvent extraction is more efficient in oil extraction from seed than expeller process (McDonald et al. 2002). It is therefore, helpful to have tables of feedstuffs' composition according to countries or regions having similar production conditions or processing technologies. The high CF and the low ME in R5 diets might be due to the used of rice bran, as the residues were easily identified in the feed. However, the chemical composition of ingredients cannot reasonably explain the very high rate of total ash in grower diet R2. That diet could contain exceptionally a high amount of sand as many ingredients are dried on the floor in many regions of Benin.

Despite the differences between diets in mainly ME, CP and CF, there was no significant difference in feed intake at the starter phase. Apart from the capacity of gastrointestinal tract, the dietary energy and crude fiber levels also regulate feed intake in broiler (Pond et al. 1995). The feed intake decreases when dietary energy increases and, if the diet is diluted with less digestible ingredient (like CF) the animal increases its consumption (Pond et al. 1995). The starter diet R5 that had the lowest CP and ME and the highest CF might be normally more consumed than other diets. Most of feed intakes recorded at that phase are in the interval of 35–49 g reported by Fasuyi and Aletor (2005) in broilers up to 4 weeks of age, when testing in Nigeria the optimum rate of cassava leaves in broiler diet. In this experiment, it seemed that birds were limited by their capacity of ingestion at starter phase. Hence, an increase of

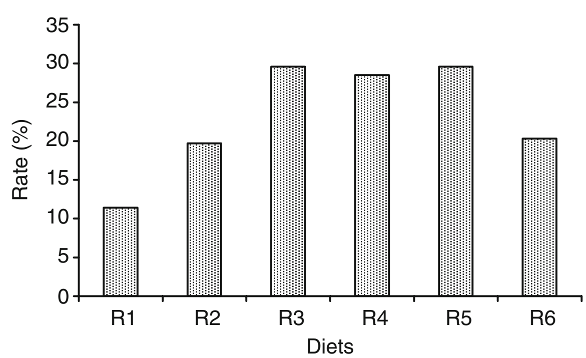

Fig. 4 Mortality rate of broilers fed control (R1) and commercial diets during 6 weeks

Table 6 Feed prices and feed costs of broilers fed control (R1) and commercial diets

		R1	R2	R3	R4	R5	R6	SE	P-value
Feed price (Fcfa[1]/kg)	Starter	200	225	220	225	175	240	–	–
	Grower	190	225	230	225	175	220	–	–
Feed cost (Fcfa/kg BWG[2])	Starter	349[a]	559[b]	566[b]	567[b]	675[c]	717[c]	39	<0.001
	Grower	407[a]	762[b]	630[b]	637[b]	850[c]	782[b]	21	<0.001
	Overall	388[a]	668[b]	603[c]	602[c]	776[d]	742[e]	14	<0.001

[a b c d e] Means with unlike superscripts in the same row differ significantly (P<0.05)

[1] 1 €=655.9 Fcfa;

[2] Body weight gain

nutrients and energy levels in diets could result in an increase of their intakes and consequently an improvement of the growth performances. The feed intakes of broilers in R1 and R5 diets during the grower phase were nearly the same as 108–123 g reported in Côte d'Ivoire by Yo et al. (1997) with different forms of diet between d 15 and d 42. However, feed intakes of overall phases were lower than 83 g recorded by Yo et al. (1998) with a complete diet. In addition, they were lower than 26 to 170 g recorded with pellets diet in Denmark by Hellwing et al. (2006) from d 3 to d 34. That difference could be due to the effect of mashed form of the diets used (Amerah et al. 2007; Jensen 2000) and the effect of environmental factors such as the high-temperature (28 to 33°C) and the high humidity (62 to 80%) during the experiment (Lin et al. 2006). The between-diet variation in feed intake was significant at grower phase only. That situation could be explained by the switch of diets combined with the poor quality of commercial diets and probably the presence of: (i) unlike ingredients (the lowest intake was recorded in R2 diet containing the highest total ash), (ii) anti-nutritional factors (probably gossypol, aflatoxin, etc.) and (iii) smells.

