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Original Research Article

Nutritional Quality of *Gnetum africanum* Welw Leaves Harvested in Makoua and sold on the Markets of Brazzaville

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Abstract: *Gnetum africanum* is one of the most consumed NTFPs in Brazzaville. These leaves are rich in water (51.37%). The titratable acidity is 0.78%. The lipid, protein, carbohydrate and fiber contents are respectively: 7.34%, 16.61%, 17.95% and 36.70%. The ash content is 6.73%. Among the ions identified, we have: Iron: 0.014%, Calcium: 0.96%, Magnesium: 0.44% and Phosphorus 0.25%. The calculated energy value gives 204.28 Kcal/ 100g. The leaves of *G. africanum* studied are a good source of dietary fiber and minerals.

Keyword: *Gnetum africanum*, PFNL, Nutritional Quality, Makoua.

I. INTRODUCTION

Congolese forests and savannahs constitute an important reserve of edible Non-Timber Forest Products (NTFPs), and the species *Gnetum africanum* Welw is the most consumed species by the population of Brazzaville (Matoumouene Goma *et al.*, 2021). The fresh leaves of *Gnetum africanum*, called "Koko" or "mfumbu", are widely used as a vegetable. They are usually cooked with meat, fish or mushrooms and sometimes eaten in salads. The leaves are chopped into thin strips and often eaten mixed with, for example, peanut-based stew (Schippers and Besong, 2018).

Gnetum africanum plays a big role in reducing hunger and diversifying income. In the DRC and Cameroon, the *Gnetum africanum* sector is a significant source of employment. It generally employs the most vulnerable social categories, which are women and pygmies (Manirakiza *et al.*, 2009, Ingram *et al.*, 2012). Many studies have also shown that the chemical composition of the leaves of this plant, gives it important nutritional properties, and its high fiber, protein and calorie content support these claims (Fadi *et al.*, 2011).

Gnetum africanum is a leafy vegetable rich in various elements and can be used as food or as a dietary supplement. Thus, due to its physicochemical composition, this plant offers enormous health benefits. It is in this context that this work falls under the general objective of which is to evaluate the food quality of the leaves of *Gnetum africanum* from Makoua, sold on the markets of Brazzaville in order to improve their use by the population.

II. MATERIALS AND METHODS

II.1 Plant Material

The plant material of our study consists of fresh leaves of *Gnetum africanum*, harvested in the forests and bushes of villages of the sub-prefecture of Makoua in the Congolese basin in the Republic of Congo.

II.2 METHODS

Determination of Hydrogen potential

The pH of *Gnetum africanum* leaves was determined according to Standards NF V76-122, NF EN 1132, 1994; AFTER 2011).

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Determination of titratable acidity

Titratable acidity was determined by potentiometric titration using a sodium hydroxide solution (After 2011).

Determination of moisture content

The moisture content was determined according to the AOAC method (2005). 30g of *Gnetum africanum* leaves stripped of the petioles are placed in a portion of aluminum foil weighed beforehand and placed in an oven (Memmert, Germany) set at 70°C until the mass becomes constant (Ossoko *et al.*, 2019a).

Determination of fat content

The lipids contained in 20g dried and ground *Gnetum africanum* leaves were extracted according to the Soxhlet method (NF ISO 82 62-3, 2006) with 200 ml of hexane for 6 hours. The excess solvent is evaporated in an oven (Memmert, Germany) at 70°C (Ossoko *et al.*, 2019b).

Determination of protein level

About 0.1 g of the leaves of *Gnetum africanum* are used to determine the crude protein content from the determination of total nitrogen by the Kjeldhal method (AOAC 2005). The protein rate was obtained by multiplying the total nitrogen content by a convention factor of 6.25 (Ossoko 2020).

Determination of crude ash content (C) and major minerals

2g of cakes from dried, crushed and de-oiled *Gnetum africanum* leaves were used to determine the ash content. The incineration of the samples is carried out in a muffle furnace at 550°C for 8 hours. The ash content obtained after incineration is calculated (Ossoko *et al.*, 2020).

