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Study of the Optimal Conditions for the Production of Oil from *Canarium schweinfurthii* Engl. Fruits Pulp by Pressing

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Abstract: Conditions for the production of *Canarium schweinfurthii* Engl. fruits pulp oil by pressing were studied. The extraction process proposed includes : washing, softening and depulping of fruits, pulp heating and oil extraction by pressing. Prior to pressing, the pulp was heated at various temperatures (60, 70 and 80 C) for 30, 45 and 60 minutes. The oil extraction rate and the oil physico - chemical quality were evaluated. The results showed a significant influence ($P<0.05$) of the process on various responses measured. However, the different oil quality parameters (acid, peroxide values and extinction coefficient at 232 nm) remained within the limits for virgin oils. Heating of the fruit pulp at 80 °C for 60 min gave the best oil extraction rate (53,3%). Mathematical models were developed to predict the responses.

Key words: *Canarium schweinfurthii* engl., pressing, oil, quality, modelisation

Introduction

Canarium schweinfurthii Engl. (Burseraceae) is a tall tree growing wild in african humid forests (Mbida Mindzie, 2000). It is widespread in sub-Saharian Africa from the west (Sierra Leone) to the east and the south of Angola (Mbida Mindzie, 2000; Aubreville, 1959 and Vivien and Faure, 1986). This tree produces black fruits similar in appearance to olives and usually called *aiele* or african olives (Fonteh, 1998). This tree is a very important multiple purpose tree specie for the populations of its growing area (Njoukam, 1998).

Scientific works done on this plant cover a large scale, ranging from agroforestry to physico-chemistry and conservation. In the food science and technology field, studies so far done are: production and physico-chemical analysis of the oil, chemical analysis of the pulp, fruits conservation and drying, softening of fresh fruits (Agbo *et al.*, 1992; Agbo and Chatigre Kouame, 1996; Kapseu *et al.*, 1996; Kapseu and Parmentier, 1997; Ajiwe *et al.*, 1998;Ajiwe *et al.*, 2000; Eromosele *et al.*, 1998;Tchiégang *et al.*, 1998;Tchiégang *et al.*, 2000;Tchiégang *et al.*, 2001;Tchiégang *et al.*, 2002;Jiokap Nono and Kapseu, 1999 and Kapseu *et al.*, 1999).

Aiele fruits contain 31-40 % oil that has a great content of linoleic fatty acid (Agbo *et al.*, 1992 and Kapseu *et al.*, 1996). One of the great problems of the *aiele* fruits pulp is the hardening process that makes it improper for direct consumption. Furthermore, during the production period, a large amount is lost by softening and hardening of the pulp, leading to high post-harvest losses (Jiokap Nono and Kapseu, 1999). Due to its high oil content, *aiele* fruit appears as a promising source of new vegetable oil and it is therefore judicious to bring out a simple technology in order to valorise the aiele fruits.

This study, which falls under the scope of the valorisation of non-conventional oil crops, consists on studying the oil production by pressing the *aiele* fruits pulp. Specifically, the response surface methodology will be used for the optimisation and modelling of the process.

Materials and Methods

Sampling: Fresh *aiele* fruits were collected in Babadjou, a village of the West-Cameroon, and transported in netted sacks within two days in the laboratory in Ngaoundere. In the laboratory, fruits were sorted to discard damaged and rotten ones, washed and treated for the extraction, according to the scheme of Fig. 1.

Procedures: The washed fruits were soaked in warm water at 45°C for 40 min to soften the pulp (Tchiégang *et al.*, 2001) and the pits were removed by hand. The pulp, nearly 0.25 cm thick was then vapour heated at different temperatures (60, 70, 80°C) for various durations (30, 45, 60 min). Nearly 500 g of the heated pulp were put in a white cotton sack and introduced in the extraction component of the manual screw press (MC AUF 2000) and pressing was carried out as described by GATE (1979) and Aboubakar Dandjouma (2000). The characteristics of this press have been reported in a previous work (Tchiegang *et al.*, 2003). The oil and water mixture obtained was separated by decantation and the oil was oven dried at 80°C for 24 hrs.

