Mango Seed Kernel From Cameroon Savannah: Characterization And Antioxidant Potential

Junior Franck Ekorong Akouan Anta, Gaston Zomegni

Abstract — The aim of the present study is to characterize mango seed kernel of some varieties from the Cameroon savannah, to evaluate their potential uses. The results have shown a total sugar content ranging from 38.81% (Indécinard) to 67.33% (Brook), oil content, from 6.27% (Brook) to 10.62% (Kent), and proteins 3.94% (Local Maroua) to 6.09% (Kent). Uses as feedings or substitution in breadmaking and bakery is possible like some authors have shown. Phenolics compounds content and antioxidant activity have also been assessed and the results are promising for a valorisation of that aspect. Similar varieties were grouped in the respect of their polyphenolic compounds and antioxidant properties.

Index Terms — Mango see kernels, valorisation, phenolic compounds, antioxidant properties, Cameroon savannah.

I. INTRODUCTION

Central Africa is a region with great diversity in terms of fruit production due to its climate. The fruit market is still increasing since the past two decades, due to the benefits that the actors in the sector are driving from it [1]. In the Cameroon savannah region, the landscape is greatly marked by the presence of fruit trees, with *Mangifera indica* being one of the most represented [2]. Because of high consumption and sales [3], small mango tree plantation can be found. Unfortunately, the high consumption of this fruit, for its pulp, and its industrial exploitation during the production of a large quantity of by-products (peel and seed) which leads to hygiene and health problems [4].

Many research studies have the valorisation possibilities of those by-products: the fat from the mango seed kernel for its properties and possible applications in cosmetics [5], and the peel or the mango seed powder as food additives because composition and antioxidant power [6]-[9]. That antioxidant power, of high interest in the food industry, is greatly carried by the phenolic compounds they contain. The multitude of mango varieties also suggests variability in potential depending on the specific characteristics of each variety. Various studies have already been carried out to determine the antioxidant power of mango almonds in various countries with high mango production [10]-[12], but there is a lack of data regarding mango from the Cameroonian savannah.

This work objective is to characterize the kernels of some mango varieties from the Cameroonian savannah, to quantify their phenolic contains and antioxidant activity before and after lipid extraction.

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II. MATERIAL AND METHODS

A. Sample preparation

11 varieties, among the most common and consume, were selected: Alphonse, Brook, David Haden, Haden, Indecinard, Julie, Kent, Local Maroua, Local Ngaoundéré, Smith, and Springfield. They were collected directly from trees in mango tree plantations in the Adamawa, North and Far-North administrative regions. The fruit chosen was mature, but not yet ripe, to be sure that the kernels have not yet begun to germinate process that begins with the ripening. The fruits were washed, and the flesh removed. The shell of the seeds was also removed without scratching the kernel inside. The kernels were then split in half, lengthwise, by the middle to obtain two halves of roughly the same shape and thickness. The kernels obtained were dried at 40°C for 72 hours to obtain almonds with a residual water content of less than 10% for preservation purposes [13], [14]. The dried kernels were then ground, and, for each variety, a part of the powder was defatted by the Soxhlet method with Hexane as a solvent. The whole mango seed kernel powder was used for proximal composition analysis, while both powders, with (B) and without fat (A), were used for the other analysis.

B. Chemical analyses

For the ash content determination, mango seed kernel powders were dried for 24 h at 105°C before being incinerated at 550°C for 6 h. It is expressed as percentage of the dry mass of mango kernel powder.

For the total proteins contains, the whole powders were mineralized according to the Kjeldahl method and the nitrogen content is then measured according to the method described in [15]. This spectrophotometric method is based on the reaction between the amine group with acetylacetone and formaldehyde in an aqueous environment to give a yellow product: 3.5- diacetyl-1. 4-dihydrolutidine. This compound has a maximum absorption at 412 NM. The protein content is obtained by multiplying the nitrogen content by the factor of 6.25 and is expressed as percentage of the dry mass of mango kernel powder.

The determination of the soluble sugar content was made by the DNS colour method (Acid 3,5-Dinitro Salicylic) described by [16]. The principle of this method is the reduction of DNS in alkaline and hot environments, by sugars and the formation of a brown-red product. The intensity of the colour developed at a maximum absorption at 540 nm and is proportional to the concentration of sugar. The

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spectrophotometric quantification of the total sugar content was done using the method described by [17]. In acidic and hot environments, pentoses (C5) and hexoses (C6) undergo cyclization to give furfural and hydroxymethylfurfural respectively. They both react with the phenol to give an orange-yellow coloured complex with maximum absorption at 490 nm. They are expressed as percentage of the dry mass of mango kernel powder.

