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Physicochemical Properties of Pretreated Flours and Organoleptic Characteristics of Couscous of Four Varieties of Yams (*Dioscorea cayenensis rotundata*) Grown in Côte d'Ivoire

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ABSTRACT

In order to reduce post-harvest losses of yams in Côte d'Ivoire by more efficient conservation methods, four varieties of local yams (Lokpa, Assawa jaune, Assawa blanc, Kponan) were pretreated with a dilute solution of juice of lemon to 1% before the production of the different flours, according to the methods of the AOAC. The results indicate that the pretreatment reduced the loss of levels of physicochemical parameters such as proteins, total sugars and reducing sugars during cooking. However, the pretreatment did not significantly influence ($p \geq 0.05$) the swelling and solubility of the flours obtained. Couscous made from pre-cooked flour was generally appreciated, especially those of flours preserved in 100 µm thick bags. In terms of grading, the most accepted couscous was that of the Assawa jaune variety followed by the Kponan variety, then the Assawa blanc variety and finally the Lopka variety.

Key words*: Yam cossettes; Yam flour; Characterization; Post-harvest*

INTRODUCTION

Yam is a tuber plant that grows in all wet, tropical and subtropical regions. Belonging to the genus *Dioscorea*, it comprises about 600 species[1] of which 40 to 50 species are cultivated or harvested[2]. The main domesticated and cultivated species are *Dioscorea rotundata, D. cayenensis, D. rotundata cayenensis complex, D. alata, D. opposita, D. trifida, D. bulbifera, D.dumetorum*[3]. Yam represents the first food crop in Côte d'Ivoire in volume, with an annual production of about 6.8 million tons[4]. Unfortunately, the actors in the yam sector are confronted with problems of post-harvest conservation[5]. In some areas of Côte d'Ivoire, traditional conservation methods such as pits, hangars and granaries are used.

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But these methods do not prevent the action of pests (termites, crickets, beetles) and rodents (rats) that cause significant damage. Rotation is also one of the factors limiting the conservation of these tubers, without, however, neglecting germination which can occur when the shelf life is extended[6].

In order to reduce post-harvest losses, farmers in Nigeria and Benin process yams into cossettes and flours before storage. These techniques allow their good conservation. But, they are not practiced in Cote d'Ivoire because consumers are used to cooking the yam in the fresh state. The various dishes are generally "N'gbo" (yams boiled in water), "Foufou" (crushed yams), "foutou" (crushed yams), "allouboué" Yam), French fries and braised yam[6]. The objective of this work is to experiment with other forms of conservation and use of local yams in Côte d'Ivoire to help reduce post-harvest losses. It will be a natural antioxidant pretreatment consisting of a solution of lemon juice to four cultivars of yams and then to compare the physico-chemical characteristics During storage.

MATERIAL AND METHODS

Sample collection, preparation and treatment

The cultivars of yams from the same species *Dioscorea cayenensis rotundata* were used during the various works. These are: *Lokpa*, *Assawa jaune*, *Assawa blanc*, *Kponan*. All tubers used in this study were harvested from eastern Côte d'Ivoire in the Zanzan region.

The yams, after washing and then peeling with a stainless steel knife, were cut into cossettes about one centimeter thick and then separated into two batches. One of the lots underwent antioxidant pretreatment with a dilute 1% lemon juice solution. The operation was carried out in the following manner: 1 kg of cossettes are totally immersed for 30 min in 5 L of an aqueous solution of lemon juice. The yam cossettes are then removed and drained for a few minutes and then boiled with water for 10 min in a container containing 3 L of boiling water. Finally, according to the treatments, the 4 types of cossettes obtained are:

- ENTCR: untreated raw samples,
- ETCR: raw pretreated samples,
- ENTCU: untreated precooked samples,
- ETCU: pretreated precooked samples.

The cooked cossettes and the raw cossettes were pre-dried in an oven at 105 ° C for 5 hours and then transferred to the ventilated oven until complete drying.

Using a grinder equipped with a 100 μm diameter sieve, the various dried chips were ground to obtain flours. The various production operations for cossettes and flours are presented in a diagram (Fig. 1).

