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Efficiency of cotton meal, cashew apple, mango peel and almond incorporation on growth and economic performances of broiler in Côte d'Ivoire

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Abstract: The objective of this study is to evaluate the effectiveness of a partial substitution of corn with local agro-food by-products, particularly cashew apple, mango peel, mango almond, and soybean meal with cotton meal in the ration of broilers during the growth phase. Thus, four rations, including one control and three experimental, were constituted, and each of them was used to feed 180 Cobb 500 strain chicks, each 18 days old. In each of the experimental rations, corn was replaced at a rate of 20% with one of the three by-products, while in each ration, soybean meal was replaced at a rate of 10% with cotton meal. The control group was fed a commercial industrial food. The different batches were raised until the age of 45 days, during which growth indicators, including body weight, daily weight gain, feed conversion ratio, and mortality, were determined. Furthermore, an economic evaluation was carried out to assess the profit margin linked to the use of these local inputs in broiler feed during breeding. The results showed that rations based on local by-products did not degrade the growth performance of broilers and even reduced the cost of production while increasing the farmer's profit margin during breeding. The study is important because it allows for the valorization of locally available by-products in producer countries as a substitute for imported ingredients. This is an advantage for farmers and poultry producers.

Keywords: *Agro-food by-products, Broiler, Efficiency, Food, Growth.*

1. Introduction

Food insecurity is one of the problems faced by most developing countries. Insufficient animal resource in the diet of populations is one of the factors contributing to malnutrition in many countries, especially in Africa [1]. Poultry farming, which is a short and viable cycle of breeding, represents not only a source of animal proteins but also generates income for the populations [2]. However, in Côte d'Ivoire the main difficulties of poultry farming are the high cost of food. Indeed, food represents 60 to 70% of the production cost. Given that poultry feed alone accounts for about 70% of the total cost of production [3]. it is important that both current and prospective poultry farmers know which feed type will give them maximum profit. It is the leading factor in the cost price of poultry and constitutes the most effective means to control production costs and the quality of meat products. However, many food ingredients commonly used in poultry diets are often in short supply due to the food competition between humans and animals [4]. Rations for monogastric animals, particularly poultry, are mainly composed of soybean meal and corn, which are raw materials partially imported. However, Ivorian

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agricultural production generates a significant quantity of by-products and waste that could be used in livestock feed. It would be an interesting alternative for animal production costs [5]. Some research studies have shown the usefulness of by-products in animal feed [6]. The use of cashew apple has been reported in the diets of albino rats [4] and ducklings [7]. Also, Kouadio, et al. [8] used cashew apple in the broiler feed, whereas [9] incorporated mango by-product in their ration. In Côte d'Ivoire, cashew apple, cotton meal and mango waste remain very poorly valued. Thus, the present project aims to evaluate the effect of diets incorporated cashew apple, mango peel, mango almond and cotton meal on zootechnical parameters and production cost of broiler chickens.

2. Materials and Methods

2.1. Collection of by-Products

This work required the use of four (4) agricultural by-products from northern part of Côte d'Ivoire. These are cashew apples from the Tanda Department; mango peel and mango almond from the COBEKO mango processing plant located in Korhogo and the cotton meal from the company COTRAF SA located in Korhogo. These various by-products were subjected to several treatments before their incorporation into the ration of broilers. Cashew apples were cut and dried. Mango peels were washed, depulped and dried. The almonds of the mango core were removed using a knife and cut into small pieces. Then these almonds were soaked in water for 24 h before being boiled at 100°C for 30 min and then dried. Concerning cottonseed meal, it was purchased in granulated form in 50 kg plastic bags. The drying of by-products was carried out at room temperature, between 30 and 35°C and at variable times until a constant weight was obtained. After drying, each by-product was ground and stored in plastic bags for use in chicken feed.

