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FUNCTIONAL PROPERTIES OF FIVE VARIETIES OF SWEET POTATO IMPROVED CULTIVATED IN COTE D'IVOIRE

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ABSTRACT

This study was done to assess the functional properties of flours from sweet potato (*Ipomoea batatas*), widely consumed in Côte d'Ivoire. Five varieties improved of sweet potato cultivated in the research station of CNRA (Bouaké, Côte d'Ivoire), were used for this study. functional properties were investigated using standard methods. All results were statistically analysed. The results showed that the dispersibility of various flours of sweet potato increased significantly between 0 and 05 min and tended to stabilize with values situated between 49 and 77%. There were no significant differences (5 %) between the absorption capacity of water (ACW) of flours of the varieties Kabode, Irène and Bela Bela (433.6 ± 13.0; 438.2 ± 12.0 and 418.8 ± 9,1, respectively). The rates of solubility indexes of sweet potato flours were between 26.9±1.6 % and 30.75±1,4 %. The foaming capacities (FC) of flours were lowers,(between 3.13 ± 1.19 % and 3.5 ± 0.35 %). Stability of foams study revealed that the foams of flours of all varieties of sweet potato were not stable, because they disappeared quickly with time (0 to 5 min) after their production. The flours of the varieties Kabode, Irène and Fatoni had highest values of apparent densities. However, no significant difference (P = 0.05) was observed between porosities and hydrated densities of various flours from sweet potato studied. Study of the wettability showed that the variety Fatoni had the highest wettability with 102.67 ± 8.5 (second). The pH of flours of sweet potatoes studied were acids and their titratable acidities were between 0,72 ± 1 and 1,11 ± 0.57 %. The smallest gellante concentration of these flours was situated between 14 ± 0.01 and 16 ± 0.01 %. Study of the absorption capacity of oil showed that the oils used were differently quite absorbed by various flours of the sweet potatoes. The values of the report hydrophile-lipophile of flours vary between the varieties. All had reports superior to 1, what involved that flours of sweet potato absorbed more water than oil. The flours of sweet potatoes studied showed good functional characteristics for use in the formulation of the infantile food or in many food industries.

KEYWORDS: Functional properties, sweet potato, flours, foaming capacity, wettability.

INTRODUCTION

The sweet potato (*Ipomoea batatas*) is a plant with tubers roots belonging to the family of *Convolvulacées*. This plant is an excellent culture in terms of food safety. Indeed, its agronomic characteristics, a strong productivity, a cycle of development short and a high nutritional value, make of the sweet potato a culture particularly important for the food safety in countries subjected to strong anthropological and vulnerable pressures in climate change. Therefore, it plays an important role in the diet of the world's population (Ofori *et al.*, 2005).

The main nutritional material in sweet potato's tubers are carbohydrates (starches and simple sugars), protein, fat and fat-soluble vitamins. Moreover, cultivars with a yellow flesh also contain significant amounts of carotenes (Allen *et al*., 2012). Sweet potato's tubers have anti-diabetic, anti-oxidant and anti-proliferative properties due to the presence of valuable nutritional and mineral components (Jaarsveld et *al*. 2005; Abubakar *et al*. 2010).

Potato flour ranks quite high in its supply of principal nutrients like protein, fiber and carbohydrates. Its protein content is superior to that of cassava and yam flour, and similar to that of rice. Potato flour has higher levels of fiber than refined wheat flour, maize meal, and rice. Its carbo-hydrate and energy contents are comparable to those of similar foods (Kulakarni et *al.*1996). Specialty flours in snack foods serve as functional ingredients, contributing to desirable attributes such as increased expansion, improved crispness, reduced oil pickup, and better overall eating quality

However, in spite of its numerous virtues, the sweet potato remains enough little known in Cote d'Ivoire and does not represent a basic food crop in the traditional supply of this country. Besides, the difficulties of transport, storage and the almost complete absence of transformations constitute major problems which mine the sector sweet potato and prevent the development of this culture in Côte d'Ivoire. The aim of this study, therefore, is to investigate the functional properties of Five varieties improved of sweet potato cultivated in the station of research of CNRA (Bouaké, Côte d'Ivoire).

