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Effect of incorporating cassava peel meal in feed on the zootechnical and economic performance and physical characteristics of ISA Brown laying hen eggs

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Abstract

A study on the laying performance and egg quality of laying hens fed feed containing cassava peel flour was carried out at the experimental farm of the livestock production program of the National Agronomic Research Center in Bouake. To obtain this, 150 hens of 20 weeks of age and an average weight of 1471 ± 14 g were randomly distributed into 15 boxes of 3.6 m² with 10 hens per box in triplicate. They were fed twice a day with four foods containing respectively 0, 10, 20 and 30 % cassava peel flour and a fifth commercial control food with a ratio of 110 g per hen. After 52 weeks, the zootechnical parameters, feed consumption and quality of the eggs produced were recorded. The results showed that up to 30 % incorporation of cassava peel flour into the laying hen's feed there is no effect on hen mortality. However, the laying rate and egg production cost were negatively affected after 20 % incorporation. The average weights of the components (yolk, white and shell) of the eggs, the thickness of the shells and the shape indices were not affected regardless of the rate of incorporation of cassava peeling flour into the food. At the end of this study, cassava peel flour can be efficiently introduced into the diet of laying hens at a rate of 20 %.

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Introduction

In Côte d'Ivoire, poultry production has increased significantly in recent years, but the under-exploitation of local inputs makes Ivorian poultry farmers dependent on external industries (Bamba *et al.,* 2023). Indeed, feed alone constitutes, in poultry farming, 70% of production the cost. In this food, energy is an essential factor. However, the main energy source used in the production of monogastrics in general and chickens in particular, is maize (Atchadé *et al.,* 2019). It covers 70 to 90% of energy needs (Archimedes *et al*., 2011; Atchadé *et al*., 2019).

However, the fluctuation of the price according to the seasons and the times of shortages of this commodity (Kambashi *et al*., 2010) constitute a constraint on the development of poultry farming. In order to reduce food-related production costs, the development of cost-effective food formulas that integrate local, unconventional, available and low-cost food resources is needed. One of the local agricultural by-products that can be used in animal feed and is available in large quantities in Côte d'Ivoire is undoubtedly cassava peelings (Kouadio *et al.,* 2019). Indeed, cassava, from which the peelings are made, is grown in all the agro-ecological zones of the national territory with an estimated production of 4.54 million tons in 2016 (FAO, 2019). In addition, peelings account for up to 20-35% of the total weight of the processed root (Oghenejoboh *et al*., 2021). It is a by-product of cassava that has already been successfully used in broiler feed (Kouadio *et al.,* 2014). Thus, its use, with a substantial reduction in the use of maize in the feed, would contribute to significantly reducing the cost of feed for laying hens and that of the eggs that will be produced. It is in this context that this study was undertaken. The objective of this study is to evaluate the zootechnical and economic performance and physical characteristics of eggs from laying hens fed with feeds containing increasing levels of cassava peel meal.

Materials and methods

Study site

The study took place on two sites of the Regional Directorate of the CNRA in the city of Bouaké. These are the Livestock Production Station, which has the experimental hen house where the chicken feeding trial took place, and the Soil, Water and Plants laboratory of the Food Crops Research Station where the various measurements of the eggs were carried out.

The city of Bouaké is located in the center of Côte d'Ivoire, between longitudes 3°54' and 5°42' W and latitudes 7°18' and 9°24' N. It is an intermediate zone between the northern plateaus and the southern plains on the one hand and between the humid forests with short dry seasons and the savannahs with long dry seasons, on the other hand (Kanga, 2017). The climate is of the "Sudano-Guinean" type (Dolidon, 2007). Temperatures fluctuate around 27°C with variations of around 3 to 5°C. The average decadal evaporation varies between 35 and 55 mm in the rainy season and the relative humidity fluctuates between 70 and 80%. The rainfall regime is bimodal with very irregular rainfall reaching an average annual total of around 1100 mm (Kouamé *et al*., 2018).

Biological material

One hundred and fifty (150) laying hens of the ISA BROWN strain 20 weeks old and with an average weight of 1471 ± 14 g were used for this study. They were divided into 15 homogeneous batches of 10 animals each. Four feeds containing respectively 0, 10, 20 and 30% of cassava peel meal were manufactured in addition to one industrial feed (Table 1) for feeding hens.

