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Nutritional and Antioxidant Evaluation and Effect of Eggplant Consumption on Anthropometric and Hematologic Parameters in Wistar Rats

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Abstract

The aim of the present study was to evaluate the nutritional quality of green and purple eggplant, their antioxidant activity and their nutritional efficacy on Wistar rats. For nutritional quality, the parameters measured are dry matter, protein, lipid, ash, carbohydrate, iron, phosphorus, calcium, magnesium and energy content. For antioxidant activity, the parameters measured are 50% DDPH free radical inhibition concentration and total polyphenol content. Nutritional efficacy was evaluated in rats fed the control diet and in rats fed the three treated diets containing eggplant meal obtained by replacing 5%, 10%, and 15% of the control diet. The parameters measured are the amount consumed, the weight of the animal and target organs, and hematologic parameters. The results of the nutritional analysis show the following values: 13.31% protein, 2.66% lipids, 0.84% calcium, 0.12% magnesium, 0.43% phosphorus for the *Solanum aethiopicum* L. species and 13.47% protein, 3.66% lipids, 0.36% calcium, 0.22% magnesium, 0.35% phosphorus for the *Solanum melongena* L. species. In terms of antioxidant activity, we obtained DDPH inhibition percentages of 40.28 mg/ml for *Solanum aethiopicum* L.

and 12.42 mg/ml for *Solanum melongena* L., respectively. Finally, hematologic and anthropometric tests showed that for the different diets used, weight loss and an increase in hematologic parameters were observed in the rats tested. This study showed that eggplant has interesting nutritional characteristics and antioxidant activity, contributing to an increase in weight and anthropometric parameters.

Keywords

Fruit Vegetables, Eggplant, *Solanum aethiopicum* L., *Solanum melongena* L., Antioxidants, Polyphenols

1. Introduction

Fruits and vegetables are part of a healthy diet and, if consumed in sufficient amounts every day, can help prevent major diseases such as cardiovascular disease and some cancers [1] In fact, low fruit and vegetable consumption is the cause of approximately 31% of ischemic heart disease and 11% of strokes worldwide [2].

Green fruits and vegetables such as zucchini, African eggplant, cabbage, chives, apples and avocados contain folic acid, which is essential for cell renewal. In total, approximately 2.7 million lives could be saved each year by increasing fruit and vegetable consumption [2].

In Africa, vegetables can be defined as the leaves, fruits and roots of cultivated plants used as crudités or in the composition of protein and vitamin sauces that accompany the calorie base (cassava, rice, millet, etc.) [3].

In Congo Brazzaville, according to the consumption survey conducted among people living with HIV/AIDS [4], eggplants were consumed by 10% of households, spinach by 6.7%, amaranths by 3.3%, and Guinea sorrel by 3.3% [4]. Similarly, a consumption frequency survey conducted by Moutoula *et al.* (2016) [5] showed that eggplant was the most consumed vegetable in the household. Eggplant is the fruit of an herbaceous plant in the Solanaceae family, which contains many antioxidants and compounds effective in lowering blood sugar and cholesterol [6]. It is rich in water and fiber, with a good concentration of minerals and vitamins, mainly from the B group, and low in vitamin D [7]. These nutritional qualities vary depending on where they are eaten or the type of eggplant. Vegetables are part of the Congolese diet. Surveys conducted by Ofouémé *et al.*, 1991 [8], showed that after bread and meat, vegetables were the daily staple of households in Brazzaville. In fact, local fruit vegetables such as common tomatoes, chilies, local eggplant and okra are widely consumed [3]. Furthermore, the 24-hour recall and frequency of consumption surveys conducted by Moutoula *et al.*, 2016 [5] to study the dietary habits of households in Brazzaville to combat vitamin A deficiency showed that eggplants were the most widely consumed in households. Although both green and purple eggplants are

eaten, their nutritional quality and efficacy are unknown.

Thus, the general objective of our study is to determine the nutrient composition of eggplant, while assessing the antioxidant activity and the effect of eggplant consumption on anthropometric and hematologic parameters in Wistar albino rats. Specifically.

- Determine the nutritional value of green and purple eggplants;
- Evaluation of the antioxidant activity of eggplant;
- Evaluation of the effect of eggplant consumption on anthropometric and hematological parameters in Wistar albino rats.

2. Material and Methods

2.1. Material

2.1.1. Plant Material

The plant material consisted of the fruits of green eggplant (*Solanum aethiopicum* L.) and purple eggplant (*Solanum melongena* L.). (Figure 1)

2.1.2. Animal Material

Albino Wistar rats weighing between 100 and 187 g and aged 3 months (young rats) (Figure 2) were used in this study. These animals were purchased from the animal house of the National Institute for Research in Health Sciences (IRSSA) in the City Scientific (Ex ORSTOM) and brought to the animal house of the Faculty of Science and Technology for the experiments. (Figure 2)

Figure 1. Photographs showing the fruits of green eggplant (*Solanum aethiopicum* L.) (left) and purple eggplant (*Solanum melongena* gilo L.) (right).

Figure 2. Photograph of Wistar albino rats.

