Original Research Article

Effect of incorporating *Hibiscus sabdariffa* seed flour (red variety) on zootechnical performance of broilers chickenscobb500 strain

.

ABSTRACT

The aim of this study was to evaluate effects of incorporating red *Hibiscus sabdariffa* seed meal into the feed ration on the growth performance, carcass characteristics and economic margins of broiler chickens in Côte d'Ivoire. To achieve this, 237 broiler chicks of the Cobb500 strain, two (2) weeks old, were divided into three (3) lots of 79 birds each. lot 1 was fed with ration that did not contain *Hibiscus sabdariffa* red variety (HSR0) seed meal. Lots 2 and 3 were fed respectively by ration HSR 2% and HSR 4% by which contain 2 % and 4 % of *Hibiscus sabdariffa* seed meal respectively. The results showed that the inclusion of *Hibiscus sabdariffa* seeds significantly reduced food consumption in subjects fed HSR 2 and HSR 4 compared with ration HSR 0 (control). It varied from 38.71 ± 1.26 g/d to 161 ± 5.08 g/d for lot 2 and from 37.85 ± 1.16 g/d to 148 ± 6.08 g/d for lot 3 compared with 39.8±1.3 g/dr to 172 ± 7.2 g/d for lot 1. On other hand, the subjects in lot 2 achieved better growth performance than the other lots. They recorded an average weight of 2,334±208.6 g compared with 2,213 ± 170.78 g and 1,958 ± 182.57 g for lots 1 and 3 respectively. Over the 4-week period, the highest mortality rate was observed in lot 1, at 10.13 %. No negative effect was observed on the carcass yield of chickens fed *Hibiscus sabdariffa* meal. In economic terms, incorporation reduced the production cost of broilers. In conclusion *Hibiscus sabdariffa s*eeds can therefore be incorporated up to 2% into chicken rations without causing any significant loss in chicken weight. Studies need to be carried out to improve the organoleptic quality of *Hibiscus sabdariffa* seeds.

Keywords : Broilers, *Hibiscus sabdariffa*, growth, production costs, Karakoro

1. INTRODUCTION

Livestock is a sub-sector that is experiencing the highest growth in developing countries, where it represents a third of agricultural GDP (Bruinsma, 2003) [1]. In sub-Saharan Africa, meat production has doubled over last fifteen years, with 7% increase in poultry production (Ruttan, 2002) [2]. Indeed, poultry farming has a predominant place in animal production in Côte d'Ivoire. Rapidity of biological cycle, high metabolism and low cost of production compared to red meats, poultry farming has experienced a spectacular boom (Koné et Danho, 2008) [3]. Despite this boom, 70% of poultry numbers come from traditional farming and 30% from modern farming for production of white meat and eggs consumption (MIRAH, 2007) [4]. As elsewhere in the world, poultry is an important source of animal protein and generates income for rural and urban populations (KonéetDanho, 2008) [3]. Thus, to contribute to fight against poverty and to reduce of the deficit in animal protein, it is necessary and essential to improve and promote modern poultry production. However, modern poultry production faces various constraints among which there is feeding. Feed represents 60 to 80% of the cost of production in poultry farming and is based on imported

raw materials(Diouf, 2013) [5]. Availability of conventional raw materials such as soybeans, peanuts and their derivatives, fishmeal, corn, etc. for poultry production is not only hampering diet of humans but also that of other monogastricspecies(Atakoun, 2012). [6]. The problem of the supply of feed inputs is crucial in livestock farming today. On the international market, the cost of ordinary raw materials, especially corn, the basis of poultry feed, but also protein raw materials such as soybean and peanut meal, fish meal are increasing (Doumbia, 2002). [7]. Thus, the protein balance of the feed is expensive while it is one of the main determinants of the technical and economic result in poultry production.

Under these conditions, the search for and development of locally available alternative food resources for feeding chickens should improve their productivity while maintaining input and production costs below the level of inflation in this poultry production system (Soniaya et Guéye, 1998) [8]. Among these alternative food resources are *Hibiscus sabdariffa* seeds.

However, according to the results of various studies, *Hibiscus sabdariffa* seeds are a food resource well provided with nutrients. They are rich in oil (18-25%). They contain 26 to 39% protein, essential amino acids, minerals and vitamins. They have fewer toxic or antinutritional factors (Mukhtar *et al*., 2007 [9]; Damang et Guluwa, 2009 [10]; Ayssiwede*et al*., 2011)[11]. They can be used as a supplement in the diet of chickens in breeding (Diarra*et al*., 2011) [12]. Despite the presence and availability of these *Hibiscus sabdariffa* seeds in Côte d'Ivoire, few studies have been devoted to their use in animal feed, particularly in broiler chickens, hence the interest of this study.

