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Valorisation of cocoa tree husks, *Theobroma cacao*, as feed for ducks in the Antalaha District, Madagascar

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Abstract: The present article was based on the valorization of cocoa husks in feed mills. Our main objective is to test the use of varied proportions of cocoa pod pericarp powder with other raw materials of organic origin in duck rations in order to determine its effects on the growth performance of the animals. Our methodology is based on production of organic feed, chemical analyzes in the laboratory and experimentation. Based on experience, cocoa shell flour has considerable nutritional values. Three experimental batches were used for nine ducklings. The best daily weight growth performance is observed in Lot C at 65 % of cocoa shell flour. The average daily weight gains of this Lot C (5.672 g/d) is very significant compared to the others during the six (06) weeks of experimentation. Ducklings cannot eat pure cocoa shell flour because of its somewhat bitter taste, but they will eat food mixed with this flour. Despite the adaptation of these ducklings during the experiment, none of them died.

Keywords: Valorization; cocoa husks; feed; ducks.

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1 Introduction

The cocoa tree (*Theobroma cacao* L.) is a tropical plant of the Malvaceae family which was introduced into Ivory Coast at the end of the 19th century in its eastern region **[2]** and **[8]**. Fine cocoa was introduced to Madagascar in the 1880s by the French, originating from the coast near a town called Anivorano, located on the east coast of Madagascar. Cocoa is now grown in the Sambirano Valley, near the small town of Ambanja and Nosy Be Islands in the northwest of Madagascar **[7]**.

The main causes of the food crisis can be explained by an insufficiency of available food resources in Third World countries. Such an insufficiency of food resources would be implied by human overload and uncontrolled

population growth. This food crisis situation has had repercussions on poultry production in competition with humans for scarcely available cereals **[10]**.

Cereal production is not always sufficient for human consumption. It is therefore important to seek other food sources for animals and thus reduce competition between humans and them. Poultry, whose staple diet is corn, can use other unconventional energy sources as long as they do not alter their growth to the point of becoming unprofitable. By-products called waste fit well into this perspective.

Man, through his activities, produces waste. Among, there is agricultural waste as cocoa pod pericarps which are very widespread in most tropical regions of Madagascar such as DIANA, more precisely Ambanja, and SAVA, especially Antalaha. The nutritional value of a food is determined above all by its energy value, its nitrogen value. The chemical composition of cocoa shell flour is rich in crude fiber 21.3 % with gross energy 4,470 Kcal/kg **[9]**. But the presence of anti-nutritional factors can make some or all of these food pericarps available for animal feed. Faced with environmental problems and the food crisis caused by the production of domestic animals in competition with humans for scarcely available cereals, this article focuses on: Valorisation of cocoa tree husks, *Theobroma cacao*, as feed for ducks in the Antalaha District, Madagascar.

The overall objective of this study is to test the use of varied proportions of cocoa pod pericarp powder in the duck ration in order to determine its effects on the growth performance of the animals. The specific objectives are to feed three batches of ducklings under the same conditions, measure growth performance and deduce the limits for the use of cocoa shell powder.

2 Methodology

2.1 Materials

2.1.1 Biological material

The experiments are based on the growth of the ducklings. Nine (09) ducklings of the local breed, one month old and robust, were chosen.

Figure 1. Ducklings

Cocoa shell flour was considered as the main raw material. Thus, it is necessary to give the botanical classification of the cocoa tree **[1]**, known as the Malagasy name Kakao.

Reign : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
Order : Malvale
Family : Sterculiaceae
Gender : *Theobroma*
Species : *Theobroma cacao L.*

Other raw materials were used to ensure mixing in the production of feed, namely: rice bran, fish meal and corn flour, with water.

2.1.2 Rice bran

Rice bran is a product obtained from the hulling of paddy (Figure 2). The majority of Malagasy farmers use it in livestock farming. This pushed us to introduce it among the basic foods during the weeks of breeding.

2.1.3 Fish meal

Fish meal is used as a nutritional supplement to the ration of ducklings studied and raised (Figure 3).

2.1.4 Corn flour

It constitutes the basic diet of ducklings and is necessary for their growth (Figure 4).

