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Effect of the Substitution of Corn by Bili-bili Spent Grains on the Growth Performances and on the Hematological Profile of the Rabbit (*Oryctolagus cuniculus*)

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Abstract The effect of the substitution of maize by spent grains of bili-bili on the zootechnical performances and the haematological profile of the rabbit (*Oryctolagus cuniculus*) was carried out on 60 young rabbits of 5 weeks age of 678 ± 26.3 g, randomly and equitably allocated among four batches in different levels of spent grain of bili-bili (0-25-50-75%). If improvements are observed for the differents diets rates, that of 25 SB showed the highest improvement rate with values of 148.71 ± 13.20 g; 21.78±1.63 g/d; 69.5±17.54 and 3.21 ± 0.25 respectively for the average daily gain (ADG), body weight gain (BWG), the daily food intake (DFI) and the consumption index (CI) which are within the range of balanced rabbit diet. There is no significant variation for the different treatments on carcass yields, but improvements were observed for the 25SB substitution (63.01 ± 5.7%). No mortality was recorded and the rabbits showed a good hematological profile for the different treatments, i.e. 33.1-45.1% (lymphocytes); 5.3-9.1x10^9/l (white blood cells) and 3.95-6.23 x 10^{12}/l (red blood cells). Economically, the production cost of 1kg of rabbit drops drastically with a substitution rate of 75 SB from 1870 FCFA to 1280 FCFA, moreover, it is 25 SB which brings the best growth performance and the best ratio price/quality.

Keywords: *rabbit, bili-bili's spent grain, diet, zootechnical performance, hematology*

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1. Introduction

The rabbit (*Oryctolagus cuniculus*) is a fast-growing animal, adapted to the tropical environment and having very good meat performance (high carcass yield with a short reproduction cycle) [1]. Rabbit meat has high dietary qualities and an energy intake of 167 kcal per 100 g of meat [2]. It is rich in protein (20 g/100 g) with high levels of: α linolenic acid, iron (1 to 1.3 mg), selenium (90 µg) [1,2,3]. Rabbit meat is a white meat, lean and tender, due to its low connective tissue content [3]. Rabbit farming is a new activity, practiced in a traditional way in the Far-North Region of Cameroon, facing several climatic and food constraints. Lack of knowledge of the appropriate foods capable to cover all essential nutrient requirements for growing rabbits according to [3] seems to be the major constraint encountered by rabbit breeders, forcing them to turn to peanut haulms, cotton seed cakes with maize at the first position to formulate food diet. Corn is a common food and mainly used in the formulation of feed mills, in this respect this cereal is subjected to a problem of availability and price fluctuation. The partial substitution by waste from secondary processing and which gives performance comparable to maize would be an interesting approach to address the constraints. In this dynamic, industrial spent grains have largely benefited from scientific and technological appeal [4,5]. Bili-bili spent grains, scrap from traditional beer production, rich in protein (26%) and metabolizable energy (2486 Kcal/kg), available locally throughout the year, in large quantities, appears to be a source of first choice to be tested in the formulation of rabbit feed. The aim of the present study was to evaluate the effect of bili-bili spent grain through partial substitution of corn in the rabbit diets on growth, felling performances, economic gain and hematological profile of rabbits.

2. Material and Methods

This work was carried out at Rabbit Research Laboratory of Animal Production of the Institute of Agricultural Research for Development of Maroua in Cameroon and the chemical analysis was performed at the Bioscience Laboratory of the National Advanced School of Engineering of the University of Maroua (Cameroon).

2.1. Experimental Diets

Three experimental diets were formulated to cover all essential nutrient requirements for growing rabbits, in which 25, 50 and 75 % of the corn grains (CG) in the rabbit diet was substituted by bili-bili spent grains: 0SB (control); 25SB; 50 SB and 75 SB% of the total diet (Table 1).

Table 1. Composition for 30 kg of diets (%/kg)

Ingrédients (%)	0BS	25BS	50BS	75BS
Corn	62	46.5	31	15.5
Bili-bili spent grain	0	15.5	31	46.5
Sorghum	10.8	10.8	10.8	10.8
Fish meal	7	7	7	7
Bone powder	5	5	5	5
Nutribet	6	6	6	6
Salt	0.2	0.2	0.2	0.2
corn bran	6	6	6	6
CMAV	3	3	3	3
TOTAL	100	100	100	100

BS: Bili-bili spent grains.