2.2. Methods

2.2.1. Food Selection

Literature Search

This bibliographical research was carried out by consulting scientific publications dealing with fruits and vegetables of native flora consumed in Congo Brazzaville.

Selection of vegetables used

These two vegetables were studied on the basis of two key criteria:

- High frequency of fruit and vegetable consumption;
- There are very few scientific studies on the nutritional efficacy of these two vegetables.

2.2.2. Determination of Nutrient Content

Sample preparation

The samples were oven-dried at 70˚C for 48 hours to obtain a dry weight; they were then ground with a porcelain mortar and the powder obtained constituted our experimental material.

Analyses included the determination of dry matter, macronutrient, ash and mineral content, determination of energy value, determination of antioxidant activity and effect of eggplant consumption on anthropometric, nutritional and hematological parameters.

Dry matter content

The dry matter content was determined by oven-drying the green and purple eggplants. A mass *Mf* of fresh eggplant was weighed and placed in an oven at a temperature of 70˚C. The drying was stopped when the constant mass *Ms* was obtained.

The water content was determined using the following formula:

$$Ms\ \text{content}(\%) = \frac{Ms}{Mf} \times 100$$

With %: percentage; *Mf*: fresh sample mass, *Ms*: dry sample mass.

Determination of lipid content

The lipid content of each sample was determined by Soxhlet extraction using hexane as the extraction solvent. For this, 30 g (*Mp*) of the previously dried and ground sample was placed in a cartridge which was then placed in a Soxhlet. 150 ml of solvent was added to a pre-weighed empty 250 ml flask (*M*0). The flask was heated for 4 hours and then cooled. The solvent was completely removed by evaporation in an oven at 70˚C. After evaporation, the flask containing the lipids was weighed (*M*1). The difference in mass between the flask containing the lipid and the empty flask gave the lipid mass.

The lipid content was determined using the following formula:

$$\%\ \text{lipids} = \frac{Mh}{Mp} \times 100$$

With

Mh: mass of oil obtained

Mp: mass of powder

Protein content

The protein content was determined by the Kjeldahl method (AOAC, 1990) [9].

0.5 g of the ground sample, oven-dried at 65˚C, was placed in a flask. Then a spatula tip of mineralization catalyst (composed of selenium, copper sulfate and potassium sulfate) and 10 mL of concentrated H_2SO_4 were added. The mattress was placed on the mineralization ramp for 30 minutes of cold mineralization followed by 2 hours of hot mineralization. The solution is green when hot, then clear when cold. Approximately 20 mL water and 30 mL sodium hydroxide 400 g/L were added (until the solution turned brown). Distillation was then started and the distillate was collected in a 150 mL conical flask containing 20 mL of boric acid and a few drops of color indicator to a volume of 125 mL (4 min distillation). The solution in the conical flask was dosed volumetrically with N/20 sulfuric acid in a burette; the dosing was stopped when the solution turned from green to pink (pH = 5.1) and the volume of H_2SO_4 used was recorded.

The nitrogen content was calculated using the following formula:

$$\%N = \frac{V_{H_2SO_4} \times 0.007}{M(\text{sample})} \times 100$$

The protein content was determined according to the following formula:

$$\%P = \%N \times 6.25$$

With

%*N*: nitrogen content; $V_{H_2SO_4}$: volume of sulfuric acid used for dosing

Mp: powder mass; %*P*: protein content:

Ash content

The ashes were incinerated in a muffle furnace at 550˚C for 8 hours, then weighed after cooling in a desiccator. A 2g mass of eggplant powder (*M*1) contained in a pre-weighed dish (*Mo*) was introduced into a muffle furnace where the temperature was maintained at 550˚C for 8 hours. The oven was stopped and left to cool until the following day. The dish was removed from the oven and weighed (*M*2).

The following formula was used to calculate the ash content

$$\%TC = \frac{M2 - M0}{M1 - M0} \times 100$$

which

TC: ash content; *Mo*: mass of the empty dish or crucible; *M*1: mass of the dish or crucible containing the powder before combustion; *M*2: mass of the dish or crucible containing the powder after combustion.

Carbohydrate content

The carbohydrate content (%*G*) was calculated using the following formula:

$$\%G = 100 - (\%\text{Lipids} + \%\text{Protein} + \%\text{Ash}).$$

which:

%*G*: Carbohydrate content

Energy Value

The corresponding energy value was calculated using the Merrill & Watt (1955) [10] specific coefficient for proteins, lipids and carbohydrates.

The calculation is made using the following formula:

$$VE = (G \times 4) + (P \times 4) + (L \times 4)$$

which:

VE: Energy value; *G*: Carbohydrates; *P*: Protein; *L*: Lipids

Determination of iron content

After oxidation in an acidic medium, the iron is reduced to the ferrous state and colorimetrically assayed using the red coloration given by ferrous salts with phenantroline. 5 ml of the mineralized powder solution was placed in a plastic pillbox to which 5 ml of 1% hydroxylamine chloride, 2 ml of 3% sodium citrate, 2 ml of sodium acetate pH 3.5 and 2 ml of 0.2% ortho-phenanthroline were added successively. At the same time, an iron range was taken. The staining was allowed to develop for 30 minutes and measured at 490 nm using a spectrophotometer.