Figure 2. Rice bran

Figure 3. Fish meal

Figure 4. Corn flour

2.1.5 Other materials

Water plays a determining role in the life of animals and their development. Some materials were also used during the experiment, namely:

- **Large cage**: it divided into 3 sectors are used to place the ducklings in order to distinguish them according to the lots.
- **Bowls**: 3 bowls serve as manual waterers for the ducklings.
- **Analytical balance:** it has a capacity of 5 kg: it is used to weigh food every day as well as ducklings every week in order to monitor their weekly weights (Figure 5).

Figure 5. Analytical balance

2.2 Methods

2.2.1 Other materials

Cocoa shells were collected fresh from the farmers' plantation in the Ambanja District, Sambirano Region. Shelling is an operation which consists of breaking the pods and extracting the beans. It is usually done by hand. The simplest is to hit the pod with a large stick so as to break the shell perpendicular to the largest diameter of the pod. The cocoa shells were cut into pieces and dried in the sun for 8 to 10 days before being crushed.

2.2.2 Preparing cocoa shell flour

After preparing and drying the cocoa shells, they are pounded in a mortar and pestle. This produces a brown powder to facilitate agglutination.

2.2.3 Method of analysis in a laboratory

❖ **Determination of dry matter content**

The flour sample, with a mass determined by weighing, is dried in an oven at 105 °C to a constant mass. The dry matter content of the sample is determined as the percentage of its mass after steaming relative to its mass before steaming.

The flour samples (2 g) are weighed in small aluminum containers previously dried in a ventilation oven at 105 °C, cooled in a desiccator then weighed with their lid. The containers containing the samples are then returned to the ventilation oven at 105 °C; each lid being placed under the corresponding container. After 24 hours, the containers are removed from the oven and covered with their lid. They are cooled in a desiccator for approximately 40 minutes, then weighed using a precision balance. The dry matter contents (%DM) of the cocoa shell flour samples are determined using the following formula (1):

$$\% MS = \frac{100(M2 - M0)}{M1}$$

With, M0: Mass of container with lid, without sample (g);

M1: Mass of the product before steaming (g);

M2: Mass of the container with lid and sample after cooling in a desiccator (g).

❖ **Determination of crude fat content**

The fats are extracted using hexane. Extraction is based on the insolubility of lipids in water and their considerable solubility in non-polar organic solvents. The extract obtained is weighed after removing the extraction solvent. The crude fat contents (% MGB) of the flour samples (based on dry flour) are calculated from the following formula (2):

$$\% \text{ mgb} = \frac{(\text{M2} - \text{Mo}).10^4}{\% MS.\text{M1}}$$

With, M0: Mass of the empty flask intended to receive the fat (g);

M1: Mass of the fresh sample analyzed (g);

M2: Mass the cooled flask filled with fat after steaming (g);

% MS: Dry matter content of the analyzed sample.

❖ **Determination of crude protein content**

Under the action of sulfuric acid concentrated in the sample and in the presence of a catalyst, the nitrogenous organic materials of a product are destroyed. Carbons and hydrogens are released in the form of carbon dioxide and water. While organic nitrogens are converted into ammonium salts. Treated with a dispersing agent, the ammonium salts formed are decomposed and release ammonia. The crude protein contents (% PrB) of the flour samples (dry matter basis) are determined using the following formula (3):

$$\%\text{PrB} = \frac{0{,}0075.C.V1.FA}{\%MS.\text{M}.V2}$$

With, C: Protein concentration, in mg/l, read by spectrophotometer;

V1: Total volume of the diluted mineralization (ml);

V2: Volume of the analyzed mineralization (ml);

FA: Nitrogen to used protein conversion factor;

M: Mass of the flour sample analyzed in the fresh state (g);

% MS: Dry matter content of the analyzed flour sample.

2.2.4 Breeding experimentation device

The experimental observation study lasted six (06) weeks, from October 30, 2023 to December 15, 2023: the breeding of ducklings designed for the use of the obtained flour.

