

Nutritious and Nutritional Values of « milks » from *Blighia sapida* (K.D. Koenig) Arils and Soya Beans (Glycine Max)

Howélé Ouattara¹, Alassane Méité², Bazoumana Ouattara¹ & Séraphin Kati-Coulibaly²

¹Training and Research Unit of Biological Sciences, Department of animal biology, University Peleforo GON COULIBALY of Korhogo, BP: 1328, Korhogo, Côte d'Ivoire

²Laboratory of Biology and Health, Biosciences Training and Research Unit, University Félix Houphouët-Boigny of Cocody-Abidjan, BP: 22 BP 582 Abidjan 22, Côte d'Ivoire

Correspondence: Howélé Ouattara, Training and Research Unit of Biological Sciences, Department of animal biology, University Peleforo GON COULIBALY of Korhogo, BP: 1328, Korhogo, Côte d'Ivoire. E-mail: ouattarahowe@gmail.com

Received: April 13, 2023

Accepted: June 30, 2024

Online Published: July 31, 2024

doi:10.5539/jfr.v13n2p38

URL: <https://doi.org/10.5539/jfr.v13n2p38>

Abstract

African nations are not self-sufficient in milk and related solutions. So, some fruit, which get nutritious and nutritional value, can be valorized.

The aim of this work was to evaluate the effect of *Blighia sapida* arils "milk" consumption on growth of rats and on the induction of diarrhoea compared to that of soya bean "milk".

For that, arils "milk" were produced using 0.5 kilogram of arils/ liter of distilled water and soya bean "milk" was brought. The two "milks" were freeze-dried and the powders were used to prepare concentrations (0, 200, 400 and 800 mg / kg of body weight) to be administered every three days to seven groups of rats during 15 days. Every three days, body weight was taken, faeces were collected and their moisture content was determined.

Analysis showed that both powders are nutritiously rich. Soya bean "milk" powder protein and lipids content are higher than that of arils "milk" powder but its carbohydrates, calcium and phosphorus content are lower. Both "milks" are in favor of gain weight and they do not induce diarrhoea. So, we can envisage much production of it for human consumption.

Keywords: *Blighia sapida* arils mik, soya bean milk, body weight, diarrhoea

1. Introduction

Milk is a whitish liquid produced by the mammary glands of mammals. It is the primary source of nutrition for young mammals before they become able to consume solid food (Van Winckel et al., 2011). It is therefore the food source for young humans. It is a food recognized for a long time as good for health because of its high calcium content and its high proteins content with a high quality of essential amino acids (Franworth et al., 1953; FAO, 1995). For this, Man does not deprive himself of it all his life. Thus, during his life, humans replace breast milk with the milk of other mammals such as cow's milk, sheep's milk, goat's milk collected properly without colostrum (Konte, 1999). However, despite a steady increase in milk production, the FAO estimates that the quantity produced will not be able to meet the growing demand linked to increase of milk consumption in the developing world (FAO, 2007). Under these conditions, production of beverages which have nutritional value comparable to those of milks extracted from animals, and which aspects close to them from the visual point of view, seems to be an interesting alternative. It is also a boon for the nutrition of children who have a digestive system which is not yet well developed, to vegetarians whose eating habits exclude the consumption of meat, and to vegans who refuse to exploit animals (Lafitedupont, 2011; Anonymous 2, 2020). Again, because milk contains lactose (Pehrsson, 2000), beverage production will be a boon for lactose intolerant. These beverages, because of their origine and because they are used to replace milk, are called "vegetables milks". The most "vegetables milks" know in the world is the drink produced from soya bean seeds. It is therefore up to African countries, which are generally developing countries, to make up for the lack of milk through the large-scale production of seed soya bean "milk". This requires an increase in soya bean production. Unfortunately, this is an almost impossible challenge because since the introduction of soya bean cultivation in Africa, production has

never been able to meet the needs. In fact, African soya been production represents only 1 % of world production (Anonymous 1, 1999). Thus, Africa remains dependant on the major world producing countries. It seems appropriate to promote fruits of spontaneous wild plants originated from West Africa. These fruits should have an interesting visual appearance and get nutritional value. *Blighia sapida*, a wild spontaneous plant native to West Africa, produces a wild fruit that meets these characteristics (Morton, 1987; Oyeleke *et al.*, 2013; Ouattara *et al.*, 2010; 2016 a, b). This study was therefore conducted in order to evaluate the effect of the consumption of *Blighia sapida* arils "milk" powder on growth of rats and on the induction of diarrhea compared to that of soya been "milk".

2. Materials and Methods

2.1 Plant Identification

The plant was identified by a specialist from the National Floristic Center of Côte d'Ivoire located in Félix HOUPOUËT-BOIGNY University. A specimen is registered in this Center under the code UCJ016262.

2.2 Processes for Producing *Blighia Sapida* Arils "milk"

The fruits of mature *Blighia sapida* (opened alone under the action of solar radiation) were harvested in the North of Côte d'Ivoire. From these harvest fruits, the arils were separated from the black seeds and then sorted, washed and weighed. After that, 500 grams of fresh arils were mixed with one liter of distilled water (0.5 kg/liter of distilled water). The mixture obtained was first ground in a blender for 12 minutes, then filtered with a 0.8 mm mesh sieve and finally pasteurized at 60°C for 30 minutes. At the end of the process, a whitish solution was obtained and we named it "milk" extracted from the aril of *Blighia sapida*. The "milk" obtained was decanted into a container and placed in the refrigerator at 5°C for storage. The extraction yield of aril "milk" was 2.43 litres/kg of aril.

2.3 Soya Been "milk" Origin

Soya been "milk" was brought in a super market at Korhogo, the town where the experiment was done.

2.4 Freeze-drying Process

The two "milks", *Blighia sapida* arils "milk" and Soyabean "milk", were freeze-dried in order to preserve both the volume, the appearance and the properties of the treated products (Pikal *et al.*, 1983). Then, we obtained two powders (the powder of *Blighia sapida* arils "milk" and the powder of Soya been "milk"). Two liters of each milk were lyophilized. Figure 1 summarized the different stages of *Blighia sapida* arils milk production and the process used to obtain the powders of the two "milks".

