Journal of Food and Nutrition Sciences
2023; 11(2): 37-42
http://www.sciencepublishinggroup.com/j/jfns
doi: 10.11648/j.jfns.20231102.12
ISSN: 2330-7285 (Print); ISSN: 2330-7293 (Online)

Comparative Study of *Mbuja* and *daddawa* Oils in View of Their Use in the Treatment of Some Chronic Diseases

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To cite this article:

Doumta Charles Falang, Bebbe Fadimatou, Ghomdim Nzali Horliane, Ngangoum Eric Serge. Comparative Study of *Mbuja* and *daddawa* Oils in View of Their Use in the Treatment of Some Chronic Diseases. *Journal of Food and Nutrition Sciences*. Vol. 11, No. 2, 2023, pp. 37-42. doi: 10.11648/j.jfns.20231102.12

Received: February 27, 2023; **Accepted**: March 17, 2023; **Published**: April 13, 2023

Abstract: *Mbuja* and *daddawa* are food condiments obtained by traditional uncontrolled fermentation of *Hibiscus sabdariffa* and *Parkia biglobosa* seeds respectively in African countries (Burkina Faso, Mali, Niger, Nigeria, Cameroon and Sudan etc...). These condiments are known for their nutritive values and for their health properties in traditional medicine to cure some chronic diseases. In spite of their nutritional and healthy properties the consumption of *Mbuja* and *daddawa* are less appreciated in urban areas. This is due to their strong smell, to their bad condition of manufacturing practices which leads to the rapid alteration of nutraceutic values. The main problem now is how to lead people to consume these condiments which nevertheless contains bioactive molecules, and can help in the treatment or in the prevention of some cardiovascular diseases. Among those bioactive molecules, the lipidic is one of the main element which has an impact on some chronic diseases. The fact that *daddawa* and *mbuja* are used for the same treatment, means that oils of both condiments could have same contents. For this reason the goal of this study target the comparative analyses of bioactive compounds of *daddawa* and *mbuja* oils that can justify the used of both condiments in the treatment of chronic diseases. To overcome this, the physicochemical composition of different oils were assessed by using classical methods. The results obtained show similitude values in colour, acid index, iodine value, saponification value, crude phenolic compounds, tannin as well as SFA, MUFA, PUFA. Based on these results, the physicochemical composition of *daddawa* and *mbuja* seem to be identic and can be applied for the same treatment.

Keywords: *Mbuja*, *daddawa*, Oils, Same Composition, Nutraceutic Activities, Chronic Diseases

1. Introduction

Hibiscus sabdariffa and *Parkia biglobosa* are plants used for medicinal purposes, especially in alternative medicine. They are folk remedy for abscesses, cancer, cough, debility, dyspepsia, dysuria, fever, hangover, diuretic, mild laxative, heart ailments, neurosis, scurvy and strangury [1]. *H. sabdariffa* and *P. biglobosa* have been reported to have antiseptic, aphrodisiac, emollient, purgative, refrigerant, sedative, stomachic and tonic activities. *H. sabdariffa, P. biglobosa* and their fermented seeds (*Mbuja and daddawa* respectively) are used in the treatment of hypertension, hypocholesterolemic, anti-oxidative and hepatoprotective effects in animals [2, 3]. *Mbuja* (also known as *Bikalga; dawadawa botso; datou; Furundu*) and *daddawa* (also called *sumbala*, *netetu, iru, dawadawa*) are food condiments obtained by traditional uncontrolled fermentation of *H. sabdariffa* and *P. biglobosa* seeds respectively in African

countries, including Burkina Faso, Mali, Niger, Nigeria, Cameroon and Sudan among others. These condiments are known for their nutritive values and for their health properties [2, 3].