The extraction efficiency or extraction rate was calculated according to Wiemer and Altes (1993), Tchiégang *et al.* (2003), after the determination of the fresh (untreated) pulp total oil content by hexane extraction method.

Chemical Analysis: The oil extracted in different conditions was analysed for its acid, peroxide, iodine and refractive values as well as for its ultraviolet (UV) characteristics by measuring the absorbance at 232 and 270 nm (AFNOR, 1981 and AOCS, 1993). Results obtained were compared to CODEX standard values for food oils (CODEX, 1999 and CODEX, 1989).

Experimental design and statistical analysis

The modelling of the oil extraction process was carried out using a factorial design (Sado and Sado, 1991 and STATGRAPHICS, 1997). The process variables were temperature (T) and heating duration (D). The relation between the process variables (T, D) and the response factors (Y) (extraction rate and physico-chemical characteristics of the oil) was expressed using a second order polynomial equation $Y = a_0 + a_1t + a_2d + a_3t^2 + a_4dt + a_5d^2$ (with t and d : reduced temperature and duration, $t = 0.1\ T - 8$, $d = 0.066\ D - 3$). The process variables coded and uncoded values are shown in (Table 1).

The results obtained were statistically analysed by the analysis of variance to show the influence of the process variables on the measured responses, the multiple regression analysis and the response surface methodology were used to develop mathematical models and to represent the results. Statgraphics 3.0 Plus (STATGRAPHICS, 1997) and Statistica (STATSOFT, 1995) softwares were used for that purpose. The retained models were those showing a regression coefficient (R^2) higher than 0.75 (Henika, 1982).

Results and Discussion

Pulp Water Content: After softening and depulping, the pulp was vapour heated at different temperatures for various durations. The water content was then measured and the results obtained are shown on Fig. 2. During the heating process the aiele pulp absorbed water to reach a maximum value of 60 %. The analysis of variance showed a significant influence ($P<0.05$) of both process variables on the pulp water content with a non significative ($P>0.05$) interaction between the variables (Table 2). The mathematical model proposed according to its high regression coefficient ($R^2 = 0.98$) is suit to simulate the experimental phenomenon.

Table 1: Coded and uncoded values of the variables for the modelling of *C. schweinfurthii* pulp oil production

Variable level	D (Duration in min)	T (Temperature in °C)
- 1	30	60
0	45	70
+ 1	60	80

Table 2: Coefficients of the proposed mathematical model ($Y = a_0 + a_1t + a_2d + a_3t^2 + a_4dt + a_5d^2$) for water content (g/100g), extraction rate (%) and chemical characteristics of *C. schweinfurthii* fruits pulp oil

Variables	Water content	Extraction rate	Acid value	Peroxide value
a_1	3.037 (0.000)	10.062 (0.000)	0.450 (0.000)	3.680 (0.000)
a_2	1.285 (0.000)	3.969 (0.000)	1.180 (0.000)	2.959 (0.003)
a_3	-0.530 (0.000)	0.330 (0.396)	-0.048 (0.404)	1.215 (0.422)
a_4	-0.012 (0.887)	1.055 (0.001)	0.121 (0.009)	1.700 (0.146)
a_5	-0.481 (0.000)	2.069 (0.000)	-0.050 (0.943)	1.250 (0.409)
a_0	56.416	34.750	1.980	6.405
R^2	0.98	0.98	0.97	0.84

(   ) : p .values

Table 3: Iodine value of the *C. schweinfurthii* fruits pulp oil

	Temperature (°C)		
Duration (min)	60	70	80
30	104.49±0.60	104.72±0.38	104.60±0.54
45	105.19±0.39	104.87±0.42	104.65±0.42
60	104.16±0.36	104.24±0.34	104.94±1.03

Table 4: Refractive value of the *C. schweinfurthii* fruits pulp oil

	Temperature (°C)		
Duration (min)	60	70	80
30	1.4651 ± 0.0001	1.4649 ± 0.0001	1.4648 ± 0.0001
45	1.4653 ± 0.0001	1.4649 ± 0.0001	1.4643 ± 0.0003
60	1.4650 ± 0.0001	1.4651 ± 0.0001	1.4649 ± 0.0001