Phosphorus Content

The phosphorus content was determined by colorimetric spectrophotometric analysis of the extract. The solution obtained from the mineralized sample was taken and placed in a pillbox to which Murphy's reagent (a mixture of several products) was added. A blue color was developed, which was read with a spectrophotometer; the sample result was obtained by calculation, taking into account a phosphorus range curve.

Calcium Content

The calcium content was determined volumetrically in the mineralized plant extract. A given volume (depending on the sample concentration) of the mineralized plant solution was taken and placed in a 150 ml Erlenmeyer flask and made up to 50 ml with distilled water. We added 1 ml potassium turcianate (KCN) and 5 ml triethanolamine N-hydrochloride (complexing agent) and adjusted the pH to 12.5 with NaOH 2.5N. We then added a pinch of calcein and measured with EDTA N/50 (0.01M) until the color changed from purple red to light blue. The mass of calcium was calculated from the volume of EDTA required for the assay.

Determination of Magnesium Content

Magnesium content was determined by volumetric determination of the Ca-Mg complex of the extract with an EDTA titrant solution at N/50. A sample of the mineralized solution was taken from each eggplant and placed in a 150 ml Erlenmeyer flask, which was then made up to 50 ml with water. The solution was adjusted to pH 10 with a buffer solution (a mixture of ammonium chloride and ammonia), then a pinch of black erochrome T (NET) was added and tested with EDTA N/50 solution until the color changed from purple-red to apple green. Magnesium was calculated as the difference between Ca and Mg combined mi-

nus Ca alone.

Determination of the antioxidant activity of macerates

Each sample was soaked in a hydroalcoholic solvent (50% water and 50% alcohol) for 48 hours (Nogaret, 2003). After filtration, a macerate was obtained and evaporated. DPPH or 2,2-diphenyl-1-picrylhydrazyl acts as an effective stable free radical reduced by an antioxidant, showing an absorption spectrum at 517 nm with a violet color, the reduction of this radical results in the color yellow (Lee *et al.*). The anti-free radical activity of the hydroalcoholic extracts of each sample was measured by the DPPH test according to the protocol described by Hannebelle, 2006. The solution test was performed by mixing 10 ml of 10 mg/250ml DPPH solution with 100 µl of ester extract at different concentrations (10 mg/ml, 5 mg/ml, 2.5 mg/ml, 1.25 mg/ml, 0.625 mg/ml).

The values obtained were measured at 517 nm using a spectrophotometer after 40 minutes of incubation protected from light.

The concentration was calculated as follows:

$$C = \frac{M}{V}.$$

with C = concentration; M = mass of extract weighed; V = volume of solvent withdrawn

The inhibition percentage is calculated as follows:

$$\%I = \frac{D.Oblanc - D.Oei}{D.Oblanc} \times 100$$

With $D.Oblanc$: Optical density white; $D.Oblanc$ = 1.048

Determination of Total Polyphenols

The polyphenols were determined with a spectrophotometer. The optical densities obtained from our extracts were compared with those obtained using a gallic acid standard of known concentration. The assay was performed as follows: 0.1 ml of fruit extract was placed in a test tube, 0.9 ml of distilled water was added, 0.9 ml of Folin-Ciocalteu reagent (1N) was added and immediately 0.2 ml of $NaCO_3$ solution (20%) was added. The resulting mixture was incubated at room temperature for 40 minutes in the dark. The absorbance was then measured with a spectrophotometer at 725 nm against a methanol solution used as a blank. It should be noted that a calibration line was established prior to the analysis with gallic acid under the same conditions as the samples to be analyzed. The results obtained are expressed in mg of gallic acid equivalent per 100 g of dry matter (mgE Ga/100 gMs).

Evaluation of the effect of eggplant consumption on anthropometric and hematologic parameters in Wistar albino rats

Constitution of diets food

Four diets were developed:

- A controlled diet

- Three treated diets containing eggplant meal were obtained by replacing 5%, 10% and 15% of the control diet.

Creation of animal batches and experiments

Twenty-one (21) rats were used, three (3) per diet based on body weight, in individual metabolic cages with wire mesh floors. The animal experiment was conducted according to the model [11]. It was conducted over a period of fourteen (14) days.

Performing the Experiment and Affected Measurements:

Food was distributed in freeze-dried form once a day (morning at 11 am). Water was provided ad libitum and replaced at two-day intervals. Animals were weighed at the beginning of the experiment and then at two-day intervals. The final weighing was performed at the end of the experiment. The difference between the amount of food given and the amount of food left over, in terms of dry matter, was used to determine the amount consumed.

Assessment of hematological and anthropometric parameters (organ weights)

For hematologic analysis, blood samples were collected from the retro-orbital region of the eye using hematocrit tubes from 3 rats per batch. Samples were collected at the end of the experiment, but the animals were fasted for 24 hours beforehand. Blood was collected in EDTA (Ethylene Diamine Tetra Acetic Acid) tubes and the following parameters were determined: red blood cells, white blood cells, hemoglobin and platelets. These parameters were evaluated at the Laboratory of Biochemistry and Pharmacology (FSSA) using a Yumizen H550 hematological analyzer. For anthropometric parameters, the different organs such as the liver, kidney, heart and spleen were weighed after the rats were sacrificed.