2.2. Experimental Animals and Housing

The young rabbits (60 subjects) at six weeks old, with an average initial live body weight of 650 ± 15 g were triplicated allocated at random among four groups made up of 15 young rabbits, corresponding to the three treatments plus the control. Average initial BW of the assigned groups was nearly similar. Each experimental group was received one of the experimental diets. The experiments were conducted on 8 weeks on 4 batches of 15 rabbits caged in metal galvanized cages under the same managerial conditions in well-ventilated block building. In addition to the basic diet (Table 1), all the rabbits received at will fodder diet (*Azadirachta indica* and *Arachis hypogea* leaves) and followed the same prophylactic plan in order to assess the impact of spent grains on growth parameters and hematological profile. Fresh water was automatically available all the time by stainless steel nipples. The experimental diets were offered to rabbits and the all rabbits were kept under the same environmental, hygienic and managerial conditions. Body weight (BW) and daily feed intake (DFI) were individually recorded weekly for estimating average daily gain (ADG), while feed conversion ratio was calculated as g feed/g gain.

2.3. Physical, Gravimetric and Hematological Analyzes

The growth parameters (BWG, DFI, CI) were measured, the rabbits were weighed daily without stress at the same time and after a transition period of one week in order to allow the rabbits to adapt to the feed and 7 weeks of experiments. At the end of the fattening period, the rabbits were slaughtered according to standard practices and the various organs were weighed (skin, carcass, head, liver, heart, lungs, kidneys, full digestive tract, empty digestive tract, cold carcass, perineal fat, foreleg, thigh). The bloods were sampled and hematological parameters were measured automatically in 1 cubic mm of whole blood and the hemogram was produced using a hematological counter (Mindray BC 3000, SHENZHEN, China) which provides the concentrations and proportions.

2.4. Economic Parameters

The following economic parameters were measured:

Cost of production for one kg of rabbit = Consumption Index x price of kg of experimental feed;

Profit margin = value of production – cost of feed;

Cost per kg of feed = Unit price of the feed on the market x Rate of incorporated diet of the ingredient in the feed.

2.5. Statistical Analysis

All physical, gravimetric and hematological data were performed in triplicate and the results expressed as mean ± standard deviation. The comparison of the means was carried out by ANOVA and the significantly different means were classified by Duncan at $p = 0.05$ (Statgraphics Centurion XVI, Virginia, USA).

3. Results

3.1. Impact of Bili-bili Spent Grains on the Growth Performance of Rabbits

The 25BS diet (Figure 1) carries the best BWG (148.71±13.20 g) in secondary association with the 0BS diet (143.52±15.15 g). The 50BS (131±13.78g) and 75BS (114.38±9.87g) diets have little impact on the BWG. No significant difference is observed between 25BS and 0BS at $p < 0.05$, but there is a significant difference between 25BS and 50BS at $p < 0.05$ and between 25BS and 75BS at $p < 0.05$.

The average daily gain (ADG) of rabbits fed by 25BS diet is significantly higher (21.78±1.63 g/d) than the 0BS control group (20.50±1.81 g/d) (Table 2). This difference in gain remains similar for 25BS and 50BS (18.71±1.6 g/d); and for 25BS and 75BS (16.34±1.32 g/d). The 0BS control diet was more consumed (67% with a consumption index of 3.42±0.30) compared to 25BS (61% with a feed conversion index of 3.21±0.25); at 50BS (65% with CI of 3.6±0.44) and at 75BS (62% with CI of 4.24±0.37) (Table 2).

