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FUNCTIONAL PROPERTIES OF FLOURS FROM DRIED AND ROASTED *BLIGHIA SAPIDA* ARILS CAKES HARVESTED IN CÔTE D'IVOIRE

Armelle Moya Felarry Hoba[1], Yolande Dogoré Digbeu[2], Michel Archange Libra[3], Lucien Patrice Kouamé[1] and Edmond Ahipo Dué[1]*

[1]Biochemistry and Food Technology Laboratory, Nangui Abrogoua University, 02 BP 801 Abidjan 02, Côte d'Ivoire.
[2]Laboratory of Food Safety, Nangui Abrogoua University, 02 BP 801 Abidjan 02, Côte d'Ivoire.
[3]Laboratory of Biochemistry Genetic, Peleforo Gon Coulibaly University, BP 1328 Korhogo, Côte d'Ivoire.

***Corresponding Author: Prof. Edmond Ahipo Dué**

Biochemistry and Food Technology Laboratory, Nangui Abrogoua University, 02 BP 801 Abidjan 02, Côte d'Ivoire.

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ABSTRACT

Blighia sapida is a very important plant in food, the study of the functional properties of dried aril cakes (DAC) and roasted cakes (RAC) showed a wealth of proteins which were at 36.37 ± 0.37% for DAC and 39.87 ± 0.84% for RAC. Regarding functional properties, Roasting had improved some functional properties of powders compared to those dried and were significantly different ($p \leq 0.05$). Indeed, The solubility in alkaline solutions according to the pH was better in NaCl (25.13-33.02% and 38.38-49.73% for RAC) solution than that of NaOH (15.94-55.37% for DAC and 20.3-60.62% for RAC), with the powder of roasted aril cakes with low solubility at pH 4 and pH 8 of the arils and high solubility at pH 6 and pH 10 of *Blighia sapida*. As a result, they were more likely to be soluble in water and gave a good water absorption capacity (700.25 ± 9.25% DAC against 761.83 ± 13% RAC), water solubility index (20.5 ± 0.5% for DAC against 47.25 ± 2.25 for RAC) and have an affinity for unrefined oils such as red Palm oil (730.1% and 648.47% DAC and RAC respectively) and which had the lowest hydrophilic-lipophilic ratio (0.96% (DAC); 1.01% (RAC)). The aril cake showed good functional characteristics for use in many food industries.

KEYWORDS: Ackee (*Blighia sapida*), arils, cakes, dried, functional properties, roasted

1. INTRODUCTION

Blighia sapida, commonly referred to as Ackee, or vegetable brain or Ackee apple,[1] is an evergreen tree more widely known for the edible part of its fruit: aril. It belongs to the family *Sapindaceae* and grows to a height of 10 to 12 m at maturity. The Ackee is indigenous to the forests of the Ivory Coast and Gold coast of west tropical Africa. In Côte d'Ivoire it is most common in the transition zone between dry and moister forest. *Blighia sapida* is both known for its food values and its poisonous properties.[2 It is a major food in Jamaica and is noted for its high protein and fat contents.[3] Previous studies have really shown that Ackee arils have high oil content, comparable to those of peanuts, rapeseed and sunflower seeds and higher than that of soybeans.[4]

The different study that are effected physicochemical compositions of arils oil (Ackee) most often refers to dried arils in oven or in the sun. While, secondary or tertiary ackee products for increased application in food are limited. Flours are major ingredients in industrial food processes. Ackee flours could find several useful applications in the food industry. Defatting could contribute to improved quality properties and shelf stability of the flours. Also, a study of the effect of drying method on dehydrated food products is necessary for the development of a product with optimum quality for the food industry. The objective of the present research, therefore, was to investigate the functional properties of full defatted dried and roasted ackee aril flours.

2. MATERIAL AND METHODS

Collection of Samples: Matured fruits of *B. sapida* were collected during fruiting seasons of April to June 2017 from Abidjan (Côte d'Ivoire). The arils were separated manually from seeds and washed with distilled water.

2.1. Cake aril production: 3 kg of arils was dried in the sun (30-35°C) for 2 weeks. The dried arils were separated into two equal portions. The first batch (1.5 kg of dried arils) was ground into a paste using Moulinex blender. This batch represents DA (Dried Arils), and the second batch (1.5kg of dried arils) was roasted at 120 °C for 10 min in dry heat bath. This batch, which represents RA (Roasted Arils) was ground into a paste using Moulinex blender. The tow portions DA and RA was defatted according to the method by Meite *et al.*,[5] by soaking in hexane in a ratio of 1:3 (w/v) for 7 h with magnetic agitation. After defatting, the mixture was bounded at the vacuum agitation to separate hexane from residual. The process was repeat twice with hexane. The one that dried after defatting flour result in cake dried aril (DAC) and the one that roasted after defatting flour result in cake roasted aril (RAC). The resulting residue was dried in an oven at 45 °C for 48 hours to be dried and weighed. These cakes are milled using a mixer and sieved using a sieve (350 µm). The cake obtained was packed in airtight polyethylene bags and stored in a freezer at -18 °C for further analysis.