Data Processing

Data processing and entry, as well as the preparation of raw tables and figures, were carried out using Word 2016 and Excel (Office 2016), using Student's t-test, which is the software used for statistical processing of results at the 5% threshold. Values in this document are presented as mean ± standard error (SE), with a significance level of $p < 0.05$.

3. Results

3.1. Water, Macronutrient, Ash, and Energy Content

Table 1 shows the composition of dry matter, macronutrient and ash contents. The table shows that green and purple eggplant have water contents of 90.25% and 92.31%, protein contents of 13.31% and 13.47%, lipid contents of 2.66% and 3.66%, carbohydrate contents of 79.24% and 77.87%, and ash contents of 4.79% and 5% per 100 g of dry matter, respectively.

Green and purple eggplants have energy values of 386.14 Kcal and 398.3 Kcal per 100 g of dry matter, respectively. (Table 1)

3.2. Mineral Content

Table 2 shows the mineral composition of eggplant.

Table 1. Total composition by type of eggplants.

Contents	Green eggplants	Purple eggplants	Significance
Dry matter (g/100 g fresh matter)	9.75 ± 0.02	7.69 ± 0.02	P = 0.000
Protein (g/100 g dry matter)	13.31 ± 0.04	13.47 ± 0.05	P = 0.018
Lipids (g/100 g dry matter)	2.66 ± 0.07	3.66 ± 0.13	P = 0.000
Ash (g/100 g dry matter)	4.79 ± 0.19	5.00 ± 0.13	P = 0.554
Carbohydrates (g/100 g dry matter)	79.24 ± 1.01	77.87 ± 0.02	P = 0.080
Energy value (Kcal)	386.14 ± 0.94	398.30 ± 1.74	P = 0.000

Values are mean ± standard deviation for n = 3.

Table 2. Mineral content of eggplant.

Contents	Green eggplants	Purple eggplants
Calcium (g/100 g dry matter)	0.84	0.36
Magnesium (g/100 g dry matter)	0.12	0.22
Iron (g/100 g dry matter)	0.008	0.008
Phosphorus (g/100 g dry matter)	0.43	0.35

Values are means ± standard deviation for n = 3.

The table shows that green and purple eggplant have calcium contents of 0.84% and 0.36%, respectively, magnesium contents of 0.12% and 0.22%, iron contents of 0.008% for both types of eggplant, and phosphorus contents of 0.43% and 0.35% per 100 g of dry matter(Table 2).

3.3. Antioxidant Activity

The results in Figure 3 show the 50% inhibition concentration of the DPPH free radical in eggplants. Green and purple eggplants inhibit the DPPH radical at concentrations of 40.28 mg/ml and 12.24 mg/ml respectively. A low value for the 50% inhibition concentration of the DPPH free radical indicates high antioxidant activity in a sample. Purple eggplants therefore have better antioxidant activity than green eggplants. (Figure 3)

3.4. Total Polyphenol Content

Figure 4 shows the different concentrations of total polyphenols in eggplant. Purple eggplants contain higher levels of polyphenols (antioxidants) than green eggplants. In fact, the figure shows that green eggplant has a polyphenol concentration of 11.29 mgEGa and aubergine has 20.61 mgEGa. (Figure 4)

3.5. Weight Evolution, Quantity Consumed, Total Dry Matter Ingested and Weight Gain

The weight of rats fed the control diet, rats fed the diet enriched with green eggplant (5%, 10%, and 15%), and rats fed the purple eggplant (5%, 10%, and 15%) were monitored during the 14-day experiment. Figure 5 shows the weight development of the rats as a function of time (day). Compared with the group of

rats fed the control diet, rats fed the green and purple eggplant-enriched diets lost weight. This reduction was significant ($p < 0.05$ from D2-J6 and $p < 0.01$ from D0-J14) for the groups of rats fed the purple eggplant (5%, 10%, and 15%) and green eggplant (5%, 15%) enriched diets, respectively. On the other hand, for the group of rats fed the diet enriched with 10% green eggplant, we observed, on the one hand, a non-significant decrease (J2-J6 then J12-J14, $p > 0.05$) and on the other hand a significant decrease (J8-J610, $p < 0.05$). This weight loss in treated rats compared with those fed the standard diet did not affect the animals' general behavior (Figure 5).

Results are expressed as mean ± standard error, n = 3 rats per batch. *$p < 0.05$ and **$p < 0.01$ significant difference from standard diet rats; ns: not significant.

Table 3 shows the food intake (g/d), total dry matter intake (g/d), and weight gain (g/d). With regard to food intake, the results show a non-significant increase in food intake for all green and purple eggplant diets, except for the 5% green eggplant diet, which showed a non-significant decrease.