The contents of mineral elements are measured by atomic absorption spectrophotometry (Perkin-Elmer 1100) on the ashes obtained after mineralization. Before dosing, the ashes are diluted in a solution containing 10% lanthanum chloride as an interaction corrector (concentration: 116 g of LaCl3 in 1 liter of concentrated HCl diluted to a quarter) (Ossoko *et al.*, 2019a).

Determination of total carbohydrate content

The carbohydrate content was estimated by the difference method. It was calculated by subtracting the sum of moisture, fat, protein and ash contained in the sample from 100 (Ossoko *et al*., 2020).

Determination of crude fiber content

The crude fiber content of *Gnetum africanum* was determined by Weende's method. For this, 1g of dried, crushed and de-oiled *Gnetum africanum* leaves (M) is boiled in 50 ml of sulfuric acid (0.25 N) and then in 50 ml of sodium hydroxide (0.31 N) for 1 hour. The residue obtained is dried at 105°C for 8 h and then weighed (Ossoko *et al*., 2019b).

Determination of the Energy Value

The energy value was determined using the formula below: VE (Kcal/100g) = (CHO x 4) + (CL x 9) + (CP x 4) with CHO = % of carbohydrates, CL = % of lipids and CP = % protein (Ossoko 2020).

III. RESULTS AND DISCUSSION

The hydrogen potential of *Gnetum africanum*

The results obtained show that *Gnetum africanum* has a neutral pH (7). This species has a higher pH than that of the fruit pulp of *Saba comorensis* (3.2), of *Clitandra cymulosa* (3.55) (Enzonga *et al.*, 2019), of the fruit of *Arbutus unedo* which varies between 3.53 and 3.55 (Doukani and Tabak 2015) and black plum (*Vitex doniana*) fruit pulp (4.50-5.11) (Kone *et al.*, 2018) which are all acidic.

The titratable acidity of *Gnetum africanum*

Gnetum africanum is a species that has a titratable acidity of 0.78%. This value of the titratable acidity obtained is higher than those obtained by Doukani and Tabak (2015) on the fruit of *Arbutus unedo* (0.74%).

The titratable acidity (0.78%) obtained from *Gnetum africanum* is sensitive to those obtained by Hanna (2021) on apple and pear (0.36 and 0.80%), Mango (0.34 and 0. 84%), table grapes (0.4 and 0.9%), sweet cherry (0.24 and 0.94%), tomato (0.34 and 1%), and strawberry (0. 6 and 1.1%). But it is lower than those obtained by Hanna (2021) on orange (0.8 and 1.4%), pineapple (0.7 and 1.6%), plum and sour cherry (0.94 and 1.64%), Grapefruit (1.2 and 2.0%), Cranberry (1.6 and 3.6%), Lemon (4 and 6.2%).

Humidity

The leaves of *Gnetum africanum* from Makoua have a moisture content of 51.37%. This result shows that the leaves of *Gnetum africanum* studied are very rich in water, contrary to the results obtained by Ekop in 2007 (31.60%) on the seeds of the same product. *G. africanum* is richer in water than: *Passiflora edulis* fruit seeds (15.18%) (Ossoko *et al.*, 2020); *Aframomum alboviolaceum* seeds (30.68%) (Ossoko, 2020); Kernels of *Hyphaene guineensis* (37.32%) (Ossoko *et al.*, 2019a); kernel of *Anisophyllea quangensis* fruit (39.2%) (Binaki *et al.*, 2013); the fruit of Borassus aethiopum (45.31%) (Ossoko *et al*., 2019b). This Humidity value is sensitive to that obtained by Fadi *et al.*, (2011) on the leaves and seeds of *Gnetum africanum* (12 and 73.2%). But it is lower than those obtained by: Doukani and Tabak (2015) on the fruit of *Arbutus unedo* (62.87%); Kone *et al.*, (2018) on the pulp of *Vitex doniana* fruits (74.18%); Itoua Okouango *et al*., (2015) on the leaves of wild spinach *Phytolacca dodecandra* (81.87%) and *Spinacia oleracea* (91.19%); Tchatchambe *et al.*, (2017) on the leaves of wild food plants *Vitex welwitchii* (86.58%), *Dewevrea bilabiata* (87.58%), *Ipomoea aquatica* (91.44%) and *Vernonia hochstetteri* (94.66%).