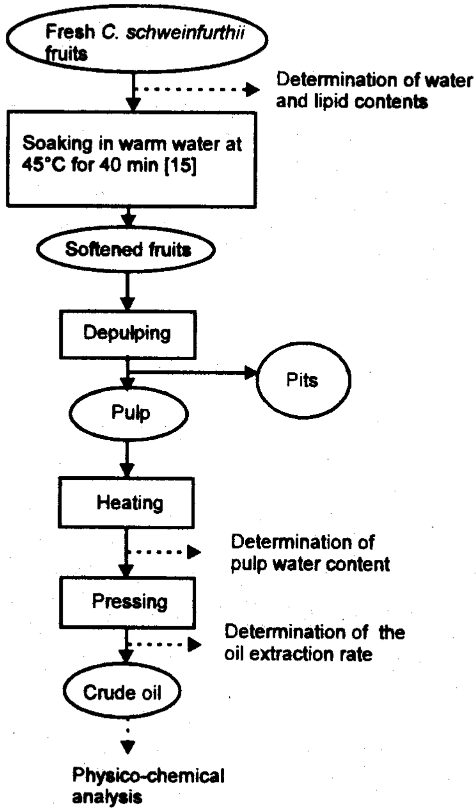

Fig.1: Flowsheet of the oil extraction procedure

Oil Extraction Rate: The oil extraction rate increased with temperature and heating duration (Fig. 3). These variables had a significative influence (P< 0.05) on the extraction rate (Table 2). The highest value recorded was 53.3%, eventhough acceptable, this value can be improved by using a hydraulic press which releases a much pressure. Enzymatic hydrolysis of the pulp can also be used. The pasty texture of the pulp reduced the extraction rate and this phenomenon could be avoided by the addition of cotton or coffee husk to the pulp prior to pressing. The mathematical model proposed has a regression coefficient higher than 0.75 and can suitably be used to predict the oil extraction rate.

Influence of the Extraction Process on Oil Quality: The extraction technology could have a great influence on the quality of the oil obtained (Orthoeffer, 1996 and Koné, 1998). In this way some oil quality parameters were analysed in order to bring out the best pulp treatment conditions prior to pressing.

Acid value: The evolution of the oil acid value in relation with the process variables is shown on Fig. 4.
The acid value of the oil increased with both temperature and heating duration to reach a maximum of 3.5 mg KOH g^{-1} of oil whereas the oil extracted from fresh (untreated) pulp showed a 0.40 ± 0.02 acid value. The acid value increase shows the acidification of the oil due to hydrolysis of triglycerides under the combined action of water and heat. Nevertheless the highest value recorded is less than 4 mg KOH/g of oil, the limit recommended for virgin food oils (CODEX, 1999). According to this quality parameter, the technology used is suitable.