The objective of this study is to contribute to improving the diet of broiler chickens by incorporating *Hibiscus sabdariffa* seeds. Specifically, it involves formulating a feed with *Hibiscus sabdariffa* seed flour, determining the growth performance of broiler chickens, and determining the carcass characteristics and the production cost of broiler chickens.

2.1. MATERIAL AND METHODS

2.1.Material

2.1.1 Biological material

Biological material is composed of animal biological material and plant biological material. The animal biological material consists of 237 broiler chicks of the COBB 500 strain aged 14 days with an average weight of 298±10 g. As for the plant material, it consists of industrial feed produced and marketed by company and*Hibiscus sabdariffa* seeds of the red variety which allowed us to formulate three experimental rations.

2.1.2 Technical material

Equipment was used to conduct the breeding. It is a breeding building of 8 meters long and 6 meters wide. Ten feeders and 10 drinkers were used for feeding and watering the chickens. A CAMRY brand scale with a capacity of 20 kg and an accuracy of 100 g was used to weigh the feed and an electronic scale of the Scale brand with a capacity of 15 kg and an accuracy of 1 g for weighing the chickens. A camera of 13pixel has been use for taking pictures; and mercury thermometer to measure the internal temperature of the building. Also gloves , coat and boots have been used for personal protection.

2 2.METHODS

2.2.1 Study site

WOWOYELA is a structure located in Nogotanakaha(in the north of Côte d'Ivoire), 9 km from the city of Korhogo and 11 km from the city of Karakoro. The farm has an area of 5 hectares, 3 ha of which were used for breeding and 2 ha for market gardening. There are 5 buildings that house several activities including broiler chicken breeding, laying hens breeding, pig breeding and bee breeding.

2.2.2 Lot constitution

Lots were constituted after two weeks of start-up. On the fifteenth day of breeding, chicks were transferred to the experimental henhouse. The start-up period of the rearing of chicks

used was carried out in the same farm. After individual weighing, 237 chicks 14-day-old were randomly divided into 3 batches of 79 subjects each and corresponding to the HSR0, HSR2 and HSR4 food treatments.Each lot was delimited by tarpaulins so as to have a density of 6 subjects per square meter. The different lots formed were randomly assigned to the compartments.

2.2.3 Formulation of rations

Hibiscus sabdariffa seeds were purchased in city ofKorhogo (Rep.of Ivory Coast) market. These seeds were winnowed to remove debris and stones that were found there. Then, we proceeded to grind the seeds in the mill. Three (3) experimental growth-finishing rations for broiler chickens were formulated. These are the control rations HSR 0 (not containing *Hibiscus sabdariffa* flour, red variety) and those based on seeds HSR 2 and HSR 4 in which the flour of *Hibiscus sabdariffa* seeds, red variety was incorporated as an additive at respective rates of 2 % and 4 %. The preparation consisted of manually mixing the flour of *Hibiscus sabdariffa* seeds with the industrial feed.

2.2.4 Bromatological analysis

The bromatological analyses of the feed were carried out in the laboratory of the vocational high school of Odienné (Rep of Ivory Coast). These analyses concerned the determination of dry matter, carbohydrates, lipids, crude proteins and ash.

2.2.5 Breeding management

Before the arrival of the chicks, the compartment in front of the brooder was emptied, cleaned with soapy water and then disinfected with bleach and sleet. All the breeding equipment was also washed and disinfected with bleach. The day before the reception of chicks, breeding area of the brooder was covered with litter made of rice straw. For lighting of the building, a 60 watt lamp was installed. In addition, a footbath filled with water and sleet was installed at the entrance to the building. The Cobb500 chicks, upon arrival, underwent routine checks (number, legs, liveliness, etc.). The chicks were mass-reared for two (02) weeks of start-up before being transferred to the breeding building. During the first two weeks of age, the chicks received a commercial crumbled starter feed and borehole water as drinking water. After the transfer, a food transition was made over four (4) days, i.e. from the 15th day to the 18th day. From the 18th day until the end of the trial at 45 days of age, the chicks were fed the previously formulated experimental feed. Water and feed were distributed ad libitum throughout the experimental phase. Each lot of chickens corresponding to a food treatment was subjected to a single type of feed ration throughout the entire trial period. The lighting of the building was permanent throughout the trial. It was ensured on the one hand by natural daylight and on the other hand by artificial light (night lighting) produced by 60-watt bulbs installed in the henhouse. All lots were subjected to the same health prophylaxis (Table 1).

