International Food Research Journal 21(5): 1837-1841 (2014)
Journal homepage: http://www.ifrj.upm.edu.my

Influence of the storage time on the fats and oil composition of safou (*Dacryodes edulis*) dried pulp

[1*]Noumi, G. B., [2]Djounja, T., [2]Ngameni, E. and [3]Kapseu, C.

[1]*Department of Chemistry, Faculty of Science, University of Ngaoundere, P . O. Box 454 Ngaoundere, Cameroon*
[2]*Laboratory of Analytical Chemistry, Department of Inorganic Chemistry, Faculty of Science, University of Yaounde 1, P. O. Box 812, Yaounde, Cameroon*
[3]*Department of Process Engineering, National Advanced School of Agro-Industrial Sciences (ENSAI), University of Ngaoundere, P. O. Box 455 Ngaoundere, Cameroon*

Article history

Received: 30 August 2013
Received in revised form: 6 March 2014
Accepted: 10 March 2014

Keywords

Dacryodes edulis
Drying
Storage
Oil
Fatty acid
Composition

Abstract

Dacryodes edulis from Makenene (Centre region of Cameroon) were dried in an oven to a final water content of 5.36 %, then stored in polyethylene for 0, 2, 3, 4, 5, 6,7, 8, 9, 10, 11 and 12 months. The dried pulp of safou was then ground before extraction of lipids with hexane. The analysis of oil extract showed that the acid index varies from 4.52 and 10.12 mg KOH/g oil; while the iodine and saponification indexes vary respectively from 52.54 - 58.22 g iodine/100 g of oil, and 170.16 - 211.21 mg KOH/ g oil. The one phase gas chromatographic analysis indicated that the oils are composed of nine to eleven fatty acids with 45.53% saturated, 30.81% mono unsaturated and 23.59% poly unsaturated. In general, the storage of dried pulp in colourless polyethylene bags for 12 months did not significantly ($p > 0.05$) influence the chemical properties of the oil.

Introduction

Dacryodes edulis tree belongs to the *Burseraceae* family and is found in Africa where it is distributed from Ghana to Angola through Congo Brazzaville. In Cameroon, it is mostly found in the south and in the Adamawa plateau (Onana, 1998). The tree produces fruits commonly known as safou. The fruit pulp is generally eaten fresh or roasted. It is an important source of oil with a content of 50 % dry weight (Silou, 1991; Silou *et al.*, 1991; Kapseu *et al.*, 1999). Fruits are fragile and about one half of harvested fruits are lost due to softening and spoiling (Noumi *et al.*, 2006). From the literature, previous works on safou have been concentrated on its biology. Nga Ngatchou (1998) studied the stakes and perspectives of safou production in Central Africa and some constraints of its promotion. Youmbi and Benbadis (1998) studied the effect of callogenesis and rhizogenesis on the safou cotyledons cultivated *in vitro* and revealed its high capacity in rhizogenesis. Koumpo (1996) and Ali *et al.* (1998) studied the influence of the drying process on the physico-chemical properties of safou pulp and revealed its high content in lipids (33-62%). From their study on the production and characterization of safou oil in Cameroon, Kemmengne Kamdem *et al.* (1997) found that the composition in fatty acid was as followed: palmitic acid (41%), oleic acid (33%), and linoleic acid (22%). Silou *et al.* (1991) revealed that oil extracted from safou pulp was indicated for use in agro-nutritional and cosmetic industries. Considering the fragile character of fruits and the nutritive value of the derived oil, it is interesting to conduct research on its conservation of dried pulp in order to consider its further utilization as oil source. Hence, the aim of the present work was to follow the influence of the storage time of dried pulp within colourless polyethylene bags on the chemical composition of safou oil.

Material and Methods

Plant material

Safou fruits used in this work were sampled from Makenene farms, a town located in the centre region of Cameroon at 80 Km away in the north of Bafia. They were transported in net bags in the laboratory, cleaned, cut longitudinally with knife to separate the pulp from the kernel. The drying of pulp at residual water content of around 6% allowed its storage in high density colourless polyethylene bags for 12 months.

Drying of safou pulp and storage study

The safou pulp was dried in a Memmest Roucaire oven at 50°C, as this temperature have shown to avoid modification in its texture (crusting phenomenon) (Ali *et al.*, 1998). The safou dried at fairly identical

*Corresponding author.
Email: gnoumi@yahoo.fr

final water content were conditioned in polyethylene bags for 0, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 months in order to follow the influence of storage time on oil chemical composition.