MATERIAL AND METHODS

Sampling
Five varieties improved of sweet potato cultivated in the research station of CNRA (Bouaké, Côte d'Ivoire), were used for this study. These tubers were harvested in physiological maturity, in December 2017. They were then packed in bags of jute, then transported up to the Laboratory of Biocatalysis and Bioprocesses, of Nangui Abrogoua University (Abidjan, Côte d'Ivoire). The studied tubers of sweet potatoes were the varieties Kabode, Irène, Fatoni, Tib and Bela Bela (Table 1).

Table 1: Characteristics of five varieties improved of sweet potato.

variety	statute	Flesh colour
Kabode	improved	Pale orange
Irène	improved	Dark orange
Fatoni	improved	Cream
Tib	improved	Pale orange
Bela Bela	improved	yellow

Flour production
The sweet potato tubers were washed in the tap water and peeled. They were sliced by means of a manual slicer. The cut tubers were plunged into the hanging hot water 1 min, then dried in the steam room (Memmert) at 65°C during 48 hours. Flours were obtained by grinding of dried tubers (type BLENDER's crusher) and sieved by means of a sieve of stitch 250 µm. Flours were then packaged in bags in polyethylene to prevent the exchanges of humidity and stored in a refrigerator at 4°C before use for analysis.

Determination of proteins: Methods of Association Analytical Chemists (AOAC, 1990) were employed in determining protein content (% total nitrogen × 6.25) was determined by Khedjahl.

Functional properties determination: The Solubility of sweet potato flours protein were measured according to the method described by Kenfack (2010). The method of Narayana and Narasimga (1982) was used to determine apparent density, the method modified of Phillips *et al.* (1988) and Anderson *et al*. (1969) was used to determine water absorption capacity and water solubility index. The foaming capacity were measured according to the method described by Coffman and Garcia (1977). The dispersibility was determined using the method of Kulkarni *et al.* (1991). The method of Onwuka (2005) 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.* (1974). Lipophilic-hydrophilic ratio was determined using the method of Njintang *et al.* (2001).

RESULTS

Flours dispersibility
The dispersibility of various flours of sweet potato increased significantly between 0 and 05 min. Beyond 05 min, it tended to stabilize with values situated between 49 and 77%. Flours of the varieties with yellow and cream flesh (Fatoni and Bela Bela) were more dispersible than flours of the varieties with flesh orangy color (Kabode, Irène and Tib) (Figure 1).

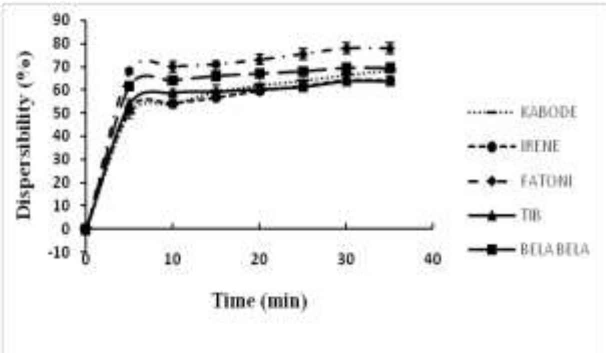

Figure 1: Dispersibility of sweet potato flours.

Absorption capacity of water(ACW), index of solubility in water (SW) and foaming capacity (FC) of flours
Statistical analysis revealed that there were no significant differences (at 5 %) between the absorption capacity of water (ACW) of flours of the varieties Kabode, Irène and Bela Bela which were respectively 433.6 ± 13.0; 438.2 ± 12.0 and 418.8 ± 9,1. However, these values were significantly superior to those of the varieties FATONI and TIB which were respectively 351.2 ± 9.5 % and 328.13 ± 9.7 %. The rates of solubility indexes of sweet potato flours were between 26.9±1,6 % and 30.75±1,4 %. These rates were significantly different (P = 0.05) according to the test of Duncan (Table 2).

