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Full Length Research Paper

Effect of tree age on nutritional, anti-nutritional and proximate composition of *Moringa stenopetala* leaves in South west Ethiopia

Fikremariam H. Desalegne[1*], Zewdu Y. Ayele[2] and Abeje E. Wasse[2]

[1]Wood Technology Research Center, Ethiopian Environment and Forest Research Institute, P. O. Box 2322, Addis Ababa, Ethiopia.
[2]Central Ethiopia Environment and Forest Research Center, P. O. Box 30708, Addis Ababa, Ethiopia.

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Moringa stenopetala **is one of the indigenous agro-forestry tree species cultivated in multi-storey inter-cropping system in the southern dry land areas of Ethiopia. It is an economically important tree species in which most parts of the plant are used for different purposes. Leaves of the plant collected from age classes of the tree are edible after processing. Despite its wider usage in the southern parts of the country, little is known about the nutritional composition of the leaves at different age classes of the tree. We investigated the effect of tree age on nutritional, ant-nutritional and proximate composition of** ***M. stenopetala*** **leaves and determined the moisture content, ash content, crude fiber, crude protein, fat, tannin content, phytate content, iron, calcium, phosphorus and potassium in the leaves. Authentic representative** ***M. stenopetala*** **leave samples were collected from 3, 4, 5, 6 and 7 years old tree in** ***Derashe*** **area, southern part of Ethiopia. The collected leaf samples were dried and subjected to physico-chemical analysis following standard methods of analysis. The laboratory results were analyzed using SAS Statistical software. The analysis indicated a significant difference in the main effect of all nutrition and anti- nutritional parameters between the five classes at 1% significant level. However, there was no significant difference in the cationic composition of iron and zinc among age classes of the tree. This study suggests that plant age has an influence on nutrition, anti-nutritional composition and most of the proximate elements.** ***M. stenopetala*** **trees that grew up well and reached age of five had better nutritional, anti-nutritional and proximate composition implying that leaf collection should to be done on trees that are established and grown well and reached at least five years of age.**

Key words: Moringa stenopetala, nutritional, anti-nutritional, proximate composition.

INTRODUCTION

The Eastern Africa region is predominantly a dry land with about 60% of the total land area classified as arid or semi-arid (Funk et al., 2008). The rural economy is dominated by subsistence agriculture or pastoralists that

*Corresponding author. E-mail: kafbabi2011@gmail.com.

are dependent on the available natural resources. Drought poses the greatest challenge to the livelihoods ofcommunities in this region, a problem that is compounded by over-reliance on traditional farming/ pastoral activities, which cannot cope with adversity brought about by drought. Moringa stenopetala is widely cultivated in Southern Ethiopia especially in Gamu-Gofa, Sidama, Konso and the adjoining provinces Abuye et al. (2003). *Moringa* is a drought tolerant fast growing indigenous tree mainly planted and maintained for its nutritional value (Assefa et al., 2015). Literature shows that Moringa leaves are rich sources of minerals and amino acids (Anjorin et al., 2010; Wakil and Kazeem, 2012).

Related to the above mentioned points, the country gives great attention to the most important local survival strategies and intensifies the agricultural system to overcome the reaped climatic shocks that hamper agricultural production leading to food shortage (Guinad and Lemessa, 2000). Strategies to overcome climatic shocks and reduce agricultural production include strengthening the households' resources base (Erhabor and Emokaro, 2007; Ibrahim et al., 2009) and diversifying alternate food sources (Ghosh et al., 2011). This study focused on determining the appropriate age of *Moringa stenopetala* for better nutritional composition. We investigated impact of different age classes on nutritional value of *M. stenopetala* leaves.

MATERIALS AND METHODS

Site description

The plant leaves for the experiment were collected from the *Derashe woreda* of the South Nations and Nationalities Peoples Region (SNNPR). *Derashe woreda* is one the best potential sites for growing and production of *M. stenopetala* trees. It is located in the Great Rift Valley Region at 630 Km South west of Addis Ababa in Ethiopia, at 7°4°N latitude and 38°31°E longitude. The *Woreda* has an altitudinal range from 1300 up to 2545 m above sea level and average annual rain fall of 952.1 mm. The mean temperature ranges between 12 and 27°C.

Sample preparation

M. stenopetala tree ages of 3, 4, 5, 6 and 7 were randomly selected from farmers' field/garden. The fresh leaf samples were collected in the morning by hand from the crowns of each selected tree in four directions (North, South, West and East) to capture possible variations in the leaf characteristics. Composite leaf samples per tree were taken for further analysis. The sample leaves were transported to the Wood Technology Research Center in Addis Ababa in plastic bags. The leaves were spread on thin canvas sheet placed in a greenhouse and dried in the open air until the leaves were dried uniformly. The dried leaves were hand-crushed and further grounded using mortar and pestle to 2 mm size. The crushed leave samples were then put in the paper bag and kept at room temperature until the laboratory analysis was carried out.

Nutritional and proximate composition analysis

Analysis on the nutritional and proximate composition of *M. stenopetala* leaves was done in the nutritional laboratories of Ethiopian Health Institute. The nutritional aspects/characteristics of the *Moringa* leaves included moisture content, ash content, crude fiber, nitrogen content, crude protein and mineral contents.

Determination of moisture content

Three replicates of ground Moringa leaves that weigh accurately 2 g from each tree age was weighed and dried at 105°C for 5 h using Oven (Memert Germany ALC-210.4 model). Oven dry weight was recorded after allowing the samples to cool in a desiccator before reweighing. Moisture content was expressed as a percentage of the weight loss from the original weight (Yebeyen et al., 2009; Nilsen SS 2010.

Determination of ash

Three replicates of grounded *Moringa* leaves that weigh accurately 2 grams from each tree age were first heated on a burner in air to remove its smoke. Then each leaf sample was burned in a furnace at 550°C for 1.30 h. The ash content was expressed as a percentage ratio of the weight of the ash to the oven dry weight (Nielsen SS 2010).

Determination of total nitrogen and crude protein

Exactly 0.5 g of each Moringa leave sample, in three replicate for each tree age, was weighed and transferred into 2300 Kjeldahl digestion tube plus one Kjeldahl tablet, copper sulfate-potassium sulfate catalyst. Then 10 ml of concentrated, nitrogen free and sulfuric acid was added. The tube was then mounted in the digestion heating system which was previously set to 240°C and capped with an aerated manifold. The solution was then heated at the above temperature until a clear pale yellowish-green color was observed. This indicates the completion of the digestion. The tubes were then allowed to cool at room temperature. Their content was quantitatively transferred to Kjeldahl distillation apparatus followed by addition of distilled water and 30% (w/v) sodium hydroxide. Steam distillation was then started and the released ammonia was absorbed in 25 ml of 2% boric acid. Back titration of the generated borate was then carried out versus 0.02 M Hydrochloric acid using methyl red as an indicator. Blank titration was carried out in the same way. The percentage of nitrogen content was then calculated (AOAC, 1990).The protein content was calculated using the nitrogen conversion factor of 6.25 as proposed by Greenfield and Southgate, 2003).

Determination of mineral content

Ash from a sample of Moringa leaves was dissolved in concentrated sulfuric acid. Then, the solution was used for the determination of the minerals studied except for phosphorus which was determined by an atomic absorption spectrometer. Appropriate standard solution was prepared for each metal and used by atomic absorption spectrometer (model AAA-6800) to prepare the graph for the determination of the amount of each metal from the test solution. Wet ash method was used for the determination of phosphorus in the sample leaves. The ash was dissolved in

Table 1. Analyses of Variance for characterization of *M. stenopetala* leave with different age for nutritional and proximate composition analysis.

Source of variation	DF	Average Mean									
		MC	AC	CF	CP	Fat	Fe	Zn	Ca	P	K
Age	4	8.98***	11.22***	35.74***	32.29***	0.38***	18.58^{ns}	1.44ns	282.03***	352.05***	1710.46***
CV		2.13	5.73	0.53	0.48	4.27	22.13	20.43	7.89	2.56	0
R^2		0.98	0.91	0.99	0.99	0.88	0.45	0.08	0.55	0.99	1

***: Significant at p = 0.001; **: Significant at p = 0.01.

vanadomolybdic acid reagent in which phosphate reacts to form a yellow molybdovanadophosphoric acid. Finally, the amount of phosphorus was determined using CECL 1021 model a UV–VIS spectrometer at 400 nm in 1 cm cells, and expressed as % Na_3PO_4 (AOAC, 2005).

Phytate determination

This was determined using the method described by Latta and Eskin (1980). A 0.5 gm of dried *Moringa stenopetala* sample leaves was extracted with 10 ml of 0.2N HCl for 1 h at an ambient temperature. 2 ml of wade reagent solution was added into 3 ml of the supernatant extraction solution; the solution was homogenized and finally centrifuged for 10 min at 3000 rpm. The clear supernatant solution was taken to measure the absorbance at 500 nm using UV-VIS spectrophotometer (CECL 1021 model mad in England). The amount of Phytic acid was calculated using Phytic acid standard curve and result was expressed as Phytic acid in mg/100 gm (Burns et al., 2001).