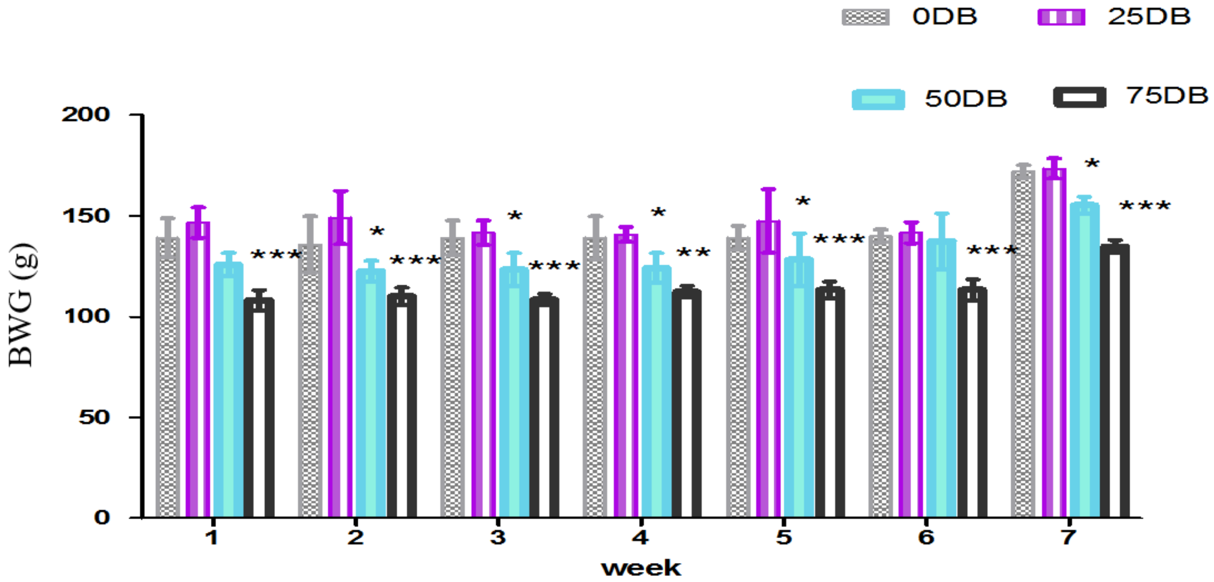

Figure 1. Evolution of BWG vs week and diets

Table 2. Impact of bili-bili spent grains on CI, DFI and ADG

Parameters	CI				(g) DFI				(g/j) ADG			
Weeks	0BS	25BS	50BS	75BS	0BS	25BS	50BS	75BS	0BS	25BS	50BS	75BS
W1	3.08 ± 0.23^{a}	3.11 ± 0.14^{a}	4.44 ± 0.22^{c}	4.13 ± 0.24^{b}	194.00 ± 4.47^{b}	164.67 ± 5.05^{a}	230.67 ± 3.72^{d}	223.00 ± 5.62^{c}	19.88 ± 1.39^{c}	20.95 ± 1.08^{c}	17.98 ± 0.84^{b}	15.45 ± 0.73^{a}
W2	3.66 ± 0.37^{b}	3.24 ± 0.31^{a}	4.11 ± 0.15^{c}	4.08 ± 0.17^{c}	236.33 ± 9.31^{b}	206.33 ± 4.76^{a}	261.50 ± 3.27^{d}	251.00 ± 4.73^{c}	19.40 ± 1.99^{c}	21.31 ± 1.89^{d}	17.50 ± 0.75^{b}	15.74 ± 0.61^{a}
W3	3.70 ± 0.27^{ab}	3.55 ± 0.16^{a}	4.03 ± 0.50^{b}	4.76 ± 0.16^{c}	265.17 ± 5.98^{a}	265.83 ± 3.66^{a}	272.50 ± 3.08^{b}	266.33 ± 4.50^{a}	19.88 ± 1.23^{c}	20.24 ± 0.87^{c}	17.62 ± 1.17^{b}	15.50 ± 0.39^{a}
W4	3.41 ± 0.26^{b}	2.92 ± 0.07^{a}	4.08 ± 0.19^{c}	4.71 ± 0.15^{d}	315.33 ± 6.53^{c}	310.00 ± 4.60^{c}	290.00 ± 3.58^{b}	279.33 ± 3.01^{a}	19.88 ± 1.53^{c}	20.12 ± 0.54^{c}	17.74 ± 1.05^{b}	16.05 ± 0.42^{a}
W5	3.40 ± 0.39^{a}	3.41 ± 0.40^{a}	3.84 ± 0.40^{b}	4.31 ± 0.13^{c}	340.00 ± 6.99^{b}	331.83 ± 7.14^{b}	304.67 ± 4.66^{a}	292.50 ± 3.08^{a}	19.88 ± 0.84^{bc}	21.07 ± 2.25^{c}	18.33 ± 1.84^{b}	16.19 ± 0.58^{a}
W6	3.76 ± 0.07^{b}	3.38 ± 0.10^{a}	4.19 ± 0.39^{c}	4.02 ± 0.18^{bc}	359.50 ± 6.19^{c}	359.17 ± 7.44^{c}	338.83 ± 6.37^{b}	323.00 ± 3.03^{a}	20.00 ± 0.45^{b}	20.24 ± 0.74^{b}	19.64 ± 1.96^{b}	16.19 ± 0.74^{a}
W7	2.99 ± 0.05^{ab}	2.90 ± 0.07^{a}	3.05 ± 0.09^{b}	3.71 ± 0.10^{c}	395.50 ± 5.92^{c}	308.33 ± 5.50^{a}	364.00 ± 3.03^{b}	345.83 ± 4.62^{b}	24.60 ± 0.44^{c}	24.79 ± 0.72^{c}	22.19 ± 0.59^{b}	19.26 ± 0.47^{a}
Overall	3.42 ± 0.30	3.21 ± 0.25	3.96 ± 0.44	4.24 ± 0.37	300.83 ± 71.87	278.02 ± 70.18	294.59 ± 45.76	283 ± 41.93	20.50 ± 1.81	21.24 ± 1.63	18.71 ± 1.69	16.34 ± 1.32