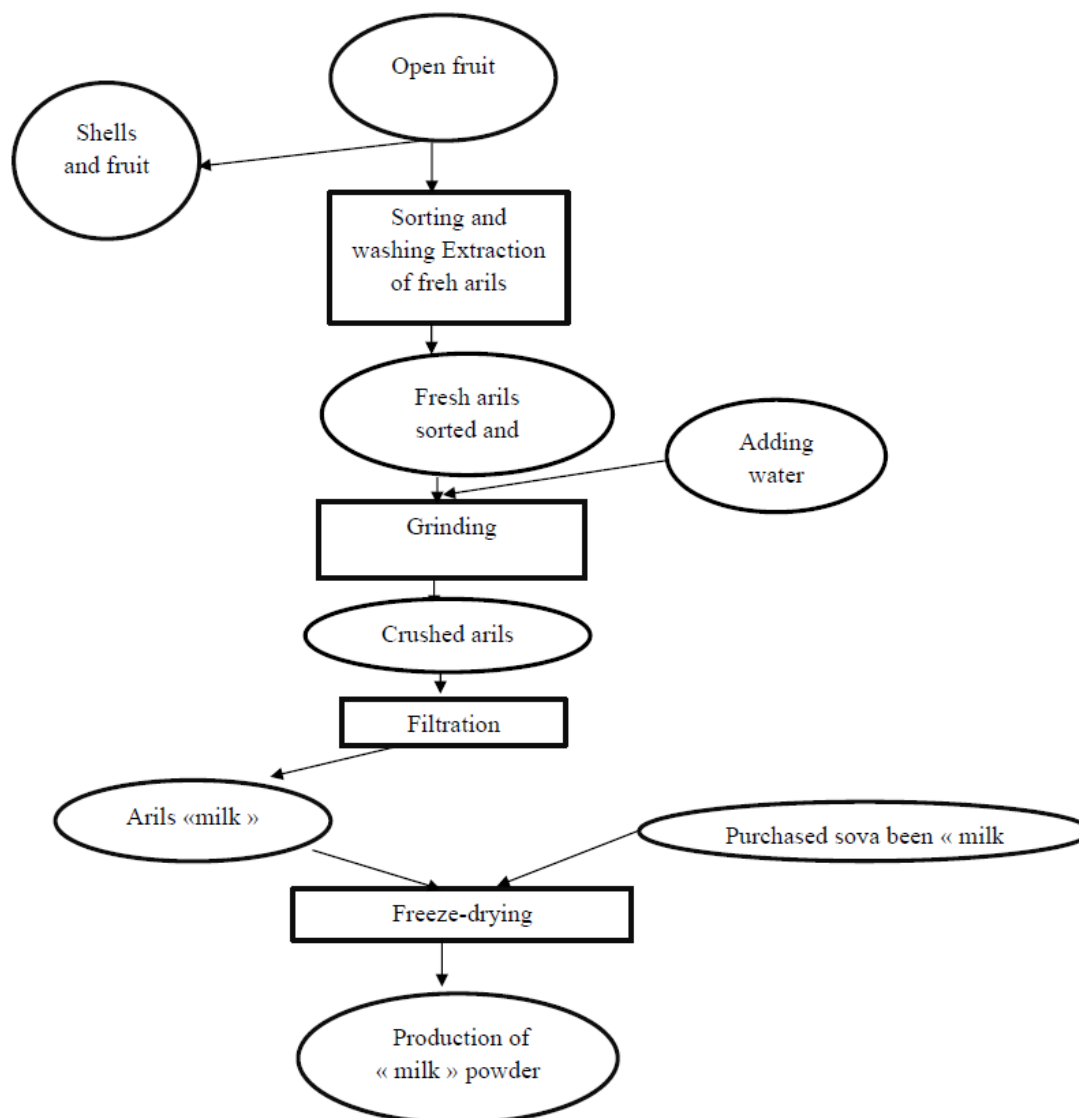


Figure 1. Diagramm which show processes used to produce *Blighia sapida* arils « milk » and to obtain the differents kinds of « milks » powders

2.4 Determination of the Proximate Composition

The recommend methods of Association Analytical Chemists (AOAC, 1975) were employed in determining the levels of moisture, ash, crude protein and crude fat.

Moisture content was determined by heating 2 g of samples to a constant weight in crucible placed in an oven (MMM Medcenter GmbH (D-82152, Munich, Germany) maintained at 105°C for 4 hours.

Ash was determined by incineration of 1 g samples placed in a muffle furnace (P Selecta, Espagna) maintained at 550°C for 6 hours.

Crude protein content (% total nitrogen \times 6.25) was determined by Khedjahl method (Pearson, 1976), using 1 g samples.

Crude fat was obtained by exhaustively extracted 5 g of each sample in a Soxhlet apparatus for 8 hours using hexane as the extractant (Bourelly, 1982).

Total carbohydrate (%) was estimated by difference as show in the equation:

$$\text{Total carbohydrate (\%)} = 100 - [\text{Protein (\%)} + \text{Lipids (\%)} + \text{Asch (\%)} + \text{Fibre (\%)}]$$

2.4.1 Vitamin C Dosage

Ascorbic acid was measured using the iodine oxidation method as described by Fabert (1964). Vitamin C was obtained after grinding in an acid medium (2 % HCl).

The following protocol was adopted:

2.4.2 Extraction of Vitamin C

Five (5) g of, each « milk », powders were weighed and ground in a mortar and then transferred to a beaker. Then, 25 ml of 2 % HCl was added and the mixture was allowed to stand for 10 minutes. The extract obtained was transferred to 100 ml volumetric flask and the volume was completed to the gauge line with the 2 % HCl solution. Each extract was stirred and filtered immediately.