Tannin determination

This was determined using the method described by Burns et al. (2001).One gram of dried M. stenopetala leaf sample was extracted with 10 ml of 1% HCl in methanol using mechanical shaker for 24 h at room temperature and centrifuged for 5 min. 1 ml of the clear supernatant solution was taken and mixed with 5 ml of Vanillin HCl reagent and stood for 20 min until the reaction was completed. The absorbance of the clear supernatant solution at 500 nm was measured using UV-VIS spectrophotometer (CECL 102 model mad in England). The amount of Tannin was calculated using SPSS plot's slope; and intercept of the standard curve is as given in the mathematical equation (Latta and Eskin, 1980).

$$Tannin\ in \frac{mg}{g} = (As - Ab) - \frac{Intercept}{Slope * d * w}$$

Where: As = Sample absorbance, Ab = Blank absorbance, d = Density of solution (0.791 g/ml) and w = Weight of sample in gram.

Data analysis

The nutritional value, photochemical and anti-nutrient analysis data were subjected to one way of variance analysis (ANOVA) statistical method using Generalized Linear Models Procedure (GLM) (Gomez and Gomez, 1995). A total of five age treatments with three replications and 12 test parameters were designed in the experiment. Statistical analysis of data was carried out using SAS Version 9. Means that exhibited significant differences were compared using Least Significant Difference (LSD) at (P <0.001) level.

RESULTS AND DISCUSSION

Nutritional and anti-nutritional composition parameters

The analysis of variance showed that the effect of all nutrition and anti- nutritional composition parameters differed among the five tree ages at 1% significant level. Exception to this was for the cationic composition of iron and zinc that did not show any difference between tree ages (Table 1).

Moisture content

The overall mean moisture content for the *M. stenopetala* leaves across the age in the experiment was 8.99%.Trees at the age of four had significantly higher moisture content (10.60%), followed by trees at the age of three (9.88%). The lower moisture content of leaves was obtained at trees with the age of five (7.79%) and six (8.07%) (Table 3). In this study, the moisture contents of matured tree of 6 and 7 years *M. stenopetala* leaves were compared (Abinet et al., 2011). Almost similar values were observed. Similar to the situation, we have noted that maximum moisture content (9.88, 10.6 and 7.79%) was found in the study on tree of 3; 4 and 5 of *M. stenopetala* leaves compared to the previous results (6.43 to 6.83%) obtained by Stevens et al. (2015) on proximate and anti-nutritional composition on different accession of *Moringa oleifera* leaves across Nigeria.

The variation of moisture content in different studies was predictable as tree age variation, leaves collection period (harvesting time) and different system of cultivation managements used.

Table 2. Main effects of different age of *M. stenopetala* leaves for nutritional and proximate composition.

Source of variation	Mean square							
	MC	**AC**	**CF**	**CP**	**Fat**	**Ca**	**P**	**K**
3	9.88^{b}	10.53$^{\mathbf{bc}}$	32.84^{e}	31.53^{d}	0.36^{b}	315.19^{a}	304.61^{d}	1713.15^{c}
4	10.6$^{\mathbf{a}}$	14.33$^{\mathbf{a}}$	34.57^{d}	32.54^{b}	0.42^{a}	262.21^{b}	85.19^{e}	1874^{b}
5	7.79^{d}	11.22^{b}	35.31^{c}	34.40^{a}	0.44^{a}	263.33^{b}	467.24^{a}	1878.12^{a}
6	8.07$^{\mathbf{d}}$	10.07^{bc}	35.36^{a}	31.83c	0.35^{b}	292.94^{ab}	456.12^{b}	1420.40^{e}
7	8.59$^{\mathbf{c}}$	9.99^{bc}	37.62^{b}	31.16^{e}	0.35^{b}	276.52^{ab}	447.11^{c}	1666.67^{d}
Mean	8.99	11.23	32.29	32.29	0.38	282.04	352.05	1710.47

Ash content

The overall mean ash content for the *M. stenopetala* samples across the age in the experiment was 11.23%. Ash content of *M. stenopetala* leaves from tree of 4 years showed significantly higher ash content (14.33%) than all other tree ages (Table 2). No significant difference was observed in ash content among tree of 3, 6 and 7 years. The ash content of this study compares with those previously analyzed (3.91 to 4.74%) by Steven et al. (2015) and similarly studied by Aberra et al. (2015) in which the value ranged from 7.10 to 8.03%; it was maximum but similar to Abuye et al. (2003)'s study, which was reported to be 9.1 to 14.2%.

Crude fiber

The crude fiber content ranged from 35.36% (age = 6) to 32.84% (age = 3) with the overall mean crude fiber content of 32.29%. These crude fiber contents of *M. stenopetala* leaves were higher than the crude fiber reported by Aberra et al. (2015), ranging from 16.7, 17.2 and 18.7%.

Fat

The fat content of *M. stenopetala* leaves ranged from 0.35 to 0.44% with the overall mean fat content of 0.38%. Significantly higher fat content was observed at tree age of 5 (0.44%) and 4 (0.42%) than the other tree age (Table 2). The fat content of *M. stenopetala* leaves at *Derashe* differ from other studies reported by Morlu et al. (2017) (5.8% for *Moringa avalifolia* and 6.61% for *M. oleifera*), This variation might be attributed to the difference in latitude, longitude, annual rainfall, humidity and soil type (Dechasa et al., 1995).

Crude protein

The crude protein content of *M. stenopetala* leaves ranged from 31.16 to 34.4% with the overall mean crude protein content of 32.29%. Significantly higher crude protein content was observed at tree age of 5 (34.4%) and 4 (32.54%) than the other tree age (Table 2). Statistically lower crude protein was recorded on leaves at tree age of 3 (31.53%) and tree age of 7 (31.16%), which is 10.40% lower crude protein content than the maximum (Table 2). The amount of protein found in this study is comparable with the previous study by Morlu et al. (2017), which ranged from 23.21 to 24.75% on different accretion of *M. oleifera* across Nigeria.

Proximate composition

A significant variation between tree ages was observed for Ca, P and K but not for Iron and Zinc (Table 1). The amount of phosphorus, potassium, and calcium in the *M. stenopetala* leaves ranged from 85.19 mg/100 g to 467.24 mg/100 g; 1420.40 mg/100 g to 1878.12 mg/100 g and 263.33 mg/100 g to 315.19 mg/100 g, respectively (Table 2). Significantly higher values of cationic composition phosphorus (467.24 mg/100 g) and potassium (1878.12 mg/100 g) were recorded on leaves from tree age of 5. A higher cationic composition of calcium was recorded on leaves from tree age of 3 (315.19 mg/100 g). The observed value of the different minerals in the present study differs from another study (Morlu et al., 2017).These variations might be attributed to differences in the varieties used by these researchers. Different ecotypes and varieties of *M. stenopetala* are found in Ethiopia (Eyassu et al., 2014).

Anti-nutritional composition

The results of this study showed a significant difference in values of phytate and tannin among tree ages (Table 3). *M. stenopetala* leaves from tree age of 6 contain more tannin (403.94 mg/100 g) and phytate (725.60 mg/100 g). The lower tannin (163.89 mg/100 g) and phytate (544.32 mg/100 g) content was found in leaves from tree age of 5 (Table 4). The finding of the present study is comparable with another report by Ijarotimi et al. (2013) that reported the tannin content of 347.67 mg/100 g. The tannin content reported by Ijarotimi et al. (2013) is actually 52.86% higher than the lowest value we found

Table 3. Analyses of Variance for characterization of *M. stenopetala* leave with different age for photochemical and anti-nutrient analysis.

Source of variation	DF	Average mean	
		Taannin	Phytate
Age	4	249.53***	650.45*
Cv		6.46	9.54
R^2		0.98	0.64

Table 4. Main effects of different age of *M. stenopetala* leaves for photochemical and anti-nutrient analysis.

Source of variation	Mean square	
	Tannin (Latta and Eskin, 1980)	Phytate (Burns et al., 2001)
3	244.04^{c}	708.79^{ab}
4	171.36^{d}	676.27^{ab}
5	163.89^{e}	544.32^{c}
6	403.94^{a}	725.60^{a}
7	264.44^{b}	597.29^{bc}
Mean	249.53	650.45

from leaves of 5 years old tree. Similar anti-nutritional factors in plant foods were also reported by Habtamu and Negussie (2014). The phytate content obtained in this study was higher that of the study by Abinet et al. (2011), who reported 378.44 mg/100 g of *M. stenopetala* leave samples collected from different parts of Ethiopia. The variation might be due to the differences in geographical location and soil type between the study areas.

Conclusion

This study has clearly indicated that the nutritional, anti-nutritional and proximate composition of *M. stenopetala* leaves showed variation among the tree ages. The nutrient composition of *M. stenopetala* leaves in most cases was found higher in trees of 4 and 5 years compared to those of 3, 6 and 7, while anti-nutritional compositions, which are tannin and phytate of *M. stenopetala* leaves in most cases was found least for trees of 5 years compared to tree of 3, 4, 6 and 7 years; proximate composition has an adequate amount on trees of 3 and 5 years, respectively. Therefore, in this study the authors conclude that, trees of 5 years have better nutritional, anti-nutritional and proximate composition compared to all age categories included in this study.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Physicochemical study of kernel oils from ten varieties of *Mangifera indica* (Anacardiaceae) cultivated in Cote d'Ivoire

Amian Brise Benjamin Kassi[1*], Yaya Soro[2], Emmanuel N'dri Koffi[3] and Siaka Sorho[2]

[1]Laboratory of Organic Chemistry and Natural Substances (LCOSN), Félix Houphouet-Boigny University, Abidjan, Cote d'Ivoire.
[2]Laboratory of Industrial Processes, Synthesis, Environment and New Energies, National Polytechnic Institute Felix Houphouët-Boigny, BP 1093 Yamoussoukro, Cote d'Ivoire.
[3]Department of Sciences and Technologies, Advanced Teachers Training College of Abidjan (ENS), 08 BP 10 Abidjan 08, Cote d'Ivoire.