The extraction and quantification of polyphenolic compounds (TPC), as well as the Tannin content, were done following the method described in [18], based on the principle of oxidation/reduction and use Folin-Ciocalteu. In a basic environment away from light, the Folin-Ciocalteu reagent reacts with the phenolic compounds, and the product obtained is detected at 725 nm. Non-tannic phenolic compounds cannot be distinguished from tannins with this method. Because of its strong affinity with Tannins, the polyvinylpolypyrrolidone (PVPP) is used to bind them, and they are separated from the slurry by centrifugation. The phenolic compound content is measured in the extract before and after PVPP treatment. The difference between the two values gives the tannin content. The results are expressed as an equivalent mass of Gallic Acid per gram of dry mass of mango kernel powder.

Flavonoids content was assessed by the method described by [19]. In the basic environment, with sodium nitrate and aluminium chloride, flavonoids give a red coloration that has maximum absorption at 510 nm. The Flavonoids content was expressed as an equivalent mass of Catechin per gram of dry mass of mango kernel powder.

The total reductive power (TRP) of mango almond extracts was assessed by the method described in [20]. This method is based on the reduction of Mo (VI) in Mo (V) by compounds present in the extract, with the formation of a green phosphate/molybdate complex, with a maximum absorption at 695 nm. Antioxidant activity was expressed as the effect of an equivalent mass of Ascorbic Acid per mass of dry matter.

Anti-radical activity is based on the reduction, by the active component in the extract, of the stable free radical 2.2diphenyl-picrylhydrazyl (DPPH) [21]. By trapping these radicals, the purple colour of DPPH disappears, and the medium turns yellow. Anti-radical activity (AAR) is expressed as a percentage of reduction of the DPPH.

All analyses were conducted in triplicate. The variance analysis was performed to verify the significance of the variety on the results. The Duncan multiple ranking tests was used to categorize the averages. This was done using Statgraphics XVI.I. The Pearson correlation matrix and hierarchical ascending classification were made to establish a statistical relationship between the properties analysed, and to group of varieties with similar polyphenol levels and antioxidant power, using Xlstat 2014 software.

III. RESULTS AND DISCUSSION

Table 1 shows the proximal composition of the mango seed kernels of the different varieties studied. The oil content of almonds ranges from 6.27% (Brook) to 10.62% (Kent). These values are relatively small compared to the 11% and 12% obtained by other authors [5], [8], [22], [23]. It should be noted, however, that these authors worked on a mixture of mango varieties processed in these units.

Mango seed kernels are characterized by a richness in sugar that account for almost half of the dry matter of defatted cakes. Brook (67.33%), Alphonse (61.28%), and Smith (58.40%) are the varieties with the highest in sugars content, with levels comparable to or even higher than the values obtained by [24], [8].

TABLE I: MANGO SEED KERNEL VARIETIES PROXIMAL COMPOSITION

Varieties	Fat	Ashes	Protein	Total Sugars	Soluble sugars
Alphonse	7.73±0.04 bc	2.17±0.38 b c	5.59±0.17 ^{df}	61.28±0.09 ^f	10.18±1.13 a b
Brook	6.27±0.34 a	3.39±0.23 ^e	4.66±0.31 b c	67.33 ± 0.24^{g}	7.55±0.65 a
David Haden	9.61±0.23 °	2.14 ± 0.40^{abc}	$5.87 \pm 0.23^{\mathrm{f}\mathrm{g}}$	56.83 ± 0.16^{d}	21.60±4.10°
Haden	$8.49{\pm}0.20^{\rm \; d}$	$2.33\pm0.21^{\ b\ c}$	5.45 ± 0.17^{de}	55.68 ± 0.41^{d}	$36.62\pm2.85^{\mathrm{f}}$
Indécinard	8.33 ± 0.23^{d}	$1.53{\pm}0.16^{\mathrm{a}}$	4.67 ± 0.09^{c}	$38.81{\pm}1.37^{\rm \ a}$	15.63±6.77 b
Julie	8.49 ± 0.33^{d}	3.44 ± 0.12^{ef}	4.32 ± 0.09^{b}	40.88 ± 0.45 b	$34.40{\pm}1.30^{\mathrm{f}}$
Kent	$10.62\pm0.23^{\ f}$	$4.06\pm0.38^{\rm f}$	$6.09\pm0.14^{\mathrm{g}}$	47.28 ± 0.32^{c}	$22.10\pm1.91^{c,d}$
Local Maroua	7.39 ± 0.37^{b}	1.77 ± 0.19^{ab}	3.94±0.17 a	39.28±1.34 a	7.61±3.29 a
Local Ngaoundéré	9.59±0.28 °	$2.86{\pm}0.38^{\mathrm{d}\mathrm{e}}$	5.70 ± 0.15^{ef}	$40.77 \pm 0.49^{\ b}$	7.43±1.79 a
Smith	8.14 ± 0.29^{cd}	2.89 ± 0.24^{de}	5.31 ± 0.40^{d}	58.40±0.69 °	$32.36{\pm}4.00^{\mathrm{f}}$
Springfield	9.57±0.30 °	2.59 ± 0.20^{cd}	4.87 ± 0.09^{c}	$47.69\pm0.52^{\text{ c}}$	27.36±3.58 de