The feed conversion ratio (FCR) of overall phases in control diet (1.95) was lower than 2.29 found in Nigeria by Obun et al. (2008), but was in agreement with 1.9 (Fasuyi and Aletor 2005) and 2.0 (Cisse et al. 2001) reported, respectively in Nigeria and Senegal. FCR in commercial diets (2.7 to 4.5) were higher than these references. Irrespective of the diet, FCR increased at grower phase compared to the starter phase, confirming a better efficiency of diets at the earlier growth phase of broilers (Larbier and Leclercq 1994). The highest FCR were recorded in diets R5, which was particularly rich in crude fibre (about 10%), certainly because crude fibre is almost indigestible by broilers (Spesfeed 2006; Francesch et al. 2002). Thus, the digestibility of organic matter might be lower in diets R5 than other diets.

Growth and mortality

The differences in feed intake and in chemical composition of diets affected the growth performances. Up to d 42, the daily body weight gain (BWG) of broilers in control diet (38.9 g) was higher than 30.3 g reported by Obun et al. (2008). Irrespectively of the diets, BWG increased during grower phase (Table 5) and was about 1.6 to 3 times the BWG at starter phase. Despite that, the FCR increased (Table 4) indicating a lower efficiency of grower diets comparing to starter diets. Such contrary results could be mainly explained

Table 7 Economic feed efficiency (EFE in Fcfa of BWG [1]/ Fcfa[2] feed) of broilers fed control (R1) and commercial diets

	R1	R2	R3	R4	R5	R6	SE	P-value
EFE starter	2.90[a]	1.71[bd]	1.83[b]	1.82[b]	1.64[cd]	1.46[c]	0.13	<0.001
EFE grower	2.51[a]	1.32[b]	1.64[c]	1.63[c]	1.25[b]	1.33[b]	0.09	<0.001
EFE overall	2.70[a]	1.61[bc]	1.75[b]	1.74[b]	1.33[c]	1.44[c]	0.09	<0.001

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

[1] Body weight gain

[2] 1 €=655.9 Fcfa;

Table 8 Carcass yield and relative weight of organs (% BW[1]) of broilers fed control (R1) and commercial diets

	R1	R2	R3	R4	R5	R6	SE	P-value
Carcass yield	68	67	65	67	64	66	1.6	>0.05
Feathers	3.9^{ab}	3.0^{a}	4.5^{b}	3.5^{a}	4.6^{b}	3.1^{a}	0.35	<0.01
Gizzard	2.3^{a}	3.4^{bc}	3.2^{b}	3.0^{b}	3.8^{c}	3.4^{bc}	0.17	<0.001
Liver and spleen	2.1	2.3	2.5	2.5	2.4	2.3	0.12	>0.05
Head and feet	6.2^{a}	8.2^{b}	8.1^{b}	7.8^{b}	8.3^{b}	8.0^{b}	0.24	<0.001

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

[1] Body weight

by an increase of feed intake at grower phase (2 to 3.2 times of the feed intake at starter phase), and in certain extent by the changes in the composition of diets.

On the whole, the growth of broilers was lower in commercial diets than in control diet. The final average body weight of broilers in control diet (1662 g) was similar to 1696 g recorded at the same age (d 42) in Cameroon (Dongmo et al. 2005) and was close to 1715 g reported in Côte d'Ivoire (Yo et al. 1998). The low CP in commercial diets, the low level of ME in R5 and R6 diets, and also the high crude fiber in R5 diets might explain the low growth and the high mortality found in commercial diets. Probably, a deficiency of these diets in essential amino acids (case in Senegal, Cisse et al. 2001) and in minerals could also be a reason. Further chemical analyses could therefore give more information.