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Mango consumers only use pulp and consider the kernel as wastes. This study aims to valorize the kernel of mango (*Mangifera indica*). In this study, the kernel of ten mango varieties (*Ruby*, *Kent*, *Retard*, *Key*, *Assabony*, *Smith tête de chat*, *Smith normal*, *Palmer*, *Governeur* and *Aravia*) collected at Yamoussoukro in the center of Cote d'Ivoire were used. The oils of these kernels were extracted by maceration method. Their physicochemical properties were determinate using standard methods. The yields of oils extracted are higher than 10%. The acid value of these oils varies from 2.50±0.25 to 27.06±0.35 mg of KOH/g, the saponification value ranges between 164.17±1.30 and 199.21±0.32 mg of KOH/g, iodine value varies from 36.38±0.96 to 54.46±0.54 g of iodine per 100 g of fat and the refractive index ranges between 1.458±0.001 and 1.480±0.002. The water and volatile matter content are varying between 1.08±0.19 and 12.30±0.46%. The study of the lipid composition of these fats showed a significant presence of fatty acid and unsaponifiables. The major fatty acids are palmitic acid (6.77-12.80%), stearic acid (36.36-45.76%), oleic acid (43.20-52.42%) and arachidic acid (0.85-1.65%). The major unsaponifiables are ergosterol (1.94%), sitosterol (78.65%), stigmasterol (10.67%), campesterol (5.33%) and 3-hydroxy-pregn-5-en-20-one (3.39%). The results of the study indicated that mango kernel oils could be used in cosmetics and also in human nutrition for prevention against arteriosclerosis and cardiovascular diseases.

Key words: *Mangifera indica*, Anacardiaceae, fatty acids.

INTRODUCTION

Mangifera indica, commonly known as mango is a plant in the family Anacardiaceae. It is cultivated for the sweet flavor of its fruit. The latter is an important alternative in agro-industry because of its physico-chemical composition and nutritional properties (Julio and Marie, 2005). In food processing industry after the extraction of

*Corresponding author. E-mail: amiankassi@yahoo.fr.

mango pulp and kernel butter, a considerable quantity of kernel seed cake is discarded as waste (Ahmed et al., 2007a).

Mango seeds are used traditionally against gastric pathogens, especially in children treatment, or in anti-diarrhoeal cure (Sairam et al., 2003). Mango parts, such as stem bark, leaves, and pulp are known for various biomedical applications, including antioxidative and free radical scavenging (Gabino et al., 2008), and anticancer activities (Susan et al., 2006). Several studies carried out on the various organs (leaves, roots, barks, flowers and fruits) of *M. indica* have shown their wealth in secondary metabolites (Yango et al., 2004).

Studies on the kernel of *M. indica* fruit have shown the presence of fats (Ahmed et al., 2007b) and polyphenolic compounds (Riberio and Barbosa, 2008). Other studies have shown that the mango kernel has several biological activities such as anti-diarrhea (Sairam et al., 2003), antibacterial (Thoshihide et al., 2000) and antioxidant (Ahmed et al., 2007b).

Mango is one of the most popular tropical fruits. According to FAO data (FAO, 2002), the mango occupies sixth place in world fruit production, after orange, banana, grapes, apples and plantains. In Cote d'Ivoire, the annual production of mango is about 100,000 t (Sangare et al., 2009). The kernel of mango, after extraction of the pulp, is generally abandoned in nature. Thus, this agricultural waste constitute environnemental problems; however to our knowledge, very few studies have been done about the almonds of mango species from Cote d'Ivoire. This is what justifies the choice of the study of mango kernel to better value.

A previous study (Amian et al., 2014) on the seed kernel mango showed the presence of tannins and gallic acids. In this new study, it is about to extract and characterize the almond fat from the core of 10 varieties of mango.

MATERIAL AND METHODS

Plant material

The plant material consists of kernels of 10 varieties of mango namely: *Ruby*, *Kent*, *Retard*, *Key*, *Assabony*, *Smith tête de chat*, *Smith normal*, *Palmer*, *Governeur* and *Aravia*. The most famous varieties in Cote d'Ivoire are *Kent*, *Key*, *Palmer*, *Ruby* and *Smith*. The fruits used for the study are those that have a natural ripening. The ripe fruits of these mangoes were harvested from an orchard in Yamoussoukro in central Cote d'Ivoire. The names of the species are those given by the owner of the orchard and confirmed by the vendors on the market. The fruits were then sent to the laboratory LAPISEN of INP-HB Yamoussoukro. After consumption of the pulp, the mango kernel are freed of their envelopes, and then dried for 5 days in the sun and 48 h in an oven (at 50°C). Dry almonds are crushed and stored in a refrigerator at 4°C for previous studies.

Extraction of fats

A mass of powder (1 kg) of the plant material is introduced into a flask, and then macerated with an amount of distilled hexane (1 L) with stirring for 1 h. Hexane is the solvent used for the extraction of vegetable oils (Frederic et al., 2013). The extract obtained is filtered on cotton and then on filter paper. The same operation is repeated twice on the same residue. The various filtrates are combined and concentrated on a rotary evaporator at 40°C. The crude residue obtained constitutes the fats.

Chemical characterization of the fats

Physicochemical characteristics of the fats

The physicochemical characteristics of the fats of mango kernel were determined according to the methods defined by the AFNOR standards (AFNOR, 1984):

1. Acid value (ISO 660)
2. Iodine value (ISO 3961)
3. Peroxide value (ISO 3960)
4. Refractive index (ISO 6320)
5. Saponification value (ISO 3657)
6. Moisture and volatile matter content (ISO 662)
7. Density or specific gravity (ISO 6883)
8. Unsaponifiables (ISO 3596)

Statistical analysis

Results were expressed as mean±standard deviation of three replicates. Data were evaluated by one-way analysis of variance (ANOVA) using statistica 7.1 (Stat Soft, Inc, USA) solfware. Newman-keuls test performed to determine significant.

Gas chromatography coupled to mass spectrometry (GC / MS)

The chromatographic analyzes were carried out according to the methods defined by the International Organization of Standardization: (ISO 12966-1,2). Before GC / MS analysis, the fatty acids are converted into methyl esters. GC / MS analyzes were performed with a Trace GC Thermo Finnigan gas chromatograph coupled to a Thermo Finnigan AUTOMASS mass spectrometer. The GC chromatograph is equipped with a split/splitless injector. The capillary column of BP-X5 type (5% phenyl and 95% methylpolysiloxane) is 30 m long, and has an inside diameter of 0.25 mm and a film thickness of 0.25 µm. The carrier gas is helium with a flow rate of 1 $mL.min^{-1}$. The injector and detector temperatures were set at 280 and 290°C, respectively.

The operating conditions of the electronic impact mass spectrometer are; ionization source temperature 200°C and electron energy 70 eV. The identification of the compounds was possible by comparing the spectral data obtained from the NIST libraries.

RESULTS AND DISCUSSION

Extraction of fats

The extraction yields and aspects of the 10 varieties of mangoes studied are shown in Table 1. The result of Table 1 shows that the oil yields of mango kernel ranges from 7.04±0.66 to 10.61±0.36. These yields are low compared to those of oleaginous seeds (OCDE/FAO, 2015). Knowing that maceration does not make it

Table 1. Extraction yields and aspects of the oil of different varieties of mangoes.

Variety of mango	Yield (%)	Aspects of oil at 25°C
Rubis	10.16±0.21$^{e.g}$	Butter
Kent	7.04±0.66^{a}	Oil
Retard	7.84±0.10$^{a.b.c}$	Butter
Key	8.70±0.57$^{c.d}$	Butter
Assabonie	9.88±0.29$^{e.g}$	Butter
Smith tète de chat	9.19±0.97$^{d.e}$	Butter
Smith normal	9.22±0.26$^{d.e}$	Butter
Palmer	10.61±0.36^{g}	Butter
Gouverneur	7.50±0.45$^{a.b}$	Butter
Aravia	8.40±0.18$^{b.c.d}$	Butter

In each column the averages not followed by the same lowercase letter are statistically different at a threshold of 5% (P <0.05).

Table 2. Chemical characteristics of butters and oils of ten varieties of almond mangoes.