Table 1: Applied prophylaxis on **broilers*chickens***

Âge (day)	Action	Dosage
6	Vaccination against Newcastle and Infectious Bronchitis	Bottle of 1000 doses for 1000 chickens
14	Vaccination againstGumboro	Bottle of 1000 doses for 1000 chickens
21	Reminder of the Newcastle vaccine and Infectious Bronchitis	Bottle of 1000 doses for 1000 chickens

2.2.5 Data collection

2.2.5.1 Feed consumption of broilerschickens

Daily feed consumption was obtained by daily weighing of the quantities of feed distributed and refused by each lot of chickens. These data were recorded on a feed data collection sheet and in the Excel spreadsheet.

2.2.5.2 Live weight of chickens broilers

At the end of the start-up phase (2 weeks of age) corresponding to the beginning of the experimental phase, all chickens were weighed individually and put into lots. From this moment, weights were taken weekly using an electronic scale with a capacity of 15 kg and an accuracy of 1 g. Weight data were collected on the weekly weighing sheet of the chickens.

2.2.5.3 Characteristics of carcass and organs ofbroilers chickens

At the end of the experiment, a sample of 30 subjects taken randomly at a rate of 10 subjects/food treatment was taken. The subjects taken were weighed, slaughtered, plucked with hot water and eviscerated (crop and intestine removed). The colour of the carcasses was observed with the naked eye. Then, the carcasses still containing organs such as the heart, liver, and gizzard were weighed. The organs such as the liver, heart, and gizzard were detached and weighed individually by subject and by food treatment. The various data obtained were thus collected on the collection sheet developed for this purpose. This data was collected on the same sheet as that relating to the weight of the carcass and organs.

2.2.6 Calculation of zootechnical parameters

2.2.6.1 Individual feed consumption (IFC)

Individual feed consumption is used to assess the quantities of feed consumed by animals over a given period. It is calculated from the quantity of feed distributed and that refused.

$$\textbf{IFC}\ (\text{g/subject}) = \frac{\text{Quantity of food distributed(g)} - \text{Quantity of food refused (g)}}{\text{number of subjects}}$$

2.2.6.2 Average live weight (ALW)

The average live weight is the ratio of the sum of the weights of the individuals in the same lot to their numbers.

$$\text{ALW} = \frac{\text{Sum of weights of subjects in the same lot}}{\text{Sample size of lot}}$$

2.2.6.3 Average Daily Gain(ADG)

The weekly measurements of the listed weights made it possible to calculate the average daily gain by making the ratio of the weight gain during a period to the corresponding duration.

$$\text{ADG} = \frac{\text{Final weight} - \text{initial weight}}{\text{number of days}}$$

2.2.6.4 Feed conversion ratio (FC)

This is the ratio between the average quantity of food consumed over a given period and the average weight gain corresponding to this period.

$$\text{FC} = \frac{\text{Average quantity of food consumed/period(g)}}{\text{Average weight gain/period (g)}}$$

2.2.6.5 Morbidity Rate (MR)

The morbidity rate is the set of disease symptoms that animals present. Its formula is as follows:

$$\text{MR}\ (\%) = \frac{\text{number of sick subjects}}{\text{initial number of subjects}} x100$$

2.2.6.6 Mortality rate (MR)

The mortality rate (%) corresponds to the ratio of total number of deaths to initial number of exposed subjects.

$$\text{MR (\%)} = \frac{\text{number of deaths}}{\text{initial number}} x100$$

2.2.7 Carcass yield (CY) and organ yield (OY)

Carcass yield (%) is calculated by taking the ratio of carcass weight to live weight of subject at slaughter expressed as a percentage.

$$\text{CY (\%)} = \frac{\text{Carcass weight}}{\text{Live weight at slaughter}} x100$$

Concerning organ yield, it consists of calculating the ratio between the weight of the organ and the live weight of the subject at slaughter.

It is expressed as a percentage. The organs concerned are: the liver, the heart, the gizzard.

$$\text{OY (\%)} = \frac{\text{Organ weight}}{\text{live weight}} x100$$

2.2.8 Cost of producing a chicken

The cost of producing a chicken includes all the costs incurred by a producer to produce a chicken. The costs related to feed, veterinary and maintenance products, purchase of chicks, labor, heating, lighting and litter.

2.2.9 Data analysis

For the different parameters of the study, the normality of the data was assessed by the Shapiro-Wilk test before performing the analyses of variance or the Kruskal-Wallis non-parametric tests to examine the differences in these parameters between the three types of lots studied. Each test was followed by the Tukey post hoc test to distinguish homogeneous groups from lots. These tests were performed under the SPSS statistical software version 2.0 using the Shapiro test, anova, Kruskal test and Tukey HSD functions, respectively.