Fat content

The leaves of *Gnetum africanum* studied have a fat content of 7.34%. This value obtained is higher than those obtained by: Itoua Okouango *et al.,* (2015) on the leaves of *Spinacia oleracea* (0.40%) and *Phytolacca dodecandra* (1.60%); Enzonga *et al.,* (2019) on the fruits of *Saba comorensis* (0.72%) and *Clitandra cymulosa* (0.79%); Tchatchambe *et al.,* (2017) on the leaves of wild food plants *Vitex welwitchii* (1.2%), *Vernonia hochstetteri* (1.6%) and *Dewevrea bilabiata* (1.8%); Doukani and Tabak (2015) on the fruit of *Arbutus unedo* (1.3%); Ossoko *et al.,* (2019b) on kernels of Borassus aethiopum (2.4%) and Ekop (2007) on seeds of *Gnetum africanum* (3.15%).

This value of the lipid content of *Gnetum africanum* obtained is close to or sensitive to those obtained by: Mialoundama (1985) on the leaves of *Gnetum africanum* (5.9%) and *Gnetum buchholzianum* (6.2%); Ali *et al.,* (2019) on Baobab leaves (4.23-6.66%); Fadi *et al.,* (2011) on the leaves and seeds of *Gnetum africanum* (0.3-9.6%).

The results obtained show that *Gnetum africanum* has a lipid content (7.34%) lower than those obtained by: Enzonga *et al.* (2019) on the fruits of *Aframomum alboviolaceum* (10.58%) and *Passiflora edulis* (11.65%); Ossoko (2020) on *Aframomum alboviolaceum* seeds (10.58%); Ossoko *et al.,* (2019a) on kernels of *Hyphaene guineensis* (13.51%); Ayéna and Agassounon Djikpo Tchibozo (2015) on the seeds of *Pterocarpus santalinoides* (9.20-19%); Tchatchambe *et al.,* (2017) on the leaves of the wild food plant *Ipomoea aquatica* (21%); Ossoko *et al.,* (2020) on the fruit of *Passiflora edulis* (23.65%) and Binaki *et al.,* (2013) on the almond of the fruit of *Anisophyllea* (26.72%).

Protein content

Gnetum africanum leaves from Makoua have a protein content of 16.61%. This value is higher than those obtained by: Tchatchambe *et al.,* (2017) on the leaves of wild food plants *Vitex welwitchii* (0.02%), *Ipomoea aquatica* (0.03%), *Vernonia hochstetteri* (0.03%) and *Dewevrea bilabiata* (0.04%); Enzonga *et al.,* (2019) on the fruits of Saba comorensis (3.76%), *Clitandra cymulosa* (5.23%), *Aframomum alboviolaceum* (5.78%) and *Passiflora edulis* (9.42%); Ossoko (2020) on *Aframomum alboviolaceum* seeds (5.19%); Itoua Okouango *et al.,* (2015) on the leaves of *Spinacia oleracea* (5.20%); Ossoko *et al*., (2019a) on kernels of *Hyphaene guineensis* (5.64%); Dan Gomma *et al.,* (2017) on millet stalks and rice straw (5.7%) and *Cowpea haulm* (11.3%); Ossoko *et al.,* (2019b) on kernels of *Borassus aethiopum* (5.86%); Ossoko *et al.,* (2020) on the fruit of *Passiflora edulis* (10.53%) and Ayéna and Agassounon Djikpo Tchibozo (2015) on the seeds of *Pterocarpus santalinoides* (13.29-14.70%). The protein content of *Gnetum africanum* obtained in this study is similar to those obtained by: Mialoundama (1985) on *Gnetum africanum* (16.5%) and *Gnetum buchholzianum* (18.18%); Ekop (2007) on the seeds of *Gnetum africanum* (17.50%); Ali *et al.,* (2019) on Baobab leaves (17.53-19.77%); Fadi *et al.,* (2011) on leaves and seeds of *Gnetum africanum* (7.2-21.5%). This protein content (16.61%) of *Gnetum africanum* obtained is lower than those obtained by: Itoua Okouango *et al.,* (2015) on the leaves of *Phytolacca dodecandra* (34.56%).