Variety of mango	Acid value (mg de KOH/g)	Iode value (g d'iode/100 g)	Peroxyde value (méq d'O_2/kg)	Saponification value (mg de KOH/g)	Moisture and volatile contents (%)	Unsaponifiable content (%)
Rubis	5.41±0.27^{c}	46.40±0.21^{c}	1.40±0.05^{a}	199.21±0.32^{e}	1.08±0.19^{a}	1.90±0.09^{b}
Kent	27.06±0.35^{e}	54.46±0.54^{d}	4.28±0.36^{b}	190.29±1.48^{d}	12.30±0.46^{g}	0.94±0.09^{a}
Retard	5.41±0.61^{c}	46.86±0.80^{c}	1.38±0.13^{a}	187.56±1.49$^{c.d}$	6.84±0.44^{e}	2.83±0.62^{d}
Key	7.09±0.77^{c}	45.34±0.01$^{b.c}$	2.23±0.31^{a}	ND	6.52±0.12^{e}	1.90±0.08^{b}
Assabonie	10.00±0.46^{d}	42.18±0.20$^{a.b.c}$	5.71±0.55^{c}	164.17±1.30^{a}	3.22±0.49^{d}	1.00±0.22^{a}
Smith tète de chat	10.00±0.36^{d}	36.38±0.96^{a}	20.71±0.75^{g}	ND	7.00±0.34$^{e.f}$	2.00±0.32^{b}
Smith normal	10.00±0.13^{d}	37.87±0.82$^{a.b}$	30.71±0.31^{h}	170.96±1.45^{b}	1.64±0.17^{b}	1.10±0.11^{a}
Palmer	3.33±0.52^{b}	37.88±0.73$^{a.b}$	17.50±0.86^{f}	182.85±1.67^{c}	7.50±0.14^{f}	2.00±0.10^{b}
Gouverneur	2.50±0.25^{a}	42.63±0.62$^{a.b.c}$	12.43±0.81^{e}	172.73±1.95^{b}	1.95±0.13^{c}	2.74±0.77^{c}
Aravia	5.83±0.61^{c}	42.18±0.28$^{a.b.c}$	7.14±0.13^{d}	172.45±1.34^{b}	6.32±0.24^{e}	1.20±0.07$^{a.b}$

In each column the averages not followed by the same lowercase letter are statistically different at a threshold of 5% (P <0.05).
ND: not determined.

possible to extract all of the fats, these yields could be improved by other techniques such as soxhlet and the press. The fat extracted from these mango kernels is solid at room temperature with the exception of that of the *Kent* species which is liquid. The results showed that certain almonds of mango contain more oil than other. The oil yields of *Palmer* and *Rubis* species are higher while *Gouverneur* and *Kent* species are weaker.

Physico-chemical characteristics

The physicochemical characteristics (at room temperature) of the almond oils of ten (10) varieties of mango are shown in Tables 2 and 3.

Acid value

The acid value presents the free fatty acid content of the fats. These values are equivalent to an acidity rate expressed as a percentage. The acid value of the oils of mango kernels are between 2.50±0.25 and 10.00±0.13, except of the *Kent* species oil which has an acid value of 27.06±0.35. These acid value are less than or equal to that of virgin palm oil (10 mg KOH / g oil) except for *Kent* species. The acid value of *Kent* species is similar to that of seeds of *Duranta repens* (Emmanuel et al., 2017). At the exception of *Gouverneur* species (2.50±0.25 mg KOH / g oil) and *Palmer* species (3.33±052 mg KOH / g oil), the various acid value remain higher than those allowed for edible virgin oils (≤ 4 mg KOH / g oil) (AFNOR, 1981). These undesirable fatty acids could be removed by refining these butters and oils.

Peroxide value

The peroxide value is a very useful parameter for appreciating the first stages of oxidative deterioration.

Table 3. Physical characteristics of butters and oils of ten varieties of almond mangoes.

Variety of mango	Density index (28°C)	Réfraction index
Rubis	0.85±0.01[c]	1.463±0.001[b]
Kent	0.87±0.00[c]	1.480±0.002[c]
Retard	0.88±0.01[c]	1.461±0.001[a,b]
Key	0.87±0.01[c]	1.458±0.000[a]
Assabonie	0.95±0.00[d]	1.461±0.001[a,b]
Smith tète de chat	0.81±0.00[b]	1.458±0.001[a]
Smith normal	0.77±0.02[a]	1.460±0.003[a,b]
Palmer	0.85±0.03[c]	1.460±0.001[a,b]
Gouverneur	0.81±0.01[b]	1.459±0.001[a]
Aravia	0.81±0.01[b]	1.458±0.002[a]

In each column the averages not followed by the same lowercase letter are statistically different at a threshold of 5% (P <0.05).

The peroxide value of the oils of mango kernels are between 1.38±0.13 and 30.71±0.31. The peroxide value of kernel mango oils and butters are lower than the allowed value for crude vegetable oils (≤15 mqq / kg oil) (FAO/OMS, 1999) except for *Smith normal* species (30.71±0.31), *Smith tète de chat* species (20.71±0.75) and *Palmer* species (17.50±0.86). These high values could be due to the oxidation of the unsaturated free fatty acids present in these oils and butters. However, to avoid this oxidation, antioxidants such as ButylHydroxyAnisol (BHA) or ButylHydroxytoluene (BHT) could be added to these fats.

Density

The density of the oils depends on its chemical composition. The densities of the oils of mango kernels are between 0.77±0.02 and 0.95±0.00. These values are comparable to those of butter and vegetable oils (FAO/OMS, 1999) such as shea butter (0.9), cocoa butter (0.88-0.90), palm oil (0.89- 0.90) and cotton oil (0.91-0.92).

Refractive index

The refractive index depends also on the chemical composition of the oil and the temperature. This index grows with the unsaturation or with the presence on the fatty chains of secondary functions. The refractive index values of oils and butters mango are between 1.458±0.001 and 1.480±0.002. This values are comparable to butter and vegetable oils (FAO/OMS, 1999) such as cocoa butter (1.455 to 1.458), palm oil (1.454 to 1.456), cotton seed oil (1.458 to 1.466) and shea butter (1.463 to 1.468). The refractive index of the oil of the *Kent* species (1.480±0.002) is higher. This species reflects a degree of insatuation higher than other varieties.

Iodine value

The iodine value is a chemical parameter that presents the degree of unsaturation of a fat. The iodine value of butters and oils of mango kernel are between 36.38±0.96 and 54.46±0.54. The oils and butters of mango kernels generally have a lower iodine value than shea butter (57-66) and cotton seed oil (100-105). The oil of the *Kent* species (54.46±0.54) has a value comparable to palm oil (50-55), while the other varieties have an iodine value comparable to cocoa butter (33-42) (FAO/OMS, 1999). These iodine value of butters and oils of mango are consistent with its (liquid) appearance.

Moisture and volatile matter

The moisture and volatile contents of butters and oils of mango kernels is between 1.08±0.19 and 12.30±0.46%. The values of *Rubis* species (1.08±0.19%) and *Gouverneur* species (1.95±0.13%) is comparable of shea butter (0.10-1.24%), cotton oil (0.80-1.50%) and palm oil (0.05-2%). However, the values of others species are higher than the maximum level recommended by the regulations for vegetable oils and butters (0.2%) (FAO/OMS, 1999). The high presence of water and volatile matter could promote enzymatic activity. This suggests that our butters and oil are more likely to suffer the hydrolytic or enzymatic alteration that leads to the formation of secondary products such as monoglycerides and diglycerides. These high values could also reflect the hygroscopic nature of these butters and oil in the presence of moisture in the air.

Saponification value

This index presents the richness of the oil in long chain fatty acids for a given mass of triglycerides. The different

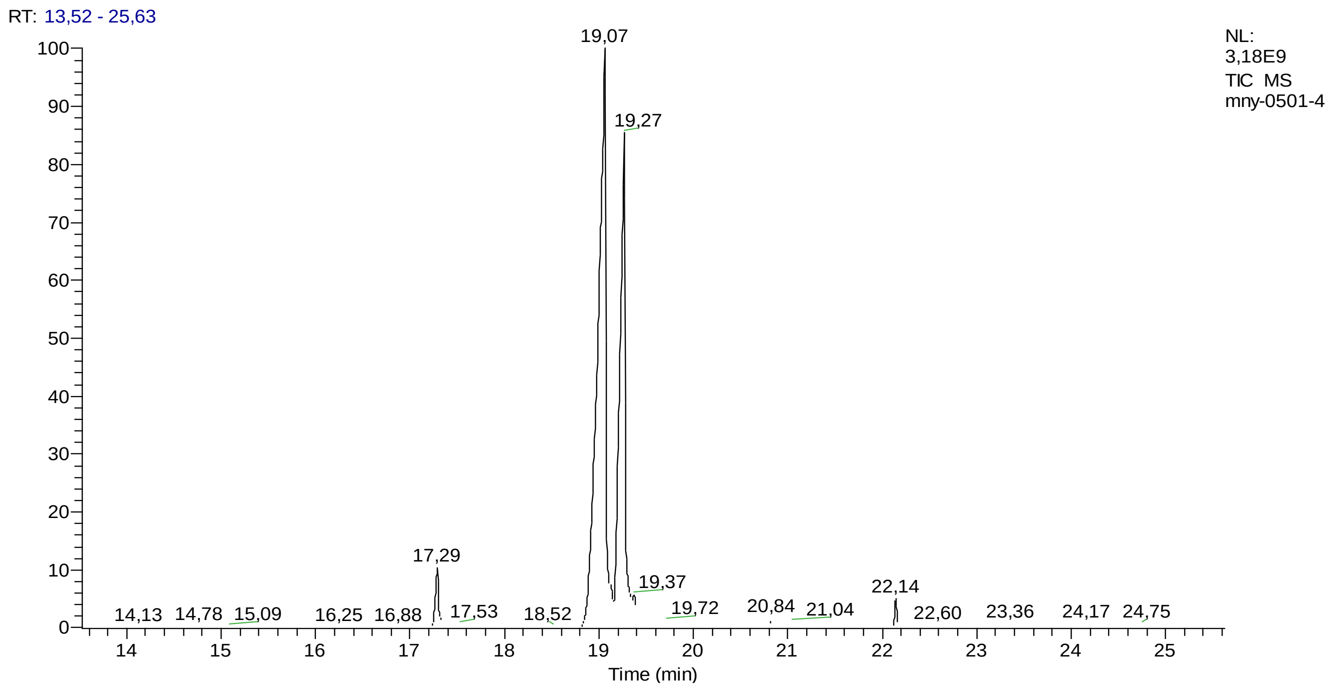


Figure 1. GC Chromatogram of Fatty Acids of *Mangifera Indica* almond.