The mortality rates in all diets were high compared to 3.3 to 6.7% (Eruvbetine et al. 2003) and 6.3 to 8.9% (Spesfeed 2006). However, the mortality rate in control diet (11.4%) was nearly the same as 11% obtained in tropical conditions in Venezuela at 42 days of age (De Basilio and Picard 2002). It was lower than the maximum mortality of 16.3% reported at 49 days of age in broilers farms by Teguia and Beynen (2004) when comparing a farm-made feed with commercial feeds in Cameroon. In this experiment, it seems that, apart from diet effect, the conditions of transport of chicks (about 350 km by car) crossing three countries (Ghana, Togo and Benin), their light weight (about 30 g) and the high-temperature along high relative humidity, increased the mortality. However, from d 14 no mortality was recorded in control diet. The present experiment did not show therefore, a significantly high late mortality as reported by De Basilio and Picard (2002) when they studied the effect of early-age thermal conditioning of chicks at d 5 on the survivability of broilers in tropical conditions. The non-recording of late mortality in this study could be linked to a low density of broilers in pens at grower phase (6 birds/m^2) comparatively to 9 or 12 birds/m^2 adopted by these authors. The results of this experiment confirmed a better survivability of broilers in case of better feeding.

Economics of feeding

During the whole experimental period, the lowest feed cost (FC) and the highest economic feed efficiency (EFE) were recorded in control diet (R1). The overall FC and EFE in R1 represented, respectively, 50 to 64% and 1.6 to 2.0 times of FC and EFE in commercial diets. These economic variables suggest that, the feeding of broilers with cheap diet might not necessary result in low FC and consequently in low production cost. This statement is supported by both R5 diets were the cheapest. Unfortunately, the overall FC and EFE in R5 were respectively the highest and the lowest. That situation was mainly due to a low efficiency of R5 diets, which were too rich in CF and poor in CP and ME. These results demonstrated the possibility to have in Benin, more efficient diets at lower prices than those offered by commercial feeds companies, even if feedstuffs are purchased at market prices, as it was the case for the control diets.

The overall FC (388 Fcfa/kg BWG) recorded in R1 was 8% lower than 422 Fcfa/kg BWG, reported by Dongmo et al. (2005) in Cameroon at d 42, while it was 22 to 43% more expensive than the values found in Nigeria up to d 35 (Ezieshi and Olumu 2004). Such differences indicate that, there was between Benin and Cameroon an economic comparative advantage in broiler production for Benin, whereas it was the opposite between Benin and Nigeria. However, these comparisons did not include the probable inflation rate on the feed prices and on the live weight of broilers from 2004 or 2005 to 2006, respectively, in Nigeria and Cameroon. Furthermore,, a rearing up to d 42 instead of d 35 could increase the results from Nigeria.

Carcass yields and proportions of organs

The significantly high relative weight of gizzard, including, proventricular found in commercial diets might be the consequence of high muscular activities of that organ during the digestion (Spesfeed 2006). The use of the richest diets in crude fibre (about 10% in R5) resulted in the highest relative weight of gizzard (3.8%). Similar results were reported by Eruvbetine et al. (2003) with relative weight of gizzard plus proventricular between 2.2 and 3.4% corresponding to diets containing, respectively, 4.6 to 7.7% of crude fibre. The carcass yields found here were in the range of 64.6 to 68.3% reported by Teguia and Fon Fru (2007) in Cameroon.

R3 and R5 diets had the highest feather relative weight. One can assume that, they contained high amount of digestible cystine and methionine as these amino acids are involved in feather growth (Spesfeed 2006; McDonald et al. 2002). The significant difference in relative weight of head plus feet might be a consequence of the significant difference in body weight between diets.

On the whole, the significant differences, found between control diet and commercial diets in mortality, growth performances, feed cost and feed efficiency, suggest that, farmer benefits in broilers production could be improved, if more efficient and cheap diets were supplied by feed companies. As feedback, the demand of commercial diets could increase, resulting in an increase of benefit of feed companies and the development of poultry production in Benin.

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