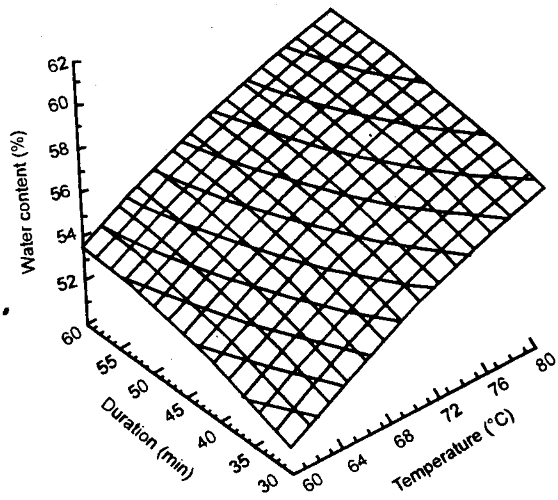

Fig.2: Evolution of the aiele pulp water content with process variables

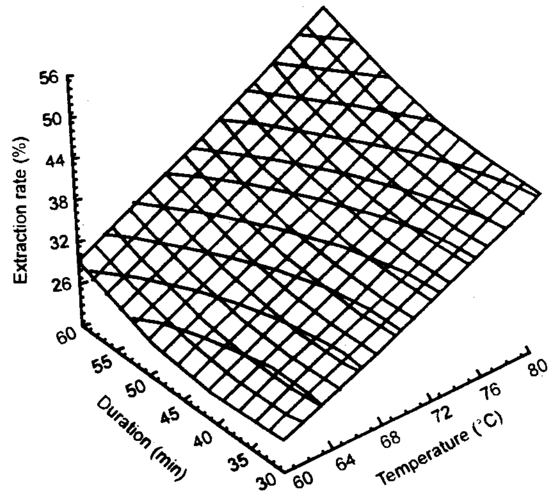

Fig.3: Response surface plot showing the evolution of aiele pulp oil extraction rate

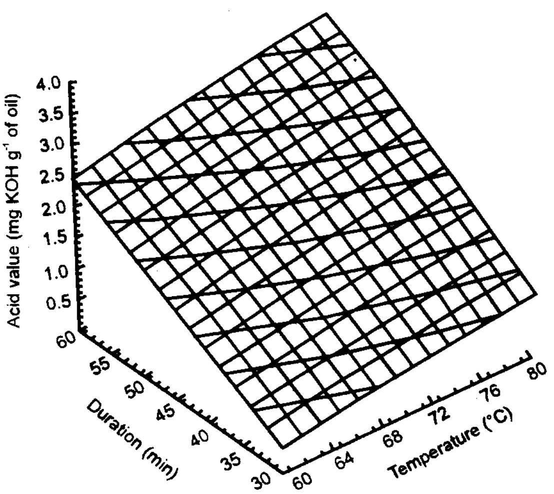

Fig.4: Evolution of aiele pulp oil acid value

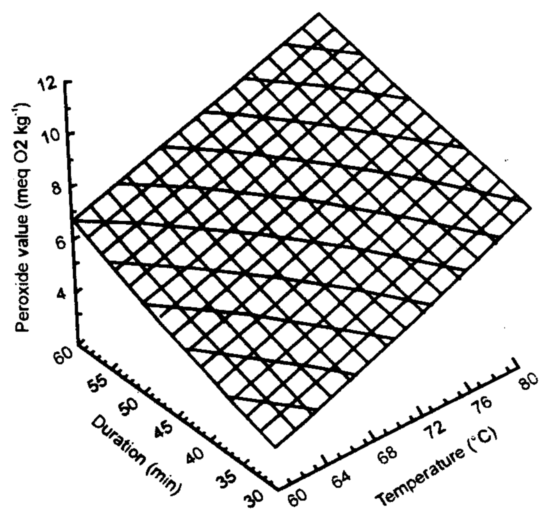

Fig.5: Response surface plot of the peroxide value of aiele pulp oil

Peroxide Value: Peroxide is a major oil quality parameter. In fact rancidity, the principal cause of oil deterioration is due to oxidation, hydroperoxides being the first components formed. The evolution of the oil peroxide value with temperature and heating duration is shown on figure 5. As for the acid value, the peroxide value increased with temperature and heating duration. The maximum value observed was 11.5 meq O_2 kg^{-1} of oil and the oil extracted from untreated pulp had a peroxide value of 3.08 ± 0.04 meq O_2 kg^{-1} of oil. Though the significant influence ($P<0.05$) of the process variables on the responses observed (Table 2), the highest value obtained was less than 15 meq O_2 kg^{-1} the maximum value accepted for virgin food oils (CODEX, 1999). The mathematical model proposed, with a 0.84 regression coefficient can be retained as suitable to predict the experimental results.