2.2. Formulation Of Experimental Diets and Broiler Chicken Management

This study involved 180 chicks aged 19 days and with an average weight of 606.17 ± 0.84g, selected after a three (3) day feeding transition from the 16th day, between a commercial starter feed and a feed formulated according to the batches constituted. The 180 chicks were divided into four (4) batches of 45 chicks and each batch was subdivided into triplicate and identified according to the ration allocated in particular, one RT control batch and three R1 experimental batches; R2 and R3. The trial began with chicks 19 days old and ended on the 45th day of age, i.e., a duration of 27 days. In each of the three (3) experimental batches, soybean meal, which is a protein source, was partially replaced by cotton meal due to a 10% substitution. However, as for corn, which constitutes the main source of energy in the food, it has been partially substituted in different proportions depending on the formulated ration. Thus, in the R1 ration, 20% corn was replaced by 20% cashew apple and 10% soybean meal by 10% cotton meal. In the R2 ration, 20% corn was replaced by 20% mango peel and 10% soybean meal by 10% cotton meal. In the R3 ration, 20% corn was replaced by 20% mango almond and 10% soybean meal by 10% cotton meal. After formulation, the different formulated rations were subject to a bromatological analysis according to the AOAC [10] to determine their chemical composition. Raw cellulose was obtained using the Lema [11]. The metabolizable energy of each sample was calculated using the formula of [12]. The content of calcium, magnesium and sodium was determined using an atomic absorption spectrophotometer according to the AOAC [10]. Regarding phosphorus, its quantification was done with the spectrophotometer according to the BIPEA [13]. For the commercial food (RT), only nutritional composition indicated on the label was considered (Table 2). All chicks were subjected to the prophylaxis program provided by the hatchery.

2.3. Data Collection and Determination of Zootechnical Parameters

During the test, the quantities of food ingested by each batch were determined by weighing the difference between the quantity of food served and that remaining in the feeders from 6 a.m. to 6 p.m. The animals were weighed using an electronic scale at the 19th, 28th, 35th and 45th days of age. The number of chickens that died during the experiment was recorded. From the measurements carried out,

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zootechnical parameters such as daily feed intake (DFI), live weight (BW), daily weight gain (DWG) and feed conversion index (FCR) were determined. Given that the only factor that differentiates the different batches is the feed ration, the economic analysis did only based on the production costs of the food in relation to the commercial weight at 45 days.

2.4. Statistical Analysis

Zootechnical parameters such as DFI, BW, DLWG and FCR were subjected to an analysis of variance (ANOVA) at a significance threshold factor of 5%. The carcass characteristics were subjected to a non-parametric Kruskal-Wallis test at the 5% threshold.

Table 1.
Centesimal composition of the ingredients of experimental diets formulated.

Food inputs	Food rations		
	R1	**R2**	**R3**
Corn (%)	43	43	43
Cashew apple (%)	20	-	-
Mango peel (%)	-	20	-
Mango almond (%)	-	-	20
Wheat bran (%)	4	4	4
Soybean meal (%)	16	16	16
Cotton meal (%)	10	10	10
Fish flour (%)	2	2	2
Shellfish (%)	0.25	0.25	0.25
Vitamin- mineral premix (%)	3.5	3.5	3.5
Salt (%)	0.25	0.25	0.25
Oil (%)	1	1	1
Total (%)	100	100	100

Note: RT: control diet; R1: 20% cashew apple and 10% cotton meal; R2: 20% mango peel and 10% cotton meal; R3: 20% mango almond and 10% cotton meal.

Table 2.
Nutrient composition of diets.

Chemical composition	Food rations			
	RT	**R1**	**R2**	**R3**
Dry matter	-	87.015	90.57	87.28
Crude protein (%)	17	21.75	20.13	22.17
Fat (%)	5	3.307	2.84	2.864
Ash (%)	13	7.60	5.68	7.06
Crude cellulose (%)	4.7	7.83	8.25	8.50
Calcium (%)	3.44	1.18	1.06	1.16
Phosphorus (%)	0.58	0.58	0.43	0.52
Potassium (%)	-	1.2	1.08	1.18
Magnesium (%)	-	0.25	0.18	0.27
Sodium (%)	0.17	1.56	1.37	1.28
Metabolizable energy (kcal/kg)	2768	3126.30	3141.98	3064.80

Note: RT: control diet; R1: 20% cashew apple and 10% cotton meal; R2: 20% mango peel and 10% cotton meal; R3: 20% mango almond and 10% cotton meal.