3. RESULTS AND DISCUSSION

3 1 RESULTS

3.1 1.Bromatological analysis of the rations

The nutritional values obtained after analysis of the different experimental foods are recorded in Table 2. These values show us that the experimental foods are rich in carbohydrates with the best rate contained in the HSR 2 ration (62.01±0.09%). The proportions of crude proteins are also important in these rations. The highest rate of protein is contained in the HSR 4 ration (24.31±0.28%) and the lowest in the HSR 0 ration (21±0.08%).

Table 2: Bromatological composition of rations

Chemical composition (%)	*Hibiscus sabdariffa*	HSR 0	HSR 2	HSR 4
Carbohydrates	50.14±0.078	61.1±0.08	62.01±0.09	59.8±0.31
Lipids	12.3±0.08	10.9±0.06	9.94±0.06	10.03±0.04
CrudeProtein	28.75±0.12	21±0.08	22.13±0.16	24.31±0.28
Ashes	6.8±0.01	5.4±0.02	5.4±0.01	5.6±0.02
Moisture	2.01±0.13	1.6±0.05	0.51±0.1	0.24±0.03

3.1.2.Growth performances*broilers chickens*

3.1.2 1 Food consumption

Food consumption is presented in figures 1 and 2. This consumption increased progressively in the three lots during the test period. However, the consumption of rations composed of *Hibiscus sabdariffa* seeds decreased significantly (P<0.05) for subjects in lots 2 and 3 over the entire experimental period, unlike control subjects. It went from 39.8±1.3a g/d to 172±7.2a g/d for subjects in lot 1, i.e. a cumulative total of 2,742.6 g. Subjects in lot 2 recorded a food consumption that went from 38.71±1.26b g/d to 208±5.08b g/d, i.e. a cumulative total of 2.599.87g. That of subjects in lot 3 went from 37.85±1.16c g/d to 148±6.3c g/d, i.e. a cumulative total of 2,402.89g.