❖ **Marking and nomenclature of ducklings**

The ducklings were bought in the Mahajanga city market. Each individual was marked and named to distinguish it from the others. All the ducklings in each Lot A, Lot B and Lot C have the same sign, but they have different names. The name was chosen in order of the numbering of the ducklings, that is, from duckling n°1 to ducklings n°9.

❖ **Food distribution**

The distribution methods were as follows: the duckling maintenance methods were divided into two distributions (twice a day): Morning (at 6:00 a.m.) and evening (at 5:00 p.m.); the water was changed after each distribution of food; ducklings should eat as much as they want. In this case, the food was placed continuously during the day in the different batches. All leftover food is removed at nightfall (around 6:00 p.m.).

❖ **Weighing of the ducklings before and during the experiment**

Each duckling in the 3 (three) existing batches was weighed before the test (feeding): their weights must be determined at the end of each week, during the six (06) weeks of application. The ducklings were divided into groups of 3 (three).

3 Results

3.1 Nutritional value of cocoa shell flour

The nutritional value of the elements analyzed is presented in the table below. M0 = 3 g; M1 = 2 g; M2 = 4, 82; so, MS = 91, 19 %.

Table 1. Chemical composition of cocoa shell flour.

Chemical characteristic	Cocoa shell flour
Dry matter, % and fresh matter	91
Crude protein, %MS	5,8
Fat, % MS	2,1

3.2 Produced power

The following Figure 6 shows the basic types of food with the quantities given weekly to each individual according to the existing lots: Lot A (corn flour, rice bran, fish meal), Lot B (C.C flour, corn flour, rice bran) and Lot C1 (C.C flour) and Lot C4 (C.C flour, corn flour, rice bran, fish meal). Note that Lot A serves as a control, that is to say without cocoa nut flour. Also, we added greens (green herbs) to these foods and of course water. Each lot received in moderation the same quantity and quality of these elements per week.

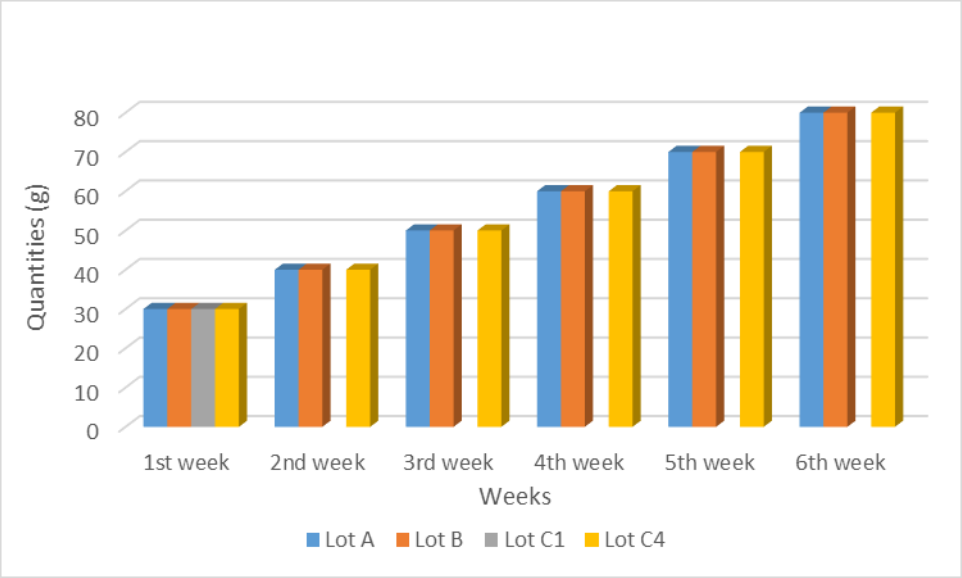

Figure 6. Amounts of basic food types

3.3 Nutritional composition of the produced food

Figure 7 below shows the composition of the basic foods given to ducklings. The calculation of sharing (in %) is based on 100 g of food.

