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Manufacture and Physicochemical Characterization of Safou (*Dacryodes Edulis*) Pulp-based Chips in Congo-Brazzaville

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Abstract :- The aim of this work is to manufacture a snack product based on local products, including the pulp of safou. The saffron was precooked in hot water to extract the pulp. The pulp obtained was mixed with other ingredients to obtain a batter. Three (03) types of pastes were obtained: a simple or plain paste (containing no ingredients), a salted paste and a sweet paste. The doughs were fried at 150 (plain chips), 160 (salted chips) and 170 °C (sweet chips) to give plain chips, salted chips and sweet chips. The biochemical composition of the chips showed protein contents ranging from 5.85±0.15 and 7.42±0.12% for the salted and plain chips respectively. The lipid content varied between 65.51±0.29 and 69.32±0.30% for salted and plain chips respectively. The chips obtained are rich in minerals with Ca and P contents of 64.04 and 70.37 mg for salted chips and 31.86 and 45.78 mg for sweet chips, respectively.

Keywords:- *Nutritional value, fried, pulp, mineral salts, chips.*

I. INTRODUCTION

According to the FAO, Africa has 60% of the world's uncultivated land. This makes it dependent on imports [1]. For in 2020, according to UNCTAD, nearly 80% ($ 60.5 billion) of the food commodities consumed by African countries came from outside the continent. During this time, the African continent has many forest resources. In this wealth, NTFPs (non-timber forest products) represented by several species, capable of preserving and improving the food level of the most fragile rural and urban populations, are in a good place [2]. Sub-Saharan Africa has 312 million hectares of cultivable land. Congo-Brazzaville alone has an area of 10 million hectares [3]. Among the crops grown is the safflower (*Dacryodes edulis*), which produces fruits called safou.

The safflower (*Dacryodes edulis*) belongs to the family of the Burseraceae [4]. It is a forest tree that has several therapeutic properties. Its fruit, called safflower, has a nutritious pulp that contains 40 to 65% lipids [5] and 10 to 30% protein [6].

After each harvest season, a large quantity of safflower fruit is discarded due to softening because of the lack of means of conservation, processing and marketing [7]. The existing techniques are much more oriented towards the extraction of the safflower oil and the transformation of the pulp into paste [8]. The transformation of safflower into chips becomes an alternative to ensure the permanent availability of safflower-based products during the periods when safflower is not produced, to fight against post-harvest losses and to add value to the fruits of the safflower tree.

Potato chips, also known as potato chips in Canada, are thin vegetable slices fried in oil, which makes them crunchy. They are made of potatoes, but can also be made of vegetables (cassava, sweet potato, beet, kale etc.) or fruits (apple, banana, durian, etc.) [9].

This study consists in the development of a manufacturing process of a snack product, in particular the chips from the pulp of safou. Thus this work is divided into four (04) parts namely: introduction, material and method, results and discussion and finally the conclusion.

II. MATERIALS AND METHODS

A. *Plant material*

The experimental material is mainly made up of safous purchased in Makoua in the Cuvette Department.

- *Experimental protocol*

  Extraction of the safou pulp and formulation of the batter

The extraction of the pulp of safou and the formulation of the paste to be fried it makes according to the diagrams presented in figure 1 below:

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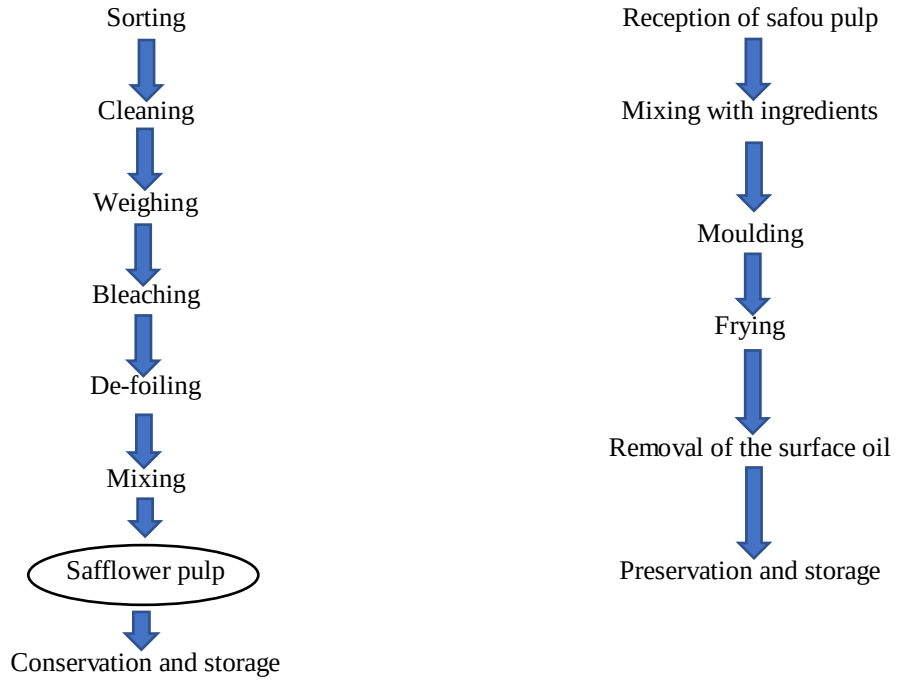