The values followed by the same letter in the same column are not significantly different (P<0.05).

With a maximum at 6.09% for Kent, mango seed kernels studied does not have a protein content comparable to the findings of other authors, for varieties from different African countries [22]-[24], [8]. Despite the relative low protein content of the kernel, these proteins contain the majority of essential amino acids at rates higher than the FAO reference. Only methionine, threonine and tyrosine are the exception [23].

With ash content of the studied mango seed kernel varieties vary from 1.53% (*Indécinard*) to 3.44% (*Julie*). These values are comparable or higher than the findings of other studies [25], [23], [4], [8].

Table 2 shows the total Polyphenols, Tannins and Flavonoids contents in the mango seed kernels the 11 studied varieties. Similarly, it presents their total reductive power and anti-radical activity. Column (A) presents the results obtained without lipid extraction and column (B) the results with lipid extraction.

The total polyphenol content of mango kernels, without lipid extraction, ranged from 0.158 mg/g (David Haden) to 0.206 mg/g (*Indécineard*). After lipid extraction the levels ranged from 0.225 mg/g (Julie) to 0.303 mg/g (Mabrouka). Tannin content, before lipid extraction, ranged from 0.03 mg/g (Brook) to 0.163 mg/g (Indécineard). After lipid extraction, it ranged from 0.115 mg/g (Julie) to 0.244 mg/g (Indécineard). The flavonoid content, before lipid extraction, ranged from 0.021 mg/g (Indécineard) to 0,141 mg/g (Brook). After fat extraction, it ranged from 0.01 mg/g (Alphonse) to 0.112 mg/g (Julie).

From these, a clear effect of the lipid extraction can be observed, with a significant increase of the extraction yield after lipid extraction. That enhancement effect on the extraction yield can be explained by the fact that polyphenolic compounds and lipids are both soluble to Acetone, used for polyphenol extraction. Therefore, in the whole mango kernel powder, they are extracted at the same time, and the solvent is rapidly saturated and leads to a lower extraction yield. But that does not happen when lipids are extracted before polyphenols. In [26], the authors suggested that lipid extraction makes polyphenols more polar, and therefore more soluble in extraction solvents. The quantity of polyphenols extracted from the mango seed kernels from the Cameroon savannah can be seen relatively comparable or a little bit less than to those from others countries like in [23], [27], [4].

As we observed with the phenolics compounds content, the antioxidant activities, evaluated by the Total Reducing Power and the Anti-Radical Activity, is also affected by the lipid extraction. The total reducing power of extracts, evaluate before lipid extraction, varied from 11.25 mg/g (Haden) to 16.62 mg/g (*Julie*). After fat extraction, it varied from 2.02 mg/g (Alphonse) to 3.02 mg/g (Julie). Similarly, for antiradical activity, before fat extraction, the percentages range from 93.241% (Haden) to 95.269% (Alphonse). Results after fat extraction, ranged from 72.092% (David Haden) to 90.806% (Local Maroua). The results showed better antioxidant properties from whole mango seed kernel powder, than the defatted one. Mango seed kernel fat are rich in vitamins as vitamin A, E, K [27], which have antioxidant activities. Therefore, it is highly possible to extract them along with the phenolic compounds when working with whole mango seed kernel powder. The results of anti-radical activity don't show a difference as bigger as for the total reducing power. This suggests that the extracted polyphenols are the main actors in the trapping of free radicals.