CI; Consumption Index; DFI: Daily Food Intake; ADG: Average Daily Gain.
N.B: Values with the same letters in a row do not differ significantly at the probability threshold ($p < 0.05$).

Table 3. Effect of different diets on carcass yield

(%) Yields	0BS	25BS	50BS	75BS
Skin	10.6 ± 0.4^{a}	12.5 ± 2.01^{a}	12.8 ± 5.8^{a}	12.7 ± 3.02^{a}
Commercial carcass	60.04 ± 12.8^{a}	63.01 ± 5.7^{a}	62.05 ± 9.1^{a}	54.06 ± 2.01^{a}
Head	8.04 ± 0.58^{a}	8.79 ± 1.33^{a}	9.5 ± 1.41^{a}	8.89 ± 0.75^{a}
Liver	1.71 ± 0.2^{a}	2.76 ± 0.3^{b}	2.86 ± 0.4^{b}	2.7 ± 0.3^{b}
Heart	0.28 ± 0.02^{a}	0.36 ± 0.05^{b}	0.43 ± 0.08^{b}	0.41 ± 0.05^{b}
Lungs	0.52 ± 0.03^{a}	0.7 ± 0.03^{a}	0.71 ± 0.03^{a}	0.72 ± 0.02^{a}
Kidneys	0.53 ± 0.03^{a}	0.85 ± 0.25^{b}	0.82 ± 0.19^{b}	0.71 ± 0.29^{ab}
TD Full	19.13 ± 0.5^{ab}	18.49 ± 1.7^{ab}	15.82 ± 2.9^{a}	20.24 ± 5.1^{b}
TD Empty	5.79 ± 0.1^{ab}	7.09 ± 1.2^{ab}	7.19 ± 1.7^{a}	7.93 ± 1.7^{b}
Cold Carcass	50.1 ± 1.4^{a}	55.9 ± 18.8^{a}	61.9 ± 28.3^{a}	52.02 ± 2.1^{a}
Perineal fat	0.54 ± 0.02^{a}	0.61 ± 0.01^{ab}	0.6 ± 0.03^{ab}	0.84 ± 0.01^{b}
Foreleg	18.9 ± 0.9^{a}	20.8 ± 2.1^{a}	23.1 ± 3.8^{a}	21.4 ± 1.6^{a}
Thigh before cooking	4.9 ± 0.2^{a}	5.03 ± 0.9^{b}	6.6 ± 1.01^{c}	5.4 ± 0.1^{bc}
Thigh after cooking	1.7 ± 0.1^{a}	3.7 ± 0.5^{b}	3.8 ± 0.6^{b}	3.4 ± 0.3^{b}

Table 4. Effect of different diets on hematological parameters (x109/L)