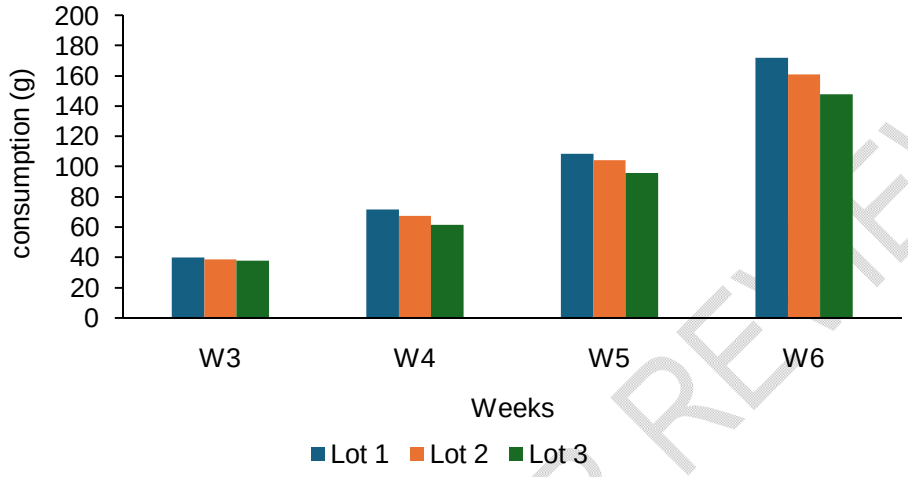

Fig. 1: Average daily feed consumption of broiler chickens

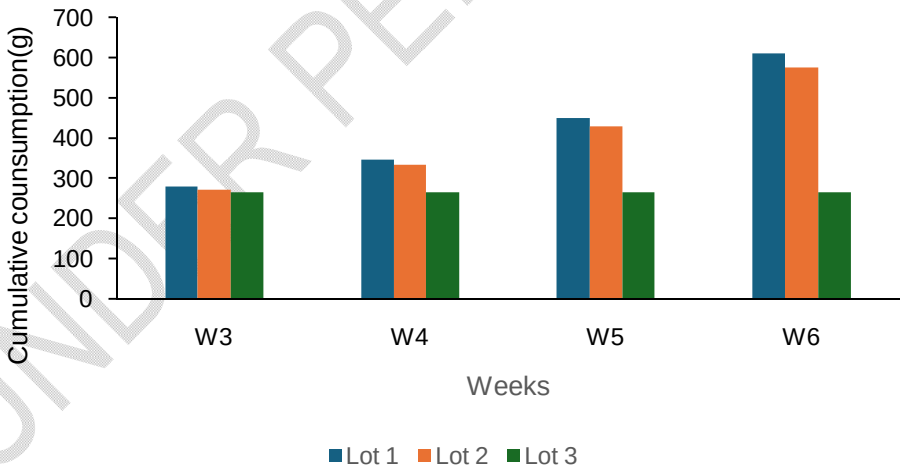

Fig. 2: Cumulative feed consumption of broiler chickens

3.1.2.2 Average live weight

According to Figure 3, the subjects of lot 2 obtained a better average live weight compared to the subjects of lots 1 and 3 during the experiment. They obtained an average weight of 2.334±208.6a g at the end of breeding against 2.213±170.78a g and 1.958±182.57b g corresponding respectively to the average weights of the subjects of lots 1 and 3. A significant difference (P<0.05) between the average live weight of the subjects of lot 3 and the average live weights of lots 1 and 2 at the end of the trial was observed.

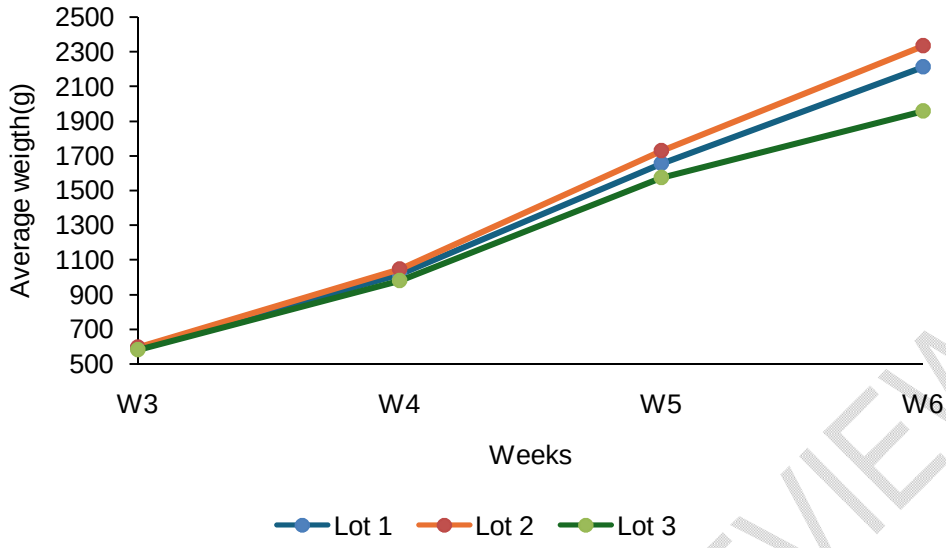

Fig. 3: Average individual weight of broiler chickens

3.1.2.3. Average daily gain

The ADGs obtained by the subjects of the different lots are recorded in Table 3. The subjects of lot 2 obtained better ADGs over the entire experimental period compared to the other lots. The ADGs of the different lots increased progressively from the 3rd week to the 5th week of age. They evolved from 41.91±1.057a g/d to 91.42±4.3a g/d for the subjects of lot 1 and from 42.41±0.35b g/d to 97.85±3.53a g/d for the subjects of lot 2. The subjects of lot 3 having obtained the lowest ADGs, saw their ADGs progress from 40.38±1.43c g/d to 85±6.06a g/d from the 3rd week to the 5th week of age. During the 6th week, a slight decrease in the ADG was observed in all three groups. According to the statistical analysis, a significant difference was observed between the ADGs of the different groups during the first two weeks of the test. However, during the last two weeks no significant difference (*P*> 0.05) was noted between the ADGs. Values with different letters indicate a significant difference between these values (Table 3).

Table 3: Average Daily Gain of different lots of chickens broilers

	ADGs			
Age (weeks)	Lot 1	Lot 2	Lot 3	*P*-value
W3	41.91±1.057^{a}	42,41±0.35^{b}	40.38±1.43^{c}	0.000
W4	60.2±3.62^{a}	64,3±2.67^{b}	57.05±5.13^{c}	0.001
W5	91.42±4.3^{a}	97.85±3.53^{a}	85±6.06^{a}	0.15
W6	79.71±18.82^{a}	86.28±5.65^{a}	54.71±25.35^{a}	0.37

*Legend: a, b, c: values with different letters on the same line are significantly (*P<*0.05*)

3.1.2.4 Consumption index

The consumption index is presented in fig. 4. The subjects of lot 2 who consumed the HSR2 ration obtained the best consumption indices during the test compared to the other groups. This increased from 0.91±0.01b in the 3rd week to 1.87±0.24a at the end of the experiment for chickens broilers in lot 2. The consumption index of the subjects in lot 1 (0.94±0.02a to 1.19±0.05a) was higher than that of the subjects in lot 3 (0.95±0.02a to 1.13±0.1c) from the 3rd week to the 5th week of age. On the other hand, the opposite effect occurred in the last week of the test in subjects of lot 1 and 3. During this last week, subjects of lot 1 obtained 2.16±0.5a as a feed conversion index against 2.7±0.42a for subjects of lot 3. Statistical test

(ANOVA) indicates that there is a significant difference (P<0.05) between the feed conversion indices of the different lots.