The foaming capacities (FC) of flours of the five varieties of sweet potato were represented in the Table 5. All the studied flours had a low foaming capacity, which varies of 3.13 ± 1.19 % to 3.5 ± 0.35 %. The statistical analysis revealed that there were no significant differences between the foaming capacities of flours of the various varieties of sweet potato (Table 2).

Table 2: Absorption capacity of water (ACW), index of solubility in water (SW) and foaming capacity of flours of sweet potato.

Parameters (%)	Flours				
	Kabode	Irène	Fatoni	Tib	Bela Bela
ACW	433.6 ± 13[b]	438.2 ± 12[b]	351.2 ± 9.5[b]	328.2 ± 9.7[a]	418.8 ± 9.1[a]
SW	26.9 ± 1.6[a]	30.0 ± 1.41[a]	28.8 ± 1.55[a]	28.65 ± 1.6[a]	30.75 ± 1.4[a]
FC	3.13 ± 0.19[a]	3.36 ± 0.21[a]	3.5 ± 0.35[a]	3.19 ± 0.2[a]	3.33 ± 0.3[a]

Stability of Foams of sweet potato flours

The foams of flours of all varieties of sweet potato were not stable, because these foams disappear quickly with time (0 to 5 min) after their production.

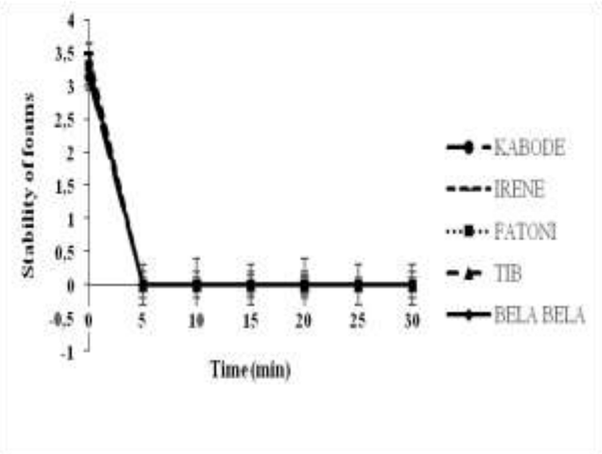

Figure 2: Stability of Foams of sweet potato flours.

Apparent density, porosity, hydrated density, wettability, pH and titratable acidity

The flours of the varieties Kabode, Irène and Fatoni had the highest values of visible densities. They were respectively, 0.94±0.06 g/ml; 0.94±0.03 g/ml and 0.94±0.05 g/ml. The varieties Tib and Bela Bela presented the lowest values of visible densities with 0.85 ± 0.04g/ml and 0.85±0.05 g/ml respectively. On the other hand, no significant difference (P = 0.05) was observed between porosities and hydrated densities of various flours from sweet potato studied with 28.88±1.63 %; 25.58±1.41 %; 27.27±1.55 %; 25.53±1.59 %, 25.53±1.43 % and of 0.3 ± 0.05 g/ml; 0.3 ± 0.05 g/ml; 0.3±0.03 g/ml; 0.35±0.07 g/ml; 0.35±0.05 g/ml respectively for Kabode, Irène, Fatoni, Tib and Bela Bela.

Study of the wettability of sweet potato flours showed that the variety Fatoni had the highest wettability with 102.67 ± 8.5 (second). This value was significantly superior to that of the variety Bela Bela which was of 63.67±2.30 (second). The values of the most low wettabilities were obtained with flours of the varieties Kabode, Irène, and Tib which were respectively, 48.67 ± 9.04 (second); 38 ± 9.84 (second) and 40.33±9.29 (second).

The pH of flours of sweet potatoes, varieties Kabode, Irène, Fatoni, Tib and Bela Bela were respectively 6.16 ± 0.02; 5.56 ± 0.01; 6.34 ± 0.01; 6.05 ± 0.01 and of 6.22 ± 0.02. The titratable acidities of the same flours were between 0.72 ± 1 and 1.11 ± 0.57 %. The smallest gellante concentration of the flours of sweet potato was situated between 14 ± 0.01 and 16 ± 0.01 %.

Tableau 3: Apparent density, porosity, hydrated density, wettability, pH, titratable acidity and Smaller concentration gellante of flours from sweet potato.