Technical equipment

The technical equipment consisted of a building divided into 16 boxes of 3.6 m² each. Fifteen boxes were used for the trial. Each lodge was equipped with a 5-litre drinking trough, a metal feeder, and a 4-nest nest for laying eggs. Cells for collecting eggs, two scales (a 5 kg ±1 g scale and a 500 g ± 0.1 g scale) for the various weighings and a caliper, were also used. The technical laboratory equipment consisted of an electromagnetic stirrer, a pH meter, a knife and petri dishes.

Table 1. Nutritional compositions and feed costs

Ingredients	CCF*	CPF**0 %	CPF10 %	CPF20 %	CPF30 %
Maize	-	50	40	30	20
Low rice flour	-	3	3	3	3
Cassava peel	-	0	10	20	30
Wheat bran	-	10,2	8,7	6,5	4,4
Cotton cakes	-	8	8	8	8
Soybean meal	-	8,6	10	11,8	13,5
Fish meal	-	5	5	5	5
Shells	-	12	11,5	11,2	11
Lysine	-	0,12	0,12	0,12	0,12
Méthionine	-	0,13	0,13	0,13	0,13
Multivitamin complex	-	0,25	0,25	0,25	0,25
Palm oil	-	2,4	3	3,7	4,3
Lodized salt	-	0,3	0,3	0,3	0,3
Total	100	100	100	100	100
Chemical characteristics and calculated feed costs					
Metabolizable energy (kcal/kgMS)	2640	2712,66	2711,26	2715	2709,22
Fat (%)	7,3	5,71	6,18	6,73	7,17
Crude protein (%)	16,2	17,33	17,29	17,33	17,34
Phosphorus (%)	0,3	0,45	0,47	0,49	0,51
Calcium (%)	3,6	3,97	3,93	3,94	3,99
Lysine	-	0,97	0,99	1,02	1,04
Méthionine	-	0,42	0,42	0,42	0,41
Feed kg cost (FCFA)	305	262,92	251,52	241,61	228,35

*CCF: Commercial Control Feed; **CPF: Cassava Peelings Flour

Fig. 1. Egg collection by batch at the barn and measurement of their weight

Experimental design

The 150 laying hens were divided into 15 homogeneous batches of 10 animals in triplicata. Each feed was distributed twice a day with a ration of 110 g per hen, or 1,100 g per batch. Data were collected for 12 weeks to determine the physical quality of the eggs and for 52 weeks for the calculation of spawning and economic performance. To do this, the eggs were collected per day by compartment and weighed (Fig. 1).

Data collection

Laying performance

Laying rate: The laying rate is obtained by the following formula: number of eggs laid per day divided by the number of hens present multiplied by hundred.

Mortality rate: The mortality rate is obtained by dividing the number of dead animals by the number of animals at the outset multiplied by hundred.

Average egg weight: Average weight is the total weight of the eggs divided by the number of eggs.

Measure of eggs physical characteristics

For twelve weeks, three eggs per batch, i.e. twelve eggs per treatment collected per day, were measured in order to determine the following parameters:

Evolution of the average egg weight: The average weight of eggs is determined each day after collection.

Evolution of the egg shape index: The length (large-tip – small-tip distance) and width (diameter of the equatorial region) of the eggs were measured using a digital caliper for the determination of the shape index (each day after weighing) from the formula of Rap *et al.* (1979) below:

Shape Index = {(Egg width)/ (Egg length)}×100

Weight of egg constituents: The eggs were broken with a knife in petri dishes. The constituents (white, yellow and shell) were separated and weighed.

Economic performance

Production cost per kg of feed: The price per kg of feed was assessed on the basis of the market price of the ingredients at the time of the study.

Cost of egg production: It is the cost of the feed consumed for a period divided by the number of eggs produced for the same period.

Data processing

The data collected was recorded using the Excell 2017 software. These data were analyzed with Statistica Version 7.1 software. The mean values per treatment from the study criteria were subjected to an analysis of variance (ANOVA), followed by a comparison of the mean according to the Newman-Keuls test at the 5% significance level in the event of a significant difference. The numerical and graphic calculations were carried out with the Excel 2017 software.