2.4.3 Extract Titration

One (1) ml of each extract was taken and added to 3 ml of distilled water contained in an Erlenmeyer flask. Then 0.5 ml of potassium iodide ((KI) 1 %) and 2 ml of the 0.5 % starch solution were added. The mixture was immediately titrated with a fresh solution of potassium iodide oxide (KIO₃) 0.001N using a burette until the solution turned a persistent blue color on stirring. A control test was carried out under the same conditions using 1 ml of 2 % HCl instead of the vitamin extract. The ascorbic acid content was determined by the following expression:

$$\Omega = [(v_e - v_b) \times N \times 88 \times v_t / (p \times v)] \times 100$$

Ω : amount (mg) of ascorbic acid in 100 g of fresh material;

v_e : volume (ml) of KIO₃ used to titrate the extract;

v_b : volume (ml) of KIO₃ used to titrate the control;

N : normality of KIO₃ (0,001N);

88: weight of one milliequivalent of ascorbic acid;

v_t : total volume of extract;

P : weight (g) of the powder;

V = Volume of titrated extract

2.4.4 Dosage of Some Minerals

The determination of minerals is based on the principle of the destruction of organic compounds by calcination at high temperature (550°C) followed by the solubilization of the raw ash in a mineral acid (Munganga, 2013). To carry out the dosage of minerals, one (1) g of each « milk » powder was taken and then heated in an oven at 550°C for 4 hours in order to obtain ashes. The ashes of each sample was left to cool in a desiccator. Then, five (5) ml of nitric acid ((HNO₃) 6M) was added in each ash. The whole was slowly heated on a hot plate until there was about one (1) milliliter left. Another five (5) ml of HNO₃ (3M) were added, then the whole was heated for a few minutes. The solution was filtered hot and transferred to a 50 ml flask. Finally, distilled water was added up to the mark (50 ml). The solutions obtained were used for the determination of minerals, in particular calcium, magnesium, iron and phosphorus.

2.4.5 Calcium Dosage

Calcium was measured using complexometric/colorimetric titration method as described by Kajalkar and Gaikwak (2013). Then, one milliliter (1) ml of each mineralizate was introduced into an Erlenmeyer flask. After that, two (2) ml of distilled water, one (1) ml of potassium cyanide (KCN) and one (1) ml of triethanolamine hydrochloride were added successively. Soda (NaOH, 2N) was slowly added in order to adjust the pH to 12. The add of two drops of 0.4 % calcon turned the solution to a purple-red color. Finally, the titration was carried out with ethylene diamine tetraacetic ((EDTA) 0.02N) until the color changed to blue. The following formula permit to determine the proportion of calcium in 100 g.

$$\%Ca = V_x N \times 20$$

% Ca: percentage of calcium;

V : volume (ml) of EDTA used for the titration;

N : normality of EDTA (0.02 N);

20: dilution factor.

2.4.6 Magnesium Dosage

Magnesium was determined by complexation of the sum of Ca^{2+} and Mg^{2+} . The principle is exactly the same as that of the determination of calcium but, here the magnesium has been complexed as $\text{Mg}(\text{OH})_2$ (Ryan and Barbour, 1998). The pH was below 12 (pH-10). The pH was maintained using the ammoniacal buffer. Ten (10) ml of the mineralizate were introduced into a 250 ml Erlenmeyer flask and the volume brought to 100 ml with distilled water. Successively, two (2) ml of KCN, ten (10) ml of ammonia buffer and a pinch of eriochrome black were added. The solution then takes on a red-violet color. With EDTA (0.02N), the solution was titrated slowly until the appearance of true blue or washed out blue. The magnesium content was determined by the following formula:

$$\% \text{ Mg} = (v_1 - v_2) \times N \times \text{FC} \times 12.10^{-3} \times 10^2 / p \times a$$

% Mg: percentage of magnesium;

V1: volume in ml of EDTA for the sum of Ca + Mg;

V2: volume in ml of Ca EDTA;

N: normality of EDTA (0.02 N);

FC: EDTA correction factor (1.064)

12: milliequivalent Mg^{2+}

10^{-3} : Conversion factor from mg to gram;

10^2 : Total volume of mineralizer (extracted);

P: weight of the incinerated sample (1 g);

a: aliquot (10 ml);

10^2 : 100 g of dry matter.

2.4.7 Iron Dosage

Iron was determined according to the method described by Maljournal *et al.* (1983). In this method Iron +II is reacted with o-phenanthroline to form a coloured complex ion. The intensity of the coloured species is measured using a Spectronic 301 spectrophotometer.

Two (2) ml of the mineralizate were taken, then 2 ml of concentrated H_2SO_4 was added. Then, 3 drops of diphenylamine (1%) were added. The mixture was titrated with potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$ 0.01N). The appearance of the persistent blue-violet color indicated the end of the titration. The percentage of iron is given by the following formula:

$$\% \text{ iron} = V \times 1,675$$

% Iron: iron percentage;

V: Volume (ml) of $\text{K}_2\text{Cr}_2\text{O}_7$ used for titration;

1.675: dilution factor.

2.4.8 Phosphorus Dosage

Phosphorus was determined by the method without deproteinization described by Daly and al. (1972). This principle is based on the fact that orthophosphates form with molybdate in an acidic medium a soluble salt. The complex that forms is reduced by molybdenum. Then, two (2) ml of mineralizate were taken and 1 ml of the molybdc solution was added. Then, 1 ml of the reducing solution was also added. Finally, the optical density of the solution was read with a spectrophotometer after development of the blue color at 420 nanometers. The percentage of phosphorus was determined by spectrophotometer according to the following formula:

$$\% \text{ P} = (\text{DO}_{\text{IN}} / \text{DO}_{\text{St}}) \times 1,25 \cdot 10^{-1}$$

% P: Percentage of phosphorus in the dried material;

DO_{IN} : unknown optical density;

DO_{St} : standard optical density; 0.125 = Dilution factor.

2.5 Animal Experimentation Process

2.5.1 Animals Breeding

Albino Wistar rats used in this experimentation were bred in the animal house of Ufr Biological sciences of

the University Peleforo GON COULIBALY of Korhogo (Côte d'Ivoire). During the breeding, rats were fed with food made by a society in Côte d'Ivoire call IVOGRAIN which is specialized in mass production of livestock food. This food is making up by crud protein matter (15 %), crud fat matter (3.5 %), cellulose matter (12 %), mineral matter (9 %), calcium (1 %), phosphorus (0.9 %), sodium (0.3 %), vitamin A (15000 ui/kg), vitamin D3 (3000 ui/kg), vitamin E (10 mg/ kg). They were maintained under standard laboratory conditions (temperature 25 ± 2 °C) with dark and light cycle (12h/12h). Rats had free access to water and food.

2.5.2 Formation of Batches of Rats

35 *albino Wistar* rats weighing between 159 g and 235 g were used for the experimentation. Their age was between three and four months. They were teamed up in seven homogeneous groups of rats (5 per group) corresponding to the number of batches of animals that will be used during the experimentation.