Fig. 1: Chip manufacturing diagram

➢ *Formulation :*
For the preparation of safflower paste, the formula presented in Table I was used :

Table 1: composition of the mixture of safflower paste

Ingrédients / **Nature of the product**	**Safflower pulp (g)**	**Salt (g)**	**Sugar (g)**
Plain potato chips	100	-	-
Salted potato chips	100	2.5	-
Sweet potato chips	100	-	2.5

Three types of chips were made : plain chips (without salt and sugar) cooked at 150 °C, salty chips cooked at 160 °C and sweet chips cooked at 170 °C.

B. Physico-chemical analysis

➢ *Water content [10]*
The water content was determined after drying 10 g of chip sample in the oven (INDERLAB 0 - 250 °C) at 105 °C for 24 h.

➢ *Protein content [11]*
The protein content was determined after determination of total nitrogen according to the Kjeldahl method (VELP SCIENTIFICA DK 6) after sulfuric mineralization in the presence of selenium catalyst. The nitrogen content value obtained was multiplied by 6.25 to quantify the protein content.

➢ *Lipid content [12]*
The extraction of lipids was done by n-hexane using the Soxhlet (PIERRON 250 mL). After extraction, the oil obtained was placed in an oven at 50 °C to evaporate the remaining solvent.

➢ *Ash content [12]*
The ash content is obtained after incineration of the potato chip grit at a temperature of 450-550 °C in an electrically heated muffle furnace for 8 h until a constant mass is reached.

➢ *Crude fiber content [13]*
Determination of the fiber content of the composite flour according to the AOAC method [13]

➢ *Carbohydrate content (AOAC, 2005) [14]*
The carbohydrate content was determined according to the method proposed by AOAC:

% Carbohydrates = 100 - (% Water + % Protein + % Fat + % Ash) (1)

➢ *Energy value*
The energy value was calculated using Atwater's specific coefficients for protein, fat and carbohydrate [15].

Energy value (Kcal) = [(% Carbohydrates × 4) + (% Protein × 4) + (% Fat × 9)](2)

➢ *Mineral content*

The phosphorus was determined by spectrocolorimeter. The potassium, calcium and magnesium were determined by flame photometry with wave lengths of 766 nm.

➢ *Hedonic tests*

The hedonic tests were carried out on 14 people. Four (04) parameters were evaluated, namely, taste, flavor, color and texture.

III. RESULTS ET DISCUSSION

The manufactured chips are shown in Figure 2 below:



Plain chips Sweet chips Salty chips

Fig. 2: The three categories of manufactured chips

A. Physico-chemical characteristics of the chips

The physico-chemical composition of the chips is presented in the following table II:

Table 2: Physico-chemical composition of chips

Nature de chips	**Chips natures**	**Salted chips**	**Sweet chips**
Température (°C)	**150°C**	**160°C**	**170°C**
Eau (%)	5.15±0.16	2.70 ± 0.06	5.13 ± 0.15
Protéines (%)	7.42±0.12	5.85±0.15	6.41±0.11
Lipides (%)	69.32±0.30	65.51±0.29	62.29±0.16
Glucides (%)	17.16±0.17	24.99±0.45	25.20±0.13
Fibres brutes (%)	0.98±0.14	0.094± 0.002	0.15 ± 0.003
Cendres (%)	0.95±0.38	0.95 ± 0.37	0.97 ± 0.13
Valeur énergétique (kcal/100gMS)	722.20±12.85	712.95 ± 0.42	687.05 ± 0.32