Crude ash content

Gnetum africanum leaves from Makoua have a crude ash content of 6.73%. This value is higher than those obtained by: Doukani and Tabak (2015) on the fruit of *Arbutus unedo* (0.51%); Ossoko (2020) on *Aframomum alboviolaceum* seeds (1.18%); Ekop (2007) on seeds of *Gnetum africanum* (1.20%); Enzonga *et al.,* (2019) on the fruits of *Clitandra cymulosa* (1.35%), *Saba comorensis* (3.60%), *Passiflora edulis* (3.77%) and *Aframomum alboviolaceum* (3.84%); Ossoko *et al.,* (2019b) on *Borassus aethiopum* kernel (1.60%); Ossoko *et al.,* (2020) on the fruit of *Passiflora edulis* (1.70%); Ossoko *et al.,* (2019a) on kernels of *Hyphaene guineensis* (2.35%); Binaki *et al.,* (2013) on the kernel of the fruit of *Anisophyllea quangensis* (3.6%); Kone *et al.,* (2018) on the pulp of *Vitex doniana* fruits (3.43-3.64%); Tchatchambe *et al.,* (2017) on the leaves of the wild food plant *Vernonia hochstetteri* (3.7%);

This value of the ash content of *Gnetum africanum* obtained is close to or sensitive to those obtained by: Tchatchambe *et al.,* (2017) on the leaves of the wild food plant *Ipomoea aquatica* (6.9%); Fadi *et al.,* (2011) on the leaves and seeds of *Gnetum africanum* (1.2-8.7%).

But this ash content of *Gnetum africanum* obtained in this study is lower than those obtained by: Yoka *et al.,* (2014) on the leaves of *Vigna unguiculata* after 3 months (10.6%), 2 months (11.6%) and 1 month (16.2%) of sowing; Tchatchambe *et al*., (2017) on the leaves of wild food plants *Dewevrea bilabiata* (10.7%) and *Vitex welwitchii* (18.3%) and Itoua Okouango *et al.,* (2015) on the leaves of *Phytolacca dodecandra* (20.50%) and *Spinacia oleracea* (30.62%).

Mineral content

Iron content

The leaves of *Gnetum africanum* from Makoua have an iron content of 0.014%. This value is higher than the iron content contained in: the seeds of *Aframomum alboviolaceum* (0.00%) (Ossoko, 2020); *Aframomum alboviolaceum* fruit (0.005%) and *Passiflora edulis* fruit (0.006%) (Enzonga *et al.,* 2019); Baobab leaves (0.006% and 0.007%) (Ali *et al.,* 2019); the fruit of *Passiflora edulis* (0.01%) (Ossoko *et al*., 2020).

The iron content value obtained in this study shows that *Gnetum africanum* is less rich than: the fruit

of *Saba comorensis* (0.03%) (Enzonga *et al.,* 2019); the leaves of *Phytolacca dodecandra* (0.04%) and *Spinacia oleracea* (0.08%) (Itoua Okouango *et al.,* 2015); fresh kernels of *Borassus aethiopum* (0.04%) (Ossoko *et al.,* 2019b); kernels of *Hyphaene guineensis* (0.06%) (Ossoko *et al.,* 2019a) and seeds of *Gnetum africanum* (1.50%) (Ekop 2007).

Calcium content

The leaves of *Gnetum africanum* from Makoua have a calcium content of 0.96%. This value of the content obtained is higher than those obtained by: Itoua Okouango *et al.,* (2015) on the leaves of *Phytolacca dodecandra* (0.04%) and *Spinacia oleracea* (0.11%); Enzonga *et al.,* (2019) on the fruit of *Passiflora edulis* (0.07%), *Aframomum alboviolaceum* (0.07%) and *Saba comorensis* (0.46%); Ossoko *et al.,* (2019b) on fresh kernels of *Borassus aethiopum* (0.28%); Mialoundama (1985), on the leaves of *Gnetum buchholzianum* (0.34%); Ossoko *et al.,* (2020) on the fruit of *Passiflora edulis* (0.36%); Ossoko *et al.,* (2019a) on kernels of *Hyphaene guineensis* (0.44%); Ossoko (2020) the seeds of *Aframomum alboviolaceum* (0.72%).