2.5.3 Preparation of Solution Which will be Administered

The solutions were prepared at different doses. These are low dose (200 mg/kg.bw), medium dose (400 mg/kg.bw) and high dose (800 mg/kg.bw). These doses were prepared in such a way that by taking 1 ml of each, the desired dose was obtained. The dose administered were 200 mg/kg.bw or 400 mg/kg.bw or even 800 mg/kg.bw. Then, seven solutions (S_t , S_1 , S_2 , S_3 , S_4 , S_5 and S_6) were prepared according to the following description:

- S_t : 0 mg of « milk » powder/ml of distilled water;
- S_1 : 200 mg of aril « milk » powder / ml of distilled water;
- S_2 : 200 mg of soy « milk » powder / ml of distilled water;
- S_3 : 400 mg of aril « milk » powder / ml of distilled water;
- S_4 : 400 mg of soy « milk » powder / ml of distilled water;
- S_5 : 800 mg of aril « milk » powder / ml of distilled water;
- S_6 : 800 mg of soy « milk » powder / ml of distilled water.

2.5.4 Methodology of Experimentation

During the experiment, the animals were fed *ad libitum* with the same food as during their breeding. The experiment using animal lasted 15 days. Each of the batches of rats were administered every three days, by gavage, with one of the solutions previously prepared (S_t or S_1 or S_2 or S_3 or S_4 or S_5 or S_6). At each gavage, one (1) ml of solution was withdrawn using a gavage cannula and administered orally to each rat. Thereby:

- Each rat of the control group received, every three days by force-feeding, one (1) ml of the S_t solution corresponding to a dose of 0 mg/kg.bw;
- Each rat in batch 1 received, every three days by force-feeding, one (1) ml of the S_1 solution corresponding to a dose of 200 mg/kg.bw of aril « milk » powder administered;
- Each rat of batch 2 received, every three days by force-feeding, one (1) ml of the S_2 solution corresponding to a dose of 200 mg/kg.bw of soy « milk » powder administered;
- Each rat of batch 3 received, every three days by force-feeding, one (1) ml of the S_3 solution corresponding to a dose of 400 mg/kg.bw of aril « milk » powder administered;
- Each rat of batch 4 received, every three days by force-feeding, one (1) ml of the S_4 solution corresponding to a dose of 400 mg/kg.bw of soy « milk » powder administered;
- Each rat of batch 5 received, every three days by force-feeding, one (1) ml of the S_5 solution corresponding to a dose of 800 mg/kg.bw of aril « milk » powder administered;
- Each rat of batch 6 received, every three days by force-feeding, one (1) ml of the S_6 solution corresponding to a dose of 800 mg/kg.bw of soy « milk » powder administered.

The different solutions were administered to the fasting rats between 8 am and 9 am. The rats were weighed at the start of the experiment and every three days, i.e. on Day 0 (D0), Day 3 (D3), Day 6 (D6), Day 9 (D9), Day 12 (D12) and Day 15 (D15).

They received *ad libitum*, after force-feeding, the diet consisting of pellets.

Twenty-four (24) hours after each force-feeding session, the faeces were collected, then their moisture content was determined by drying in an oven at 105°C until a constant weight was obtained corresponding to elimination of all the water contained in the faeces.

2.6 Statistical Analysis

The curves were plotted using Excel version 2016 software. The results were presented as the mean followed by their standard deviation. Statistica software version 7.1 was used to make comparisons of means. Specifically, Students t-test for independent samples per variable was used. More specifically, Students t test for independent samples per variable was used. The significance threshold was set at 5 %.

3. Results

3.1 Determination of Nutritional Value of Powders

3.1.1 Nutrient Composition of *Blighia sapida* and Soya Bean Arils Powders

The freeze-drying of two (2) liters of aril "milk" permit to obtain 170.15 g of aril "milk" powder which corresponds to 85.07 g of powder/liter of milk freeze-dried, while two (2) liters of freeze-dried soya bean "milk" permit to obtain 130.15 g of soya bean "milk" powder which correspond to 65.07 g of powder/liter of "milk" freeze-dried. After analysis of the powders, the results indicate that soya bean powder has a higher moisture content than aril powder [(10.46 ± 0.42 %) > (4.21± 0.30 %)]. Soya bean powder is richer in protein [(48.57±0.37 %) > (27.67±0.12 %)] and in lipids [(6.87±0.11 %) > (5.63±0.29 %)] than aril powder. On the other hand, aril powder is richer in carbohydrates [(55.74±0.31 %) > (31.54±0.44 %)] than soya bean powder. Aril powder has a higher ash content [(6.74±0.26 %) > (2.92±0.056 %)] than that of soya bean powder. These different values are presented in Table 1.

Table 1. *Blighia sapida* arils and soya been "milks" composition

Components	% Content	
	Soya been	Aril
Moisture	10.46± 0.42 ^a	4.21±0.30 ^b
Protein	48.57±0.37 ^b	27.67±0.12 ^a
Lipids	6.87±0.11 ^a	5.63±0.29 ^a
Carbohydrates	31.54± 0.44 ^a	55.74±0.31 ^b
Ash	2.92±0.056 ^a	6.74± 0.26 ^b

Each value expresses the mean ± standard deviation of three determinations

Values in the same row assigned the same letter are not different at the 5 % significance level.

3.1.2 Some Micronutrients Found in *Blighia sapida* Aril and Soya Been Powders

In Table 2, it is present the results of some micronutrients found in *Blighia sapida* aril and soya been powders. It is noticed that all the micronutrients measured are significantly different ($p \leq 0.05$) from one "milk" to another. The aril "milk" powder is rich in calcium (208±0.91 mg/100 g), phosphorus (48.9±0.30 mg/100 g), magnesium (86.02±0.88 mg/100 g) and vitamin C (69.57±0.40 mg/100 g) than soya been "milk" powder. The calcium, phosphorus, magnesium and vitamin C values of the soya been "milk" powder are respectively 109.53 ± 1.70 mg /100 g, 46.05 ± 0.24 mg /100 g, 15.87±0.07 mg /100 g, and 31.1±0.24 mg /100 g. However, soya been "milk" powder contains more iron (40.55 ± 0.67 mg/100 g) than aril "milk" powder (27.13 ± 0.17 mg/100 g).