These condiments are mainly produced by women and constitute an economical source for the producers. They are the most popular food condiments in North-Cameroon and are used as meat replacement mainly by low-income population. *Mbuja* and *daddawa* are also used in traditional medicine to cure high blood pressure, diarrhoea, and cardiovascular diseases or are used as an antiseptic. In spite of their nutritional and healthy properties the consumption of *Mbuja* and *daddawa* are less appreciated in urban areas. This is due to their strong smell, to their bad condition of manufacturing practices which leads to the rapid alteration of nutraceutic values [2, 3]. The main problem now is how to lead people to consume these condiments which nevertheless contains bioactive molecules, and can help in the treatment or in the prevention of some cardiovascular diseases [1]. Among those bioactive molecules, the lipidic is one of the main element which has an impact on hypertension, Hypocholesterolemic activity and cardiovascular diseases. The fact that *daddawa* and *mbuja* are used for the same treatment, means that oils of both condiments could have same contents. No scientific study on the comparative analyses of *daddawa* and *Mbuja* oils was found in literature review. For this reason, the goal of this study target the comparative analyses of bioactive compounds of *daddawa* and *mbuja* oils that can justify their use in the treatment of cardiovascular diseases. The present study was undertaken essentially to investigate the potential contents of *daddawa* and *Mbuja* oils. To overcome this, the composition of *daddawa* and *mbuja* oils on dietary fatty acid compounds were assessed.

2. Material and Methods

2.1. Oil Sampling and Proximate Composition

Productions sites were identified in different places of Cameroon (Adamaoua, North and Far-north), and the production process followed throughout the fermentation. Unfermented and fermented seeds of *H. sabdariffa* and *P. biglobosa* were sampled (100 g) at different production sites. Unfermented and fermented seeds of *H. sabdariffa* and *P. biglobosa* of different sites were mixed and dried in oven at 40°C for 72 hours before grinding using a mortar and pestle. Powders obtained were used for the biochemical analyses. The lipid composition was determined by exhaustively extracting a known weight of sample with hexane using a Soxhlet apparatus [4].

2.2. Physical Properties of Different Oils

During the fermentation, lipids from *daddawa* and *mbuja* can undergo physicochemical changes. The aim here is to make a comparative study of physical properties of *mbuja* and *daddawa* oils. According to the data collected during the preliminary survey, colour is one of the characteristic parameter of good quality of fermented condiments. The colour was measured using a colorimeter (Lovibond RT Colour Measurement Kit V 2.28, France) with a 10° observation window and a D65 light source. The instrument was calibrated with a white ceramic standard supplied by the manufacturer of the parameters: L* = 93.87; a* = 0.18; b* = 2.71.

The sample powders were exposed directly to the radiation of the instrument and then, the parameters L*; a*; b* are measured directly by the colorimeter. The total colour difference (ΔE) is determined by the equation:

$$\Delta E = [\Delta a^2 + \Delta L^2 + \Delta E b^2]^{1/2} \quad (1)$$

The physical properties (density, refractive index, colour spectrophotometry) of the lipids extracted from the different samples were evaluated by the IUPAC method [5].

2.3. Chemical Properties of Different Oils

The chemical properties (acid value, saponification value, iodine value) of the lipids extracted from the different samples were evaluated by the IUPAC method [5]. The vitamin A content was evaluated by the method of Wolff [6, 7]. According to the conversion of Coultate [8], 6 µg of carotenoids = 1µg of vitamin A. The method of Kivçak & Mert [9] is used for the determination of α-tocopherol which is the most abundant of tocopherols. The fatty acid profile of the oil samples was determined by gas chromatographic method [10].

2.4. Determination of Some Anti-Nutritional Elements

Some anti-nutritional compounds are known for their therapeutic properties [11]. These properties can be impacted by condiment and by the production process applied. The objective of this part of study is to evaluate the influence of the quality of the condiment on anti-nutritive elements. The total crude phenolic compounds were assessed according to the method of Marigo [12]. Flavonoid contents in the different samples were assessed by the method described by Mimica-Dukic [13]. Proanthocyanidin contents were determined by the method described by Hagerman *et al*., [14]. The tannin content of the different samples was assessed by the method described by Bainbridge *et al*., [15]. The extraction and determination of phytates was done by the method of Mohammed *et al*., [16].