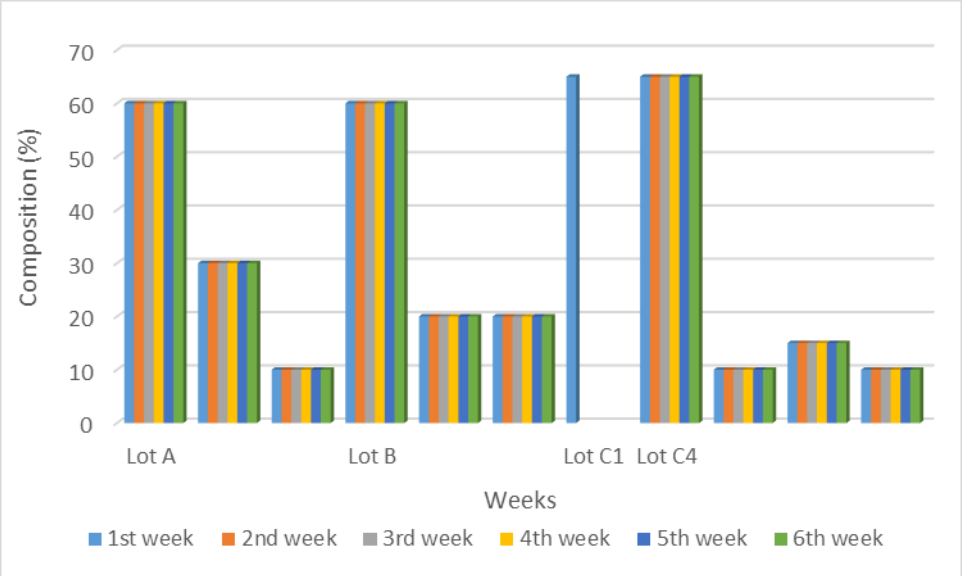

Figure 7. Proportion of duckling food quantities per week

3.4 Weight assessment of each studied duckling

To know the growth of the ducklings in different batches, it is necessary to record the weight of each individual per week during the six weeks of rearing. The following Figure 8 shows the weight growth of the ducklings from the first week to the sixth week of the experiment.

From the beginning until the third week of rearing, all the ducklings from lot A have very large weights while at the fourth and sixth week, the ducklings from lot C containing 65 % of the cocoa shell flour have very high weights are n°7 having 307.48 g and n°9 having 305.25 g.

On the other hand, the weight growth at batch B level with the composition of 60 % cocoa shell flour remained the lowest weight from the third week until the sixth week of aging. The minimum and maximum weight of the ducklings raised in the different batches at the end of the experiment varies between 140.11 g for n°5 and 307.48 g for n°7.

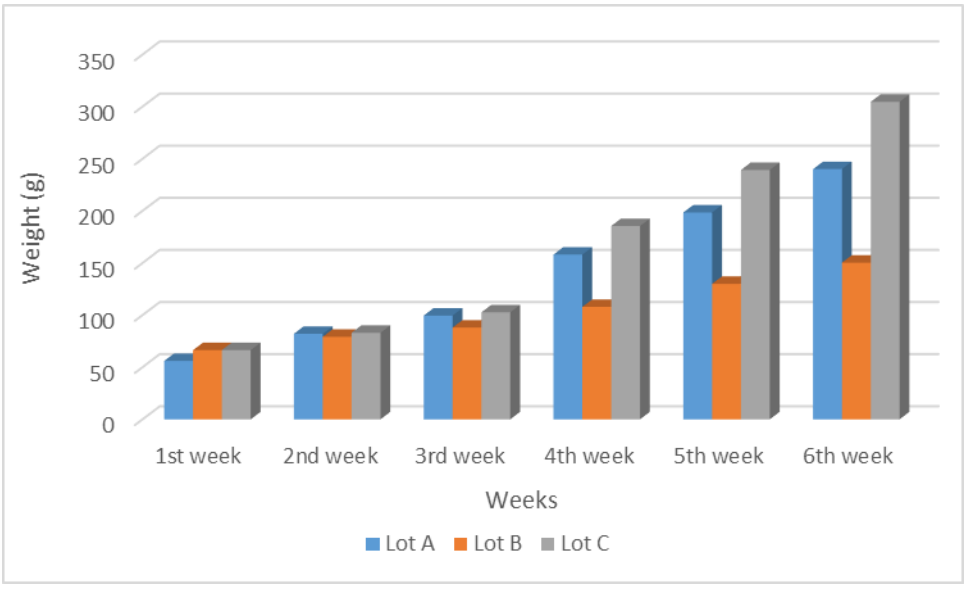

Figure 8. Weights of studied individuals in batches for six weeks

3.5 Comparative analyzes of the weight growth of each individual per lot

The growth analysis results were obtained using formula (2) on the previous page in Table 2 below. The daily weight growth of the ducklings in each batch is listed in the order: Lot B < Lot A < Lot C.