Determination of the chemical characterization of safou pulp

The determination of the residual water content was done as described by Noumi (2003) and the determination of oil content was done as described by AFNOR (1981).

Determination of the chemical characteristics of oil

Oil was extracted using hexane in a soxhlet apparatus. Solvent was removed in a rotavapour. The acid, iodine and saponification indexes were determined according to the procedure described by AFNOR (1981) while the gas phase chromatography in capillary column allowed the determination of fatty acids composition of different samples. Fatty acids compositions were determined by capillary gas chromatography after transesterification. The methylic esters of fatty acids were determined by Adrian *et al.* (2004) method. The fatty acid methyl esters (FAME) were analysed on PerichromTM 2000 chromatograph equipped with a flame ionisation detector (FID). A capillary column Omegawax 320 (0.32 mm internal diameter, 30 m length and 0.25 µm film thicknesses) was used at a head column pressure of 10 psi. Helium at 25 mL s^{-1} was used as the gas carrier. The FID and injector temperatures were both maintained at 260°C. The injection mode was splitless, and 1 µL of samples was injected with a 10 µL loop. The initial oven temperature was 70°C and programmed to reach 210°C at 2°C min^{-1}. The oven was held at this temperature until the analysis was completed.

Statistic analysis

Data were statistically analyzed by ANOVA. Data were discriminated using the Ducan Multiple range test of the R stat program (2004).

Results and discussions

The values of some constituents of dried pulp are reported in Table 1. Water content was determined as it is the main key determining the essential evolution of the product during conservation. The water content obtained varied from 5.21 ± 0.06 to 5.98 ± 0.21% and was not significantly different between various conditioning times.

The extraction indicated that the pulp of safou was very rich in oil. The oil contents varied from 49.45 ± 0.59 and 51.79 ± 0.28% dry weight, and were not significantly different from one conditioning times to another. Compared to groundnuts (50%), soybean (15 – 25%), cotton seed (35 – 40%), maize (45 – 50%) (Karlesking and Wolff, 1992), safou is quantitatively very rich in oil.

Table 1. Changes in moisture and lipid content of safou dried pulp with storage time

Time (months)	Chemical composition	
	Water content (%)	Oil content (%)
0	5.36 ± 0.05	50.95 ± 1.57
2	5.50 ± 0.04	51.30 ± 1.76
3	5.62 ± 0.12	51.79 ± 0.28
4	5.44 ± 0.24	51.33 ± 2.39
5	5.58 ± 0.21	51.62 ± 0.79
6	5.48 ± 0.33	50.19 ± 0.49
7	5.98 ± 0.21	49.50 ± 1.22
8	5.41 ± 0.26	51.27 ± 1.86
9	5.60 ± 0.31	50.87 ± 2.16
10	5.32 ± 0.16	49.45 ± 0.59
11	5.21 ± 0.06	50.09 ± 1.06
12	5.36 ± 0.21	50.27 ± 1.16

Table 2. Changes in the safou oils indexes with storage time

Time (months)	Characteristics		
	Acid index (mg KOH/g oil)	Iodine index (g iodine/100 g of oil)	Saponification index (mg KOH/g oil)
0	4.58 ± 0.15^{a}	53.17 ± 0.08^{a}	211.21 ± 3.79^{b}
2	4.52 ± 0.09^{a}	52.57 ± 0.38^{a}	189.72 ± 2.31^{c}
3	4.63 ± 0.20^{a}	57.25 ± 0.50^{c}	199.26 ± 3.08^{c}
4	5.48 ± 0.13^{b}	54.65 ± 0.19^{b}	197.70 ± 3.39^{c}
5	5.95 ± 0.16^{b}	53.87 ± 0.27^{ab}	170.16 ± 0.81^{a}
6	7.88 ± 0.04^{c}	54.90 ± 0.17^{b}	190.70 ± 1.97^{b}
7	9.97 ± 0.21^{d}	58.22 ± 0.53^{c}	187.55 ± 0.79^{b}
8	8.98 ± 0.07^{d}	54.25 ± 0.15^{b}	200.36 ± 1.29^{c}
9	9.51 ± 0.10^{d}	52.54 ± 0.23^{a}	186.22 ± 2.07^{b}
10	9.87 ± 0.20^{d}	58.05 ± 0.34^{c}	207.05 ± 2.58^{b}
11	10.12 ± 0.08^{d}	53.61 ± 0.32^{ab}	171.28 ± 1.04^{a}
12	9.96 ± 0.16^{d}	57.28 ± 0.61^{c}	192.50 ± 0.96^{b}

Values in the same line followed by the same letter in subscript are not significantly different at 5% level of significance.