Iodine and Refractive Values: The results on iodine and refractive values of the oils are shown on Tables 3 and 4 respectively.
Whatever the temperature and heating duration, the iodine value of the oil is not affected. In fact, no significant influence ($P<0.05$) was revealed by the analysis of variance. Hence, within the heating conditions applied on this

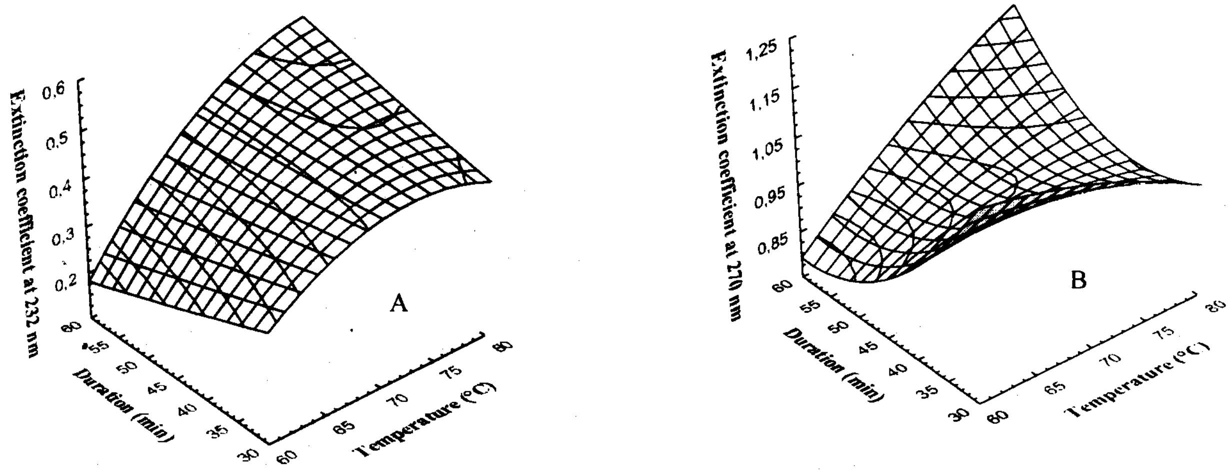

Fig.6: Evolution of the extinction coefficient of the aiele fruit oil at 232 nm (A) and 270 nm (B)

study, the proposed technology does not affect the double bonds of the aiele pulp oil fatty acids. The observation is the same for the refractive value of the oil, which is not significantly ($P>0.05$) affected by the processing conditions.

Extinction Coefficient in Ultraviolet: Extinction coefficient in ultraviolet light at 232 and 270 nm is an important indicator of the quality of food oils (COI, 1980). In fact, the oxidation of linoleic and linolenic fatty acids yields hydroperoxides, conjugated dienes and oxidised fatty acids, which show a maximum absorption in ultraviolet at 232 nm, whereas other secondary oxidation products have a maximum absorption at 270 nm (AFNOR, 1981). Fig. 6 shows the extinction coefficient values at 232 nm (A) and 270 nm (B) of the *aiele* pulp oil with the treatment variables. The extinction coefficient in 232 nm increased with temperature and heating duration, to reach a maximum of 0.55. At 270 nm, the evolution is not regular and the maximum value observed was 1.13. The increase in both cases shows an accumulation of oxidation products.
Nevertheless, the highest value observed at 232 nm far less from 3.5, the maximum value admitted for virgin olive oil (CODEX, 1989). At 270 nm contrarily, all the values observed are higher than 0.30, the limit for virgin olive oil (CODEX, 1989). The fruit pulp heating conditions showed a significant influence ($P<0.05$) on the UV characteristics of the oil.

Conclusion

The processing conditions (heating temperature and duration) of the aiele fruit pulp prior to oil extraction by pressing greatly influenced ($P<0.05$) both the oil extraction efficiency and quality. Apart from iodine and refractive values that remained constants, all the other oil quality parameters: acid and peroxide values, UV characteristics as well as the pulp water content and the oil extraction rate were influenced. Nevertheless, in the scope of experimental design, the oil quality parameters remained within limits admitted for virgin food oils. Hence, the technology applied is acceptable. The heating of the pulp at 80°C for 60 min yielded the maximum oil extraction rate: 53 %. This value can be improved to better valorise the activity. The production of aiele fruits oil by pressing is therefore a simple process which appears as a solution to the reduction of post-harvest losses.

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