3. Results

3.1. Daily Feed Intake of Broilers

Table 3 presents the daily food consumption (DFI) of the different batches during the trial. A significant variation in food consumption is recorded between the different batches for a given age group. ($P < 0.05$). During the period of 19 to 28 days, the IFD value of batch R2 (111.76 ± 20.79g) was significantly lower than that of the other three (3) batches. However, the latter (RT, R1 and R3) recorded statistically similar ($P > 0.05$), daily food consumption values with an average for the three batches of 116.95 ± 18.33 g/d. In the period from 29 to 35 days, conversely, batch R2 recorded a daily food consumption value (151.67 ± 10.83g) significantly higher ($P < 0.05$) than that of the three (3) other batches while the consumption remained statistically similar ($P > 0.05$) for these three batches. The average consumption of the three batches RT, R1 and R3 is 142.58 ± 6.90g. For the period of 36 to 45 days, the food consumption of all batches was very different from each other ($P < 0.05$). The highest consumption was recorded in batch R2 (161.59 ± 1.30g/d). Indeed, the consumption of this batch was significantly higher than that of the other three batches. The consumption of this batch is respectively 1.09 times, 1.06 times and 1.12 times higher than that of batches RT, R1 and R3. Over the entire duration of the trial, notably from 19 to 45 days, no significant difference was observed between the food consumption of the four (4) batches. The average quantity consumed by all batches was 136.54 ± 20.81g/j/animal.

Table 3.
Daily feed intake (g/d) of different batches of broilers.

Daily food consumption	**Grower phase**			
	19-28 days	**29-35 days**	**36-45 days**	**19-45 days**
RT (g/d/animal)	116.57 ± 20.29^{a}	142.48 ± 5.59^{a}	148.55 ± 2.43^{a}	135.13 ± 19.24^{a}
R1 (g/d/animal)	117.28 ± 16.21^{a}	142.89 ± 6.03^{a}	153.05 ± 6.49^{b}	137.17 ± 19.26^{a}
R2 (g/d/animal)	111.76 ± 20.79^{b}	151.67 ± 10.83^{b}	161.59 ± 1.30^{c}	140.56 ± 26.38^{a}
R3 (g/d/animal)	116.99 ± 18.49^{a}	142.38 ± 9.07^{a}	143.73 ± 8.95^{d}	133.29 ± 18.36^{a}
P-value	<0.001	<0.001	<0.001	> 0.05

Note: Superscript alphabetic letters, when different, indicate a significant difference between the means ($P < 0.05$). Otherwise, there is no difference ($P > 0.05$). RT: control diet; R1: 20% cashew apple and 10% cotton meal; R2: 20% mango peel and 10% cotton meal; R3: 20% mango almond and 10% cotton meal

3.2. Body Weight of Broilers

Figure 1 shows the evolution of the body weight (BW) of chickens during the experiment. The results indicate an increasing evolution in the body weight of the chickens in each batch, with however a significant difference ($P < 0.05$) in the growth of the animals from the different batches. With an average body weight per chick varying between 604,77 and 606.77 over the four (4) batches including an overall average of 606.17 ± 0.84 g at the age of 19 days for all the chicks, the control batch RT recorded a significantly higher body weight value than the three (3) experimental batches regardless of the duration of the test. Indeed, with an average weight of 604.77g at 19 days, the RT control batch recorded weights of 1219.67g, 1637.33g and 2360.11g at 28 days, 35 days and 45 days respectively. Batches R1 and R3 recorded statistically similar body weight values over the entire study period ($P > 0.05$). In addition, the body weights of the animals in these two (2) batches were very close to those of the control batch although statistically different. In these two (2) batches, the body weights varied from 1061 to 1118g; from 1466 to 1548 and from 2158 to 2177 respectively at 28 days, 35 days and 45 days. In this trial, batch R2 recorded significantly lower body weight values than the other batches. The values at 28; 35 and 45 days are respectively 1001g, 1343g and 1849g.