Results

Zootechnical performance

The inclusion of increasing levels of cassava peel meal in the laying hen's diet indicate that the average laying rates over the 32-week period of CCF, CPF0, CPF10 and CPF20 treatments are statistically identical ($p \geq 0.05$) of 73.04 ± 1.65, 72.00 ± 3.16%, 73.89 ± 1.34% and 71.82 ± 1.75%, respectively. The egg-laying rate of CPF30 (61.60 ± 5.00%) is statically lower compared to other treatments. These rates are on a downward trend with increasing levels of cassava peel flour in the feed. In terms of the amount of feed consumed per batch, the averages are statistically identical ($p \geq 0.05$) for CCF (277.35 ± 12.14 kg), CPF0 (278.730 ± 1.108 kg) and CPF10 (276.627 ± 17.085 kg). For these same treatments, the results showed that the quantities of food consumed are all lower than those of the CPF20 (282.670 ± 9.295 kg) and CPF30 (283.607 ± 2.958 kg) treatments. Also, for the CPF20 and CPF30 treatments, the quantities of food consumed are statistically equal. No mortality was reported for any treatment (Table 2).

Table 2. Zootechnical production parameters as a function of treatment

Parameters	Treatments				
	CCF*	CPF**0	CPF10	CPF20	CPF30
Average egg weight (g)	56,07 ± 0,55^a	55,99 ± 0,64^a	56,05 ± 0,50^a	56,13 ± 0,15^a	57,18 ± 0,90^a
Average laying rate over the period (%)	73,04 ± 1,65^a	72,00 ± 3,16^a	73,89 ± 1,34^a	71,82 ± 1,75^a	61,60 ± 5,00^b
Mortality rate (%)	0	0	0	0	0
Amount of feed consumed per batch (kg)	277,35 ± 12,14^a	278,73±1,11^a	276,63±17,08^a	282,67±9,29^b	283,61±2,96^b

a, b : On the same line, there is no significant difference ($p \geq 0.05$) between two means with the same exponent.

*CCF: Commercial Control Feed; **CPF: Cassava Peelings Flour

Economic performance

The production costs per kg of feed are 305; 262,92; 251,52 ; 241.61 and 228.35 FCFA respectively for CCF, CPF0, CPF10, CPF20 and CPF30 treatments. The cost per kg of feed is falling with increasing levels of cassava peel flour in the feed. Regarding the cost of feed consumed per batch, the values are 84,591.75 ± 2885, 73,283.69 ± 2227.70, 69,577.98 ± 3417.89, 68,295.90 ± 1851.39 and 64,762.34 ± 1536.43 CFA francs respectively for CCF, CPF0, CPF10, CPF20 and CPF30 treatments. These costs are statistically equal for treatments, CPF0, CPF10, CPF20 and CPF30 ($p \geq 0.05$). However, they are all inferior to that of CCF processing. The cost of producing the egg is 52.53 ±

1.45; 46.16 ± 1.53; 42.70 ± 1.55; 43.12 ± 1.36 and 47.68 ± 3.53 FCFA respectively for CCF, CPF0, CPF10, CPF20 and CPF30 treatments. The rate of treatment (CCF) is statistically higher than that of other treatments (Table 3).

Physical characteristics of eggs

Evolution of the average egg weight over twelve weeks

Overall, the average weight of eggs from each treatment increases similarly with laying age (Fig. 2). They start with an average weight of 51.15 ± 0.73 g and end up with an average weight of 59.46 ± 0.85 g after 12 weeks. The inclusion of cassava peel meal in the laying hen's diet has no effect on the weight evolution of the eggs produced.

Evolution of the egg shape index

The egg shape indices for each treatment are shown in Fig. 3. These form indices evolve indifferently from food treatments. They decrease overall with the age of laying, indicating that the inclusion of cassava peel meal does not influence the evolution of the laying index.

Table 3. Economic parameters for laying hens subjected to the different treatments

Parameters	Treatments				
	CCF	CPF0	CPF10	CPF20	CPF30
Average number of eggs laid per lot	1610,45 ± 35,16^{b}	1587,67 ± 69,76^{b}	1629,33 ± 29,54^{b}	1583,67 ± 38,68^{b}	1358,33 ± 110,26^{a}
Quantity of feed consumed/batch (kg)	277, 35 ± 12,14^{a}	278,73 ± 1,108^{a}	276,63 ± 17,085^{a}	282,67 ± 9,295^{b}	283,61 ± 2,958^{b}
Cost per kg of feed (FCFA)	305	262,92	251,52	241,61	228,35
Cost of feed consumed/batch (FCFA)	84 591,75 ± 2885^{b}	73 283,69 ± 2227,70^{a}	69 577,98 ± 3417,89^{a}	68 295,90 ± 1851,39^{a}	64 762,34 ± 1536,43^{a}
Egg food production cost (FCFA)	52,53 ± 1,45^{c}	46,16 ± 1,53^{b}	42,70 ± 1,55^{a}	43,12 ± 1,36^{a}	47,68 ± 3,53^{b}

a, b, c: On the same line, there is no significant difference (p ≥ 0.05) between two means with the same exponent.
*CCF: Commercial Control Feed; **CPF: Cassava Peelings Flour