2.2 Determination of proteins: Methods of Association Analytical Chemists[6] were employed in determining protein content (% total nitrogen × 6.25).

2.3 Functional properties determination: The Solubility of DAC and RAC protein as a function of pH (2,4, 6,8, 10) at different concentrations of NaOH (0,02 ; 0,03 ; 0,04 ; 0,05 N) and of NaCl (0,2 ; 0,4 ; 0,6 ; 0,8 M) were measured according to the method described by Kenfack.[7] The method of Narayana. and Narasimga, [8] was used to determine apparent density, the method modified of Phillips *et al.* [9] and Anderson *et al.* [10] was used to determine water absorption capacity and water solubility index. The foaming capacity was measured according to the method described by Coffman and Garcia. [11] The dispersibility was determined using the method of Kulkarni *et al.*[12] The method of Onwuka [13] was used to determine Wettability. The oil absorption capacity of the ackee aril cake was determined with the Coconut oil, palm oil refined 〝Dinor〞, Olive oil, Red palm oil and Sunflower oil using the method of Lin *et al.* [14] Lipophilic-hydrophilic ratio was determined using the method of Njintang *et al.*[15]

3. RESULTS AND DISCUSSION

3.1 Proteins composition: The results showed that dried and roasted arils cakes had high levels of protein (36.37 ± 0.37% for DAC and 39.87 ± 0.84% for RAC). They were closed to rapeseed cakes from Vioque *et al.*[16] whose value was 40.4 %. On the other hand, they are superior to those of Dossou *et al.* [17] (22.04 ± 0.16 and 23.0 ± 0.19) ± 1.20) respectively in oven dried defatted powders and lyophilized arils. This high protein content of Aril cake could be explained by the degree of extraction of the fat. In fact, the reduction in lipid content leads to an increase in protein levels. [17] The primary function of proteins present in a food is to provide, through the digestive process, amino acids for the synthesis of proteins and other nitrogenous substances. [18] All these values are significantly different at the 5% level.

3.2. Functional properties of cakes DAC and RAC

The Table 1 presents a few functional properties of the arils cakes of *Blighia sapida*. The study of other functional properties such as the water solubility index and the foaming capacity gave higher values for RAC (47.25 ± 2.25 and 7.74 ± 0.1%) and DAC (20.5 ± 0.5 and 3.12 ± 0.13%); this could be explained by the partial decomposition of proteins which increased their solubility and foaming capacity. [19] Oven roasting applicate, thus contributing to the partial denaturation of the sample proteins. This was observed by Dossou *et al.*,[17] with solubility and foam capacity of kiln dried arils compared to freeze dried. The solubility value of RAC is greater than 39.45% and 38% from Dossou *et al.*,[17] for defatted arils, kiln dried and freeze-dried arils, respectively. But that of TAS is inferior to it, it is the same in the foaming capacity 5,67 ± 0.58% and 4.33 ± 0% of the defatted flours dried in the oven and lyophilized respectively. This confirms the previous assertion because roasting involved a higher temperature than baking. Also, compared to that of beans and lentils (25-80%),[20] they were minimal. Foaming power is an important property in fillings, frozen desserts, cakes or cookies;[21] mosses are used to improve the texture, consistency and appearance of foods.[22]

The wettability (30-31 s) and the density apparent (0.345-0.52 g/mL) that roasting may not have had a significant effect on these different properties because they stay much the same whatever cake type. Apparent density (AD) determines the suitability of a flour to be easily packaged, which would facilitate the transport of a large amount of food.[23] The values obtained, 0.52 g/mL (DAC) and 0.345 g/mL (RAC) were lower than those from wheat flour (0.80 g/ml).[24] At nutritional level, a low Apparent density (AD) promotes the digestibility of food products, especially in children because of their immature digestive system.[25] Thus, the low AD of arils flour from *Blighia sapida* could be useful in the formulation of infant food. Wettability is the time takes for a flour to be completely wet. According to Pohl *et al.*, [26] a flour is considered very wettable if the wettability time is less than 30 s. if time is less than 60 s, the flour is considered as wettable and non-wettable if this time is greater than 120 s. Thus, powders of arils RAC and DAC will wettable because their wettability values are less than 60 s. This wettability is due, on the one hand, to the composition of flours and to the affinity between its components and water and, on the other hand, to the accessibility of water in terms of structure (porosity and capillarity). To the constituents of flours.[27,28]