Table 2 indicates the characteristics of the oils as affected by storage time. Acid index is measured to quantify the free fatty acid present in oil. Their presence constitutes an alteration factor of oil (Adrian *et al.*, 1998). The analysis of variance at 5% level of significance showed that oil samples obtained after 0, 2, 3 months possessed similar acid index. This was equally observed for samples at 4 and 5 months, in one hand, and 7, 8, 9, 10, 11 and 12 months on other hand. The values of acid index obtained from extracted oil samples after 0, 2, 3, 4 and 5 months were similar to those of maize oil (I_a = 5 mg KOH/g oil) and Canarium oil ($4.13 \leq I_a \leq 6.93$) mg KOH/g oil, but were lower than that of Cameroonian palm oil ($9.4 \leq I_a \leq 12.4$) mg KOH/g oil (Karlesking and Wolff, 1992, Kapseu *et al.*, 1998), and Shea butter ($7.86 \leq I_a \leq 19.51$) mg KOH/g oil (Aboubakar *et al.*, 2009). The increase of acid index with storage time is explains by the increasing of oxidative degradation of oil.

Iodine index was determined in this study in order to follow the degree of unsaturated fatty matter during storage of dried pulp. The iodine index values varied from 52.54 ± 0.23 g iodine/100 g of oil (9 months) to 58.22 ± 0.53 g iodine/100 g of oil (7 months). The analysis of variance at 5% level of significance indicated that samples obtained after 0, 2, 5, 9, 11; 4, 5, 6, 7, 11 months; 3, 7, 10, 12 months of storage were similar. The iodine index obtained were lower than those of oils currently used such as soybean (125 - 138 g iodine/100 g of lipid); cotton oil (102 - 115 g iodine/100 g of lipid); groundnuts (80 - 106 g iodine/100 g of lipid); olivine (75 - 94 g iodine/100g of lipid). Safou oil has very little unsaturation in the

Table 3: Influence of storage time on the composition of safou fatty acids

Fatty acids	Samples (months)										
	0	2	3	4	5	6	7	8	9	10	11	12
Satured	46.44 ±0.18^{cd}	46.05 ±0.03^{cd}	46.93 ±0.32^{d}	46.34 ±0.28^{cd}	43.13 ±0.49^{a}	44.54 ±0.18^{ab}	45.51 ±0.54^{bc}	45.11 ±0.17^{bc}	46.10 ±0.22^{cd}	44.37 ±0.17^{ab}	46.31 ±0.21^{cd}	45.54 ±0.48^{bc}
C12:0	-	-	0.10	0.11	0.10	0.11	0.32	0.26	0.30	0.29	0.31	0.29
C14:0	0.19	0.13	0.15	0.16	0.13	0.14	0.14	0.17	0.15	0.13	0.14	0.13
C16:0	43.74	43.37	44.54	43.99	40.67	41.97	42.92	42.58	43.25	41.76	43.78	42.78
C17:0	0.18	0.15	0.08	0.07	0.14	0.15	0.09	0.10	0.06	0.12	0.09	0.13
C18:0	2.21	2.29	2.07	2.03	1.97	2.07	2.06	2.00	2.24	2.07	1.99	2.10
C20:0	0.13	0.11	-	-	0.13	0.11	-	-	0.10	-	-	0.11
Mono unsatured	29.59 ±0.03^{a}	29.69 ±0.30^{a}	29.01 ±0.93^{a}	30.71 ±0.73^{ab}	34.02 ±0.28^{b}	32.20 ±0.31^{b}	30.56 ±0.59^{ab}	29.06 ±0.61^{a}	31.41 ±0.07^{b}	30.26 ±0.75^{ab}	32.35 ±0.09^{b}	30.89 ±0.54^{ab}
C16:1	0.16	0.16	0.09	0.11	0.26	0.20	0.16	0.17	0.21	0.08	0.12	0.11
C18:1	29.43	29.54	28.92	30.61	33.66	31.91	30.40	28.89	31.20	30.18	32.16	30.78
C20:1	-	-	-	-	0.11	0.09	-	-	-	-	0.07	-
Poly unsatured	23.99 ±0.17^{a}	24.25 ±0.34^{a}	24.02 ±0.68^{a}	23.59 ±0.11^{a}	22.63 ±0.83^{a}	23.27 ±0.31^{a}	23.94 ±0.24^{a}	22.60 ±0.71^{a}	23.28 ±0.18^{a}	23.62 ±0.15^{a}	24.28 ±0.19^{a}	23.59 ±0.70^{a}
C18:2	22.62	22.93	22.68	22.28	21.35	22.01	22.65	21.34	21.97	22.34	22.98	22.25
C18:3	1.37	1.33	1.34	1.31	1.29	1.27	1.30	1.26	1.31	1.28	1.30	1.34
C18:2/C16:0	0.52 ±0.01^{a}	0.53 ±0.01^{a}	0.51 ±0.01^{a}	0.51 ±0.01^{a}	0.53 ±0.03^{a}	0.53 ±0.02^{a}	0.53 ±0.01^{a}	0.50 ±0.01^{a}	0.51 ±0.01^{a}	0.53 ±0.02^{a}	0.52 ±0.02^{a}	0.52 ±0.01^{a}