This same value of the calcium content (0.96%) obtained is close to that obtained by Mialoundama (1985), in his doctoral thesis, on *Gnetum africanum* (0.83%), but it is below those obtained by: Ali *et al.,* (2019) on Baobab leaves (2.24%-4.01%) and Ekop (2007) on *Gnetum africanum* seeds (7.01%).

Magnesium content

The leaves of *Gnetum africanum* from Makoua have a Magnesium content of 0.44%. This value of the magnesium content obtained is high compared to those of: Enzonga *et al.,* (2019) on the fruit of *Passiflora edulis* (0.06%) and *Aframomum alboviolaceum* (0.17%); Mialoundama (1985) on the leaves of *Gnetum buchholzianum* (0.18%); Ossoko *et al.,* (2019b) on fresh kernels of *Borassus aethiopum* (0.25%); Ossoko (2020) on the seeds of *Aframomum alboviolaceum* (0.29%).

This value (0.44%) obtained is close to those obtained by: Mialoundama (1985), on the leaves of *Gnetum africanum* (0.39%); Ali *et al.,* (2019) on Baobab leaves (0.36%-0.47%); Kouassi *et al.,* (2013) on the Dioula variety (Gombo) (0.48%). On the other hand, this content is low compared to those obtained by: Kouassi *et al*., (2013) on the Baoulé variety (Gombo) (0.61%); Ossoko *et al.,* (2020) on *Passiflora edulis* seeds (0.60%); Ossoko *et al*., (2019a) on kernels of *Hyphaene guineensis* (0.65%); Enzonga *et al.,* (2019) on the fruit of *Saba comorensis* (1.09%) and Ekop (2007) on the seeds of *Gnetum africanum* (5.48%).

Phosphorus content

The leaves of *Gnetum africanum* studied have a phosphorus content of 0.25%. The phosphorus content obtained in this study is higher than those obtained by: Enzonga *et al.,* (2019) on the fruit of *Saba comorensis* (0.04%), *Aframomum alboviolaceum* (0.02%) and *Passiflora edulis* (0.03%); Ali *et al.,* (2019) on Baobab leaves (0.03%-0.04%); Ossoko *et al.,* (2019b) on fresh kernels of *Borassus aethiopum* (0.08%); Mialoundama (1985) on the leaves of *Gnetum buchholzianum* (0.11%) and *Gnetum africanum* (0.17%); Ossoko (2020) on *Aframomum alboviolaceum* seeds (0.14%) and Ossoko *et al.,* (2019a) on kernels of *Hyphaene guineensis* (0.18%).

This phosphorus content obtained in this study is close to that obtained by Ossoko *et al.,* (2020) on the fruit of *Passiflora edulis* (0.24%). But it is lower than those obtained by: Itoua Okouango *et al.,* (2015) on the leaves of *Phytolacca dodecandra* (0.67%) and *Spinacia oleracea* (0.84%).

Total carbohydrate content

Gnetum africanum leaves from Makoua have a total carbohydrate content of 17.95%. This value obtained is higher than those obtained by: Itoua Okouango *et al.,* (2015) on the leaves of *Phytolacca dodecandra* (2.30%) and *Spinacia oleracea* (3.20%); Enzonga *et al.,* (2019) on the pulp of *Saba comorensis* (2.52%) and *Clitandra cymulosa* (3.54%); Ayéna and Agassounon Djikpo Tchibozo (2015) on the seeds of *Pterocarpus santalinoides* (3.53-9.80%) and Doukani and Tabak (2015) on the fruit of *Arbutus unedo* L (11.45%).

The value of the total carbohydrate content obtained in this study is close to or sensitive to those obtained by: Mialoundama (1985) on the leaves of *Gnetum buchholzianum* (16.75%) and *Gnetum africanum* (17.50%) and Fadi *et al.,* (2011) on the leaves and seeds *of Gnetum africanum* (0.2-87.6%).