Table 4. Major fatty acid composition of butters and mango almond oils.

Rt	Mass	Compound	Yield (%)
17.29	m/z 256.25	Palmitic acid (C16:0)	(6.77-12.80%)
19.07	m/z 282.27	Oleic acid (C18:1)	(46.60-58.24%)
19.27	m/z 284.28	Stearic acid (C18:0)	(31.06-45.76%)
20.84	m/z 312.32	Arachidic acid (C20:0)	(0.85-1.65%)

values of the saponification index obtained for butters and oils of mango kernels are between 164.17±1.30 and 199.21±0.32 mg of KOH / g of oil. These values are comparable to those of vegetable oils and butters (FAO/OMS, 1999) used in soapmaking such as shea butter (178-193), cocoa butter (188-200), peanut oil (187-196), cotton seed oil (189-198) and colza seed oil (168-181).

Unsaponifiable content

Unsaponifiables generally consist of several families of compounds such as paraffins, tocopherols, sterols, carotenoid pigments and fat-soluble vitamins. The results show that the various butters and oils of mango kernels contain 0.94±0.09 to 2.83±0.62% of unsaponifiables. Except *Kent* species (0.94±0.09), these values are higher than those of vegetable oils in general (≤ 1%) (FAO/OMS, 1999).

Composition in fatty acids

The analysis of the fatty acids is carried out using a gas chromatograph coupled to the mass (GC / MS). The molecules were identified on the basis of mass spectral analysis compared with the National Institute of Standards and Technology (NIST) mass spectral library (version 2.0 dated April 26, 2005).

Analysis of the chromatogram of Figure 1 coupled to the mass as shown in Table 4 shows that the butters and oils of the almonds mango are predominantly rich in oleic acid (45.82-58.24%) and stearic acid (31.06-45.76%). They are also composed of palmitic acid (6.77-12.80%) and arachidic acid (0.85-1.65%). The analysis of the different varieties as indicated in Table 4 shows that the fatty acid contents differ from one variety to another. The oils and butter of mango almonds have fatty acids comparable to butters and oils from oilseeds (Odile and Xavier, 2012; Davrieux et al., 2010) known for their various biological properties.

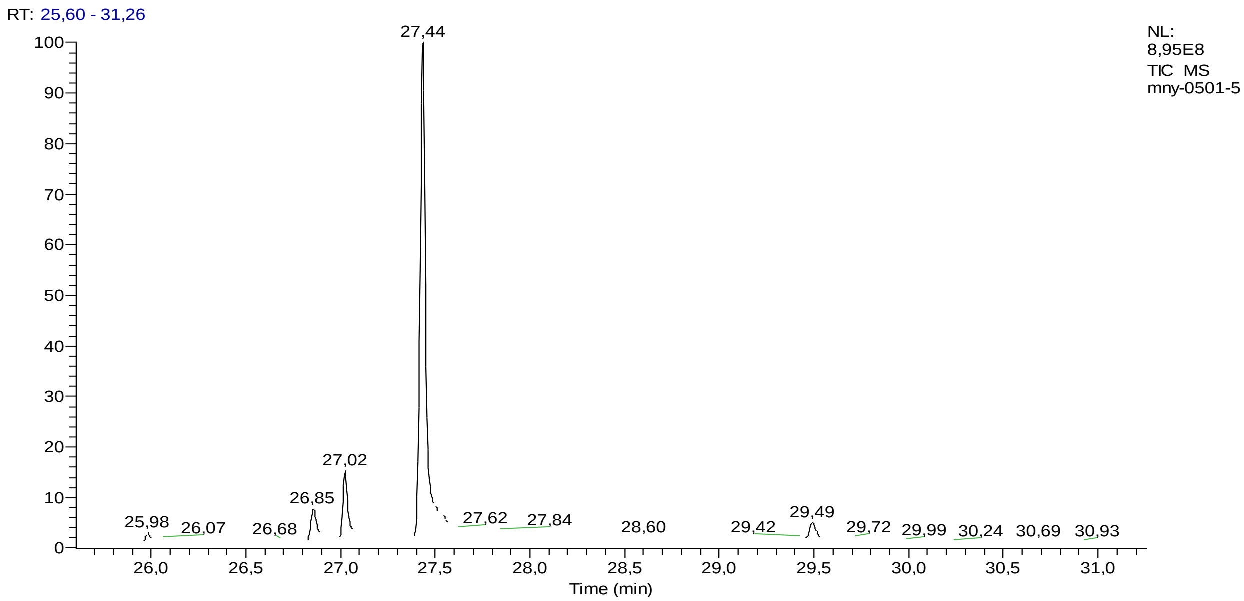


Figure 2. GC Chromatogram of unsaponifiables of butters and oils of mango kernels.

Table 5. Fatty acid content of butters and almond oils of eight varieties of mangoes compared to that of shea butter and cacoa.

Fatty acid	Kernels mango oils (GC MS analysis)								Reference (Odile and Xavier, 2012)	
	Assabonie	Ruby	Key	Retard	Kent	Smith cat head	Smith normal	Governor	Shea	Cacao
Palmitic acid (C16: 0)	6.77	12.80	10.56	8.33	9.7	8.33	9.09	8.84	3-5	24-30
Stearic acid (C18: 0)	45.76	38.20	39.83	41.66	31.06	45.00	36.36	37.16	28-45	30-37
Oleic acid (C18: 1)	46.60	48.00	47.96	4916	58.24	45.82	53.63	53.08	42-59	33-39
Linoleicacid (C18: 2)	0	0	0	0	0	0	0	0	3-9	2-5
Arachidic acid (C20: 0)	0.87	1.00	1.65	0.85	1.00	0.85	0.90	0.92	0	0
Saturated fatty acids	53.40	52.00	52.04	50.84	41.76	54.18	46.37	46.92	35	61
Unsaturated fatty acids	46.60	48.00	47.96	49.16	58.24	45.82	53.63	53.08	60	35

They have an oleic acid content (45.82-58.24%) comparable to shea butter (42-59%) and superior to cocoa butter (33-39%).They have a stearic acid content (31.06-45.76%), close to those of shea butter (28-45%) and cocoa (30-37%).

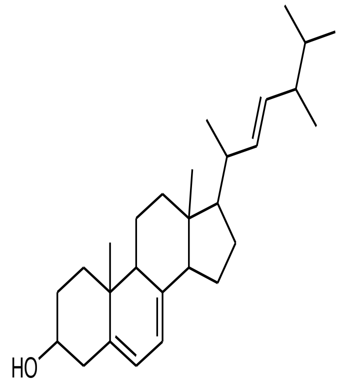
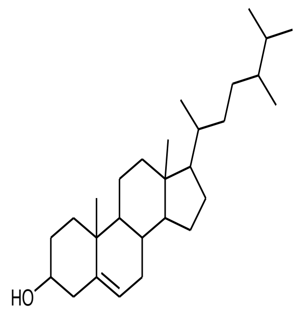
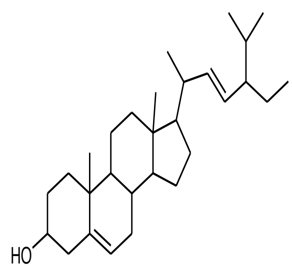
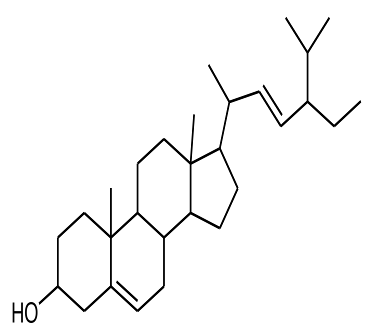
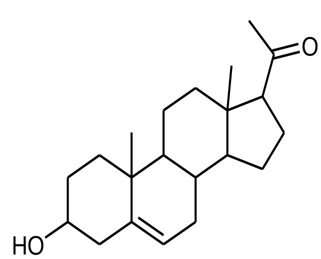
They are generally richer in palmitic acid (6.77-12.80%) than Shea butters (3-5%) but poorer than cocoa butter (24-30%). The *Kent* species has the highest unsaturated fatty acid content (58.24%), which explains its liquid appearance at room temperature (Table 5).

Chemical composition of unsaponifiables

Unsaponifiables are analyzed by Gas Chromatography coupled to GC/MS Mass Spectrometry. Figure 2 shows the GC chromatogram of the unsaponifiable fraction. Molecule structures were also identified based on mass spectral analysis compared with the National Institute of Standards and Technology (NIST) mass spectral library (version 2.0 dated April 26, 2005). Spectral analysis as shown in Table 6 reveals that the unsaponifiables of mango kernel oil consist of sterols, the majority of which are: Ergosterol (A: 1.94%), campesterol (B: 5.33%), stigmasterol (C: 10.67%), sitosterol (D: 78.65%) and 3-hydroxy-pregn-5-en-20-one (E: 3.39%). In the unsaponifiable, the sitosterol is the compound higher while the ergosterol is the compound weaker. The sitosterol is being studied for its potential to reduce benign prostatic hyperplasia (Kim et al., 2012) and blood cholesterol levels (Rudkowska et al., 2008).