Water absorption capacity (WAC), is an index of the maximum amount of water that a food product would absorb and maintain.[29] The WAC from powders DAC and RAC was very important with a content of 700,25-760.83 ± 13 % and was higher than those of rice (uncooked rice 225% ; cooked 250 %) reported by Abulude, [30], and than that of the defatted flour of the *Blighia sapida* aril collected in Ghana (565.53 ± 9.06 %).[17] This difference is due to the defatting method and the growing area. Indeed, according to Nelson-Quartey *et al.*,[25] the presence of lipids in flour reduces the binding capacity of water to specific substances, thus limiting WAC. The high water absorption capacity is mainly due to the hydrophilic groups of proteins,[31] because the polar amino acid residues of proteins have an affinity for water molecules. This is a required property in food formulations especially those involving the handling of dough.[32]

Table. 1: Functional properties of *Blighia sapida aril* cake.

	Content (%)	
properties	**DAC**	**RAC**
Apparent density (g/ml)	0.52±0.1[a]	0.345±0.2[a]
Water solubility index	20.5 ± 0.5 [a]	47.25±2.25[b]
Absorption capacity in water	700.25±9.25[a]	761.83±13[b]
Foaming capacity	12± 0.13[a]	7.74±0.1[b]
Wettability (S)	31± 2.5[a]	30±1[a]

DAC: dried aril cakes**; RAC**: roasted arils cakes**.** On the lines, the averages assigned to the common letter are not significantly different from each other at the 5% threshold, according to the Duncan test.

3.3 The dispersibility: As shown in Figure 1, the dispersibility of powders of the aril in 40 min ranges from 0-25 ± 5% (DAC) and 0-5 ± 5% (RAC). These values were lowers than that obtained with the yam flour (*Elubo*) by Kafilat, [33] recorded values of 6.00 to 72.50 %. Thus, the aril flour could not be used as an enhancer of the resultant products of emulsions and foams. Dispersibility is associated with the fine particle size. [12] Moreover, high percentage of dispersibility of flour shows a high capacity to replenish in water to give a fine and consistent paste.

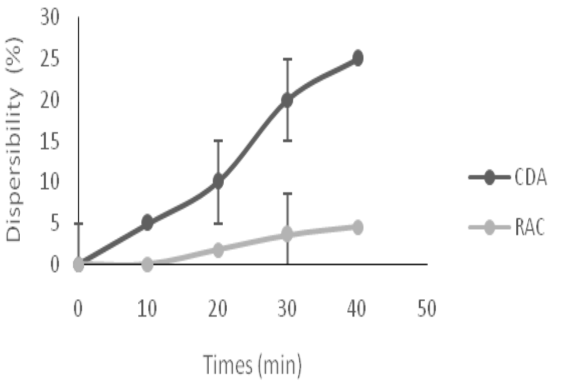

Figure. 1: Dispersibility of powders DAC and RAC.

DAC: dried arils cakes; RAC: **arils roasted cakes**

3.4 Oil absorption capacities and the lipophilic hydrophilic ratio: The results of the absorption capacities of the various oils used were represented by the histogram of the Figure 2a and were inversely proportional to the lipophilic-hydrophilic ratio (HLR) presented by the histogram of the figure 2b. There was a significant difference at the 5% level on both sides of the two types of cakes.

Oil absorption capacity (OAC) is an important property in food preservation because it prevents the development of oxidative rancidity. [34] According to Njintang et *al.*, [15] the variation of OAC in compound flours is associated with the presence of non-polar chains. Indeed, the capacity of absorption in oil is influenced by the type and the quantity of proteins. [35] The absorption capacity of these oils, high with RAC compared to that of DAC would be due to a high amount of protein. Indeed, the DAC protein content (36.37%) was significantly lower than that of RAC (39.87%). The absorption capacity of oil is influenced by the type and amount of protein. [35] The oil is absorbed by physical crosslinking in the protein matrix, so the larger the oil, the more oil is absorbed. [36] The oil absorption properties are mainly due to the availability of lipophilic groups. [37] OAC gives an indication of the retention capacity of the flavor of flour.[8] Moreover, it is useful over a long period of food preservation especially in baked goods or meat products.[38] It is an interesting property because it allows a good retention of the flavor during food processing processes thus improving palatability and the texture.[39,31]

The HLR of the red oil (0.96% (DAC); 1.01% (RAC) close to the value 1 would suggest that this flour has more affinity for the red oil than for water. Regarding HLR refined oils are higher it is 1. These results clearly show that the resulting flour has more affinity for the refined oil. Consequently, powders of DAC and RAC arils from *Blighia sapida* should be preferentially used in the design of products requiring strong WAC.