Fig. 4: Consumption index of different lots of chickens

3.1.3 Morbidity rate

According to figure 5, the incorporation of *Hibiscus sabdariffa* seed flour had no adverse effect on the health of broilers. Subjects of control lot 1 recorded the highest morbidity rate during the test compared to the other lots. This rate decreased from 2.53% to 0% from the 3rd week to the 6th week of age for the subjects of lot 1. As for the chickens of lot 2, only one sick subject was recorded at the 3rd week of age corresponding to 1.27 %. The chickens of lot 3 also recorded one sick subject during our trial, corresponding to 1.27%. According to the statistical test, there is no significant difference (P>0.05) between the morbidity rates of the different lots.

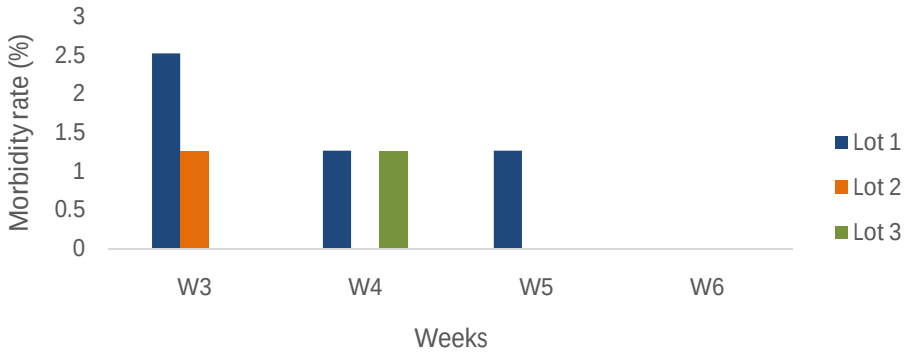

Fig. 5:Morbidity ratesin different lots of broiler chickens

3.1.4 Mortality rate

The mortality rate of broiler chickens is presented in Figure 6. Chickens in lot 1 recorded the highest mortality rate. Mortalities were observed over the first three weeks of testing in subjects in lot 1, i.e. a rate of 10.12%. No mortality was observed in subjects in lot 3 during the experiment. On the other hand, subjects in lot 2 recorded only one death during the 3rd week of age, i.e. a rate of 1.27%. There is no significant difference (P>0.05) between the mortality rates of the different lots.

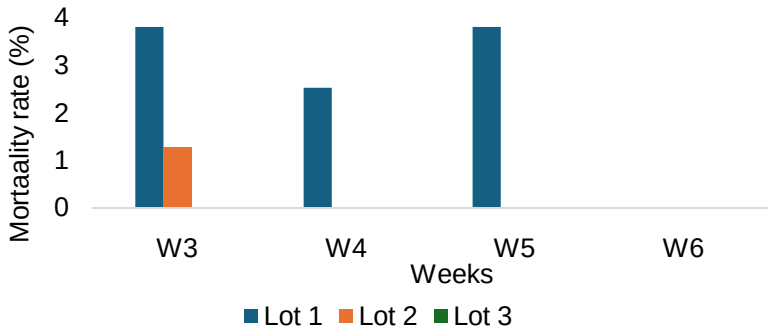

Fig. 6: Mortality rate of broiler chickens in different lots

3.1.5.Carcass characteristics and production cost

3.1.5.1 Carcass characteristics

3.1.5.1. 1 Coloration

Figure 7 shows the carcass coloration of the different treatments. A red coloration is observed in the carcasses of subjects who consumed *Hibiscus sabdariffa* seed flour compared to control subjects. This coloration is all the more important as the incorporation rate is high.

HSR0 HSR2 HSR4

Fig.7: Coloring of the carcasses depending on the treatment

3.1.5.1.2 Carcass yield and organ weight

The results of the effect of incorporating *Hibiscus sabdariffa* red seed meal on carcass and organ characteristics of chickens are reported in Table 4. The subjects of lot 2 obtained a higher carcass weight 1,770±15.5 g compared to lots 1 and 2 which recorded carcass weights of 1,692.83±10.6 g and 1,485.5±8.4 g respectively. Broilers that consumed *Hibiscus sabdariffa* obtained the lowest carcass yields compared to the control lot. The latter recorded respective rates of 76.1% and 75.9% for lots 2 and 3 against 76.5% for lot 1. In terms of organ yield, a significant increase in the overall weight of organs was observed in chickens that consumed rations containing *Hibiscus sabdariffa* seed flour.