Values in the same line followed by the same letter in subscript are not significantly different at 5% level of significance.

carbon chain than oils currently used. It was; however, lower than the values reported by Noumi (2003) for Canarium oil ($102.77 \leq I_i \leq 118.16$) g iodine/100 g of lipid, a non conventional oil crop like *Dacryodes edulis*.

The determination of saponification index consists of transforming the soluble soaps (sodic or potassic soap), thus the whole of fatty acid present into esterified state in a fatty matter and regenerating glycerol (Adrian *et al*., 2004). The saponification index varied from 170.16 ± 0.81 to 211.21 ± 3.78 mg KOH/g oil for the oils obtained at 5 and zero months of storage of dried pulp, respectively. The analysis of variance at 5% level of significance indicated that samples obtained after 0, 6, 7, 9, 10, 12; 2, 3, 4, 8 months; 5, 11 months of storage were similar. From this analysis, the storage of dried pulp in polyethylene did not significantly modify the saponification index of oil. These values of saponification index of safou pulp oils are comparable to those of oil currently used in food diet: Soybean (188 - 195); cotton oil (188 - 190); olivine (184 -196); groundnuts oil (187-196) (Karlesking and Wollf, 1992). These values are similar to those obtained by Noumi (2003) for Canarium oil ($178.41 \leq I_s \leq 206.21$) mg KOH/g oil.

Fatty acids are a class of lipid composed of carbon, hydrogen and oxygen. These acids are characterized by their hydrophobic and solubility in organic solvents. They play a double role in organism: an energetic storage role in human, a specific structural role in the constitution of cell wall lipids (Boulanger *et al*., 1989). The nutritional value of fatty acid depends on its biochemical properties resulting from its chemical nature (Noumi *et al*., 2002; Noumi *et al*., 2011; Pengou *et al*., 2013). The fatty acids composition of safou pulp is presented in table 3. The table indicated that the oils samples presented most of the common fatty acids usually observed in oils used for human nutrition. In this respect, palmitic acid (C16:0), Oleic acid (C18:1) and linoleic acid (C18:2) are the major components of samples, whereas palmitic acid with a level of 94.32% was the most represented saturated fatty acid (SFA). For all samples, oleic acid represents 99.44% of mono unsaturated fatty acids (MUFA.), and linoleic acid 94.47% of poly unsaturated fatty acids (PUFA.).

The analysis of variance at 5% level significance showed that the saturated fatty acids compositions of extracted oils at 0, 2, 4 , 7, 9 and 11 months after storage were similar to those at 6, 7, 8, 10 and 12 months, and 0, 2, 3, 4 months. As far as mono unsaturated fatty acids were concerned, oils obtained at 0, 2, 3, 4, 7, 8 and 12 months after storage of dried pulp on one hand, and those at 4, 5, 6, 7, 9, 11 and 12 months on the other were similar. About poly unsatured fatty acids, oils were identical irrespective of the storage time of dried pulp. Globally, the fatty acids were similar from one storage time of dried pulp to another. From table 3, the average composition of our oil samples was 45.53 ± 0.27% for saturated fatty acids, 30.81 ± 0.44% for mono unsaturated and 23.59 ± 0.02% for poly unsaturated fatty acids. Canarium oil was reported to contain 37.98% saturated fatty acids, 33.82% of mono unsaturated fatty acids and 28.65% of poly unsaturated fatty acids (Noumi *et al*., 2003); that is similar to safou, which is a non conventional oil crop like Canarium. Compared to Cameroonian palm oil composed of 48.10% saturated fatty acid, 41.10% mono unsaturated fatty acid and 10.80% poly unsaturated fatty acid (Kapseu *et al*., 1998), and which is used in cooking, safou oil could be indicated for nutritional purpose. From the literature, saturated fatty acid indirectly participates to the increment of the cholesterol rate in blood, leading to cardiovascular diseases and cerebral alteration, while unsaturated acids decrease the rate of bad cholesterol blood; they are important growth factors of lipidic tissues and the central nervous system when synthesis in the membrane is intense, as well as to the maintenance of the integrity of tissues.