With respect to weight gain, the results show that rats fed the green and purple eggplant diets had a non-significant decrease in weight compared to rats fed the standard diet, except for rats fed the 10% purple eggplant diet, where there was a non-significant increase in weight gain. (Table 3)

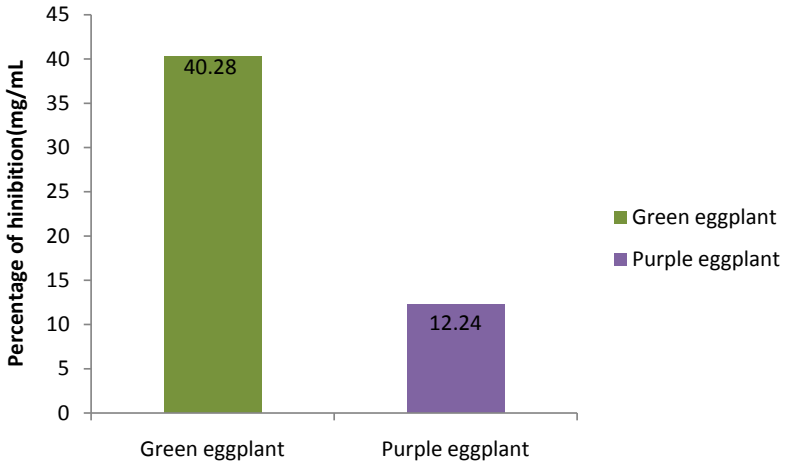

Figure 3. 50% inhibition concentration of the DPPH radical in eggplant.

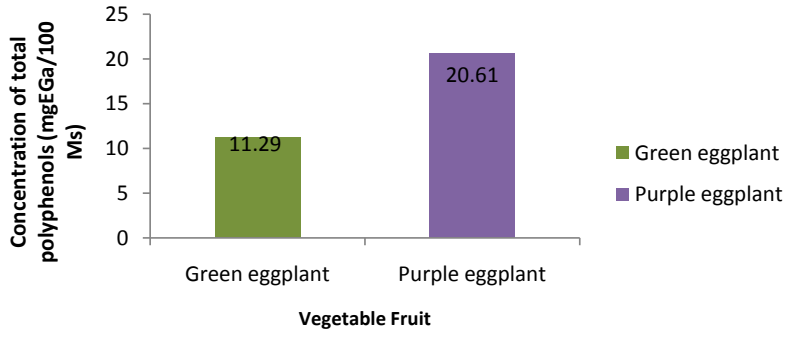

Figure 4. Total polyphenol concentrations in eggplant.

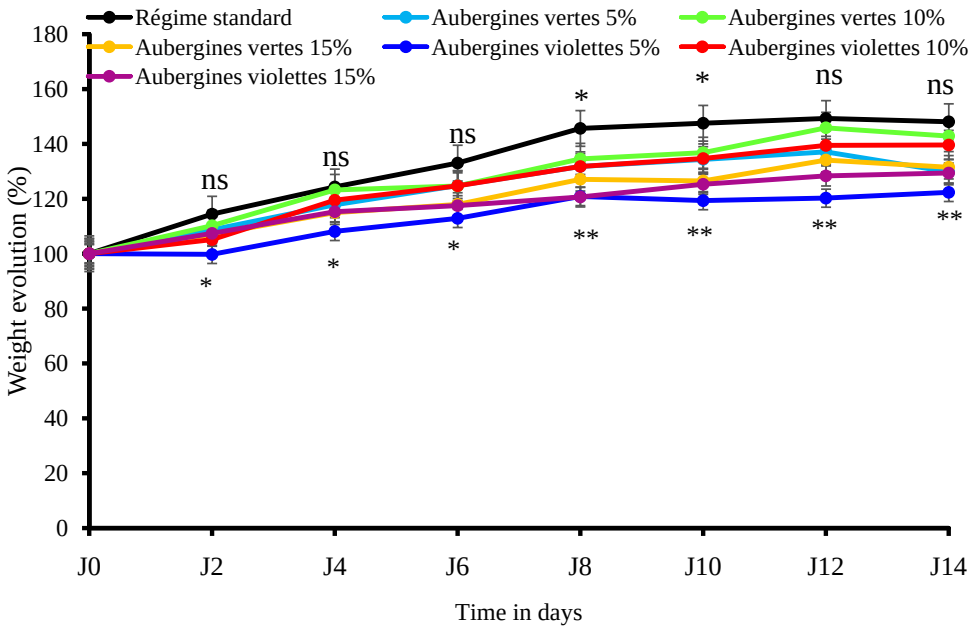

Figure 5. Effect of diets enriched with green and purple eggplants on body weight changes in rats.

Table 3. Quantity consumed, total dry matter ingested and weight gain.