Table 4: Characteristics of broiler carcasses and organs

Label	Lot 1	Lot 2	Lot 3
Carcassweight (g)	1 692.83±10,6	1 776±15.5	1 485.5±8.4
Carcassyield (%)	76.5	76.1	75.9
Gizzard (g)	27.5±3.48	30±2.5	34±3.27
Liver (g)	42.5±2.7	50±4.1	45±3.81
Heart (g)	5.66±0.5	7,2±0,72	7.5±0.98
Organweight (g)	75.66±6,68	87.5±7.32	86.5±8.06
Organyield (%)	3.42	3.74	4.42

3.1.5.2 Production cost

Production cost of broiler chickens is presented in Table 5. According to the latter, the incorporation of *Hibiscus sabdariffa* seeds reduced the production cost of chickens. The production cost of a broiler chicken from lot 1 (control) is higher than that of the other lots with 4.05 ± 0.44 USD. Chickens from lots 2 and 3 were produced at the respective average price of 3.92 ±0.41USD and 3.76±0.47 USD.

Table 5: Cost production of chickenbroilers according to lots

label	Lot 1	Lot 2	Lot 3
Purchase of chick (USD)	1	1	1
Food (USD)	2.4	2.27	2.11
Veterinaryproducts (USD)	0.12	0.12	0.12
Heating and litter (USD)	0.09	0.09	0.09
Labor (USD)	0.3	0.3	0.3
Depreciation of building and equipment (USD)	0.14	0.14	0.14
Total (USD)	4.05	3.92	3.76

DISCUSSION

The bromatological analysis of the different rations showed that the latter are rich in protein and carbohydrates. Our results are consistent with those of Atakoun (2012) [6].The individual and daily food consumption recorded in the control subjects is of the order of 97.95 g/d, lower than those (124 and 129 g/d) obtained respectively by Atakoun (2012) [6] and Ayssiwèdé*et al*. (2010) [11]. This could be explained by the fact that these authors conducted their trials during the cool period when temperatures are low unlike our trial period when they are higher. Indeed, heat increases the metabolic activity of chickens, which leads to a decrease in food consumption. Furthermore, the incorporation of the flour of the seeds of the red variety of *Hibiscus sabdariffa* in the ration of broiler chickens significantly reduced feed consumption in subjects receiving the HSR2 and HSR4 rations compared to control subjects. The decrease in consumption is all the more marked as the incorporation rate is high. Our results are consistent with those of Ouédraogo*et al*. (2021)[12]. The latter incorporated *Hibiscus sabdariffa* seeds at rates of 10% and 15% and obtained a significant decrease in feed consumption. Indeed, and Mukhtar (2007) [9] etDiarra*et al*. (2011) [13] reported an acidic taste and an unpleasant smell of *Hibiscus sabdariffa* seeds which would explain this decrease in individual feed consumption. The results of the evolution of the growth of broiler chickens show that the final average weight of the subjects of lot 2 (2,334 g) is higher than that of the subjects of lot 1 (2,213 g). The incorporation of *Hibiscus sabdariffa* at a rate of 2% reinforces the assimilable nutrients present in the feed. These observations are different from those of Diouf (2013) [5]. By incorporating *Hibiscus sabdariffa* at rates of 5 %, 10 % and 15 %, he obtains a proportional decrease in the live weight of the subjects in comparison with the control subjects. The subjects of lot 3 having consumed 4 % of the *Hibiscus sabdariffa* seed flour obtained a weight (1958 g) lower than that of the subjects of the control lot 1. These results are similar to those of Sourokou (2014) [14] . According to him, the incorporation of *Hibiscus sabdariffa* seed flour significantly reduces the live weight of broilers. This decrease in live weight can be explained by the presence of antinutritional factors (tannins and phenolic compounds, traces of gossypol) in *Hibiscus sabdariffa* seeds Ojokoh*et al*., 2002[15] ; Mukhtar, 2007[9] which unbalance the absorption of nutrients when the incorporation rate is high. Subjects who consumed 2% of *Hibiscus sabdariffa* seed flour obtained better ADGs compared to control subjects over the entire trial period. Our results are similar to those of Thomas *et al*. (2005) [16] . They reported an increase in weight gain in broilers fed a *Hibiscus sabdariffa* seed diet compared to controls. This improvement in weight gain would be linked to a high amino acid content. However, subjects who consumed 4% of the *Hibiscus sabdariffa* seed flour obtained the lowest ADG. These results

are consistent with those of Mukhtar (2007) [9] The latter mentions that body weight gain decreased with the increase in *Hibiscus sabdariffa* seed flour in the diet. This decrease in growth would be linked to the adverse effects of antinutritional factors contained in *Hibiscus sabdariffa* seeds. During the trial, the ADG of the different lots increased from the 3rd to the 5th week of age and decreased at the 6th week. Our results are consistent with those of Ghaffari*et al*. (2007) [17] who stipulate that the ADG increases very quickly with age and then deteriorates from the fifth week because for him when the chickens get older, feed consumption is no longer proportional to weight gain.