Parameters	Flours				
	Kabode	Irène	Fatoni	Tib	Bela Bela
Apparent density	0.94±0.06[b]	0.94±0.03[b]	0.94±0.05[b]	0.85±0,04[a]	0.85±0,05[a]
Porosity	28.88±1.63[a]	25.58±1.41[a]	27.27±1.55[a]	25.53±1.59[a]	25.53±1.43[a]
hydrated density	0.3± 0.05[a]	0.3± 0.05[a]	0.3±0.03[a]	0.35±0.07[a]	0.35±0.05[a]
wettability	48.67±9.04[a]	38±9.84[a]	102.67±8.5[c]	40.33±9.29[a]	63.67±2.30[b]
pH	6.16±0.02[c]	5.56±0.01[a]	6.34±0.01[e]	6.05±0.01[b]	6.22±0.02[d]
titratable acidity	0.78±0.5[ab]	1.11±0.57[c]	0.72±1[a]	0.85±0.5[b]	0.84±0.57[b]
smallest gellante concentration	14 ± 0.01	16 ± 0.01	14 ± 0.01	14 ± 0.01	14 ± 0.01

Absorption capacity of oil

The figure 3 represents the absorption capacity of oil of various flours of sweet potatoes. The oils used were differently quite absorbed by flours of sweet potato. This study showed that for all the flours, the red oil was the most absorbed (122 ± 1.13 to 149.65 ± 1.1 %). Then the refined palm oil and the olive oil had absorption capacities of oil which varied of 81.9 ± 2.68 to 109.1 ± 1.73 % and of 79.8 ± 0.14 to 95.4 ± 1.82 % respectively.

sunflower oil had the lowest absorption capacity (76.45 ± 2.72 to 89 ± 0.9 %).

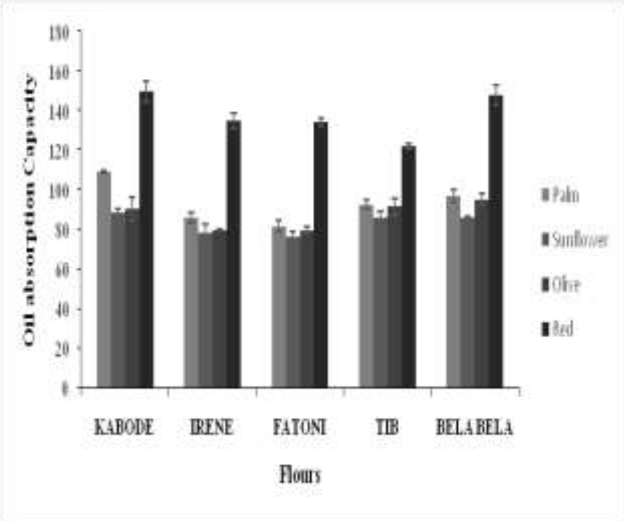

Figure 3: Absorption capacity of oil of flours of sweet potato.

Report hydrophile-lipophile

The values of the report hydrophile-lipophile of flours of sweet potato vary statistically (5%) between the varieties. All the flours of sweet potato had reports superior to 1, what involved that flours of sweet potato absorbed more water than oil.

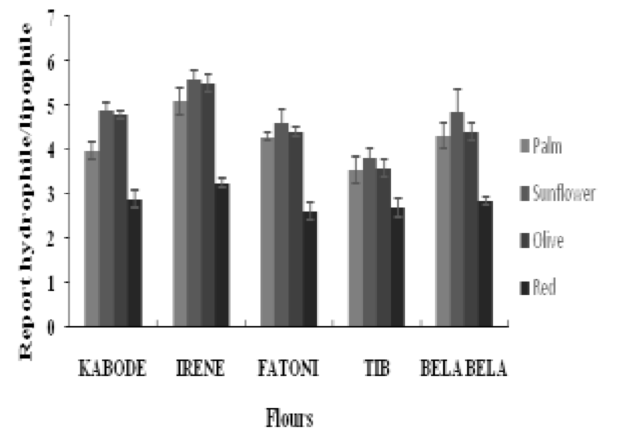

Figure 4: Report hydrophile-lipophile of flours of sweet potato.