The analysis of the table shows us that: the water contents of salted potato chips, sweet potato chips and plain potato chips with saffron are 2.70 ± 0.06%, 5.13±0.15% and 5.15±0.16%, respectively. The values obtained with the salted saffron chips are lower than 2.29% recommended for salted potato chips (CIQUAL 2013). The water contents of the chips obtained from safflower pulp are lower 68.29±0.31% found with the chips based on plantain [16]. These values obtained show that, these chips could be preserved for a long time, because the alteration of foodstuffs by molds intervenes when the humidity of the product exceeds 12% [17].

The protein contents of sweet potato chips, salted potato chips and plain potato chips are 5.85 ± 0.15%, 6.41 ± 0.11% and 7.42±0.12% respectively. These values are close to 6.50 g/100 g of salted potato chips According to [18]. These potato chips could be an additional protein intake in the diet of the young child.

The lipid contents of the chips obtained varied between 62.29±0.16 and 69.32±0.30% for sweet chips and plain chips respectively. The salted chips (65.51±0.29%) have a slightly higher lipid content than the sweet chips. This difference can be explained by the duration of passage of each type of chips in the frying oil and also by the cooking temperature applied. A high absorption of frying oil has been observed at 120 °C [19]; [20]. The lower the frying temperature the longer the frying time. The values obtained with safflower chips are higher than those found by [18], which states that 100 g of potato chips provide 12% lipids.

The carbohydrate contents of the potato chips are 17.16±0.17% and 29.20±0.13% for plain and salted potato chips respectively. The carbohydrate content of the sweet potato chips is higher than that of the others due to the addition of sugar in its formulation. The carbohydrate content of saffron-based chips is lower than that of salted potato chips (52.90%) according to Anses, [21]. With these values, the saffron chips could be a necessary food supplement to contribute to the carbohydrate energy intake in a food ration.

The fiber contents are 0.15 ± 0.003% for sweet potato chips, 2.70 ± 0.06% for salted potato chips and 0.98±0.14% for plain potato chips. The fiber content of plain potato chips is higher than that of salted and sweet potato chips. These fiber contents are lower than 5% according to Anses, [21].

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Fiber, especially cellulose, plays an important role in the functioning of the intestinal muscles, and therefore in the intestinal transit. Foods rich in fiber provide a feeling of satiety that helps prevent overweight, contribute to reduce blood cholesterol levels and prevent cardiovascular diseases. They also reduce the risk of gallstones and some cancers.

The ash contents of the chips ranged from 0.95 ± 0.37 to 0.97 ± 0.13% for salted and sweetened safflower chips, respectively. The ash contents of the different are similar. These values are less than 4.02% according to [22].

The energy values of sweetened saffron chips and plain chips are 687.05±0.32 kcal/100gMS and 722.20±12.85 kcal/100gMS, respectively. These values are higher than 487 kcal/100g of salted potato chips [23]. These high values can be explained by the amount of oil absorbed by the chips during frying.

The mineral composition of the chips is presented in the following Table III:

Table 3: Mineral content

Minerals (mg/100g) / Chips	Calcium (Ca)	Phosphorus (P)	(P) Potassium (K)	Magnesium (Mg)
Salt	64.04	105.12	219.74	70.37
Sugar	31.86	93.19	302.07	45.78

The analysis of this table shows that, the salted saffron chips contain more minerals than the sweetened saffron chips. Indeed, for the salted chips we have 64.04 mg of calcium, 105.12 mg of phosphorus and 70.37 mg of magnesium. On the other hand, in the case of sweet chips we note 31.86 mg of calcium, 93.19 mg of phosphorus and 45.78 mg of magnesium. In addition, with regard to potassium, the sweet potato chips are richer with 302.07 mg against 219.74 mg. According to [18], salted potato chips contain 23.8 mg of calcium, 106 mg of phosphorus, 754 mg of potassium and 27.70 mg for magnesium. On the whole, the results obtained are higher than those of the literature, except for potassium, whose value is more than double. These high contents could allow the chips of safou to contribute to an important part of the RDA in minerals. Because according to Anses [21], 97.00 mg of phosphorus would represent 14% of the RDA in phosphorus.