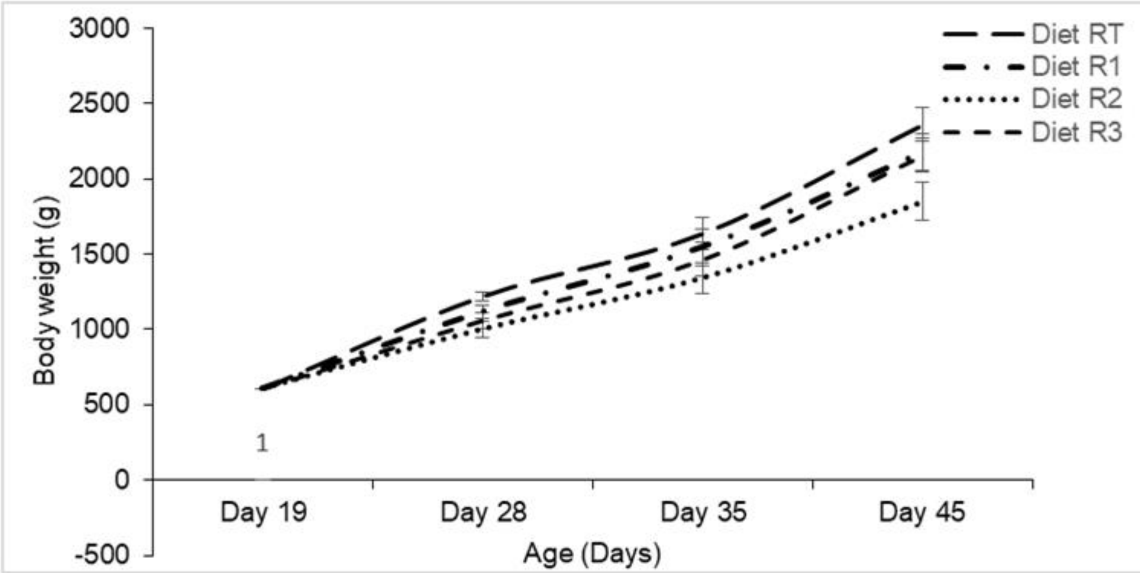

Figure 1.
Evolution of the body weight of broiler chicken subjected to the different diets.

3.3. Daily Weight Gain

Table 4 gives the evolution of the average daily weight gain of the different batches. In this trial, over the entire duration of the study, the daily weight gain of the RT batch was significantly higher than that of the other three batches ($p<0.05$), particularly R1; R2 and R3. Indeed, the daily weight gain of RT is respectively 1.12 times, 1.41 times and 1.13 times higher than that of R1; R2 and R3. The same observation is observed during the first period, notably from 19 to 28 days. During this period, the value (61.49 g/d) of daily weight gain of batch RT is significantly higher respectively by 1.20 times, 1.56 times and 1.35 times than that of batch R1; R2 and R3. However, this trend is not respected for the other periods. Indeed, over the period of 29 to 35 days, batches RT, R1 and R3 recorded statistically similar daily weight gain values ($p > 0.05$) with an average for the three of 59.34 ± 5, 48g/d. The daily weight gain values of these three batches are significantly higher ($p < 0.05$) than that of batch R2. Finally, over a period of 36 to 45 days, batches RT and R3 recorded daily weight gain values that were statistically similar but significantly higher than those of batches R1 and R2. For this period, the average value of daily weight gain between the RT and R3 batches was 70.71 ± 10.13g/d and higher by 7.79 points and 20.15 points respectively than the daily weight gain values of the lots R1 and R2. During the different growth phases, the daily weight gain value of batch R2 remained statistically lower ($p < 0.05$) than that of all the other batches.

Table 4.
Daily weight gain (g/d) of broiler chickens subjected to the different experimental diets.

Daily weight gain (g/d)	Batches				P-value
	RT	**R1**	**R2**	**R3**	
19-28 days	61.49 ± 8.00^{a}	51.13 ± 7.99^{b}	39.49 ± 6.65^{c}	45.42 ±5.44^{d}	<0.001
29-35 days	59.67 ± 4.91^{a}	61.45 ± 4.87^{a}	48.79 ± 5.71^{b}	57.90 ±6.06^{a}	<0.001
36-45 days	72.28 ± 6.97^{a}	62.92 ± 5.42^{b}	50.56 ± 7.79^{c}	69.14±13.28^{a}	<0.001
19-45 days	65.01 ± 5.87^{a}	58.17 ± 5.11^{b}	46.00 ± 6.25^{c}	57.44 ± 7.96^{b}	<0.001

Superscript alphabetical letters indicate the statistical difference between daily average gain values. On the same line, the same letters indicate a similarity of values ($p > 0.05$) while different letters indicate a significant difference ($p < 0.05$). RT: control diet, R1: 20% cashew apple and 10% cotton meal, R2: 20% mango peel and 10% cotton meal, R3: 20% mango almond and 10% cotton meal