DISCUSSION

The absorption capacity of water (ACW) is an index of the maximum quantity of water that a food product would absorb and maintain (Marero et *al*., 1988). It is important for certain characteristics of the product, such as the moistening of the product and the downgrading of the starch (Siddiq et *al*., 2010) . In this study, the ACW of flours of sweet potatoes varies from 328.2 to 438.2 %. The higher values of ACW for the varieties Kabode, Irène and Bela Bela showed that these varieties had a bigger capacity to fixe the water compared with the varieties Fatoni and Tib. So, it is likely that the granular arrangements of Kabode, Irène and Bela Bela were less compact and as a consequence, their granules could have intermolecular spaces higher than the two other varieties. Besides, proteins of structures and hydrophilic carbohydrates would be responsible for variations of the absorption capacities of water of flours. Indeed, according to Appiah et *al*., (2011), the absorption capacity of water was influenced by the availability of polar amino acids of flours. The values of the ACW flours of sweet potatoes were in the margin of those of the taro *Colocasia esculenta* (Fagbemi et Olaofe, 2000) (247.5 % a 562.5 %), of the hardened *Dioscorea dumutorum* yam (Medoua, 2005), some fruit of *Artocarpus altilis* (341.85 – 484.72) (Oulaï, et *al*., 2014). However, these values were higher than those observed by Olapade and Ogunade. (2014); N' Dangui. (2015) and Tortoe et *al*., (2017), in flours of native sweet potatoes respectively of Nigeria (142-143 %), of Congo Brazzaville (2,9 – 3.5 g/g) and of Ghana (87.5 to 114.6 %). Wolf, (1970) showed that the absorption capacity of water is an important property of flours used in cake pastry, because this property allows the pastry cooks to add from water to the dough a lot while improving its manipulation. Besides, the use of flours in the preparation of the local dishes such as the porridge and the doughnuts depends widely on their interaction with the water in the process of rehydration (Himeda, 2012). It thus emerges from this work that flours of sweet potato, varieties Kabode, Irène, Fatoni, Tib and Bela Bela could be used as ingredients in the cake pastry and in the infant food.

The index of solubility in the water (SW) reflects the scale of the degradation of the starch (Mbofung et *al*., 2006). Indications of solubility in water of flours of sweet potato was similar to those reported by Mbofung et *al*., (2006), (18 in 27%) and Olatunde et *al*., (2015) (6,7 in 26.5 %), respectively on flours vineyard of taro and of sweet potato native of Nigeria. These values were superior to those obtained by N'Dangui, (2015) (16.6 to 20.9%) and Tortoe et *al*. (2017) (3.4 to 9.7%) on flours of sweet potato native of Congo Brazzaville and of Ghana. The differences between the values of the solubility in water of flours of the various varieties of sweet potato would be attributed to the differences of structure and morphology of starches, to the report amylose / amylopectine, in the presence of salts, proteins and other components were brought by the genetic differences between the varieties (Tortoe et *al*., 2017). The strong values of the SW flours could suggest that the grinding severely damaged the starch of sweet potato flours. This physico-functional characteristic plays an important role in the choice of flours that must be used as épaississants in the food industry (Kaur et *al*., 2011).

The dispersibility of flour which is an indicator of its power of reconstruction in the water, is a useful functional feature in the formulations of diverse foodstuffs (Mora-Escobedo et *al*., 1991). The dispersibility percentages of the flours from five varieties of sweet potato varies from 49 to 77%. These percentages were similars to those reported by Amon, (2017), Oulaï and *al*., (2014) and Eke-Ejiofor et *al*., (2011) witch worked respectively on flours of horns not boiled of taro *Colocasia esculenta* (63%), some pulp of the fruit of *Artocarpus altilis* (62-72%) and some local rice of Nigeria (56-66%). More the percentage of dispersibilité is raised, and more the flour has a big capacity to be reconstituted in the water to give a thin and coherent crust. A percentage of dispersibility raised is an indicator for good absorption capacity of water (Kulkarni et *al*., 1991).