Diet	Quantity consumed (g/day)	Total dry matter ingested (g/day)	Weight gain (g/day)
Standard diet	24.08 ± 2.60	2.17 ± 0.15	50.33 ± 4.87
Green eggplant 5%	23.9 ± 2.67 ^{ns}	2.31 ± 0.16 ^{ns}	36.56 ± 5.90 ^{ns}
Green eggplant 10%	26.23 ± 2.15 ^{ns}	2.64 ± 0.18 ^{ns}	42.23 ± 2.98 ^{ns}
Green eggplant1 5%	28.78 ± 3.01 ^{ns}	2.84 ± 0.20 ^{ns}	35.6 ± 11.33 ^{ns}
Eggplants violettes 5%	31.01 ± 5.55 ^{ns}	2.78 ± 0.19 ^{ns}	40.5 ± 19.54 ^{ns}
Eggplants violettes 10%	32.06 ± 1.88 ^{ns}	2.90 ± 0.20 ^{ns}	58.26 ± 7.88 ^{ns}
Eggplants violettes 15%	31.71 ± 2.57 ^{ns}	2.91 ± 0.20 ^{ns}	45.7 ± 6.72 ^{ns}

Results are expressed as mean ± standard error (SE), for n = 3, ns = not significant ($P > 0.05$).

3.6. Evaluation of Hematologic and Anthropometric Parameters

Table 4 shows the effect of eggplant consumption on the levels of hematological parameters in rats compared to the standard diet. It can be seen from this table that the addition of green eggplant leads to a non-significant increase ($P > 0.05$) in all hematological parameters, except for the 15% diet, where a significant increase ($P < 0.05$) in hemoglobin is noted compared to the standard diet. Purple eggplant, on the other hand, produced a significant ($P < 0.05$) increase in erythrocytes and hemoglobin for the 5% and 10% diets ($P < 0.05\%$) and ($P < 0.01\%$), and a non-significant increase for the 15% diet, compared with the standard diet. Thus, this increase is inversely proportional to the diets. Also in comparison with the standard diet, the 5%, 10% and 15% purple eggplant diets showed a non-significant ($P > 0.05$) decrease in white blood cell count and a non-significant

decrease in the 5% and 15% diets in blood platelets, whereas the other two 10% diets showed a non-significant increase decrease in these. (Table 4)

Table 5 shows us the variation in weight of different organs according to the diets. The table shows that the eggplant-enriched diets for organs such as liver, left kidney and right kidney showed no significant difference ($p > 0.05$) from the standard diet. On the other hand, organs such as the heart and spleen showed significant differences ($p < 0.05$) for the 5% green eggplant diets. (Table 5)

4. Discussion

4.1. Water Content, Macronutrients, Ash and Energy Value

Our results show that eggplant has a high water content (90.25% to 92.31%). These results are close to those obtained by Briki *et al.* (2021) [12] in Solanum melongena L (91.64%), Lannoy (2001) [13] in tomato (93.8%), and Malaisse (1997) [14] in some fruit vegetables such as *Aframomum polyanthum* and *Garcinia buchneri* with contents of 80% and 84.8%, respectively. Moreover, they are much higher than those found by Tchatchambé (2016) [15] in a contribution to the chemical and nutritional analysis of three plants in the city of Kisangani, who found 59.93% water content in *Solanum aethiopicum* L, those of Solomo *et al.*, 2011 [16], who found 47.56% water content in Solanum americanum, and those of 28.84% found by Onyamboko *et al.* (1988) [17] in *Garcinia cola* fruits. This high water content could be explained by the nature of the species, the places where it is grown, especially since African eggplants are often grown in

Table 4. Effect of eggplant addition on hematological parameters in rats.

Parameters	witness standard diet	Green eggplant 5%	Green eggplant 10%	Green eggplant 15%	Purple eggplant 5%	Purple eggplant 10%	Purple eggplant 15%
GR (10^6/µL)	6.54 ± 0.22	7.21 ± 0.13 ^{ns}	6.64 ± 0.10 ^{ns}	7.63 ± 0.33 ^{ns}	8.04 ± 0.34*	7.47 ± 0.17*	6.91 ± 0.47 ^{ns}
HB (g/dL)	13.23 ± 0.37	14.15 ± 0.08 ^{ns}	13.53 ± 0.18 ^{ns}	14.85 ± 0.37*	15.5 ± 0.20**	14.66 ± 0.12*	13.96 ± 0.54 ^{ns}
GB (10^3/µL)	6.46 ± 2.34	8.18 ± 1.48 ^{ns}	4.67 ± 2.56 ^{ns}	7.72 ± 1.44 ^{ns}	6.30 ± 1.66 ^{ns}	6.17 ± 1.58 ^{ns}	3.99 ± 1.38 ^{ns}
PLA (10^3/µL)	924 ± 105.38	1092.66 ±106.7^{ns}	1186.66 ±34.26 ^{ns}	1021.33±23.75^{ns}	922 ± 60.32 ^{ns}	1070.66 ± 89.69 ^{ns}	855 ± 87.17 ^{ns}

Results are expressed as mean ± standard error (SE) for n = 3, ns = not significant; * = significant at *p < 0.05 and ** at p < 0.01.

Table 5. Effect of adding eggplant on anthropometric parameters.