Table 2. Some micronutrients contain in *Blighia sapida* arils "milk" powder and soya been "milk" powder

Components	Value in (mg/ 100g)	
	Soya been	Aril
Calcium	109.53±1.70 ^a	208.7±0.91 ^b
Phosphorus	46.05± 0.24 ^a	48.9±0.30 ^b
Iron	40.55± 0.67 ^a	27.13±0.37 ^b
Magnesium	15.87±0.07 ^a	86.02±0.88 ^b
Vitamin C	31.1±0.24 ^a	69.57±0.40 ^b

Each value expresses the mean ± standard deviation of three determinations

Values in the same row assigned the same letter are not different at the 5 % significance level.

3.2 Animal Experimentation

3.2.1 Weight Gain of Rats from Different Batches

There was a level of weight gain of rats in all experiment batches compared to those of the control batch. On the

other hand, the weight gain of the rats of batch 3 (13.52 g) is greater than that observed in the rats of the other batches. Also, in batch 2, the weight gain of the rats (9.25 g) is greater than that of the rats of batch 1 (5.025 g). Gain weight of rats of batch 5 (7.33 g) is greater than weight gain of the rats of batch 6 (6.19 g). These results are shown in Figure 2.

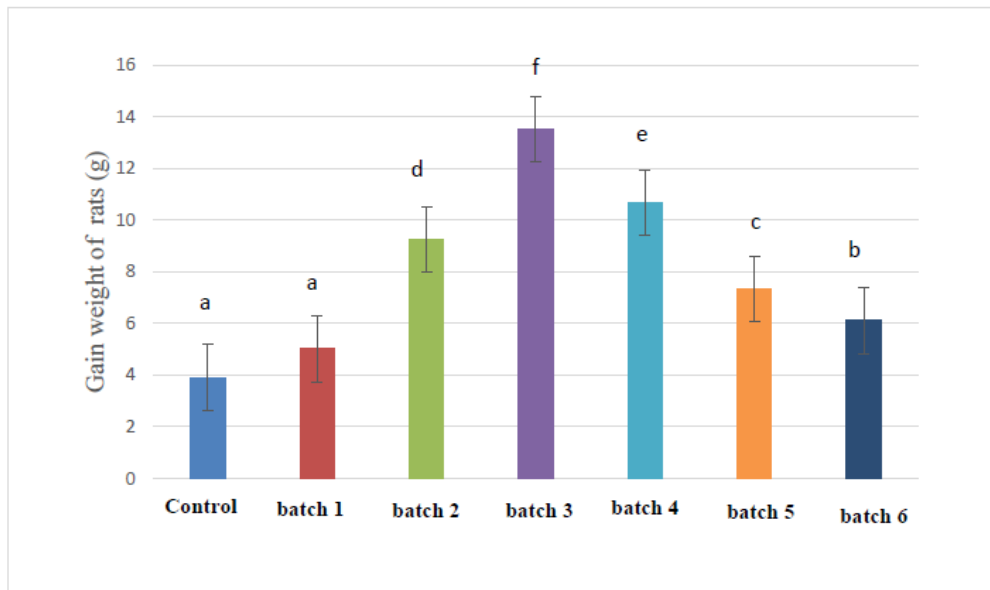


Figure 2. Graphs which show the different weight gain in each batch

The graphs assigned the same letters are not significantly different from each other at the significance level of 0.05 %.

3.2.2 Comparison of Weight Gains According to the Doses Administered

The doses administered were all responsible for weight gain. However, the doses 400 mg of aril "milk" or soya bean "milk" caused greater weight gains compared to the other doses (200 mg and 800 mg). These results are shown in Figure 3.

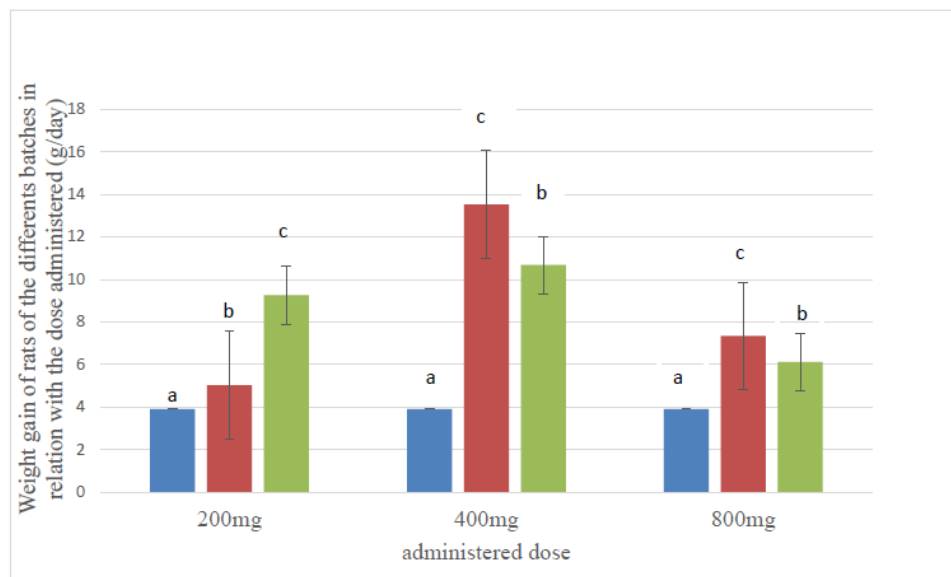


Figure 3. Weight gain of rats of the different batches in relation with the dose administered

The graphs assigned the same letters for the same dose are not significantly different from each other at the significance level of 0.05 %.

Graph in blue color is the control one: each rat received 0 mg of « milk » powder/ml;
 Graph in red color is when rats of the batch received 200 or 400 or 800 mg of arils « milk »;
 Graph in green color is when rats of the batch received 200 or 400 or 800 mg of arils « milk ».

3.2.3 Average Moisture Content of Rat Faeces

Whatever the dose administered, the faeces of the rats of the different batches contained high quantity of moisture. The moisture content of the faeces of the rats of the control batch and that of the faeces of the rats of batch 1 were 45 %. That of the rats in batch 2 was 39 %. It was 41 % for the faeces of the rats of batches 3, 4 and 5 and 42 % for the faeces of the rats of batch 6. These results are shown on Figure 4.