2.5. Statistical Analysis

Results were expressed as means ± standard deviation. The result obtained was the mean for three tests. All results were analyzed using a one-way analysis of variance. The data sets were expressed as mean ± standard deviation (n=3). Analysis of variance (ANOVA) was done using One-Way Analysis of Variance to test for the difference in means. Duncan's Multiple Range Test was carried out to test for the means that are significantly different ($p < 0.05$) from each other, which are presented by alphabets in superscripts.

3. Results and Discussion

During fermentation, many reactions (hydrolysis, oxidation, decarboxylation, transamination, etc.) take place under the action of microorganisms, which can lead to significant biochemical changes in nutrients. In the case of fermented foods, oxidation of lipids is responsible for the formation of undesirable chemical compounds, resulting in an unpleasant taste and smell. This oxidation is also responsible for the reduction of the nutritional quality of the food and can be harmful to health, hence the importance of studying the physicochemical properties of the oils produced. This study focuses on oils from fermented kernels compared to the lipids extracted from cooked kernels.

3.1. Physical Properties of Different Oils

The physical properties studied concern the density, refractive index and trichromatic parameters. The different results are presented in Table 1.

Density of an oil is a value that increases with the length of the fatty acid chains [17]. Table 1 indicate that the densities of DO (0.94±0.01 g/mL) and MO (0.88±0.01 g/mL) oils are different according to Duncan's test ($p<0.05$). The data oils from the cooked and unfermented kernels MS (1.52±0.01 g/mL) and DS (1.12±0.01 g/mL) show higher density than DO and MO. It can be assumed that during fermentation there is a reduction in the chain length of the fatty acids.

Table 1. *Some physical properties of different oils analysed.*

Parameters	DO	MO	MS	DS
Density (g/mL)	0.94 ± 0.01^{b}	0.88 ± 0.01^{a}	1.52 ± 0.01^{d}	1.12 ± 0.01^{c}
Refractive index	1.90 ± 0.02^{c}	2.01 ± 0.10^{d}	1.48 ± 0.01^{b}	1.23 ± 0.01^{a}
Colour parameters				
L*	25.35 ± 0.65^{a}	27.1 ± 1.98^{a}	26.75 ± 3.99^{a}	25.41 ± 3.11^{a}
a*	8.58 ± 0.25^{ab}	9.34 ± 1.68^{b}	6.52 ± 1.64^{a}	8.51 ± 1.48^{ab}
b*	17.92 ± 3.67^{a}	20.11 ± 4.91^{a}	19.80 ± 2.65^{a}	21.56 ± 2.12^{a}
ΔE	32.21 ± 1.53^{a}	35.01 ± 2.02^{a}	33.91 ± 1.42^{a}	34.39 ± 1.22^{a}

Values on the same line with the same superscript letters are not significantly different ($p<0.05$).
MO: *Mbuja* oil; DO: *daddawa* oil; MS: Cooked almonds of *H. sabdarifa* seeds; DS: Cooked almonds of *P. biglobosa* seeds.

The refractive index is a quantity that increases with the unsaturation and the length of the fatty acid chains. It is used as a purity test for oils. The results in Table 1 show that the refractive index increases with fermentation. From 1.23±0.01 (DS) and 1.48±0.01 (MS) the values change to 1.90±0.02 (DO) and 2.01±0.10 (MO) respectively. This means that during fermentation, structural changes of the lipids can occur leading to the formation of unsaturated fatty acids [18]. Following the Duncan's test, there is a significant difference ($p<0.05$) between the refractive indexes of different oils analysed. The value obtained with MO is slightly higher than DO. The high refractive indexes obtained with the both fermented kernels are justified by their high unsaturated fatty acid content (57% of the fatty acid content).

The values of the different colour parameters recorded in Table 1 show that the characteristics vary significantly ($p<0.05$) between the different samples. According to the L* values, DO (L* = 25.35±0.65%) is more coloured than MO (27.10±1.98%). Fermented samples (DO and MO) have the same brightness as the unfermented control (MS and DS). These observations are confirmed by the ΔE values which show not significant difference ($p<0.05$) between samples. The colouration of the oils is attributable to the presence of anthocyanins, tannins and flavonoids [19]. DO results in darker coloured compared to MO, MS and DS.