But this value of the total carbohydrate content of *Gnetum africanum* obtained is lower than those obtained by: Ossoko *et al.* (2019a) on kernels of *Hyphaene guineensis* (41.18%); Ossoko *et al.,* (2019b) on *Borassus aethiopum* kernels (44.83%); Ossoko *et al.* (2020) on Passiflora edulis fruit (48.94%); Ossoko (2020) on *Aframomum alboviolaceum* seeds (52.37%); Ali *et al*., (2019) on Baobab leaves (64.10%-73.53%) and Ekop (2007), on *Gnetum africanum* seeds (87.62%).

Crude fiber content

The leaves of *Gnetum africanum* from Makoua have a crude fiber content of 36.70%. This value is higher than those obtained by: Ekop (2007), on the seeds of *Gnetum africanum* (0.80%); Ossoko (2020) on *Aframomum alboviolaceum* seeds (3.86%); Dan Gomma *et al*., (2017) on wheat bran (9.9%), Gao pod (29%), cottonseed cake (30.8%) and crushed rice straw (32%); Ossoko *et al.,* (2019a) on kernels of *Hyphaene guineensis* (10.85%); Ossoko *et al.,* (2019b) on kernels of *Borassus aethiopum* (13.05%); Ossoko *et al.,* (2020) on the fruit of *Passiflora edulis* (13.76%); Doukani and

Tabak (2015) on the fruit of *Arbutus unedo* (18.5%) and Ali *et al.,* (2019) on Baobab leaves (22.98%-33.90%). This value of the crude fiber content obtained in this study is close to or sensitive to those obtained by: Dan Gomma *et al.,* (2017) on the stem of millet contains (35.8%) and *Cowpea haulm* (41.8%); Mialoundama (1985) on the leaves of *Gnetum buchholzianum* (39.5%) and *Gnetum africanum* (40%); Fadi *et al.,* (2011) on the leaves and seeds of *Gnetum africanum* (0.8-87.8%).

Energetic value

The leaves of *Gnetum africanum* from Makoua have a caloric density of 204.28 Kcal/100g. The result of this study shows that the species *Gnetum africanum* produces more energy than the leaves of wild spinach *Spinacia oleracea* (37.2Kcal/100g) and *Phytolacca dodecandra* (161.84Kcal/100g) (Itoua Okouango *et al.,* 2015). The caloric density of *Gnetum africanum* (204.28Kcal/100g) obtained is close to that of fresh almonds of *Borassus aethiopum* (224.36Kcal/100g) (Ossoko *et al.,* 2019b). But however lower than those released by: almonds of *Hyphaene guineensis* (308.87Kcal/100g) (Ossoko *et al.,* 2019a); *Aframomum alboviolaceum* seeds (325.46Kcal/100g) (Ossoko, 2020); Baobab leaves (395.43-413.42kcal/100g) (Ali *et al.,* 2019); leaves and seeds of *Gnetum africanum* (248.8-448.3Kcal/100g) (Fadi *et al.,* 2011); seeds of *Gnetum africanum* (448.83kcal/100g) (Ekop 2007) and the fruit of *Passiflora edulis* (450.73Kcal/100g) (Ossoko *et al.,* 2020).

CONCLUSION

The food consumption of *Gnetum africanum* leaves is very high in Brazzaville, especially since this species is the most sold edible Non-Timber Forest Product, appreciated and consumed by the population of this sub-prefecture. *Gnetum africanum* offers a very appreciable notional and energy contribution. With a neutral pH and a titratable acidity of 0.78%, it has a moisture content of almost 50%. It provides the body with 7.34% fat, 16.61% protein, 17.95% total carbohydrates and 204.28 Kcal/100g of energy. This species of edible NWFP has more than 35% dietary fiber, and it is very rich in major minerals with 0.96% calcium, 0.44% magnesium, 0.25% phosphorus and 0.014% iron. This study improves knowledge on the nutritional value of *Gnetum africanum* consumed in Congo.

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