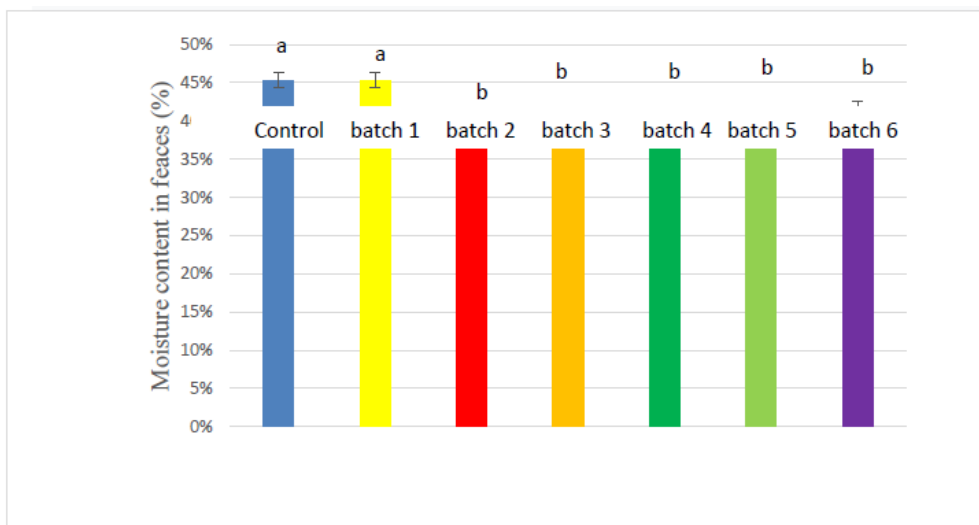


Figure 4. Mean moisture content in rats faeces of each batch

The graphs assigned the same letters for the same dose are not significantly different from each other at the significance level of 0.05 %.

3.2.4 Comparison of the Moisture Content of the Faeces According to the Doses Administered

The percentage of moisture content of the faeces of rats which received the dose 200 mg (42 %) is higher than the percentage of moisture content of the faeces of the rats which received the dose 400 mg (41 %) and than that which received the dose 800 mg (41,5 %). However, these percentages remain low compared to the percentage of moisture contained in

the faeces of the rats of the control group. These results are found on Figure 5.

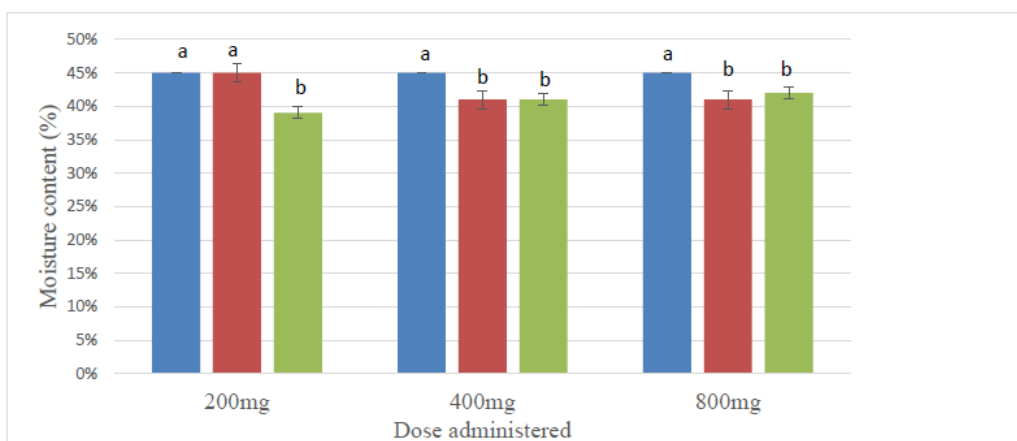


Figure 5. Moisture contain in rats faeces of the different batches in relation with the dose administered

The graphs assigned the same letters for the same dose are not significantly different from each other at the

significance level of 0.05 %.

Graph in blue color is the control one: each rat received 0 mg of « milk » powder/ml;

Graph in red color is when rats of the batch received 200 or 400 or 800 mg of arils « milk »;

Graph in green color is when rats of the batch received 200 or 400 or 800 mg of arils « milk ».

4. Discussion

The analysis of the two "milk" powders (soya bean powder and aril powder) indicates that they are nutritiously rich. In fact, the both powders contain all macronutrients (proteins, carbohydrates, lipids) and micronutrients (calcium, phosphorus, magnesium, potassium, iron and vitamin C).

Although the protein content of aril powder, $27.67 \pm 0.12\%$, is lower than that of soya bean "milk" powder ($48.57 \pm 0.37\%$), it is very far superior to the value recommend by the FAO which is 12 % of the total diet component. This attesting that aril powder could be an interesting protein source to meet the protein needs of humans.

The lipid content of aril "milk" powder, $5.63 \pm 0.29\%$, is almost equal to that of soya bean "milk" powder, $6.87 \pm 0.11\%$. This indicates that the method used to prepare aril "milk" permitted to eliminate a large part of the lipids since according to the work made by Ouattara et al. (2010), the amount of lipids in the sun-dried *Blighia sapida* arils from Côte d'Ivoire, 45.32 %, is very high. The fact that lipids proportion in *Blighia sapida* arils "milk" powder is low is a good thing because the risks of dyslipidemia linked to its consumption will be low. The moisture content of *Blighia sapida* aril "milk" powder, $4.21 \pm 0.30\%$, is lower than that of soya bean "milk" powder, $10.46 \pm 0.420\%$. Under these conditions, the "milk" powder of *Blighia sapida* aril could be stored for quite a long time without attack by microorganisms compared to the storage of soya bean "milk" powder.

According to Aryee et al. (2005), a humidity level in a sample higher than 12 %, promotes the growth of microorganisms. However, our two "milks" powders have humidity levels below 12 %. This suggested that the freeze-drying method is a good method because it permitted to remove a high quantity of water so that the two powders can be stored for a long time without major attack of microorganisms.