Table 2. Parameter of weight growth of ducklings.

Settings	Lot A	Lot B	Lot C
Average initial live weight in grams (g)	56.06	66.38	66.44
Average final live weight in grams (g)	240.103	150.253	304.676
Average daily weight gain in g/d	4.381	1.996	5.672

3.6 Physical and physiological behaviors of ducklings

To fully appreciate the cocoa shell flour diet, we followed the behavior of the ducklings, the observation results of which are in Table 3 below.

Table 3. Behavior and growth of the individuals during the experiment.

Lots	Behavior and growth
Lot A	- The individuals have grown up and have no physiological complications. - Their growth is quite significant.
Lot B	Their growth lags behind the others, they remain less active than the others.
Lot C	- Their growth is greater than that of individuals in batches A and B. - No physical problems were noted.

4 Discussion

The pod shell is very rich in gross energy, 4150 kca1/kg or 0.42 UF/kg M.S **[3].** The richness of the cellulose shell, approximately 18 p. 100, limits its use because it is poorly digested by monogastrics. In addition, its richness in theobromine alkaloids 3 p. 100 and caffeine 1.5 p. 100; limits its large-scale use in ruminants **[5]**. Pod hull flour can replace corn and make up 35 p. 100 of the ration **[4]**. But beyond that, there is a drop in performance. This must be done after detoxification by cooking in water for half an hour followed by filtering and drying. Dittmar in Brazil in 1956 successfully fed pigs with cocoa husks **[6]**. We carried out our research into the use of these hulls in duckling breeding feed mills.

The growth of ducklings is directly related to the quality and quantity of food as well as the conditions in which they are raised **[10]**. According to table I, the cocoa shell contains crude protein 5.8 and fat 2.1. From a physical point of view, all individuals (ducklings) appear to be in good shape. Moreover, they do not have appetites during the first weeks but from the second week they recover a little until the end of the experience. Individuals in lot B which contain a 60 % food proportion based on cocoa shell flour have a low growth rate. This could be justified by the taste of the flour in this cocoa shell.

The ducklings from Lot A (control lot) are certainly not affected by this change: they eat perfectly. Consequently, the food waste of these ducklings in the control group is less significant than that of the ducklings in group B, whose food scraps represent more than half of the distributed food.

While in Lot C, four (04) days before the test with 65 % of the proportion of cocoa shell flour, the rejects constitute almost all of the food given. After changing the composition of the food to 65 % cocoa hull flour, 10 % corn flour, 15 % fish meal and 10 % rice bran, the food leftovers are quite less.

5 Conclusion

According to our research which lasted 6 weeks, ducklings can expect a weight of 307.48 g with the composition of 65 % cocoa shell flour. Lot C which has strong growth compared to the others, thanks to the nutritional value contained in this shell. We can then say that the growth of ducklings is directly related to the quality and quantity of food as well as to the conditions in which they are raised.

The best daily weight growth performance is observed in batch C at 65 % of cocoa shell flour. The average daily weight gains of this Lot C (5.672 g/d) is very significant compared to the others during the six (06) weeks of experimentation. Ducklings cannot eat pure cocoa shell flour because of its somewhat bitter taste, but they will eat food made from this flour. Despite the adaptation of these ducklings during the experiment, none of them died.

The following recommendations can be put forward to improve and strengthen the results obtained from our research: First, check the toxicity uncertainty contained in the cocoa shell; then, popularize the use of cocoa shell flour in livestock other than poultry; in addition, inform people about the nutritional value contained in the cocoa shell; and finally, carry out experiments on the cocoa shell in the diet of other poultry taking into account the toxicity carried in the cocoa shell.

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