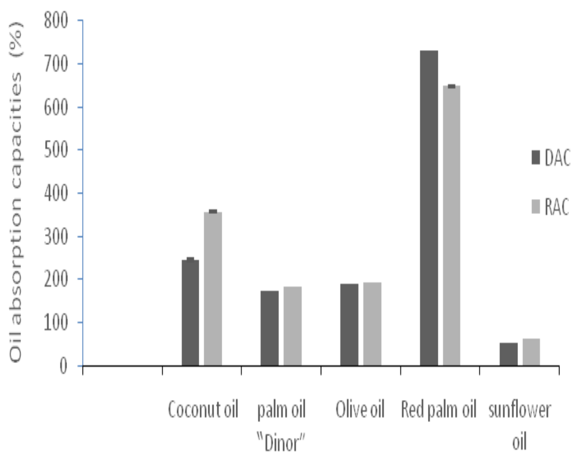

Figure. 2a: Oil absorption capacity powders DAC et RAC.

DAC: dried arils cakes; RAC: arils roasted cakes

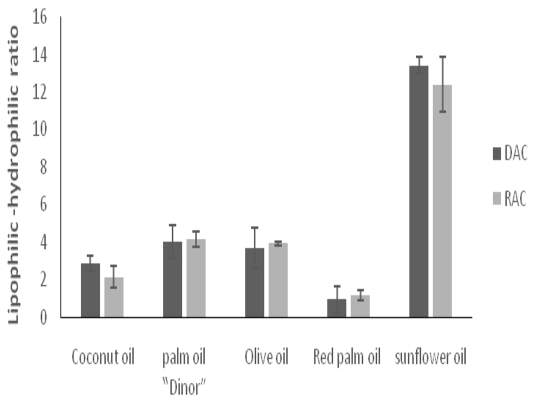

Figure. 2b: Hydrophilic-lipophilic ratio powders DAC et RAC.

DAC: dried arils cakes; RAC: arils roasted cakes

3.5 Solubility in function of pH and NaOH and NaCl concentrations: Solubility is considered one of the most important functional properties of proteins and their hydrolysates. Other functional properties such as emulsification ability and foaming properties are affected by solubility, as these properties will depend on the ability of these hydrolysates to solubilize.[40] The study of the solubility of DAC and RAC powder proteins in function of pH at various concentrations of NaOH showed two areas of high solubility of proteins at pH 6 and 10; and two weak areas soluble protein at pH 4 and 8 (Figure 3a and 3b). Kenfack,[7] had also observed a similar behavior at the level of *R.heudelotii* and *T.conophorum* but with minima at pH 4 and 8 and maxima at pH 6. Also, the solubility of DAC proteins and RAC increased with ionic strength and was greatest in NaOH solution. Concentrations of NaOH 0.05 N and 0.04 N, soluble proteins were superior to those of 0.03 and 0.02 N; which could be justified by the mineral charge. In fact, NaOH provides hydronium and hydroxyl ions which will limit protein-mineral interactions by promoting the solubilization of proteins. [41] Also, during solubilization, the proteins are solvated by formation of sodium carboxylates.[42]

Solubility curves of DAC and RAC proteins as a function of the pH at different concentrations of NaCl were shown in (Figure 4a) and (Figure 4a) respectively. The solubility at concentration 0.8 M and 0.6 M NaCl were predominantly most important than those of 0.2 M and 0.4 M NaCl. The increase in solubility with ionic strength is explained by the fact that in the presence of neutral salts such as NaCl at concentrations below 1M, protein loaded groups do not interact with each other. The overall effect is an increase in protein-water interactions and therefore an increase in solubility. This phenomenon is known as the salting-in of the protein. [43]

From the analysis results, it appears that the water may be the solvent in which the protein solubility of the two flours from Ackee is low in fonction of the pH. The pH therefore influences the loading of acid side chains and weak basic is the reason why the proteins of the cake have a low solubility at their isoelectric Ph.[44] Boye *et al*.[45] and Carbonaro *et al.*, [46] showed that the solubility of legumes was higher as we move away from the isoelectric point of the proteins. This is explained by the fact at pHi, there are no net charges on the protein; therefore, there is no repulsive interactions and the solubility is low due to protein-protein interactions that are so privileged.[47] As one moves away from pHi, net charges are induced and protein-water interactions are favored, making the protein soluble.[48] The protein solubility minima observed at pH 4 and 8 would indicate their isoelectric pH which should be better defined for use in protein separation and purification technologies from *Blighia sapida* cake. All these values are significantly different at the 5% level.