The carbohydrate content of aril "milk" powder, $55.74 \pm 0.31\%$, is higher than that found in soya bean "milk" powder ($31.54 \pm 0.44\%$) indicating that *Blighia sapida* aril "milk" is a good source of carbohydrate. Again, the quantity of carbohydrate found in *Blighia sapida* aril "milk" is higher than the quantity recommended in human diets which is between 45 and 50 % (FAO, 2001).

As for the ashes, they are in more quantity in *Blighia sapida* arils "milk" powder than that found in soya bean "milk" powder indicating an abundance of minerals in this powder. This is justified by the analysis of the ashes composition which show that this "milk" contains many macroelements (calcium, magnesium, phosphorus), many microelements (iron, iodine, potassium, chlorine, sodium) and high quantity of vitamin C than the soya bean "milk".

The consumption of the "milk" of the aril could promote good ossification because of the calcium and phosphorus found in large proportions in this powder. Indeed, calcium (Ca) and phosphorus (P) are the two main constituents which promote bone formation (Bonjour, 2011; Zhu et al., 2012). Also, the low iron content, 27.13 ± 0.17 mg/100 g, in the aril "milk" powder compared to the soya bean "milk" powder, 40.55 ± 0.67 mg /100 g, could be an obstacle to the availability of iron for the human body compared to the consumption of soya bean "milk" powder. However, the high content of vitamin C in the aril "milk" powder could be in favor to its absorption than the case of the consumption of soybean "milk" powder (Hallberg et al., 1989). In addition, the iron content of aril "milk" powder is very high compared to the recommended of iron intakes which are between 8 and 30 mg/day (Koletzko et al., 2005).

The high proportions of carbohydrates, proteins, macroelements, microelements and trace elements as well as the low level of lipids show that *Blighia sapida* aril "milk" could be consumed in the same way as soya bean "milk". As the nutritional virtues of *Blighia sapida* aril have been verified by several previous studies (Ouattara et al., 2016; 2017), comparisons was limited only by evaluating weight gains and the effects of inducing diarrhoea.

The induction of diarrhea was apprehended by the percentage of moisture in the faeces. Oral administration of increasing doses of these two "milks" to batches of rats resulted in an overall increase in weight regardless of the dose. This is linked to the fact that the initial diet served contains all the nutrients necessary to cover the nutritional needs of the rat and also to the fact that the solutions administered do not contain molecules with harmful activities that can negatively impact the growth of rats.

There were a high growth on the batches of rats which received the different dose of "milk" compared to those of the rats of the control group suggesting that the administration of these "milks" provide other nutrients favorable to growth. And then, these nutrients contributed to potentiate the growth of rats which have received any kind of the "milk" dose compared to the growth of rats in the control group. At a dose of 400 mg, it is observed both in the case of the "milk" of aril powder and in the case of the "milk" of soya bean powder, a higher weight gain than in the case of administration of the 200 mg and 800 mg doses. This makes it possible to say that the dose of 400 mg is the optimal dose for potentiation of growth.

The fact that the faeces collected in the case of the administration of "milk" contained low quantities of water compared to the faeces of the control group attests the high digestibility of the different nutrients found in the different "milk" solutions prepared (Zentek et al., 2002; Camilleri, 2004). The advantages in favor of weight gain and in favor of the non-induction of diarrhoea of the "milk" extracted from the aril of *Blighia sapida* are comparable to those of soya bean "milk", attesting that the aril of *Blighia sapida*, available in Côte d'Ivoire could be useful for the production of "milk" endowed with good nutritional quality.

5. Conclusion

It appears from this study that the exploitation of the potentialities of *Blighia sapida* aril "milk", a fruit-product culturally accepted in some countries of Africa, is a solution to regulate the dependence in "milk" in African countries.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

Open access

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

References

- Alais, C. (1984). *Sciences du lait. Principes de techniques laitières*. 3^{ème} édition, Ed publicité France. pp. 431.
- Aboutayeb, R. (2009). *Technologie du lait et dérivés laitiers*. Retrieved from <http://www.azaquar.com>
- AFNOR. (1980). Lait et produit laitiers : méthodes d'analyses. Recueil des normes françaises, 1^{ère} édition, *Lait*, 80, 503-515.
- Anonymous 1. (1999). *Contribution du soja au développement des régions des savanes In: Bilan de la pré-vulgarisation du soja dans les régions centre*.
- Anonymous 2. (2020). *Help & Hope for children with digestive disorders*. Retrieved from www.Glkids.org
- AOAC International. (1990). *Official Methods of Analysis* (14th ed.). Washington, DC: AOAC International.
- Aryee, F. N. A., Oduro, J., Ellis, W. O., & Afuakwa, J. J. (2005). The Physicochemical properties from the roots