With these values, these chips can be recommended in the diet because Ca, P, K and Mg play an important role in the mineralization and optimal growth of the skeleton, in the growth of muscle mass and in the immune system [24]; [25]; [26]. K plays an important role in the maintenance of the balance of contractions between the intra and extracellular environment and normal blood pressure [27]. These micronutrients also help to combat infant malnutrition.

B. Hedonic results

The results of the hedonic tests are presented in Figure 3 below:

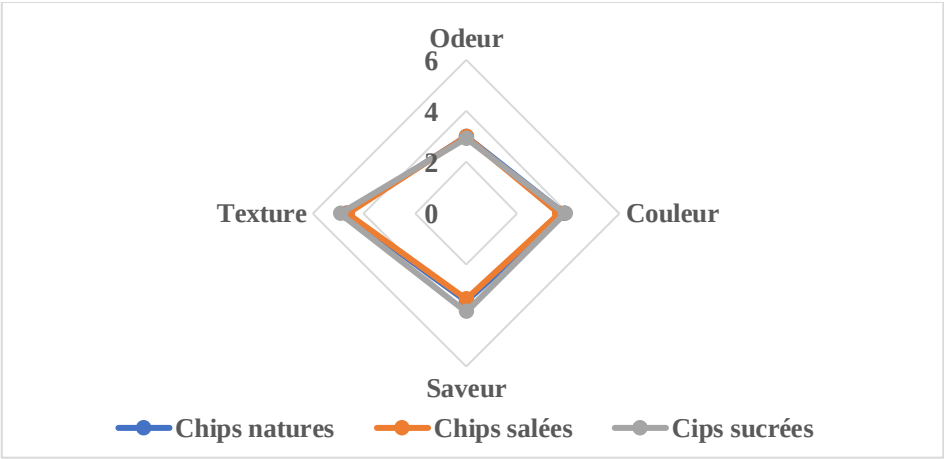


Fig. 3: Hedonic test results

The analysis of Figure 1 shows us that, from the point of view of flavor, the highest average is that of sweet potato chips (3.86±1.19) while the average is 3.36±0.89 and 3.43±1.05 for salted and plain potato chips respectively. The best-rated texture was that of sweet potato chips (4.93±0.26) followed by plain potato chips (4.71±0.45) and salted potato chips (4.64±0.48). The best rated odor was that of plain (3±0.74) and salted (3±0.81) potato chips than sweet potato chips (2.93±1.03). The best rated color was that of the sweetened chips (3.86±0.83) followed by the plain (3.85±0.74) and salted (3.64±0.81) chips.

The three chip formulations obtained have hedonic characteristics close to each other. The sweetened chips are slightly better appreciated than the plain and salted chips. This could be due to the addition of the sugar necessary for

the Maillard reaction that takes place between the amino acids and the sugars. This reaction is important because it is responsible for the production of odors, flavors and browning of when food is cooked [28]. Rapid browning can be observed at oil temperatures between 160 and 190 °C caused by rapid heat transfer [29].

IV. CONCLUSION

The objective of this study was to Manufacture and physicochemical characterization of chips based on the pulp of safflower (Dacryodes edulis), in order to propose a snacking product and to fight against the post-harvest loss of the fruits of the safflower. This study showed that the manufacture of chips from the pulp of safflower is effective. The technique used resulted in chips rich in lipids and carbohydrates but with low protein and ash contents. The use of other ingredients than salt and sugar would be necessary to improve their nutritional value. Thus, the monitoring of some parameters such as the temperature-duration of cooking would allow to optimize the technique.