Compared to olive oils (16.79% of SFA. ; 68.33% of MUFA.; 14.41% of PUFA.), maize oil (13.06% of SFA ; 25.58% of MUFA; 66.27% of PUFA), soybean oil (14.94% of SFA; 23.04% of MUFA; 64.74% of PUFA) (Dzondo *et al.*, 2005) and cotton oil (28.21% of SFA ; 19.93% of MUFA ; 51.86% of PUFA) (Prior, 2003), safou oil have a low nutritive value. In fact, according to the nutritionists, oils used for human nutrition may have equivalent proportion of SFA, MUFA and PUFA. Linoleic and palmitic acids are generally indicated as measurement and degradation indicators of oils. Linoleic acid is more sensible to oxidation, while palmitic acid is more stable. Thus the linoleic / palmitic acid ratio was used as indicator of the degree of degradation by oxidation of oil. In this study, this ratio varied from 0.50 ± 0.01 for a storage time of 8 months of dried pulp to 0.53 ± 0.03 for a storage time of dried pulp of 5 months. The analysis of variance at 5% level significance indicates that the linoleic / palmitic acid ratios were identical; whatever was the storage time of the dried pulp before oil extraction. Consequently, there was no oxidative degradation of the oil after 12 months of storage of dried pulp in polyethylene bags to a final water content of 6%.

Conclusion

The chemical characteristics of safou revealed a water and oil contents of respectively 5.21 – 5.98% and 49.45 – 50.95%, 12 months after storage of pulp polyethylene. This oil content allows the classification of safou fruit among the potential oleaginous for oil production. The acid, iodine and saponification index of the oil varied respectively from 4.52 ± 0.09 to 10.12 ± 0.08 mg KOH/g oil; 52.54 ± 0.23 to 58.22 ± 0.53 g iodine/100 g of oil; and 170.16 ± 0.81 to 211.21 ± 3.79 mg KOH/g oil. The analysis of methylic esters indicated 45.53 ± 0.27% saturated fatty acids, 30.81 ± 0.44% mono unsaturated fatty acids and 23.59 ± 0.02% poly unsaturated fatty acids. The analysis of variance at 5% level significance showed that globally, the storage of dried pulp in polyethylene for about 12 months did not influence significantly the chemical characteristics of the studied oil. There was no oxidative degradation of oil after 12 months storage of dried pulp to a final water content of 6%.

References

Aboubakar Dandjouma, A. K., Adjia, H. Z., Kameni, A. and Tchiégang, C. 2009. Procédés traditionnels de production et circuit de commercialisation du beurre de karité au Nord-Cameroun. Tropicultura 27 (1) : 3-7.

Adrian, J., Potus, J., Poiffet, A. and Dauvillier, P. 1998. Introduction à l'analyse nutritionnelle des denrées alimentaires. Tec-doc. Paris, France.

AFNOR (Association Française de Normalisation) 1981. Recueil des normes françaises. Corps gras, graines oléagineuses, produits dérivés. 2ème édition. Paris, France.

Ali, A., Kemmegne Kamdem, A. T., Koumpo, L. B. and Mbende Njoch, D. 1998. Etude comparative du séchage de la pulpe du safou au séchoir électrique à convection et au séchoir solaire indirect. 2ème séminaire international sur la valorisation du safoutier et autres oléagineux non conventionnels. Presses universitaires de Yaoundé , Cameroun.

Boulanger, P., Polonovki, J., Biserte, G. and Doutreaux, M. 1989. Biochimie médicale 1. Les constituants des organismes vivants. 2ème édition. Masson Paris, France.

Dzondo, G. M., Nzikou, J. M., Matouba, E., Etoumongo, A., Linder, M. and Desobry, S. 2005. Characterisation and nutritionnal interet of safou pulp oil. Process Biochemistry 40: 307-312.