3.2. Chemical Characteristics of the Different Oils Analysed

The chemical characterisation of the *daddawa* and *mbuja* oils produced aims to ensure that the both condiments have the same characteristic. Some of the chemical parameters of the oils analysed are shown in Table 2.

Table 2. *Chemical characteristics of the different oils analysed.*

Characteristics	DO	MO	MS	DS
Acid value	1.25 ± 0.21^{a}	1.37 ± 0.35^{a}	2.24 ± 0.02^{b}	2.33 ± 0.14^{b}
Iodine value	203.54 ± 1.83^{c}	206.46 ± 1.95^{c}	181.45 ± 1.00^{a}	195.49 ± 0.37^{b}
Saponification value	231 ± 0.42^{a}	234 ± 0.14^{a}	243.95 ± 1.00^{b}	250 ± 0.27^{c}
Carotenoids (µg/g)	0.21 ± 0.08^{a}	0.19 ± 0.06^{a}	0.43 ± 0.01^{b}	0.50 ± 0.02^{b}
Vitamin A (carotenoids /6) (µg/100g)	35.00 ± 0.11^{b}	31.20 ± 0.56^{a}	71.67 ± 1.00^{c}	83.33 ± 0.17^{d}
Vitamin E (mg/g)	14.37 ± 0.73^{b}	12.21 ± 0.21^{a}	16.75 ± 0.10^{d}	15.14 ± 0.41^{c}

Values on the same line with the same superscript letters are not significantly different ($p<0.05$). MO: *Mbuja* oil; DO: *daddawa* oil; MS: Cooked almonds of *H. sabdarifa* seeds; DS: Cooked almonds of *P. biglobosa* seeds

The acid index reflects the level of degradation of the triglycerides contained in the oil. According to the results in Table 2, between DO (1.25±0.21) and MO (1.37±0.35) values, there is no statistical difference ($p<0.05$). Compared to the controls MS (2.24±0.02) and DS (2.33±0.14), there is a decrease in the acid value during fermentation. This can be explained by the fact that microorganisms would use the free fatty acids as a substrate for other biochemical reactions such

as oxidation leading to the formation of aldehydes, alcohols and esters [18]. The acid values of the oils studied are lower than the standard set by the Codex Alimentarius [20], which is 4 for food oils, indicating the good food quality of all the oils analyses.

Iodine value determines the degree of unsaturation of the oils. The iodine value increases slightly from the controls DS (195.49±0.37); MS (181.45±1.00) to the DO (203.54±1.83) and MO (206.46±1.95) fermented products (Table 2). No significant difference ($p<0.05$) is observed between DO and MO. This increase could be linked to the production of unsaturated fatty acids by the microorganisms responsible for the fermentation. The values found for the different oils are higher than those reported by Omafuvbe *et al*. [21] [125.2-148.2 on fermented *P. biglobosa* seeds], and by Nkafamiya *et al*. [22] [50-100 on *A. digitata* and *P. africana* seeds] in Nigeria.

The saponification index determines the ability to form soap and gives an idea of the average length of the fatty acid chains of oils. The values decrease from unfermented kernels (DS: 243.95±1.00; MS: 250±0.27) to the fermented products DO and MO with 231±0.42 and 234±0.14 respectively (Table 2). Between DO and MO there is no significant difference ($p<0.05$). The decrease observed in fermented kernels may be the result of the synthesis of long chain fatty acids at the expense of short chain fatty acids during fermentation [2].

Carotenoids and α-tocopherol give to the oil its antioxidant properties. Evaluation of vitamin A content was done by converting the content of β-carotene [8]. Compared to the control oils (DS and MS), fermentation brings significant changes in carotenoids. With regards of vitamin A values, significant difference ($p<0.05$) is obtained between fermented samples. DO (35.00±0.11) show high value than MO (31.20±0.56).