REFERENCES

[1.] FAO. (2001). Système de production agricole et pauvreté. Améliorer les moyens d'existence des agriculteurs dans un monde en changement. p2
[2.] Owono A, Ingram V, Manirakiza D, Owona H. (2008). Etude de base de la filière *Dacryodes edulis* (safou) dans les provinces du bas-congo et de Kinshasa (RDC). Rapport FAO, GCP/RAF/408/EC.
[3.] FAO. (2020). AQUASTAT rapports. Profil de pays-Congo
[4.] Kapseu C, Mapongmetsen PM, Silou T, Roques M. (1999). Physico-chimie des fruits du safoutier (*Dacryodes edulis*) camerounais. Tropicultura 1998-99, 18-17, 1, 37-42
[5.] Kengué J. (2002). Fruits for future 3. Safou : Dacryodes edulis G.Don. Southampton, UK : Southampton International Centre for Underutilized Crops.
[6.] Law D.A. (2010). An energy analysis and characterization of safou (*Dacrodes edulis*) as biofuel feedstock. Theisis submitted to the Geaduate School : Apllalachian State University (USA).
[7.] Silou T., Goma Manioungou J., Boungou P. et Ouamba J.M. (1991). Etude su séchage de la pulpe de safou : résultats préléminaires, tropicultura, 9, 2, 61-68
[8.] Noumi GB, Aboubakar Dandjouma AK, Kapseu C, et pamentier M. (2006). Le savoir-faire local dans la valorisation alimentaire des fruits du safoutier (*Dacryodes edulis* (G. Don) H.J. Lam) au Cameroun. Tropicultura, 2006. 24, 1, 58-62
[9.] Anonyme 1. http://fr.m.wikipedia.org/wiki/Chips(Vu : le 02/2023)
[10.] AOAC. (1990). Official méethods of anlysis. 15th ed ; Association of Official Analytical Chemists : Arlington, VA, p70
[11.] AOAC. (2002). Méthodes s'analyse pour l'étiquetage nutritionnel. AOAC International. Sullivan et Carpenter, 1993
[12.] AOAC. (1995). Official méethods of anlysis. Fatty Acid in Seafood, Official Méthod 937.26, Arlington, VA, p14
[13.] AOAC. (2000). Official méthods of analysis for total dietary fiber : 985.29 ; 992.16 et 991.43. Gaithersburg. MD : AOAC international, 32.1.18
[14.] AOAC. (2005).
[15.] Soro S, Konan G, Elleingand E, N'guessan D and E Koffi. (2013). Formulation d'aliments infantiles à base de farines d'igname enrichies au soja. African Journal of Food, Agriculture, Nutrition and Development. ISSN.1684 – 5374
[16.] Pambou-tobi NPG. (2015). Influence des conditions de friture profonde sur les propriétés physicochimiques de la banane plantain *Musa AAb* « harton » : étude du vieillissement des huiles et modélisation des transferts de matière au cours du procédé. Thèse de doctorat, UMNG-FST, 2015 : 1-227
[17.] Mouquet (1998). Bulletin du réseau Technologie et partenariat en agroalimentaire. Dossier : les farines infantiles. p8/48. Numéro de 15 Mai 1998
[18.] Alda M. (2013). La table française de référence sur la composition des aliments.
[19.] Talburt W.F. (1987). Frozen Fris and other Frozen Products. Westport : AVI. 1987.
[20.] Rojas J., Avallone S., Brat P., Trystra G et bohuon P. (2006). Effet of deep-fat frying on ascorbic acid, cartenoids and potassiums contents of plantain cylinders. *Int J Food Sci Nutr* 2006 ; 57 : 123 – 136
[21.] Anonyme 2 . http://ciqual.anses.fr
[22.] CINQUAL. (2023).
[23.] Anonyme 3. http://sante.journaldesfemmes.fr/calories/chips-salees/aliment-4004(Vu : le 02/2023)
[24.] Anonyme 4. http://www.mesbienfaits.com/potassium(Vu : le 02/2023)
[25.] Dansou P, Akplogan, Awalla C et Omer W. (2000). Apport énergétique et calcique dans l'alimentation des adolescents de la ville de Porto-novo (République du Bénin). Médécine d'Afrique Noire : 2000, 47 (8/9)
[26.] Roberts S.B et Heyman M.B. (2000). « Micronutriments Shortfalls in Young Children's Diets : common and Owing toInadequate Intakes both at home and at Child Care Centers », Nutrition Reviews, vol. 58, n° 1, p.27-29
[27.] Bendich A et Deckelbaum R.J. (2001). Preventive Nutrition : The comprehensive Guide for health Professionals, 2e édition, Totowa NJ, Humana Press, 503p.
[28.] Machiels D et Istasse L. (2002). La réaction de Maillard : Importance et application en chimie des aliments. Ann. Méd. Vét., 2002, 146, 347-352
[29.] Courtois F., Ziaiifar AM., Trezzani I et Trystram G. (2012). Friture profonde : les interactions huile-produit. *OCL* 2012 ;19(2) : 89-95