The apparent density is generally affected by the size of the particles of flour. It is very important in the packaging, in the processing of flours and in the training of the dough in the food-processing industry (Karuna et *al*., 1996). Generally, a higher apparent density is desirable for a big ease in the dispersibilité of flours (Padmashree et *al*., 1987). The results of this study showed that flours of the varieties Kabode, Irène and Fatoni had higher values of apparent density (0.94 g/ml) than those of the varieties Tib and Bela Bela (0.85 g / ml). These variations could be justified by the differences of the properties of the shape, the size and the surface of the grains of flours. Indeed, according to Lewis. (1987) the apparent density and the porosity are influenced by the geometrical properties, the size and the surface of a given material. The apparent densities of flours of sweet potato were similars to those reported by Medoua, (2005), N'douyang et *al*. (2009) and Ijarotimi, (2012) which worked respectively on flours of the tuber hardened by the yam *Dioscorea dumetorum* obtained after soaking (0.83 g/ml), of the non-conventional tuber *Tacca leontopetaloides* from Tchad (0.82 g/ml), from some starch of wheat (0.80 g/cm3). However, they were higher to that of the starch of yam (0.49-0.63 g/cm3) (Hsu et *al*., 2003) and of the flour of sweet potato native of Nigeria (0.7 g/cm3) (Olapade and Ogunade, 2014). Flours with high apparent densities (> 0,7 g/ml) are used as épaississants in foodstuffs (Akubor and Badifu, 2004). Consequently, flours of the five varieties of sweet potato would be also used as épaississants agents.

The hydrated density is important in the process of food separation such as the sedimentation, the centrifugation and in the pneumatic and hydraulic transport of powders of food particles (Lewis, 1987). It is a factor of desirable quality of flours evaluation. On the nutritional plan, the low density favorites the digestibility of foodstuffs, in particular for children because of their immature digestive system (Nelson-Quartey et *al*., 2007). The densities hydrated of the ours sweet potato flours (0.3-0.35 g/ml) were lower than those of the flours of the horns of taro boiled and not boiled (0.4 in 0.8 g/ml) (Amon, 2017). The low density hydrated of flours of sweet potato suggests that they could be useful in the formulation of the infantile food.

The wettability can be a convenient parameter supplying information on the properties of surface of starches (Correia et *al*., 2014). In this study, the flour of sweet potato, variety Fatoni has a time of wettability widely upper to that some flours of the other varieties. It denotes of the presence of a high rate of proteins distorted in this flour. The times of wettability of flours of five varieties of sweet potato are lower than those suggested by Moutaleb et *al*. (2017) which observed a time of wettability of 234 seconds in composite flours (50-50%) of the vegetable (*Vigna unguiculata*) and of sweet potato (*Ipomoea batatas*) native of Niger.

The foaming capacity (FC) and the stability of the foam (SF) allow to improve the texture, the uniformity and the aspect of the food (Akubor, 2007). According to Yasumatsu et *al*., (1972), the training of the foam and its stability depend on the pH, the viscosity, the proteins and the processing. In this study, the values of foaming capacity obtained were between 3.13 ± 0.19 and 3.5 ± 0.35%. FC of sweet potato flours were generally low. Indeed, Adeleke and Odedeji. (2010) and Adam et *al*. (2017), obtained values of FC which were respectively 1.28% and 2 to 8% in not fermented and fermented flours of sweet potato native of Nigeria. The FC of flours of sweet potato from Cote d'Ivoire were low than those obtained with starch of manioc *Manihot esculenta* (13.70%) (Ubbor and Akobundu, 2009), with fruit from african bread *Treculia africana* (20%) and wheat (40%) (Akubor and Badifu, 2004). With these low percentages of FC and SF, the flours of five varieties of sweet potato will not be required in the preparations such as ice creams, mosses, whipped cream toppings, meringues where high FC and SF are required (Sharma et *al*., 2012).