3.4. Feed Conversion Ratio

Table 5 presents the conversion indices of the different regimes during the different periods of the trial. Over the entire study period (19 to 45 days), the conversion indices varied between 2.12 and 3.15. During this period, batch RT recorded the lowest conversion index value (2.12). This conversion index value is significantly lower than that of the other batches, in particular R1, R2 and R3. During this period, batches R1 and R3 recorded statistically similar ($p > 0.05$) conversion index values with an average for both of 2.39 ± 0.22. This average value of the conversion index of the two batches is significantly lower ($p < 0.05$) than that of batch R2 (3.15). During the 19–28-day period, batch RT recorded the lowest conversion index value (1.92) while experimental batches R1, R2 and R3 recorded one conversion index value each greater than 2 and significantly higher than that of the RT batch. During the second period (29-35 days), batches RT, R1 and R3 recorded statistically similar conversion indices ($p > 0.05$) with a common average of 2.41 ± 0.29. During this period, batch R2 recorded the highest conversion index value (3.15). From 36 to 45 days, the conversion indices of the different batches varied between 2.07 and 3.24, with batch RT having the lowest value (2.07) and R2 the highest value (3.24). The other two batches, notably R1 and R3, recorded conversion index values that were statistically different but each lower than that of R2.

Table 5.
Feed conversion ratio (FCR) of broiler chickens subjected to the different diets.

Periods	Batches or food rations				P-value
	RT	R1	R2	R3	
19-28 days	1.92 ± 0.22^a	2.34 ± 0.33^b	2.90 ± 0.41^c	2.61 ± 0.31^d	<0.001
29-35 days	2.40 ± 0.20^a	2.34 ± 0.16^a	3.15 ± 0.33^b	2.48 ± 0.21^a	<0.001
36-45 days	2.07 ± 0.17^a	2.45 ± 0.20^b	3.24 ± 0.32^c	2.06 ± 0.31^d	<0.001
19-45 days	2.12 ± 0.15^a	2.40 ± 0.20^b	3.15 ± 0.25^c	2.38 ± 0.24^b	<0.001

Superscript alphabetical letters indicate the statistical difference between daily average gain values. on the same line, the same letters indicate a similarity of values ($p > 0.05$) while different letters indicate a significant difference ($p < 0.05$). RT: control diet, R1: 20% cashew apple and 10% cotton meal, R2: 20% mango peel and 10% cotton meal, R3: 20% mango almond and 10% cotton meal

3.5. Broiler Mortality

During this test, only batch R1 recorded a mortality of 4.44% (Figure 2).

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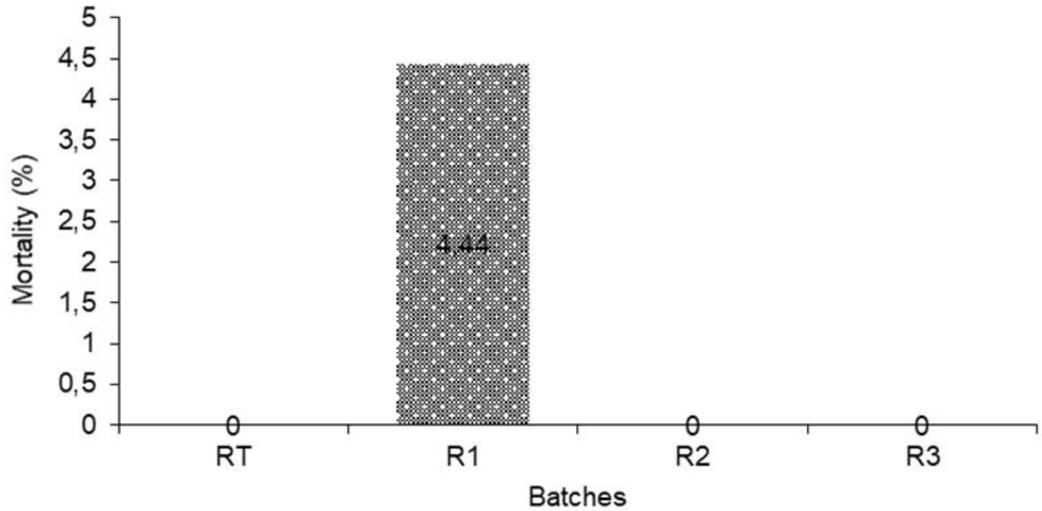

Figure 2.
Mortality rate of different experimental treatments.