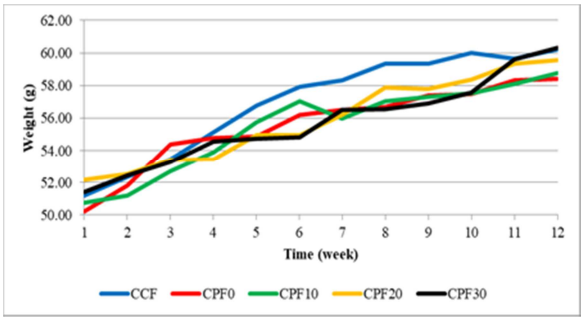

Fig. 2. Evolution of the average weight of eggs from different feed treatments according to the age of laying

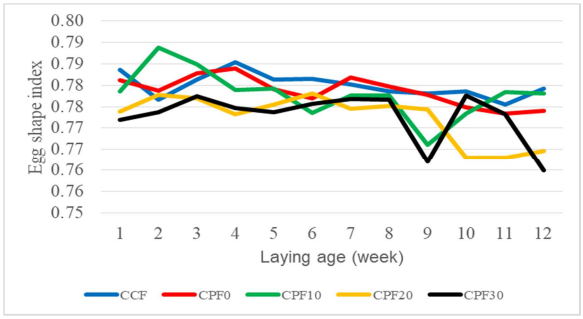

Fig. 3. Evolution of the shape index of eggs from different feed treatments as a function of laying age

Table 4. Weight of egg constituents as a function of treatment

Parameters	Treatments				
	CCF	CPF0	CPF10	CPF20	CPF30
Average egg weight (g)	56,07 ± 0,55^{a}	55,99 ± 0,64^{a}	56,05 ± 0,50^{a}	56,13 ± 0,15^{a}	57,18 ± 0,90^{a}
Average weight of egg yolk (g)	13,30 ± 0,77^{a}	13,28 ± 1,10^{a}	13,35 ± 0,14^{a}	13,58 ±0,91^{a}	13,69 ± 0,12^{a}
Average weight of egg white (g)	35,40 ± 2,40^{a}	35,74 ± 0,26^{a}	35,79 ± 0,35^{a}	35,93 ±0,03^{a}	36,68 ± 0,15^{a}
Average eggshell weight (g)	6,92 ± 0,49^{a}	7,00 ± 1,02^{a}	7,02 ± 0,30^{a}	7,60 ± 0,87^{a}	7,53 ± 0,13^{a}

a, b, c: On the same line, there is no significant difference (p ≥ 0.05) between two means with the same exponent.
*CCF: Commercial Control Feed; **CPF: Cassava Peelings Flour

Weight of egg constituents per treatment

The weights of the eggs and their components are given in Table 4. The eggs studied had an average proportion of 63.9% white, 22.7% yolk and 12.6% shell for all treatments combined. The mean egg weights of the CCF, CPF0 and CPF10 treatments are statistically comparable (56.22 ± 1.25, 56.59 ± 1.80 and 56.53 ± 0.07 respectively) and lower than those of the CPF20 and CPF30 treatments (57.88 ±1.50 and 58.32 ± 0.08, respectively), which are otherwise statistically identical. Regarding the average weights of the egg components, the results show that for the parameters studied (yolk, white and eggshell), are statistically identical for all treatments (CCF, CPF0, CPF10, CPF20 and CPF30).