The unsaponifiable constituents of the oil of mango kernels are comparable to those of cotton seed oil (campesterol 6.4-14.5%, stigmasterol 2.1-6.8%, sitosterol 76.00-87.1%) and palm kernel oil (campesterol 8.4-12.7%, stigmasterol 12.0-16.6%, sitosterol 62.6-73.1%)

Table 6. Composition of major unsaponifiables of butters and oils of mango kernels.

Rt	Mass	Compound	Strucure	Yield (%)
25.98	m/z 396.39	Ergostérol		(1.94%)
26.85	m/z 400.39	Campestérol		(5.33%)
27.02	m/z 412.43	Stigmastérol		(10.67%)
27.44	m/z 414.40	Sitostérol		(78.65%)
29.49	m/z 316.66	3-hydroxy pregn-5-en-20-one		(3.39%)

(FAO/OMS,1999).

Conclusion

We undertook the study of the almonds of 10 varieties of *M. indica* (Anacardiaceae) in order to contribute to its valuation. The study of the mango kernel has revealed the presence of about 10% fat whose physicochemical characteristics show some similarities with shea butter, cocoa, cotton oils and palm. The study of its lipid composition revealed a significant presence of oleic and stearic fatty acids, hence its potential use in dietetics and pharmacology. The butters and oils of the almonds of mango kernels can also be used in soapmaking, given their high saponification indices. The properties of oil extracted revealed that the seed of mangoes is a good source of oil which could be employed for industrial purposes

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Evaluation of the consumption and nutritional quality of *Basella alba* L. in Brazzaville

Okouango Y. S. Itoua[1,2,3*], Mananga Vital[1, 2,3], Elenga Michel[1, 2,3] and Hisseine Abdoulaye[2,3]

[1]Multi-field Team of Research in Feeding and Nutrition (Eprancongo), Congo.
[2]Laboratory of Human Nutrition and Feeding (LaNAH), Congo.
[3]Faculty of Science and Technology, University Marien, NGOUABI, Congo.

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Leafy vegetables are generally neglected by consumers because of their rural lifestyle and low social status. As a result, they are often considered a "food of the poor. The general objective of our study is to carry out a nutritional and nutritional characterization of the vegetable *Basella alba* L. A cross-sectional survey of the consumption of *B. alba* L. leaves was carried out in the 9 districts of Brazzaville and concerned 150 households, as well as physicochemical analyzes carried out in the laboratory. The results show that the average age of respondents is 41.18 ± 15.36 years. The female sex is more represented with 83.3%. Many consumers are single (38.7%). Respondents are sourcing from the market (99.3%) per purchase (98.0%). The leaves of *B. alba* L are eaten cooked 99.3%. Its frequency of consumption is 1 time in the week 46%. 71.3% of those surveyed consume them all seasons. Laboratory results give the following morphological characteristics and nutritive values: leaf length 10.75 ± 2.10 cm, leaf width 9.5 ± 2.54 cm, petiole length 4 ± 0.70 cm, leaf water (89.03 g/100 g of fresh material); protein content (11.15 g / 100 g of dry matter); carbohydrate content 68.98 g/100 g of dry matter. The ashes have a content of 15.05 g/100 g of dry matter. Energy 363.9 kcal (or 1521.102 kJ). The leaves of *B. alba* L. have a good nutritional value, take into account the content of proteins and minerals and can contribute to the improvement of the nutritional state of the populations.

Key words: Leaf vegetable, consumer survey, nutritional value, Brazzaville.

INTRODUCTION

In developing countries, leafy vegetables play an important role in the diversification of people's diets. Of the 45,000 plant species present in sub-Saharan Africa, about 1,000 may be consumed as leafy vegetables (CTA, 2004; Ogoye and Aagaard-Hansen, 2003). These leafy vegetables are rich in micronutrients and some macronutrients (Grubben and Danton, 2004; Berger, 2003; Batawila et al., 2007). As a result, they contribute to improving the nutritional status of populations in both rural and urban areas. In addition to their nutrient richness, traditional leafy vegetables are available, adapted to the agro-ecological conditions and low production cost (Abukutsa-Onyango, 2004). In Congo Brazzaville, most people depend on non-timber forest products for food and health care. In addition, through various informal channels, these products offer

*Corresponding author. E-mail: yvonvasther@gmail.com. Tel: 00 (242) 06-686-74-37.

Figure 1. *B. alba*'s foot L.

employment opportunities and generate income for the many actors involved in their exploitation and marketing (Gockwiski, 2003).

Despite their importance, leafy vegetables are generally neglected by consumers because of their rural lifestyle and may be it is due to the lack of knowledge. As a result, they are often considered a "food for the poor" (Itoua Okouango et al., 2015). Alongside all these leafy vegetables, there remains a wild vegetable called *Basella alba* L., poorly known and consumed by the population of Brazzaville. Indeed, this plant is present in the Congolese savannas resembling a vegetable much more consumed by the Congolese population, commonly called wild spinach (*Spinacia oleracea*). It should be noted that in Congo-Brazzaville, no study has been carried out on this vegetable, especially as regards its nutritional virtues and its consumption. The objective of this study is to determine the nutritional and nutritional value of the vegetable *B. alba* L. in the dietary habits of the population of Brazzaville.

METHODOLOGY

Field of study

The study was conducted among the inhabitants of Brazzaville in nine districts. Brazzaville is located on the right bank of the majestic Congo River, the second largest river in the world after the Amazon by the power of its flow (40000 m^3 / s). The agglomeration of Brazzaville covers an area of nearly 100 km^2 with a population estimated at 2,000,000 million inhabitants. It is bounded to the North by the district of Ignié, Department of Pool; South and East by the Congo River and the DRC; to the West by the district of Goma Tsétsé, Department of Pool. Brazzaville is one of the few African capitals that brings together several nationalities. It is a transit city because of its natural and exceptional geographical location which places it at the heart of the main communication routes within Central Africa. It is nicknamed "Brazza-la-verte", because of the omnipresence of the greenery.

Equipment

Target population

This survey was conducted in 150 households consuming leaves of *B. alba* L. Evaluation of the consumption and nutritional quality of *B. alba* L. in Brazzaville. *B. alba* L. leaves purchased at the Total market, located in the Bacongo district and transported to the laboratory for physicochemical analyses (Figure 1).

Teaching materials

The didactic material consisted of a survey sheet, consisting of open questions and closed questions that are asked of the respondent and whose answers are noted or checked on the form by the interviewer. The main points of this sheet were: knowledge of the vegetable, utility of the plant, methods of preparation taking into account its organoleptic characteristics and frequency of consumption.

Household survey

The fieldwork was characterized by a food consumption survey of leaves of *B. alba* L. called in vernacular (Lari) Moudjiri. The survey was conducted in Brazzaville from 17 July to 06 August 2018 among 150 households. The survey was conducted in households in nine districts of Brazzaville. The survey consists of meeting the respondent at home. In each household, only one consumer was interviewed, designated by the person who usually takes care of the meals. The respondent is submitted to the questionnaires following the chronology of the survey sheet and the answers are noted by the interviewer. The dialogue took place in the official language (French) or in the national language (Lingala and Kituba) according to the language mastered by the respondent.

Type of investigation

We used a cross-sectional survey; chosen because it was carried out on part of the population for a period of 21 days.

Inclusion criteria

The persons subject to the survey must meet the following criteria:

1. Being a consumer of *B. alba* L. (Moudjiri)
2. Reside in Brazzaville at the time of the survey
3. Agree to answer the questionnaires posed by the investigator.

Sample frame

The source population of the survey is households which were considered as statistical unit, defined as all related or unmarried persons, usually sharing the same meals, living under the authority of the same individual called the head of household and living in the same house. The choice of the household as a statistical unit made it possible to collect the desired information (information on households).

Place of identification

The plant material after purchase, was sent to the Botanical Laboratory of the Center of Study on Plant Resources (CERVE) of the General Delegation of Scientific and Technical Research in Brazzaville for the confirmation of the name of the species and of its morphological characteristics.

Chemical analyses

The chemical analyses in of sample focused on the content of moisture, dry matter, lipid, protein and ash.

Preparation of the sample for the chemical analysis

The leaves of *B. alba* L. were weighed then dried with the drying oven at the temperature of 70°C until stabilization of the mass. With the resulting one from this drying, the sheets were crushed. The powder obtained was used in this form for the chemical analysis.

Determination of the water content

The water content was determined by a drying of the leaves of *B. alba* L. to the drying oven of mark thermosi *SR3000.* A mass Mf of fresh sheets was weighed and placed at the drying oven at the temperature of 70°C. Drying was stopped after obtaining constant mass Ms and the difference in weight gives the water content reported to 100 g of fresh matter.

Determination of the content of lipids

The content of lipids of the sample was determined by extraction according to the method with the soxhlet by using cyclohexane like solvent of extraction according to the protocol hereafter: 50 g of the powder resulting from the crushing of the leaves of *Basella alba* L. was placed in a cartridge, which in its turn is placed in the soxhlet. In an empty balloon of 250 ml weighed beforehand (M0), one pours 150 ml solvent. The balloon is heated for 4 h, and then cooled. The solvent is evaporated by rotovapor. After evaporation, the balloon containing of lipids is weighed (M1). The difference in mass between the balloon containing of lipids and the empty balloon gives the mass of lipids reported at 100 g of vegetable matter.