Parameter (x109/L)	0BS	25BS	50BS	75BS
Hemoglobin	92.66 ± 11.27^{a}	104 ± 4.73^{b}	100.66 ± 8.14^{ab}	101 ± 6.57^{ab}
White globule	9.88 ± 0.89^{a}	7.27 ± 0.37^{a}	6.43 ± 0.56^{a}	8.57 ± 0.21^{a}
Red blood cell	4.88 ± 0.89^{a}	5.27 ± 0.37^{a}	5.43 ± 0.56^{a}	5.57 ± 0.21^{a}
Hematocrit	34.03 ± 5.05^{a}	35.16 ± 1.31^{a}	34.91 ± 3.07^{a}	35.67 ± 1.5^{a}
MCHC	292.66 ± 4.17^{a}	293.83 ± 3.86^{a}	289.66 ± 2.06^{a}	283.66 ± 6.94^{a}
PLT	239.83 ± 49.19^{a}	238.83 ± 41.12^{a}	396.5 ± 14.66^{b}	353 ± 43.56^{b}
TMH	18.8 ± 1.68^{a}	18.716 ± 1.22^{a}	18.516 ± 0.77^{a}	18.8 ± 1.16^{a}
VGM	66.25 ± 4.67^{a}	65.33 ± 3.54^{a}	63.86 ± 2.26^{a}	66.05 ± 2.21^{a}
IRD- CV	19.16 ± 1.49^{a}	17.7 ± 2.22^{a}	18.2 ± 0.56^{a}	17.93 ± 0.96^{a}
IRD-DS	41.83 ± 5.26^{a}	38.88 ± 2.15^{a}	39.3 ± 2.01^{a}	41.83 ± 1.72^{a}
VMP	8.3 ± 0.82^{a}	8.55 ± 0.81^{a}	8.43 ± 0.32^{a}	8.38 ± 0.74^{a}
IDP	14.76 ± 0.52^{ab}	15.2 ± 0.48^{b}	14.46 ± 0.25^{a}	14.63 ± 0.21^{a}
PCT	0.22 ± 0.05^{a}	0.19 ± 0.04^{a}	0.31 ± 0.02^{b}	0.30 ± 0.06^{b}
MID	0.8 ± 0.14^{b}	0.87 ± 0.31^{b}	0.41 ± 0.23^{a}	0.6 ± 0.08a^{b}
%Lymphocyte	36.68 ± 3.54a^{b}	38.08 ± 2.58^{b}	38.5 ± 3.29^{b}	31.83 ± 7.77^{a}
%MID	9.48 ± 1.52^{b}	8.9 ± 1.15a^{b}	8.98 ± 0.34^{ab}	8.11 ± 0.62^{a}
%Granulocyte	54 ± 4.87^{a}	53.36 ± 2.51^{a}	52.16 ± 3.37^{a}	60.48 ± 7.54^{b}

Table 5. Production cost per kg of rabbit

Variables			0BS	25BS	50BS	75BS
CI			3.42	3.21	3.6	4.24
Price per kg of food (FCFA)	Substitution rate	Corn	372	280	186	94
		BS	0	11	22	33
	Others ingredients		175	175	175	175
	Total cost		547	466	383	302
Production cost of 1 kg of rabbit (FCFA)			1870	1496	1379	1280
Difference with 0BS batch (FCFA)			0	374	491	590

FCFA is the currency of six independent states in Central Africa.

3.2. Impact on Carcass Yield

Overall, no significant difference was observed for carcass yield between 0BS (60.64 ± 12.82%), 25BS (63.01 ± 5.78%), 50BS (62.05 ± 29.18%) and 75BS (54.06 ± 2.01%). However, there is a significant difference in thigh weight between 0BS (88.3 ± 4.8g), 25BS (91.6 ± 10g), 50BS (80.0 ± 5.9g) and 75BS (65.0 ± 8.6g); and on the drop of perineal fat between batches of diets of the different treatments in the order of 0.54 ± 0.02% for 0BS; 0.61 ± 0.16% for 25BS; 0.6 ± 0.367 % for 50BS and 0.84 ± 0.11 for 75BS. The results of the analysis also showed that there is a significant difference in the vital organs: heart, lungs, liver and kidneys (Table 3).

3.3. Impact on Health

No mortality was recorded and the hematological analysis (Table 4) suggests a non-significant variation ($P > 0.05$) between white and red blood cells, but significant between PLT, lymphocytes and granulocytes ($P < 0.05$).

3.4. Economic Aspects

The price of replacing maize with bili-bili spent grains was 291, 211 and 208 FCFA, respectively for 25BS, 50BS and 75BS. Thus the production cost of 1kg of rabbit amounts to 1870, 1496, 1379 and 1280 FCFA respectively for 0BS, 25BS, 50BS and 75BS. Compared to the control diet. A gain margin of 374, 491 and 590 FCFA per kg of rabbit was obtained at the end of this study (Table 5), suggesting a good income of the substitution of maize by spent grains of bili-bili.