Table 3 presents Pearson's correlation matrix, before and after lipid extraction respectively, which, taking into account all observations of all varieties, highlighting the correlations between them in any case. Almost all correlations, between components and properties, are non-significative (P<0.05) when compare without lipid extraction. But all correlations are significative with lipid extraction.

Analysis of the results obtained before lipid extraction shows only one significant, but negative, correlation between tannin and flavonoid content. This suggest that flavonoid may be less extracted if there are more tannins. After lipid extraction, all the parameters are correlated and affect each other significantly. The positive correlation between the content of total phenolic compounds indicates an increase of the tannin content with an increase with total phenolic compounds content in all the mango kernel varieties studied. This observation has been made by many authors [28], [23], [29].

The positive correlation between flavonoid content and the total reducing power of extracts shows that flavonoids are the main carriers of the reductive property of mango polyphenols, and this tends to increase with their content in the mango seed kernels. This observation is similar to those observed by several authors [30]-[32]. On the other hand, there is a significant but negative correlation between total reducing power and anti-radical activity. The two antioxidant properties are the expression of different mechanisms of neutralisation of the free radicals. The hypothesis that can be made, regarding the results, is that, specifics compounds can be in mainly responsible for one mechanism. The negative correlation suggests that, in the varieties, an increase in one of these two properties results in a decrease in the other. Same observation has been made between tannins and flavonoids. The increase in tannins increase the Anti-radical activity which in turn leads to a decrease in the content of flavonoids, molecules that carry the total reductive power in almond extracts.

The Fig. 1 presents the similarity dendrogram allowing to regroup mango varieties in classes according to the phenolic contents and antioxidant properties, assessed on defatted kernels. Overall, the figure shows a fairly high level of similarity between almonds, as all classes are formed above 99.51% of similarity. This indicates that the mango see kernels of the Cameroon savannah are practically similar to each other. Such a strong similarity between the varieties gives the assurance of a similar conclusion when using any one of them. Transposition of results without great risk of divergence is possible.

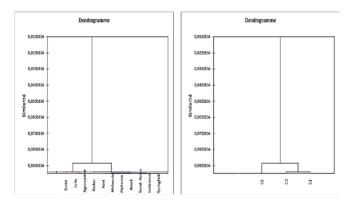


Fig. 1. Similarity dendrogram of Cameroon savannah mango seed kernel varieties, based on their polyphenol content and antioxidant properties

IV. CONCLUSION

Mango seed kernels from the Cameroon savannah have interesting potential in respect of their polyphenols content that can be valued in food industry and cosmetics. The strong impact of lipid extraction on extraction yield and the expression of antioxidant potential reinforces the need for this operation, especially taking into account the richness and possible applications of this oil.

TADLE III DITENOLIC CONTENTS AND	ANTIOXIDANT ACTIVITY OF THE STUDIED	MANICO CEED L'EDNIEL C VADIETIEC
TADLE II. PHENOLIC CONTENT AND	ANTIOADANT ACTIVITY OF THE STUDIED	MANGO SEED KEKNELS VAKIETIES