During our experiment, the feed conversion ratio of lot 2 was better (1.51) than that of the control subjects. Our results are contrary to those of Diouf (2013) [5].. He recorded a significant increase in the feed conversion rate in subjects who consumed *Hibiscus sabdariffa* seed flour. This means that subjects who received *Hibiscus sabdariffa* seed-based feed valued their feed in the same way as control subjects. This observation seems to confirm the reduction in appetite caused by the bad smell and acid taste of *Hibiscus sabdariffa* seeds reported by Mukhtar (2007) [9] . Indeed, the 79 chickens converted the feed into meat according to their level of food consumption. The incorporation of *Hibiscus sabdariffa* seeds had no adverse effect on the health of Cobb 500 broilers. Indeed, during our trial, subjects in lot 2 had a low mortality rate.

A rate of 1.27% was recorded. No mortality was observed in subjects from lot 3 (4% *Hibiscus sabdariffa* and 96% industrial feed). Our results are contrary to those of Ouédraogo*et al*. (2015) [18].. The latter obtained a high mortality rate in subjects receiving *Hibiscus sabdariffa* seed flour. The carcass yield of broilers that consumed *Hibiscus sabdariffa* seed flour is lower than that of control subjects. The incorporation of *Hibiscus sabdariffa* seed flour reduced the carcass yield of broilers. Subjects from lots 1, 2 and 3 obtained respective carcass yields of 76.5%, 76.1% and 75.9%. Our results are lower than those of Ouédraogo*et al*. (2021) [12]. The latter obtained 81.33%; 80.47% and 81.63% by incorporating boiled *Hibiscus sabdariffa* seed flour at respective rates of 0%; 10% and 15%. This can be explained by the breeding period which was 42 days during our trial against 56 days for Ouédraogo*et al*. (2021) [12]..

A slight increase in the weight of the organs (heart, liver and gizzard) of the subjects submitted to the rations containing *Hibiscus sabdariffa* seed flour is observed compared to the organs of the control subjects. These results are similar to those of Musa and Hassan (2023) [19]. . They observed an increase in liver weight compared to the control lot with the increase in the incorporation rate of *Hibiscus sabdariffa.* The increase in the weight of these organs may be linked to the need for these organs to increase their capacities for the detoxification of toxic derivatives of *Hibiscus sabariffa* seeds, including tannin. Contrary to our results, Atakoun (2012) [6]. observed a similarity between the weights of the organs in subjects who had consumed *Hibiscus sabdariffa* seeds and control subjects.

After formulating the rations, we found that the prices of rations based on *Hibiscus sabdariffa* seeds were lower (0.95.6 USD/kg for the HSR 2 ration and 0.9USD /kg for the HSR 4 ration) than that of the control ration (0.9 USD/kg). This made it possible to reduce the production cost of broiler chickens subjected to the HSR2 and HSR4 treatments. This reduction is all the more significant as the incorporation rate is high. Our results are in agreement with those obtained by Kwari*et al*. (2011) [20]., who by incorporating raw or treated *Hibiscus sabdariffa* seeds recorded a reduction in the cost of feed for laying hens.

CONCLUSION

This study allowed to evaluate the effects of the incorporation of *Hibiscus sabdariffa* seeds in the feed ration on the growth performances, the carcass characteristics and the production cost of Cobb500 chickens broilers. From the 3rd to the 6th week of age, the incorporation *of Hibiscus sabdariffa* seed flour led to a significant decrease in the feed consumption of the HSR 2 (2,599.87 g) and HSR 4 (2,402.89 g) treatments compared to the HSR 0 control group (2,742.6 g). However, the subjects of the HSR 2 treatment obtained better

zootechnical performances. The broilers of group 2 obtained an average weight of 2,334 g; an ADG of 72.71 g/d and an IC of 1.51 in 42 days of breeding. In terms of carcass characteristics, no adverse effects were observed on the carcasses and organs of broilers. Economically, the incorporation of red variety *Hibiscus sabdariffa* seed flour reduced the production cost of cobb500 broilers. In view of these results, digestibility trials should be undertaken in order to better understand the impact of antinutritional factors on the zootechnical performance of broilers.

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