3.6. Cost Evaluation and Profit Margin of Chicken Production

The prices per kg of experimental rations calculated based on those recorded on the local market for the different raw materials used are given in **Table 6**. The prices of apple, mango peel and almond were estimated considering transport, labour and collection. On this basis, the prices of apple, mango peel and almond were estimated at 75, 100 and 75 XOF per kg respectively. Thus, the price per kg of the diets (R1, R2 and R3) incorporating by-products varied between 279.87 and 284.87 XOF while that of the commercial RT diet was 395 XOF. This resulted in low feed costs of approximately 1036.64, 1081.08 and 1007.25FCFA for diets R1, R2 and R3 respectively. However, the economic analysis showed that all gross margins obtained were positive, regardless of the diet used. The diet R3 (1125.29XOF) and R1 (1123.17) had got higher margin than RT (972.23 XOF) diets. The lowest margin (626.81XOF) was obtained with the R2 diet.

Table 6.
Economic assessment of the four (4) batches according to the rations

Parameters	Batches or food rations			
	RT	R1	R2	R3
(A): Ingestion/chicken (kg)	3.649	3.704	3.795	3.599
(B): Feed price/kg (XOF)	395	279,87	284,87	279,87
(C): Feed cost = A*B (XOF)	1441.36	1036.64	1081.08	1007.25
(D): Final weight (kg)	2360.11	2177.34	1848.67	2157.71
(E): Initial weight	604.77	606.57	606.57	606.77
(F)Weight gain=D-E	1755.34	1570.77	1242.1	1550.94
(G): Chicken price/kg (XOF)	1375	1375	1375	1375
(H): Chicken cost = F*G/1000(XOF)	2413.59	2159.81	1707.89	2132.54
Gross margin per chicken = H-C (XOF)	972.23	1123.17	626.81	1125.29

Note: RT: control diet, R1: 20% cashew apple and 10% cotton meal, R2: 20% mango peel and 10% cotton meal, R3: 20% mango almond and 10% cotton meal.

4. Discussion

It had been finding overall, throughout the experimental period (J19 to 45) the incorporation of by-products had no significant effect on individual food consumption of subjects. Indeed, the incorporation of cashew apple or mango almond did not change the dietary intake compared to that of the control during the first two periods (J19 to J28 and J29 to J35). However, in the last period (J36 to J45) the intake of chickens consuming the ration containing the cashew apple increased significantly and exceeded that of the control. These results are different from those of Bhamare, et al. [14] who reported that feed intake decreased significantly in broiler chickens fed more than 10% replacement cashew apple waste. These results are also different from those of Yisa, 2019 which did not have a significant effect on food consumption with the incorporation of cashew apple. The incorporation of mango peel resulted in a very pronounced increase in ingestion during the last two periods. Our results corroborate those of Nawiri, et al. [15] who investigated the effects of inclusion of mango peel waste in the diets of laying hens on egg performance and quality in Kenya and reported an increase consumption with increased levels of mango peels (28% of mango skins). According to the same authors, this could be attributed to the high fibre content of this ration, which resulting in the dilution of nutrients, including energy sources, as a result, the birds had to be fed more to compensate for the energy deficit and other nutrients. These results are different from those of Emshaw, et al. [16] who reported no difference in feed intake when mango waste was used to replace corn in broiler chicken diets. The daily feed intake (DFI) obtained in this study (133.29 to 140.56g/d) are lower than those of Kouadio, et al. [8] who obtained DFI ranging from 147.72 to 165.33 for 50-day broiler chickens fed 15, 30 and 45% cashew apple rations. Also, these values are higher than those obtained by Ouédraogo, et al. [17] of 73.1 and 73.5 g/d in broiler chickens fed with feed where corn and fish were substituted with mango feeds and a concentrate of asparagus.

The progressive change in weight of all chicken batches indicates that all feed rations tested on chickens contain the minimum nutrients. Chickens fed with RT feed obtained the best body (BW) weight and daily weight gain (DWG) throughout the experimental period. This may be explained by the improved availability and nutritional balance of nutrients in this ration. Indeed, the presence of anti-nutritional factors such as tannins, phytates and oxalates in cashew apple, mango skin and almond [18] would have influenced the growth of chickens. Also, the low BW and DWG associated with using the R2 ration containing mango peel could be due to higher levels of tannins, phytates and oxalates in the mango skin, making nutrients unavailable [18]. Using the ration containing the cashew apple (R1) gives better results in the first two periods (J19 to J28 and J29 to J35). This may be explained by a better assimilation of the cashew apple during these two periods. In the last period (J36 to J45), use of the ration containing mango almond (R3) gives better performance. This would be justified by a better assimilation of the mango almond during this period. The average weights of chickens fed with rations incorporating by-products from our study (1878-2177 g) are much higher than those obtained by Ndiaye, et al. [19] for 40-day-old broilers fed with rations containing Senegal's cashew apple (1243.24 - 1390.27 g) and those of Ouédraogo, et al. [17] for 77days broilers fed with rations containing mango feed and Burkina Faso maggot flour (1048.8 g and 1048.5g).