Parameters (mg/100 g bw)	witness standard diet	Green eggplant 5%	Green eggplant 10%	Green eggplant 15%	Purple eggplant 5%	Purple eggplant 10%	Purple eggplant 15%
Liver	2.91 ± 0.06	3.52 ± 0.41^{ns}	2.93 ± 0.05 ^{ns}	2.94 ± 0.17^{ns}	2.48 ± 0.15^{ns}	2.8 ± 0.16^{ns}	2.81 ± 0.06^{ns}
Kidney Left	0.30 ± 0.01	0.30 ± 0.01^{ns}	0.30 ± 0.00^{ns}	0.31 ± 0.77^{ns}	0.29 ± 0.00^{ns}	0.28 ± 0.01^{ns}	0.32 ± 0.00^{ns}
RightKidney	0.30 ± 0.01	0.33 ± 0.01^{ns}	0.29 ± 0.00^{ns}	0.30 ± 0.77^{ns}	0.29 ± 0.00^{ns}	0.29 ± 0.01^{ns}	0.33 ± 0.00^{ns}
Heart	0.49 ± 0.01	0.44 ± 0.02*	0.38 ± 0.02*	0.36 ± 0.75*	0.42 ± 0.01^{ns}	0.36 ± 0.01*	0.46 ± 0.01^{ns}
Rate	0.22 ± 0.01	0.21 ± 0.00^{ns}	0.17 ± 0.02^{ns}	0.28 ± 0.78^{ns}	0.16 ± 0.00*	0.18 ± 0.01^{ns}	0.19 ± 0.00^{ns}

Results are expressed as mean ± standard error (SE) for n = 3, ns = not significant; and *p < 0.05 test significant for the eggplant diet compared to standarddiet.

swampy areas, the nature of the soil and the geographical location. With regard to lipids, the results obtained are higher than those obtained by Purseglove (1976) [18] in tomatoes, with 0.1% lipids, by Solomo (2007) [19] in *Solanum americanum*, with 0.28% lipids, and by Soro *et al.* (2012) [20] in the leaves of *Solanum aethiopicum* L., with 0.91% lipids. This may be explained by the nature of the species used and the difference in organs. They are also higher than those of Malaisse (1997) [14], who obtained 1.4%, 3% and 2% in *Aframomum albolyanthu*, *Garcinia huillensis* and *Garcinia buchneri* fruits, respectively, and those of Lannoy (2001) [13] (13) in tomato with 1.2% lipids. This may be explained by the different plant species used. Moreover, they are lower than those found by Malaisse (1997) [14] in *Solanum nigrum* with 7.5% lipids, although they belong to the same genus and family.

Regarding the protein content of our two fruiting vegetables, our results are higher than those found by Diarra *et al.* (2020) [21], who worked on the nutritional potential and phytochemical composition of fifteen wild food plants used as leafy vegetables in Mali and found a protein content of 1.68% in green eggplant leaves. This difference is thought to be due to the nature of the organs used. However, the protein content would be influenced by the use of nitrogen fertilizer during production [22] [23]. Nevertheless, compared to other studies carried out on green eggplant of another species (*Solanum nigrum*), our results are significantly lower than those of [20], with a protein content of 29.90%. These differences could be due both to the nature of the species within the same plant family and to the organs used (fruit and leaves). They are much higher than those found by Solomo (2007), who studied the nutritional and toxicological values of a number of wild food plants and obtained 0.31% Solanum americanum per 100 g dry matter.

The ash contents obtained are close to those of Solomo (2007) [19] in *Solanum americanum*, who found a value of 6.5%. The carbohydrate contents obtained are much higher than those found by Tchatchambé (2016) [15] in *Solanum aethiopicum* L., for 5.83% carbohydrates. This difference can be explained by the geographical location and the nature of the soil, which favors the biosynthesis of carbohydrates.

Regarding the energy value of eggplant, our results are lower than those found by Tchatchambé (2016) [15] in *Solanum aethiopium* L., namely 465.52 kcal, and those found by Diarra *et al.* (2020) [21] in its leaves, namely 472.90 kcal. This difference can be explained by the nature of the organs.

4.2. Mineral Content

Regarding the calcium content, the results obtained are similar to those of Tchatchambé (2016) [15] for green eggplant (*Solanum aethiopicum* L.) and lower for purple eggplant (Solanum melongena L.). In fact, the author found 0.7% in *Solanum aethiopicum* L. This can be explained by the use of chemical fertilizers, soil quality, preservation and drying methods. Moreover, they are higher than those obtained by Lannoy (2001) [13], in purple eggplant and to-

mato, with 0.22% and 0.07%, respectively, 1.769% calcium.

The results obtained for magnesium content confirm those of Parfonry and Ngueré (1991) [24] in mango with 0.17%, but are much higher than those obtained by Solomo (2007) [19] in *Solanum americanum* with 0.01% magnesium. This difference could be due to the nature of the species. The results obtained for iron content are higher than those of Lannoy (2001) [13], who found an iron content of 0.006% in tomatoes, which could be explained by the nature of the species. However, they are much lower than those found by Diarra *et al.* (2020) [21] in leaves of *Solanum aethiopicum* L. with 0.180% iron. As for the phosphorus content of eggplant, it is higher than that of Solomo (2007) [19], who found 0.032% in *Solanum americanum*, but close to that of Apfelbaum (2004) [25], who found 0.27% in tomato.