For vitamin E, regardless of the fermentation, the α-tocopherol content of DO (14.37±0.73mg/g) and MO (12.21±0.21 mg/g) decreased slightly compared to that of the cooked almond DS (15.14±0.41mg/g) and MS (16.75±0.10mg/g). DO presents greater value than MO. Significant difference ($p<0.05$) is observed between the both samples. Consumption of DO and MO can help to fight against diseases caused by vitamin E deficiency. 1g of those oils would be sufficient to meet the recommended daily requirement (10mg/kg/day) [23].

3.3. Determination of Some Anti-Nutritional Elements

Daddawa and *mbuja* are used in the treatment of some chronic diseases in traditional medicine [2, 3, 24]. This suppose that *daddawa* and *mbuja* have the same bioactive compounds. Table 3 presents the results of assessment of some anti-nutritional elements in different oils used.

The results in Table 3 show that crude phenolic contents increases with fermentation. Unfermented cooked almonds have less phenolic compounds. There is no significant difference ($p<5\%$) between values of DO (1.75±0.02 g/100g) and MO (2.03±0.19 g/100g) according to Duncan's test. But MO has the highest value. These values are not far from those detected by Doumta and Tchiegang [2] on *daddawa* oils. The presence of phenolic compounds in *daddawa* and *mbuja* oils could play the role of antioxidants [25, 26]. This aspect can justify why these condiments are used as anti-inflammatory in traditional medicine [3].

Table 3. *Evaluation of some anti-nutritional elements in different oils (mg/100g of oil).*

Elements	DO	MO	MS	DS
CPC (g/100g)	$1.75±0.02^{b}$	$2.03±0.19^{b}$	$1.90±0.29^{b}$	$1.17±0.05^{a}$
Tannins*	$0.62±0.03^{c}$	$0.57±0.05^{c}$	$0.31±0.02^{b}$	$0.11±0.01^{a}$
Anthocyanins*	$115.22±1.16^{c}$	$135.33±0.96^{d}$	$84.79±1.25^{a}$	$107.95±0.56^{b}$
Flavonoids*	$0.05±0.01^{a}$	$0.09±0.03^{b}$	$0.04±0.01^{a}$	$0.10±0.01^{b}$
Phytates*	$1.10±0.04^{c}$	$0.46±0.02^{b}$	$1.38±0.03^{d}$	$0.21±0.01^{a}$

Values on the same line with the same superscript letters are not significantly different ($p<0.05$). MO: *Mbuja* oil; DO: *Daddawa* oil; MS: Cooked almonds of *H. sabdarifa* seeds; DS: Cooked almonds of *P. biglobosa* seeds. CPC: Crude phenolic compounds *: mg/100g of oil;

The same trends are observed for tannins. No significant difference ($p<5\%$) is noted between values of DO (0.62±0.03 mg/100g) and MO (0.57±0.05 mg/100g) according to Duncan's test. But DO has presented the highest value.

In contradiction to the observation done with crude phenolic compounds, anthocyanins values present significant difference ($p<5\%$) between values of DO (115.22±1.16 mg/100g) and MO (135.33±0.96 mg/100g) according to Duncan's test. MO shown the highest value.

Variations between flavonoid levels are quietly small. From results in table 3 it is noted that between DO (0.05±0.01mg/100g) and MO (0.09±0.03 mg/100g) values there is significant difference ($p<0.05$) according to Duncan's test. MO has shown the highest value.

For phytates, their content in DO (1.10±0.04 mg/100g) is more than double of MO (0.46±0.02 mg/100g). Compared to unfermented kernels, fermentation reduce slightly phytate synthesis in MO while in DO it increases.

The presence of anti-nutritional substances in *daddawa* and *mbuja* could give them anti-viral, anti-tumour, anti-inflammatory and anti-allergic properties, which are beneficial for the health of the consumer and thus provide antioxidant functions [11].