The introduction of by-products into rations increased feed conversion ratio (FCR) compared with that of the RT control batch (2,12). These results are similar with those of Oluwatosin, et al. [20] which obtained an increase in the consumption index from 20% inclusion of cashew apple. Indeed, feeding chickens during the first two periods (J19 to J28 and J29 to J35) with the ration containing the cashew apple (R1) allows lower and therefore better IC, this would be due to the higher DWG of chickens in lot R1 compared to chickens in lot R3 with virtually the same intakes during these two periods. However, in the last period (J36 to J45), feeding chickens with the diet containing the mango almond allows a better FCR compared to the use of the R1 diet. This may be justified by the higher DWG of chickens in batch R3 compared to R1 with virtually the same intakes during this period. Also, the increases in the consumption index of chickens fed with the ration containing mango skin (R2) would be linked to a very high intake during the last two periods compared to the other batches, unlike the low BWG. The FCR obtained during our study are much lower than those of 77-day-old chickens fed with rations containing mango and maggot meal from Burkina Faso between 5.3 and 5.4 [17]. These results are also lower than those obtained by Mebanga, et al. [21] with broilers fed rations partially substituted with corn dried cottage grains with values between 3.35 and 5.22. According to Hasan, et al. [22] a lower consumption index would indicate the effectiveness of food use. Indeed, the consumption index reflects the success of

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food quality selection or preparation [22]. This is an important parameter to reduce production costs and increase profitability. However, this FCR parameter can be influenced by several factors such as environmental and social factors, maintenance management, composition and quality of the feed [22].

Chickens fed with feed containing mango waste (R2 and R3) did not show mortality during the experimental period. These rations would better protect chickens from disease. Indeed, according to Beriso, et al. [5] the presence of some important antioxidant vitamins in mango residues would help reduce the risk of disease.

The economic analysis performed in our study revealed that the incorporation of by-products into the broiler chicken ration reduced the cost of producing a kilogram of feed. This may be due to the low cost of these by-products compared to corn and soybeans [4]. Our results are consistent with those of Abasse, et al. [23] who used Moringa leaves at different incorporation rates. All rations generated a gross profit margin. However, the gross margins of R1 and R3 rations containing respectively cashew apple and mango almond were better than those of RT. The difference in gross margin observed between rations in this study could be attributed to the cost of feed used for diet formulation on the one hand, and to the body weight of chickens on the farm on the other. Indeed, the lower gross margin observed for the RT regime compared to R1 and R3 can be linked to the feed cost of chickens in the RT batch of 1441 FCFA versus those of 1036.64 and 1007.25 FCFA respectively for rations R1 and R3. For the R2 ration, the low gross margin could be due to the low body weight of the chickens, which is approximately 1.8 kg.

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5. Conclusion

It clearly emerges from this study that the substitution of 20% of corn by each of the by-products in particular, cashew apple, mango peel or mango almond in the broiler ration on the one hand and the substitution of 10% of Soybean meal by cotton meal in the ration on the other hand, did not reduce the zootechnical performances of the animals subjected to these diets compared to those of the animals of control diet. In addition, the incorporation of these by-products reduced the cost of chicken production compared to the control feed. During the trial, batch R1 recorded a mortality of 4.44%. However, despite this, the use of these by-products as ingredients in broiler feeds would benefit the poultry industry by minimizing production expenses associated with the high costs of conventional feeds. This is an advantage for poultry farmers, who can access feed made from these by-products all year round. Furthermore, to resolve a problem of competition between poultry and humans for cereals, particularly corn, the inclusion of these by-products in chicken feed can help reduce the problems of eliminating these wastes in cities and increase the profitability of agricultural producers. However, a counter-study should be carried out to locate the real causes of mortality recorded in lot R1.

Conflict of interest declaration:

All the authors have any conflicts of interest to declare

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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