The pH is an indicator of acidity or alkalinity of a product, and it affects significantly the performances of flours in several processes of food transformations. The Five sweet potatoes flours had a slightly acid pH, between 5,56 and 6,34. These values were comparable to those suggested by Van Hal (2000) and Mweta et *al*., (2010) with flours of sweet potatoes, and similar with the pH of the wheat flour (Tortoe et *al*., 2017). According to Ihekeronye and Ngoddy (1985), the acid products were more stable than the not acid products. Of these results, we can deduct that flours of the various varieties of sweet potatoes can be used in a efficient way in the food formulations, particulary in the preparation of the products of bakery and cake store.

The titratable acidity is a quality indicator of flours. The titratable acidity of flours of sweet potatoes varies from 0.72 to 1.11%. These contents were close to those obtained by Tortoe et *al*. (2017) with flours of twelve varieties of sweet potatoes native of Ghana (0.44 to 0.84%). It was reported that the acid food reduces the incidence of diarrheas at the infants (Lorri and Svanberg, 1994). So, flours of sweet potatoes, varieties Kabode, Irène, Fatoni, Tib and Bela Bela can be useful in the formulation of infantile food.

The absorption capacity of oil (ACO) is an important functional property of flours, because it plays an important role in the improvement of the flavor and the retention of the flaveur of food. In this study, the red oil is the best absorbed in all the flours, followed by refined palm oil (Aya), and olive oil. The sunflower oil has the lowest absorption capacity for all the flours. The mechanism of absorption of oil is mainly attributed to the connection of fatty acids on the non-polar chains of proteins (Wang and Kinsella, 1976). The results obtained in this study show that the red oil settles more easily on the not polar chains of proteins in comparison in the other oils. The ACO is also due to the availability of the lipophiles groupings flours (Medoua, 2005) .Les ACO of flours of sweet potato (76 to 149%) were in agreement with those suggested by Medoua, (2005) (72 to 94%), which worked on flours of the tuber hardened by the yam *Dioscorea dumetorum*. On the other hand, Moutaleb et *al*. (2017) and Adam et *al*. (2017) obtained higher ACO in mixtures of flour of the vegetable *Vigna unguiculata* and the sweet potato (1.67 to 2.04 g/g), and of flour of sweet potato fermented and not fermented (190 to 220%). Besides, the ACO of flours from sweet potatoes were widely superior to those suggested by Olapade and Ogunade, (2014) (13.3 to15.3%), which worked on mixtures of flour of sweet potato and cornstarch. The flours of five varieties of sweet potato had a good ACO, they could be good constituents lipophiles and thus to suit in the preparation of sausages, soups and cakes (Aremu et *al*., 2006).

The values of the report hydrophile/ lipophile obtained in this study for flours of five varieties of sweet potato were in agreement with those reported by Medoua. (2005) for flours from the yam *Dioscorea dumetorum* (2.5 to 4.1). However, Njintang et *al.* (2001) obtained more low values for the flour of niébé (in order of 1.12) .These results showed that flours of sweet potato had a bigger affinity with water than oils, what allows to suggest that flours of sweet potato, variety Kabode, Irène, Fatoni, Tib and Bela Bela should be intended preferentially for the formulation of products requiring a strong absorption capacity of water. The smallest gélifiante concentration (SGC) is the minimal quantity of flour which, put in the water, allows to form a firm gel after cooking. The training of the gels is a fundamental property of starches and proteins. The smallest gélifiante concentration (SGC) of flours of sweet potato varied from 14 to 16%. These results confirm those obtained by Olapade and Ogunade. (2014) (14.7 to 16%) which worked on flours of color sweet potato cremates and yellow. However Adeleke and odedeji (2010) and Adam et *al.* (2017) found values of more lower SGC in flours of sweet potato native of Nigeria which were respectively 3.60% and 6 to 10%. These SGC from various flours can be due to the variations of the reports of the various constituents such as the starch, the lipids and the proteins which compose them (Akaerue and Onwuka, 2010).

CONCLUSION

The functional properties of flours from sweet potato (*Ipomoea batatas*), widely consumed in Côte d'Ivoire were studied. Results showed that all the varieties had different functional properties importants in food transformations, nutrition, formulation of the infantile food or in many food industries.

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