3.4. Fatty Acid Composition of Different Oils Used

The fatty acid profile of different oils analysed is presented in Table 4. These results show that DO and MO have comparable fatty acid compositions. This can be seen from the % SFA, MUFA and PUFA calculated for the different

samples. Compared to unfermented almonds (DS). Four fatty acids undergo profound changes during fermentation. C16:0, C18:0 and C18:1 decrease by 42.6%, 40% and 20.13% respectively and C18:2 increases by 68% during fermentation. Regarding unfermented almond (MS), C16:0 and C18:1 decrease by 50.91% and 51.40% respectively while C18:0 and C18:2 increases by 40.59% and 43.92% respectively. It appears that during fermentation, the microorganisms synthesise C18:2 from C18:0 and C18:1. These modifications can be explained by the fact that, microorganisms responsible for fermenting the cooked kernels produce endogenous Δ9, Δ12 and Δ15 desaturases responsible for the desaturation of palmitic, stearic and oleic acids, leading to oleic, linoleic and linolenic acids respectively. This is the reason of the decrease in palmitic, stearic, oleic and the increase in linoleic and linolenic acid contents in fermented products. It can be concluded that fermentation is important to produce the C18:2 necessary for the management of cardiovascular diseases, oxidative stress and LDL cholesterol [27]. According to Evrard *et al*. [28], DO and MO can be classified as a linoleic oil in view of their composition in ω-6 fatty acids (56%).

Table 4. *Fatty acid composition (in % of total fatty acids) of the oils and characteristic quality ratios.*

Fatty Acids	DO	MO	MS	DS
C6.0	/	0.09	/	0.43
C8.0	/	0.06	/	0.37
C10.0	0.12	0.12	/	0.23
C16.0	10.75	10.55	21.49	18.72
C17.0	0.11	0.12	0.12	0.24
C18.0	13.11	12.96	7.7	21.52
C18.1t9	/	/		0.35
C18.1c9	14,44	14.53	29.90	18.08
C18.1c11	0.26	0.28	0.26	0.30
C18.2c9c12	56.52	56.36	39.16	33.64
C20.0	3.72	3.58	0.34	5.61
C18.3c9c12c15	0.87	0.91	0.57	0.36
C18.2c12t10	0.09	0.07	0.10	0.14
SFA (%)	27.81	27.48	29.53	47.12
MUFA (%)	14.74	14.81	29.90	18.73
PUFA (%)	57.48	57.34	39.73	34.14
C18: 2 / C16: 0	5.26	5.34	1.82	1.80
PUFA/SFA	2.07	2.08	1.34	0.72
ω-6/ω-3	64.96	61.93	68.70	93.44

MO: *Mbuja* oil; DO: *Daddawa* oil; MS: Cooked almonds of *H. sabdarifa* seeds; DS: Cooked almonds of *P. biglobosa* seeds. SFA Saturated fatty acid; MUFA Monounsaturated fatty acid; PUFA: Polyunsaturated fatty acid.

Linoleic and palmitic acids are usually used as indicators of oil deterioration because of their sensitivity and stability to oxidation respectively, hence the importance of calculating the C18:2/C16:0 ratio. The results of this ratio show that DO (5.26) and MO (5.34) have the same values, reflecting the high susceptibility of these oils to oxidation [29]. As for the ω - 6/ω - 3 ratios, the values noted for all oils are higher than the norms (4 - 10) [30]. This results in the nutritional blocking of the beneficial effects of omega-3 fatty acids, manifested by cardiovascular disease, pain and inflammatory diseases.

4. Conclusion

Comparative analyses of bioactive compounds of *daddawa* and *mbuja* oils that can justify the used of both condiments in the treatment of chronic diseases has shown similar values in some physicochemical contents as Colour, acid index, iodine value, saponification value, crude phenolic compounds, tannin as well as SFA, MUFA, PUFA which were not different in both condiments. Based on this, *daddawa* and *mbuja* oils seem to be identic. This is the reason why, in traditional medicine, they are used one to the place of another to cure high blood pressure, diarrhoea, and cardiovascular diseases or are used as an antiseptic. For further analyses it will be important to check the effectiveness of this assertion by making comparative analyses of both oils on chronic diseases.

Abbreviations

MUFA: Mono-unsatured fatty acids;
PUFA: polyunsatured fatty acids;
SFA: Satured fatty acids;
Vit A: Vitamin A;
Vit E: Vitamin E;
CPC: Crude phenolic compounds.

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