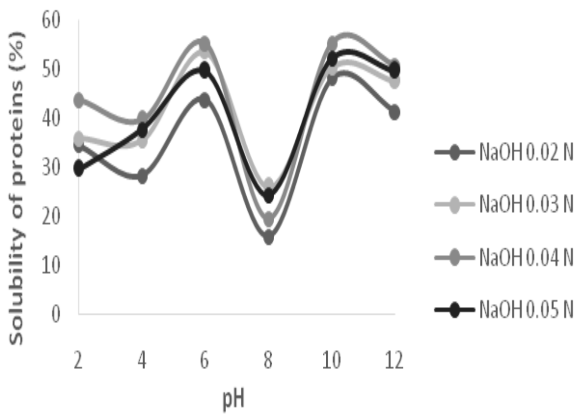

Figure. 3a: Solubility of proteins of powders DAC as a function of pH at different concentrations of NaOH.

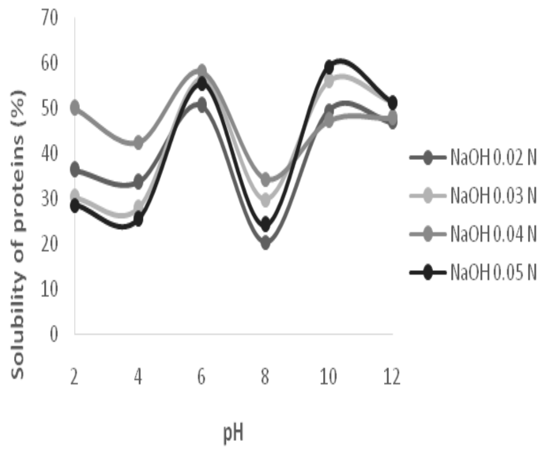

Figure. 3b: Solubility of proteins of powders RAC as a function of pH at différent concentrations of NaOH.

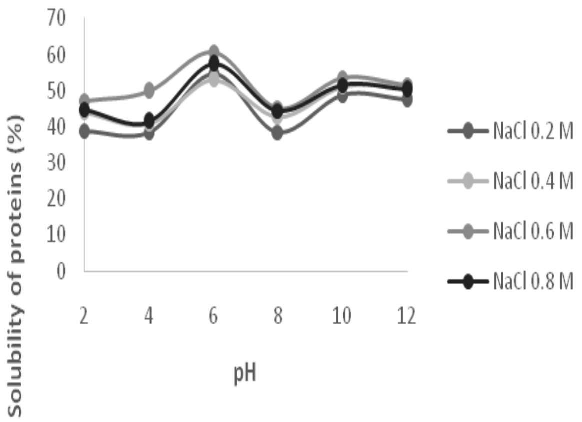

Figure. 4a. Solubility of Proteins of Powders DAC as a Function of pH at Différent Concentrations of NaCl.

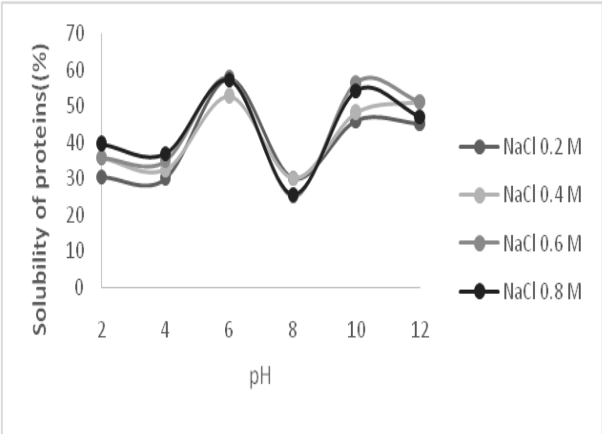

Figure. 4b: Solubility of proteins of powders RAC as a function of pH at différent concentrations of NaCl.

CONCLUSION

Thus, a reduction fats in arils fat improves the something functional properties of ackee powders and high the content protein in the cake from Blighia sapida, and with the roasted. The cakes gave a good water absorption capacity, so these two powders had a low foaming capacity and had an affinity for unrefined oils.

The solubility in alkaline solutions is better in the NaCl solution than that of NaOH, with the powder of roasted aril cakes with low solubility at pH 4 and pH 8 which could be the pHi of the arils of Blighia sapida.

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