		Compounds (mg A/g)	Tannins (mg GA/g)		Flavonoids (mg Cat/g S)		Total Reducing Power (mg AA/g MS)		Anti-Radical Activity (%)	
Varieties	A	В	A	В	A	В	A	В	A	В
Alphonse	$0.187\pm0.002^{\ f}$	0.275±0.014 ef	0.142 ± 0.001^{k}	0.219 ± 0.016^{ef}	0.041 ± 0.001 c	0.012±0.001 a	15.26±0.08 g	2.02±0.03 a	95.269±0.155 ^f	78.947±1.072 ^{c d e}
Brook	0.179±0.001 ^e	$0.233{\pm}0.007^{\;abc}$	0.034±0.001 a	0.202 ± 0.009 cde	0.141 ± 0.001^{d}	$0.013{\pm}0.001~^{\rm a}$	13.73±0.05 e	2.08±0.06 a	94.322 ± 0.507 ^{c d}	82.294±0.481 def
David Haden	$0.158{\pm}0.002~^{\rm a}$	0.277 ± 0.012 ef	$0.116{\pm}0.002^{\rm \ i}$	$0.240{\pm}0.013~^{\rm fg}$	0.038 ± 0.001 b	$0.022 \pm 0.002^{\ b}$	$14.93\pm0.04^{\ fg}$	2.06 ± 0.07	93.545±0.310 вс	72.092 ± 1.420^{b}
Haden	0.172 ± 0.001 b	$0.246\pm0.019\ b^{\ c\ d}$	0.097 ± 0.001^{h}	0.183 ± 0.021 b c	0.068 ± 0.001 g	$0.030\pm0.002^{\ c}$	11.25±0.32 a	2.34±0.07 b	93.241±0.909 а в	77.323±4.090 b c d
Indécinard	$0.206{\pm}0.001~^{\rm h}$	0.286 ± 0.015 fg	0.163 ± 0.001^{1}	$0.244\pm0.016^{\ g}$	0.021±0.001 a	$0.030\pm0.002^{\ c}$	13.32±0.21 d	2.34±0.04 b	93.917±0.710 b c d	85.867 ± 4.787^{f}
Julie	0.171 ± 0.001 b	0.225±0.005 a	$0.088{\pm}0.001~^{\rm f}$	0.115±0.001 a	0.039 ± 0.001 b	0.109 ± 0.001 g	16.62.0.11 a.m.	3.02 ± 0.15^{d}	94.728±0.101 ef	79.078±2.984 ^{c d e}
Kent	$0.173\pm0.002^{\ b\ c}$	0.277 ± 0.008 ef	$0.091\pm0.002^{\ g}$	0.211 ± 0.013^{de}	0.058±0.001 e	0.052±0.003 °	11.72±0.17 b	2.08 ± 0.06	94.288±0.255 ^{c d}	83.561±2.059 ef
Local Maroua	$0.197{\pm}0.001~^{\rm g}$	$0.303{\pm}0.010^{\text{ g}}$	$0.058\pm0.001^{\text{ c}}$	0.216 ± 0.018^{de}	$0.053{\pm}0.002^{d}$	$0.050\pm0.001^{\ e}$	20.28±0.02 i	2.37±0.09 b	95.235±0.101 f	90.806 ± 0.245 g
Local Ngaoundéré	$0.175{\pm}0.005^{cd}$	0.277 ± 0.013 ef	$0.123{\pm}0.004^{d}$	0.166±0.013 ^b	0.042 ± 0.001^{c}	$0.105{\pm}0.003~^{\rm f}$	12.56±0.17 °	2.94±0.19 d	94.221±0.537 ^{c d}	76.056±2.451 bc
Smith	0.177 ± 0.001 de	0.257 ± 0.013 de	$0.039\pm0.001^{\ b}$	0.199 ± 0.011 cde	0.080 ± 0.001 h	$0.030\pm0.002^{\ c}$	14.57±0.21 f	2.59±0.08 °	94.390±0.255 ^{c d e}	74.659±2.111 bc
Springfield	$0.177{\pm}0.001^{\text{ de}}$	$0.229\pm0.010^{~a~b}$	$0.082 \pm 0.001^{\mathrm{e}}$	$0.194{\pm}0.011^{\ td}$	$0.094{\pm}0.001^{\rm \ i}$	0.028 ± 0.001 °	12.59±0.15 °	2.28±0.04 b	94.559±0.155 ^{ef}	85.673±4.074 f

The values followed by the same letter in the same column are not significantly different (P<0.05). A: Without lipid extraction; B: With lipid extraction

TABLE III: PE	EARSON CORREL	ATION MATRIX	FOR OBSE	ERVATION	S MADE BI	EFORE (A)	AND AFTER	(B) LIPID EXT	RACTION	
	Total Phenolic Compounds		Tannins		Flavonoids		Total Reducing Power		Anti-Radical Activity	
	A	В	A	В	A	В	A	В	A	В
Total Phenolic Compounds		1								
Tannins	0,143	0,603		1						
Flavonoids	-0,161	-0,051	-0,762	-0,760		1				
Total Reducing Power	0,252	-0,252	-0,219	-0,560	-0,202	0,662		1		
Anti-Radical Activity	0.039	0.215	-0.022	0.014	-0.007	-0.012	0.541	-0.624		1

The values followed by the same letter in the same column are not significantly different (P<0.05).

A: Without lipid extraction; B: With lipid extraction

TABLE IV: GROUPING OF VARIETIES BY SIMILARITIES								
Classes								
1	2	3						
Alphonse	Haden	Julie						
Brook		Local Ngaoundéré						
David Haden	Smith							
Incinerated								
Kent								
Local Maroua								
Springfield								

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