Determination of the content of proteins

The total nitrogen content was determined by the method of kjeldahl (AOAC, 1990) which consists of the mineralization of the organic matter by the concentrated sulphuric acid, in the presence of a catalyst. The contents of proteins were determined by the method of Kjeldahl by using a coefficient of conversion of nitrogen in protein of 6.25.

Determination of the content of carbohydrates

The carbohydrates were extracted by their solubility in ethanol after delipidation of the broyat of the sheets of *B. alba* L. (AOAC, 1990).

Determination of the content total rock salt (ashes)

The contents of total rock salt were determined by incineration with the muffle furnace at a temperature of 550°C for 8 h. Once the 8 h passed, the furnace was extinct and the ashes obtained was allowed to cool until the ambient temperature. Ashes were left in the furnace, and then weighed with a balance of precision (AOAC, 1990).

Determination of the energy value

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

Statistical analysis

The counting was done with the creation of a database in the software Epi-info 6. The student test or comparison was used. It makes it possible to decide whether the difference observed between the two movements is attributable to a systematic cause or if it can be considered as the effect of a fluctuation due to chance.

RESULTS AND DISCUSSION

Sociodemographic characteristics of consumers of *B. alba* L.

The age, sex, and educational level of consumers of *B.*

Table 1. Age, sex and education of *B. alba* L. consumers.

Parameter	Variable	Effective	Percentage	Statistical test
Age of consumers	20-24	25	16.7	χ^2=20.939 ddl=149 p<0.001
	25-29	18	12.0	
	30-34	12	8.0	
	35-39	15	10.0	
	40-44	20	13.3	
	45-49	8	5.3	
	50-54	22	14.0	
	55-59	12	8.0	
	60-64	9	6.0	
	≥65	9	6.0	
	Mean = 41.18 ± 15.36 years			
Consumer sex	Male	25	16.7	χ^2=60.048 ddl=149 p<0.001
	Female	125	83.3	
Level of education of consumers	Primary	16	10.7	χ^2=35.146 ddl=149 p<0.001
	Middle School	52	34.7	
	High school	58	38.7	
	Superior	22	14.6	
	Never schooled	2	1.3	

alba L. leaves are shown in Table 1. This result shows that of the 150 households surveyed, the age ranges from 20 to 65 years and over. It appears that 16.7% have an age between 20-24 years and 14.0% are in the age group of 50-54 years. A prevalence of 13.3% was recorded for people aged 40-44 years and 12.0% for those between 25-29 years old. Other age groups are poorly represented with an average age of 41.18 ± 15.36 years. Regarding the sex of the respondents, there are more women (83.3%) than men (16.7%). Regarding the level of education, it appears that the level of education of the school was more represented with a proportion of 38.7%.

Professional activity, household composition and marital status of consumers of *B. alba* L.

The result of the professional activity, the household composition and marital status of the consumers of *B. alba* L. are shown in Table 2. Almost half of the surveyed consumers (43.3%) are informal and 38.1% are shopkeepers. Civil servants and respondents in the private sector are poorly represented, with 9.3% each.

With regard to household composition, these results show that households with 5 persons are the most represented with an occurrence of 35.3%. The proportions of households with more than 6 persons and three persons are respectively 28.0 and 22.0%. Other households are poorly represented. Consumers of *B. alba* L. live in households averaging 5.64 ± 3.28 members. As for marital status, 38.7% of consumers are single. The prevalence of 26.0% is observed for common-law unions. It is 18% for married couples. The rates of widowed and divorced are the least compared to the other categories surveyed. They represent respectively 8.0 and 9.3% of the surveyed population.

Knowledge, consumption form and organoleptic characteristics of *B. alba* L. leaves

Table 3 presents the knowledge, consumption form, and organoleptic characteristics of the leaves of *B. alba* L. where 100.0% of those surveyed know and consume *B. alba* L. whose leaves are consumed in cooked form (99.3%). A high prevalence is observed of raw consumption of the leaves of *B. alba* L. This prevalence is 0.7% of the surveyed population. The statistical analysis results reveal a "form of consumption" effect of the highly-sensitive leaves according to the Qui2 test. Regarding the organoleptic characteristics of the leaves of *B. alba* L. these results show that the rate of 48.7% of respondents stated that the leaves of *B. alba* L. are tasteless. The sweet taste of these leaves is noted at an occurrence of 45.3% of the surveyed population. Bitter and acidic tastes are poorly represented with a prevalence of 4.7 and 1.3%, respectively.

Table 2. Professional activity, household composition and marital status of consumers of *B. alba* L.

Parameter	Variable	Effective	Percentage	Statistical test
Professional activity of consumers	Official	14	9.3	χ^2=41.369 ddl=149 p<0.001
	Private sector	14	9.3	
	Informal	65	43.3	
	Merchant	57	38.1	
Household composition	1 person	10	6.7	χ2=32.937 ddl=149 p<0.001
	2 persons	10	6.7	
	3 people	33	22.0	
	5 people	53	35.3	
	6 persons	2	1.3	
	> 6personnes	42	28.0	
	Mean ± standard deviation: 5.64 ± 3.28			
Marital status	Single	58	38.7	χ^2=21.173 ddl=149 p<0.001
	Married	27	18.0	
	Divorced	14	9.3	
	free Union	39	26.0	
	Widower (Ve)	12	8.0	

Table 3. Knowledge, form of consumption and organoleptic qualities of *B. alba* L.

Parameter	Variable	Effective	Percentage	Statistical test
Knowledge of *B. alba* L.	Yes	150	100.0	
Consumption of *B. alba* L.	Yes	150	100.0	
The form of consumption	Cooked	149	99.3	χ^2=76.000 ddl=149 p < 0.001
	Flood	1	0.7	
The tastes of these leaves	Sugar	68	45.3	χ^2=21.194 ddl=149 p<0.001
	Bitter	7	4.7	
	Acid	2	1.3	
	Tasteless	73	48.7	

Form of use of leaves of *B. alba* L.

The Table 4 specifies the different forms of use of *B. alba* L. The leaves of *B. alba* L are used as seasoning or as a vegetable. Most respondents (96.0%) use these leaves as a vegetable. Only 4.0% of respondents use them as seasoning. Among the respondents, 72.7% say that the leaves of *B. alba* L. give a gooey appearance in the soup, 31.3% say that the leaves of *B. alba* L. can replace the okra. On the other hand, 68.7% say that leaves of *B. alba* L. do not replace okra and 27.0% say they do not look slimy in soup.

Association and accompaniment foods with leaves of *B. alba* L

Table 5 presents the association and accompanying foods with the leaves of *B. alba* L. From these results, among the 150 households surveyed, 82.0% of households prepare these vegetables with either smoked fish or fresh meat; 13.3% of respondents only prepare them with smoked fish. The consumption of *B. alba* leaves prepared with fresh meat is poorly represented at 4.7%. The staple foods that accompany the leaves of *B. alba* L., 61.3% of respondents alternate staple foods, 20.7% use only cassava, 17.3% use only foufou (cassava flour). Bread is weakly associated with a prevalence of 0.7%.

Frequency of weekly consumption of leaves of *B. alba* L.

Figure 2 illustrates the frequency of consumption in the week. The leaves of *B. alba* L. are consumed once in the

Table 4. Form of use of leaves of *B. alba* L.

Parameter	Variable	Effective	Percentage	Statistical test
Use of leaves as a seasoning or vegetable	Seasoning	6	4.0	χ^2=122.091 ddl =149 p<0.001
	Vegetable	144	96.0	
Can replace okra	Yes	46	31.3	χ^2=42.674 ddl=149 p<0.001
	No	104	68.7	
Does it give the thickening aspect in the soup?	Yes	109	72.7	χ^2=34.876 ddl=149 p<0.001

Table 5. Association and companion foods with *B. alba* L.