Kapseu, C., Mapongmetsem, P. M., Silou, T. and Roques, M., 1999. Physico-chimie des fruits du safoutier (*Dacryodes edulis*) camerounais. Tropicultura 17(1) : 37-42.

Kapseu, C., Nketcha, P. R., Bornaz, S., Parmentier, M. and Dirand, M., 1998. Influence des conditions locales de production et de stockage sur les propriétés de l'huile de palme et ses fractions. La Rivista Italiana Delle Sostanze Grasse 75 : 29-34.

Karlesking, A. and Wollf, J. P., 1992. Manuel des corps gras. Tome 1.

Kemmegne Kamdem, A. T., Ali, A., Tchiégang, C. and Kapseu, C. 1997. Problématique de la production de l'huile de safou au Cameroun. Fruits 52 : 325-330.

Koumpo, L. B. 1996. Etude de l'influence du séchage sur quelques propriétés physico- chimiques et nutritionnelles de la pulpe de safou (Dacryodes edulis H. J. Lam), Mémoire de Diplômes d'Etudes Approfondies (D.E.A) en science alimentaires et nutrition. ENSAI, Université de Ngaoundéré, Cameroun.

Logiciel statistique R., version 1.80 (2004).

Noumi, G., B. 2003. Contribution à l'étude physico-chimique des fruits du Canarium schweinfurthii Engl : cinétique de déshydratation, composition chimique de la pulpe, analyse de l'huile extraite. Thèse de Doctorat/Ph.D., chimie analytique, Université de Yaoundé I, Cameroun.

Noumi, G. B., Aboubakar Dandjouma, A. K., Kapseu, C. and Parmentier, M. 2006. Le savoir faire local dans la valorisation des fruits du safoutier (*Dacryodes edulis* (G. Don) H. J. Lam) du Cameroun. Tropicultura 24(1) : 58-62.

Noumi, G. B., Ngameni, E., Kapseu, C. and Broto, F. 2003. Isothermes de désorption de l'eau sur les pulpes des fruits de l'aiélé (*Canarium schweinfurthii* Engl). Sciences des Aliments 23 : 264 – 272.

Noumi, G. B., Ngameni, E., Kapseu, C. and Parmentier, M. 2002. Variation de la composition en acides gras et en triglycérides de l'huile des fruits de l'aiélé en fonction des conditions d'extraction et de la couleur du fruit. La Rivista Italiana Delle Sostanze Grasse 79 : 315-318.

Noumi, G. B., Njiné, C. B., Pengou, M. S. and Ngameni, E. 2011. Physicochemical analysis of the Cameroonian

Allanblackia Floribunda Oliver seeds oil extract. La Rivista Italiana Delle Sostanze Grasse 83: 38 – 45.

Nya Ngatchou, J. 1998. Enjeux et perspectives de la production du safou en Afrique Centrale. 2ème séminaire international sur la valorisation du safoutier et autres oléagineux non conventionnels. Presses universitaires de Yaoundé, Cameroun.

Onana, J. M. 1998. Les Burséracées du Cameroun : taxonomie, biométrie folière et biologie. Thèse de Doctorat de 3eme cycle en biologie et physiologie végétale. Université de Yaoundé I, Cameroun.

Pengou, M., Noumi, G. B. and Ngameni, E. 2013. Fatty acid composition and some physicochemical properties of oils from Allanblackia gabonensis and Allanblackia stanerana kernels, Journal of the American Oil Chemists' Society 90(1): 27 – 32.

Prior, E. 2003. Usage des corps gras alimentaires dans les différents secteurs de la technologie alimentaire. In : Lipides et corps gras alimentaires. Tec-doc. Lavoisier. Paris, France.

Silou, T. 1991. Détermination de la teneur en huile de la pulpe de safou (*Dacryodes edulis*) par refractométrie. Fruits 46 (1) : 261-266.

Silou, T., Manioqui, J. G., Boungou, P. and Ouamba, J. M. 1991. Etude du séchage de la pulpe du safou : résultats préliminaires. Tropicultura 9(2) : 61-69.

Youmbi, E. and Benbadis, A. 1998. Collogène et Rhizogenèse sur les cotylédons de *Dacryodes edulis* (Don Lam) cultivés in vitro. 2ème séminaire international sur la valorisation du safoutier et autres oléagineux non conventionnels. Presses Universitaires de Yaoundé, Cameroun.