4.3. Antioxidant Activity and Determination of Total Polyphenols

The results accurately show the variability of phenolic content in purple and green eggplant with 20.61 mgEGa and 11.29 mgEGa, respectively. The results obtained by Cherifa (2014), who worked on the total polyphenol content, obtained 20.14 mgEGa, 30.88 mgEGa and 317.36 mgEGa for the ethanolic fractions of fresh, dried and frozen purple eggplants and 317. 36 mgEGa for the aqueous fractions of fresh, dried and frozen purple eggplant, dry and frozen, 19.47 mgEGa, 26.13 mgEGa and 18.53 mgEGa, are close to our results for the fresh eggplant variety from the ethanolic and aqueous extracts, and well below those for the dry and frozen variety. This difference could be explained by the physical state (freezing or drying), which also influences the phenolic composition of eggplant. The IC50 varies between 12.42 mg/ml and 40.28 mg/ml in the fruits of *Solanum mélongena* L. (purple eggplant) and *Solanum aethiopicum* L. (green eggplant), respectively. Comparing our results with those found by Tsiba *et al.* (2020) [26] in leaves of Solanum nigrum L., our results are far superior to those found by these authors for green eggplant and close to those for purple eggplant. These differences could be explained by the reaction conditions (time, antioxidant/DPPH-ratio, type of solvent, pH) and phenolic profile [27]. For purple eggplant, our results are lower than those of Boubekri, 2014 [6] with 14.82 mg/g of dried purple eggplant variety and higher for green eggplant. The 50% DPPH free radical inhibition concentration of green eggplants (40.28 mg/ml) is higher than that of purple eggplants (12.24 mg/ml), so the latter contains more antioxidants than green eggplants, as pointed out by Bougandoura and Bendimera, 2013 [28]. These results are related to a low polyphenol concentration of 11.29 mgEGa in green eggplants compared with 20.61 mgEGa in purple eggplants.

4.4. Weight Evolution, Quantity Consumed, Total Dry Matter Ingested, and Weight Gain

Rats treated with the different eggplant diets showed a significant and non-significant reduction in body weight compared to those on the standard diet. Eggplant is said to have a diuretic effect, which explains this reduction in

body weight Chepo and *al*, 2021 [29]; Singh and *al*, 2009 [30]. Our results are inferior to those obtained by Pascal (2013) [31], who worked on "evaluating the effects of chili (Capsicum frutescens) consumption on hematological and biochemical parameters in broilers". This would be justified by the nature of the species used, their physiology and their experimental environment. Regarding the quantity consumed in g per day, there was a non-significant decrease for all the diets, except for the 10% purple eggplant diet, where there was a non-significant increase. This could be explained by the influence of saponosides, which are substances that cause the bitterness of green eggplant, and the presence of substances in purple eggplant that would influence organoleptic qualities. With regard to the total dry matter ingested, the results obtained are significantly lower than those of Pascal (2013) [31], with respectively 97.28 ± 1.30 g, for the standard diet; 97.24 ± 1.30 g, for the 5% diet and 99.95 ± 1.30 g, for the 10% diet. This is justified by the nature of the species used, then the difference in the fruit and vegetables used. Regarding weight gain, comparing our results with those of Pascal (2013), who found 3657.76 ± 28, 30 g.DM for rats on the standard diet, 3592.62 ± 28, 30 g.DM, 3610.25 ± 28, 30 g.DM, for rats on the 5% and 10% diets, they are significantly lower because, being chickens, their nutritional requirements are higher than those of rats.

4.5. Hematological and Anthropometric Parameters (Organ Weights)

The hematopoietic system is one of the most sensitive targets of xenobiotics. It represents an important marker of the physiological and pathological state of man [32]. An increase in erythrocyte and hemoglobin levels was observed in the group of animals fed the diet enriched with purple eggplant (5% and 10%) and green eggplant (15%). The increase in hemoglobin levels indicates the absence of anemia, which can be explained by the effect of eggplant on hemoglobin and erythrocyte synthesis. In addition, the number of white blood cells and platelets remained unchanged in all treated groups. This suggests that the addition of eggplant does not interfere with the synthesis of white blood cells and platelets [33]. Anthropometric parameters in this study were assessed by the weight of the different organs of the rats per batch, the results obtained showed a non-significant increase and decrease on the one hand and significant on the other hand of the different organs for the eggplant powder diets compared to the standard diet. Our results are lower than those obtained by Pascal (2013) [31] with respect to organ weights; 1he found 39 mg/g, 10 mg/g and 10 mg/g for liver, kidney and heart, respectively. This could be explained by the nature of the species used.

5. Conclusion

The present study allowed us to carry out a nutritional characterization of green and purple eggplants consumed in the city of Brazzaville, while evaluating their antioxidant activity and their effect on hematological and anthropometric para-

meters. The results showed that eggplant has a fairly high nutritional value, with interesting nutrient values, and is an important source of energy value, which would contribute to food security, especially in Africa. However, thanks to their content of antioxidant molecules, they have an effect on various diseases caused by free radical damage, so these fruit vegetables should be consumed on a daily basis. In addition, the consumption of eggplant had an effect on hematological and anthropometric parameters, with an increase in erythrocyte count, stimulation of erythrocyte and hemoglobin production, and a reduction in organ mass. Taken together, these results support the case for eggplant consumption in Congo Brazzaville.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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