4. Discussion

The control 0BS diet was the most consumed (100 g/d), followed by the 50BS diet (99 g/d); 75BS (95 g/d) and 25BS (92 g/d) diet. This can be explained by the fact that rabbits like corn more than spent grains. But this improvement of food consumption is not reflected in the BWG. The BWG of the studied animals despite the DFI remained in the range of 62.68 g/d to 128 g/d, similar to those obtained by [3,6,7,8]. Indeed, the rabbits that consumed the 25BS diet (21.78 ± 1.63 g/d) had the best BWG average throughout the experiment, followed by the control 0BS diet (20.50 ± 1.81 g/d); 50BS (18.71 ± 1.6 g/d); and 75BS (16.34 ± 1.32 g/d). These BWG values are in the range of 11.20 g/d and 25.16 g/d comparable to those of [7,9], but are slightly lower at 22.9 g/d [10,11]. This could be justified by the difference between the raw materials used. The foods used by these authors do not have the same bromatological values. The low BWG of the 50BS and 75BS batches compared to the control batch could be explained by the fact that bili-bili spent grains (2486 kcal) are energetically lower than maize (3250 kcal) [12]. But the high values of the BWG of 25BS and 0BS could be explained by the fact that a slight substitution of maize improves the protein values of this food without impacting its energy value because spent grains are foods rich in protein (30 to 40 of the DM) but moderately rich in metabolizable energy (2486 Kcal/Kg) [13]. Indeed, when the protein content of food is low, this follows a drop in growth of the rabbits with a BWG which weighs down resulting in slow growth during fattening, thus, the protein content must evolve with the energy level of the diet [10]. This increase in BWG of the rabbits of batch 25BS could therefore be due to a sufficient intake of energy (2420 kcal/kg) and protein (16 to 17%) to meet the needs of the rabbits [12]. The consumption index (CI) of the different diets varies from 3.42 ± 0.30 (0BS); 3.21 ± 0.25 (25BS); 3.6 ± 0.44 (50BS) and 4.24 ± 0.37 (75BS). These values are similar to 3.70 and 3.30 obtained by [14,15] but slightly above 2.62 obtained by [10]. The variations in the CI observed during this study explain the variations in BWG between the different treatments of the diets because if the rabbit's CI is low at 3.8, this means that the animal eats little but gains more weight [14]. This could explain the good growth performance obtained from the rabbits (25BS diet). We also notice that the CI varied over time for the same diet. This could be explained by the fact that the DFI of animals increases with age [16].

The post-slaughter results showed a variation driven by the treatments. Overall, rabbits from batch 25BS come in first position for carcass yield (63.01 ± 5.7%), followed by 50BS (62.05 ± 29.18%); 0BS (60.6 ± 12.82%) and 75BS (54.06 ± 2.01%). These results are similar to the 57% obtained by [17]. It would seem, according to these results, that the differences between the carcass yield of the food treatments are carried by both the proportion of the skin and the head of the rabbits. Overall, the results of the hematological analysis vary from 33.1 to 45.1% of lymphocytes which are slightly lower than 41-62% obtained by [18] but comparable to 36% obtained by [19]. The values $5.3\text{-}9.1.10^9$/l of white blood cells obtained are substantially equal to $6.43 \pm 0.5.10^9$/l and $9.88 \pm 0.89 \times 10^9$/l obtained by [20] and 6.10^9/l obtained by [18]. The results of red blood cells $3.95\text{-} 6.23.10^{12}$/l are lower than 7.10^{12}/l obtained by [21]. The differences obtained could come from the experimental conditions. The costs per kg of experimental feed vary from 302 F CFA to 547 F CFA and similar to 308 F CFA and 432, 305 observed by [22]. They are higher by 87 to 117 F CFA, compared to those obtained by [14]. The high cost of food would be due to the variation and increase in the price of basic necessities such as maize on the market. The variation in the cost of production of 1 kg of rabbit of 374 F CFA (25BS), 491 F CFA (50BS), and 590 F CFA (75BS) compared to 0BS could be explained by the fact that the cost of the kg of food decreases when we increase the rate of substitution of maize by spent grains of bili-bili, knowing that spent grains of bili-bili costs less compared to maize on the market.

5. Conclusion

Substitution of maize by bili-bili spent grains in the diet of rabbits was carried out successfully, without significant reduction in growth performance, nor in slaughter characteristics and hematological parameters. Rabbits that have consumed the 25 BS diet have the best zootechnical parameter and are economically more profitable for a rabbit farmer because the rabbits have better growth parameters (ADG, BWG, DFI and CI). This substitution reduces the shortage of raw material resources between human and animal food and could arouse a craze for this breeding practice which is not centuries old in the northern savannahs of Cameroon.

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