Discussion

This study made it possible to compare the zootechnical and economic performance and quality of eggs from ISA brown laying hens fed with feeds containing increasing levels (0, 10, 20 and 30%) of cassava peel meal. The inclusion of cassava peel meal up to 20% does not have a negative effect on the laying rate. But from 30% inclusion, a significant decrease is noted. This is due to the fact that the amount of crude fibre, which is too high in the feed at this rate, makes it difficult to digest. It would reduce the feed metabolism and consequently the laying rate of the hens. This result is in agreement with that of the work of Houndonougbo *et al.* (2012). According to them, the laying rate of hens is higher for rations that do not contain cassava leaves, which are naturally made up mainly of crude fibre. Similar results were presented by Walugembe *et al.* (2015) according to which the inclusion of ingredients containing fibre in moderate amounts in the diets of laying hens does not reduce the laying performance of hens. In addition, the average weight of the eggs is statistically identical regardless of the treatment. This is contrary to the results of the study by Houndonougbo *et al.* (2012) who found that a 5% level of cassava leaves improves egg weight between 21 and 32 weeks of age. On the other hand, the incorporation of cassava peel meal into the feed of laying hens does not have a deleterious effect on the health of the animals since no mortality was observed in this study. Several studies have mentioned it in the bibliography (Kouamé *et al.*, 2023, Kouadio *et al.*, 2019). In view of these zootechnical results, the efficient incorporation rate identified is 20% because it has the best performance for the same parameters of laying, mortality and consumption in terms of quantity of feed per batch.

Economically, the cost of producing food is decreasing with the increasing rate of this ingredient in the food. This is justified by the fact that the production cost of cassava peel meal is lower compared to that of most other ingredients; its introduction into the feed reduces the cost of production of the feed. This result is confirmed by the study by Kana *et al.* (2015) and by Kouadio *et al.* (2019) who found respectively that in broilers in the start-up phase, the incorporation of cassava semolina and cassava peel meal led to a reduction in feed prices. At 30% incorporation of cassava peel flour, the cost of production per kg of feed fell by 76.65 CFA francs compared to the commercial control feed and by 34.57 CFA francs compared to the manufactured control. This is a significant economic gain for the farmer, especially for large farms. This result is confirmed by the study by Houndonougbo *et al.* (2012) who also states a reduction of 12 to 20 CFA francs/kg in the price per kilogram of feed with the incorporation of cassava leaves into rations. This is also the case for the cost of food consumption per batch, which decreases by 10.25% after 30% of cassava peeling flour is incorporated. However, when these expenses are reduced to the unit of egg produced, there is an increase in the cost of producing the egg after 30% of cassava peel flour is incorporated. The efficient incorporation rate for the farmer that emerges at the level of these economic parameters is the rate of 20%.

On the quality of these eggs, the average weight of the eggs and the shape indices remain unchanged despite the increasing rates of incorporation of cassava peel meal into the feed. This is corroborated by the study by Sumiati *et al.* (2020) who, having used cassava leaf

flour at increasing rates in the feed of laying ducks, found similar mean weights and egg shape indices regardless of the inclusion rate.

Rather, it is the average weight of the eggs that increases with the age of the hen, indicating that the weight of the egg laid takes more into account the age of laying than the feed consumed by the laying hens. Indeed, the increase in egg weight during a laying cycle is linked to the aging of the hen (Travel *et al.*, 2010). As for the egg shape index, it tends to decrease with the age of the hens, regardless of the level of incorporation of cassava peel flour. This shows that the eggs are rounder in young hens and tend to elongate with the age of the hens. There is an inverse correlation between the age of laying and the shape index of the eggs. This is different from the study conducted by Kana *et al.* (2013) according to which the shape index of the egg tends to decrease when the level of incorporation of cassava flour has increased in the feed. The average weights of the components (egg yolk, egg white, shell) are not affected by the inclusion of cassava peel meal in the layer feed. This could be explained by the fact that cassava peel flour that did not contain anti-nutritional substances did not affect nutrient absorption since the food was iso-protein and iso-energetic. This result is consistent with that of Simiati *et al.* (2020) according to which the inclusion of up to 10% of cassava leaves in the duck feed did not affect the weight of the egg constituents.

The level of efficient incorporation for the farmer that emerges at the level of this parameter is the rate of 20%. Moreover, at this rate, the economic costs are the lowest of all treatments, the quality of the eggs is not affected at all and the zootechnical parameters of production are comparable to control feeds without cassava peelings.

Conclusion

The study shows that the inclusion of up to 30% of cassava peel meal in the feed of the ISA BROWN laying hen has no effect on the viability of the hens or on the average weight of the eggs produced. The shape indices and proportions of the constituents (yolk, white and shell) of the egg are also not affected by this inclusion. On the other hand, above 20% introduction, the laying rate and the cost of egg production are negatively affected. Therefore, cassava peel meal can be used efficiently in the feed of the ISA BROWN laying hen up to 20%.

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