Parameter	Variable	Effective	Percentage	Statistical test
Types of fish or meat associated with leaves	Fresh meat	7	4.7	χ^2=38.789 ddl=149 p<0.001
	Smoked fish	20	13.3	
	Alternate Association	123	82.0	
Basic food accompanying the leaves	Cassava	31	20.7	χ^2=25.468 ddl=149 p<0.001

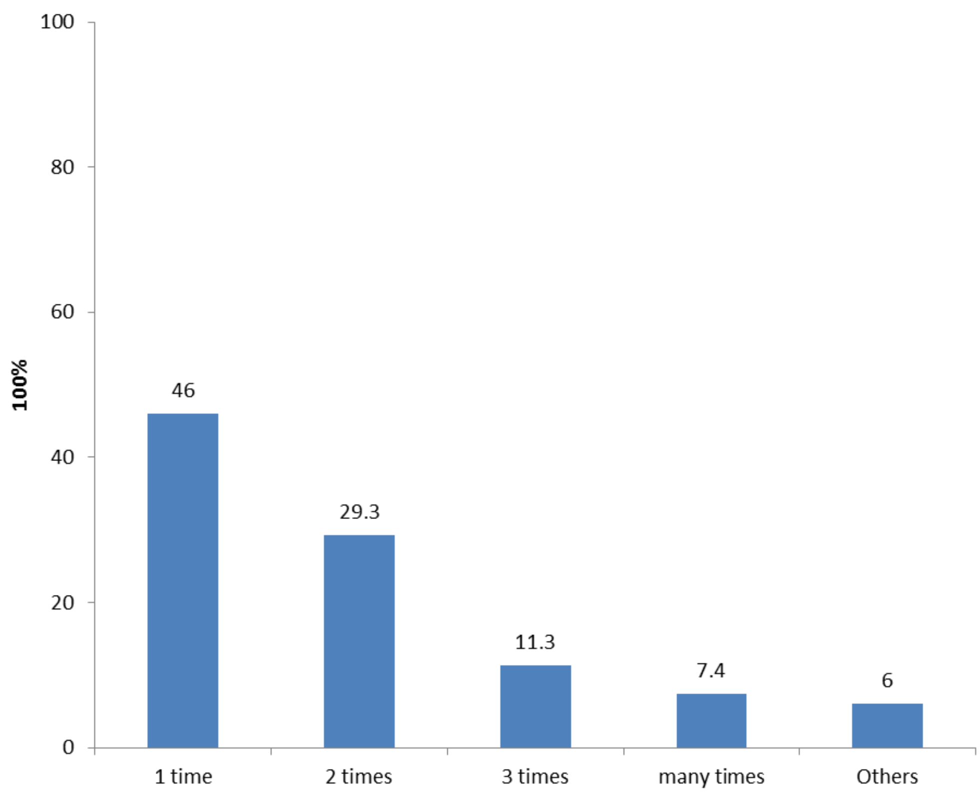

Figure 2. Distribution of respondents according to the frequency of consumption of leaves of *B. alba* L. in the week.

Table 6. Morphological characteristics of leaves of *B. alba* L.

Physical characteristics	*B. alba* L.
Length (cm)	10.75±2.10
Width (cm)	9.5±2.54
Length of the petiole (cm)	4±0.70
Number of ribs	6.5±1.0

Table 7. Nutritional and energy value of *B. alba* L.

Moisture, macro-nutriments and ashes	Value
Moisture (%)	89.03±0.10
Proteins (g/100 g)	11.15±0.68
Lipids (g/100 g)	4.82±0.84
Carbohydrates (g/100 g)	68.98±2.35
Ashes (g)	15.05±0.74
Energy in Kcal	323.68±57.89

week with a percentage of (46.0%), followed by households that consume them twice during the week (29.3%). 11.3% of households consume them three times a week, 7.4% of households consume them several times a week. However, 6% of households do not know the number of times they have consumed these leaves in the week.

Morphological characteristics of leaves of *B. alba* L.

The results in Table 6 show that *B. alba* L. has leaves that have the following morphological characteristics: leaf length 10.75 cm, leaf width 9.5 cm, number of secondary veins 5.5, number of veins main 1 and finally the petiole length 4 cm.

Overall nutritional value of *B. alba* L.

Table 7 shows the nutritional and nutritional quality of *B. alba* L.. This table shows that the leaves of *B. alba* L have a water content of 89.03% MF, the dry matter content is 10.97% from MS. However, the proteins, the lipids and the carbohydrates show respective contents of 11.15% of MS; 4.82% MS and 68.98% MS. *B. alba* leaves have an ash content of 15.05% DM. These nutrients (proteins, lipids, carbohydrates) provide 323.68 Kcal (or 1352.98 KJ).

DISCUSSION

The most important consumers of *B. alba* L. are people whose age is between 20-24 years old with a prevalence of 16.7%. The value found in our study is higher than that reported by Elenga et al. (2016) for the same age group, on a *Salacia pynaertii* study (4.3%). This difference could be explained by the choice of vegetables. Regarding the sex of the respondents, 83.3% of the consumers are female. This is analogous to what Probst (2008) said that women are responsible for choosing vegetables and cooking meals. Food-related activities are almost exclusively for women. As for the level of education of the respondents, the results of our study show that consumers of *B. alba* L have a high school (38.7%), high school (34.7%) and upper secondary (14.6%) level ofeducation %). However, 43.3% of them engage in an informal activity. These results are consistent with those of Elenga et al. (2017) on a study of the Nutritional Characterization of Local Flours of Manufacturing Units for Infants and Young Children in Congo-Brazzaville. The author mentions that the majority of respondents exercise a informal activity (54.5%). The consumption of the leaf vegetable studied is not related to the social level of the household or the educational level of the subject. Thus, Jansen et al. (2004) stated that "people in Africa often use plant species to meet their food needs and ensure food security". On the knowledge of this leaf vegetable, the present work shows that *B. alba* L. is a vegetable known by all respondents (100%). These results are in agreement with those obtained by Tchiegang et al. (2004), in a study of nutritional data and physicochemical characteristics of leafy vegetables consumed in the savanna of Adamaoua, 100% of those surveyed know leafy vegetables.

With regard to consumption, 100% of respondents consume *B. alba* L. The results corroborate with those of Elenga et al. (2016). These authors reported, in a study on the consumption of *S. pinaertii* leaves, that 100% of the respondents consume this plant. *B. alba* L is a commonly consumed vegetable in Brazzaville. The leaves of *B. alba* L. are consumed in cooked form (99.3%). This same result was found by Itoua et al. (2015) on *Phytolacca dodecandra* Herit (100%). However, Richard (2007) mentioned that "the consumption of many leafy vegetables requires cooking to avoid irritating or toxic effects".

Regarding the organoleptic characteristics of the leaves of *B. alba* L., 48.7% of households find these vegetables tasteless against 45.3% who find them sweet. The results differ from those obtained by Itoua Okouango et al. (2019) in a study on the characterization of the food value of the leafy vegetable *Lagenaria siceraria*, of which 88.6% of the respondents found these sweet vegetables compared to 11.4% who find them tasteless.

The results show that 96% of the people surveyed use the leaves of *B. alba* L as a vegetable and 4% use them as seasoning. *B. alba* L replaces *okra* for 31.3% of those surveyed and 72.7% say that it gives a thickening appearance in the soup. According to Romanchik et al. (2002), *okra* contains a mucilaginous substance, that is, it swells on contact with water and produces thick, viscous substances. This substance can be used as a thickener in various culinary preparations (soups, stews). In addition, it could be used as a substitute for fat in certain food preparations. Regarding the preparation of the leaves of *B. alba* L., 82% of the respondents make an alternating association with fresh meat and smoked fish, against 13.3% of the respondents prepare them only with smoked fish and 4.7% with fresh meat. This association with meat or fish could benefit consumers of animal protein that has good biological value than plant-based proteins.

With regard to the staple foods that accompany the leaves of *B. alba* L, the present study shows that 61.3% of the respondents alternate foufou (cassava flour) with cassava, while 20.7% only accompany dishes with cassava and 17.3% with the foufou (cassava flour). The work corroborates with those of Itoua Okouango et al. (2015), who report that foufou and cassava are part of the Congolese food habits.

Weekly consumption of *B. alba* L, 46% of respondents consume once a week, 29.3% twice. The work is superior to that obtained by Itoua Okouango et al. (2015). These authors mentioned that *P. dodecandra* L' *Herit* is consumed once a week (20%). This difference could be explained by the seasonality of leafy vegetables which reduces their frequency of consumption. On the other hand, the present work is similar to those who consume it twice a week (28%).

With regard to the morphology of the leaf, *B. alba* L has an average length of 10.75 ± 2.10 cm, and a width of 9.5 ± 2.54 cm. The petiole length is 4 ± 0.70 cm, the number of veins is 6.5 ± 1.0. Our work differs from those obtained by Mbemba et al. (2013) for *Gnetum africanum* (length: 12.92 ± 0.94 cm, width: 06.87 ± 0.49 cm with number of ribs: 10.50 ± 0.86).

With regard to the chemical composition of the leaves of *B.* alba L, the result of this study shows that the moisture content of these leaves is 89.03% fresh material. These results are close to those found by Tchiegang and Kitikil (2004), who found a moisture content of 90.85% fresh material for *Hibiscus sabdariffa*. *B. alba* L and *H. sabdariffa* are two different species or the leaves are engorged with water.

The ash content gives a value of 15.05%. These results are significantly lower than those obtained by Oulai et al. (2014) observe an ash content of 25.67% dry matter, for leaves of *Ceiba pendandra*. This difference could be explained by the maturity of the plants. The protein content gives a value of 11.15% dry matter. Our work is similar to the results obtained by Mbemba et al. (2013) obtain a protein content of 09.59 g/ 100 g dry matter on a study of *Cuervea isangiensis* leaves. The total carbohydrate analysis gives a value of 68.98% dry matter. These results are similar to those obtained by Elenga et al. (2016) on *S. pynaertii* leaves (total carbohydrate 67.54g / 100g dry matter). The energy value of the leaves of *B.alba* L. is 323.68 Kcal. The results are far superior to those obtained by Itoua Okouango et al. (2015) find a value of 161.84 Kcal for *P. dodecandra. B. alba* L, leaf vegetable studied could be an energy food.

Conclusion

B. alba L. is a vegetable commonly consumed by people with different socio-demographic levels, so this leaf vegetable fits into the eating habits of the people of Brazzaville. This study revealed that the leaves of *B. alba* L. have a good nutritional value, therefore they have an important food resource took into account to the content of in proteins and minerals and can contribute to the improvement of the nutritional state of the populations.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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