- of 31 varieties of cassava. *Food control*, 17, 916-922. <https://doi.org/10.1016/j.foodcont.2005.06.013>
- Bonjour, J-P. (2011). Calcium and phosphate: a duet of ions playing for bone health. *Journal of American College of Nutrition*, 30(5 Suppl 1), 438S-48S. <https://doi.org/10.1080/07315724.2011.10719988>
- Camilleri, M. (2004). Chronic Diarrhea: A Review on Pathophysiology and Management for the Clinical Gastroenterologist. *Clinical gastroenterology and hepatology*, 2, 198-206. [https://doi.org/10.1016/S1542-3565\(04\)00003-5](https://doi.org/10.1016/S1542-3565(04)00003-5)
- Daly, J. A., & Ertingshausen, G. (1972). Direct method for inorganic phosphate determination. *Clinical Chemistry*, 18, 263-265. <https://doi.org/10.1093/clinchem/18.3.263>
- Fabert, D. (1964). *La prodigieuse famille des vitamines*. Nouveaux horizons, paris.
- FAO. (1995). *Le lait et les produits laitiers dans la nutrition humaine*. Collection FAO Alimentation et nutrition N°28. Retrieved from <https://www.fao.org/4/t4280f/T4280F0d.htm>
- FAO. (2001). *La nutrition dans les pays en développement*. Retrieved from <https://www.fao.org/4/w0073f/w0073f00.htm>
- FAO. (2007). *La situation mondiale de l'alimentation et de l'agriculture. Organisation des nations unies pour l'alimentation et l'agriculture*. Rome 2007. Collection FAO: Agriculture N° 38. Retrieved from <https://openknowledge.fao.org/server/api/core/bitstreams/2739024e-e7db-4bee-831a-0a52438d00b6/content>
- Favier, A., Maljournal, B., Decoux, G., & Ruffier, D. (1983). Microanalysis of serum iron by atomic absorption spectrophotometry in a graphite oven: improvement and evaluation of this method. *Annale de Biologie Clinique*, 41(1), 45-50.
- Franworth. (1953). *Zootechnie générale, Tome 1, publication de la direction de l'agriculture, forêt d'élevage, Bruxelles*.
- Glowa, W. (1974). Zirconium dioxide, a new catalyst in the Kjeldahl method for total N determination. *Journal Association Analytic Chemical*, 57, 1228-1230. <https://doi.org/10.1093/jaoac/57.5.1228>
- Hallberg, L., Brune, M., & Rossander. (1989). The role of vitamin C in iron absorption. *International Journal for Vitamin and Nutrition Research*, 30, 103-108.
- Kajalkar, R. V., & Gaikwad, A. D. (2013). Colorimetry Based Calcium Measurement. *International Journal of Engineering Research and Development*, 7(8), 08-11.
- Koletzko, B., Baker, S., & Cleghorn, G. (2005). Global standard for the composition of infant formula: Recommendations of an ESPGHAN coordinated international expert group. *Journal of Pediatric Gastroenterology and Nutrition*, 5(41), 584-599. <https://doi.org/10.1097/01.mpg.0000187817.38836.42>
- Konte. (1999). *Le lait et les produits laitiers développement de systèmes de production intensive en Afrique de l'ouest*. Réf. ISRMJPV-LNERV/FEVR.
- Zhu, K., & Prince R. L., (2012). Calcium and bone. *Clinical Biochemistry*, 45(12), 936-942. <https://doi.org/10.1016/j.clinbiochem.2012.05.006>
- Labat, E. (2013). *Le soja: Influence de sa consommation sur la santé humaine et conséquences de l'expansion de sa culture au niveau mondial*. Mémoire de doctorat, Université Toulouse III Paul Sabatier-faculté des sciences pharmaceutiques. pp. 104.
- Lafitedupont, A. (2011). *Les différents laits et leur complexité. Les protéines du lait de vache aspect nutritionnel et allergie alimentaire*. Thèse de doctorat de pharmacie, faculté de pharmacie, limoges.
- Morton, J. (1987). *Fruits of Warm Climates*. J. F. Morton, Miami, Chapter Mango *Mangifera indica* L.
- Munganga, E. (2013). *Contribution à l'analyse chimique et nutritionnelle de deux plantes alimentaires sauvages consommées dans le district de la tshopo, travail de fin de cycle, faculté des sciences, Congo*.
- Ouattara, H., Niamké, B., Dally, T., & Kati-Coulibaly S. (2010). Nutritional composition studies of sun dried *Blighia sapida* (k. koenig) aril from Côte d'Ivoire. *Journal of Applied Biosciences*, 32, 1989-1994. Retrieved from <http://www.biosciences.elewa.org>
- Ouattara, H., Meite, Alassane., Kouame, P., & Kati-Coulibaly S. (2016). Impact of *Blighia sapida* (k. Koenig) aril powder level in diet on the growth and the well-being of albino Wistar rats. *African Journal of Food Science*, 10(9), 164-171. <https://doi.org/10.5897/AJFS2016.1441>
- Ouattara, H., Meite, A., Soro S., & Kati-Coulibaly S. (2016). *Blighia sapida* Aril Consumption at Degree

- Neighboring 50 % do not Affect Bone Growth of Rats, from 50 %, Bone growth is Negatively Affected. *Indian Journal of Nutrition*, 3(2). Retrieved from <http://www.opensciencepublications.com/>
- Ouattara, H., Touré, A., Méité, A., & Kati-coulibaly S. (2017). Côte d'Ivoire *Blighia sapida* Aril oil composition and efficacy on Rat's compared with Palm oil and Olive oil. *Journal of Food Research*, 6(5), 99-106. <https://doi.org/10.5539/jfr.v6n5p99>
- Oyeleke, G. O., Oyetade, O. A., Afolabi, F., & Adegoke, B. M. (2013). Nutrients, Antinutrients and Physicochemical Compositions of *Blighia sapida* Pulp and Pulp Oil (Ackee Apple). *Journal of Applied Chemistry*, 4(1), 05-08. <https://doi.org/10.9790/5736-0410508>
- Pehrsson, P. R., Haytowitz, D. B., Holden, J. M., Perry, C. R., & Beckler, D. G. (2000). USDA's National Food and Nutrient Analysis Program1: Food Sampling *Journal of Food Composition and Analysis*, 13(4), 379-89. <https://doi.org/10.1006/jfca.1999.0867>
- Pikal, M. J., Shah, S., Senior, D., & Lang, J. E. (1983). Physical chemistry of freeze-drying: measurement of sublimation rates for frozen aqueous solutions by a microbalance technique. *Journal Pharmaceutical Science*, 72(6), 635-650. <https://doi.org/10.1002/jps.2600720614>
- Ryan, M. F., & Barbour H. (1998). Magnesium measurement in routine clinical practice. *Annal of Clinical Biochemistry*, 35, 449-459. <https://doi.org/10.1177/000456329803500401>
- Tremolieres, J. (1963). Valeur alimentaire du lait. *Inra éditions*, 43(427), 384-389. <https://doi.org/10.1051/lait:196342715>
- Van Winckel, M., Velde, S. V., De Bruyne, R., & Van Biervliet, S. (2011). Clinical practice: vegetarian infant and child nutrition. *European Journal of Pediatrics*, 170(12), 1489-1494. <https://doi.org/10.1007/s00431-011-1547-x>
- Zentek, J., Kaufmann, D., & Pietrzak, T. (2002). Digestibility and effects on fecal quality of mixed diets with various hydrocolloid and water contents in three breeds of dogs. *Waltham International Symposium: Pet Nutrition Coming of Age*, 132(6 Suppl 2), 1679S-81S. <https://doi.org/10.1093/jn/132.6.1679S>
- Zhu, K., & Prince, R. L. (2012). Calcium and bone. *Clinical Biochemistry*, 12(45), 936-942. <https://doi.org/10.1016/j.clinbiochem.2012.05.006>