Fig. 1: Diagram of production of cossettes and yams *(Dioscorea cayenensis-rotundata)*

Conservation of flours in a polyethylene bags

The flours obtained from the cossettes of the various varieties were stored for 90 days (3 months) in polyethylene bags of three different thicknesses (80 µm, 90 µm and 100 µm) at a rate of 100 g per sachet. The packaged samples were analyzed for three months at the rate of one analysis each month. Resulting in a total of 3 × 4 samples per variety depending on the three pouch thicknesses ; a total of 48 samples.

Proteins

Protein levels were determined according to the Kjeldahl method[7]. One gramme of flour was heated at 400 °C for 2 h in the presence of a pinch of the catalyst mixture (selenium + potassium sulfate (K_2SO_4) and 20 mL of 97 % (v/v) sulfuric acid (H_2SO_4). The mineralization obtained was supplemented to 100 mL with distilled water and 10 mL of sodium hydroxide (40 %, w/v) was added before being boiled in a distiller of LEGALLAIS type. The ammonia released was trapped in a measuring vessel containing 10 mL of the acid-base mixture (4 %, w/v) mixed indicator (methyl red + bromocresol green) at pH 4, 4-5,8. The total nitrogen was assayed with a decimolar solution of sulfuric acid.

$$N(\%) = \frac{V(H_2SO_4) \times N(H_2SO_4) \times 14{,}007 \times 100}{1000 \times PE} \quad (1)$$

V (H_2SO_4): *Volume in mL of H_2SO_4 required for titration*
N (H_2SO_4): *Sulfuric acid standard used for titration (0.1N)*
PE: *Test sample (g)*
N %: *Nitrogen Rate*
14,007: *Atomic mass of nitrogen*
The protein content was obtained by multiplying the nitrogen content by the conversion coefficient 6.25 (Glowa, 1974).

Ethane-soluble sugars extraction

The sugars of the flours were extracted according to the technique described by Martinez-Herrera *et al*[8]. 1 g of sample was weighed and placed in a centrifuge tube. 10 mL of ethanol (80 %, v/v) was added thereto. The mixture was homogenized and centrifuged at 6000 rpm for 10 min in a centrifuge (JOUAN, BR4i multifunction, St Nerblain, France). The collected supernatant was stored in a 50 mL Erlenmeyer flask. The culot was taken up in 10 mL of ethanol (80 %, v/v), homogenized and centrifuged under the same conditions as above. The new supernatant was added to the first content in the 50 mL Erlenmeyer flask. The ethanol contained in this mixture was evaporated to the maximum on a sand bath. The deposition of sugars obtained was used for the determination of the ethane-soluble sugars.

Total sugars

The total sugars were determined according to the method described by Dubois *et al.*[9] using phenol and concentrated sulfuric acid. 0.1 mL of the ethanol-soluble extract was taken from a test tube. 0.9 mL of distilled water, 1 mL of phenol (5 %, w/v) and 1 mL of concentrated sulfuric acid (97 %) were added to this volume. The reaction medium was homogenized and allowed to cool for 5 min. The optical density reading was performed at 490 nm on a spectrophotometer (Shimadzu Spectrophotometer UV-120-02, Kyoto, Japan) against a control containing 0.1 mL of distilled water in place of the ethanol-soluble extract. Optical density was expressed as total sugars using a calibration line (0.01 to 0.1 mg/mL) constructed from glucose solution (1 mg/mL).

Reducing sugars

The reducing sugars were determined according to the Bernfeld technique[10] using 3,5 dinitrosalycilic acid (DNS). 0.1 mL of the ethanol-soluble extract was taken from a test tube. To this volume were added 0.9 mL of distilled water and 0.5 mL of the DNS solution, respectively. The mixture was taken to a boiling water bath for 5 min. After cooling for 5 min at room temperature, 3.5 mL of distilled water was added to the reaction medium. The optical density reading was made at 540 nm at the spectrophotometer (Shimadzu, Spectrophotometer UV-120-02, Kyoto, Japan) against a control containing 0.1 mL of distilled water in addition to the ethanol-soluble extract. The optical density was expressed as the amount of reducing sugars by means of the calibration curve obtained from a glucose solution (1 mg/ml).

Ashes

The ash rates were determined using the AOAC method[7]. 2 g of flour (WE) was weighed in a dried porcelain crucible of mass W1 and then incinerated in a muffle furnace at 550 °C for 8 h. The ash obtained was put in a desiccator for cooling before weighing. The crucible containing the calcined sample was weighed (W2). The ash rates were determined according to the following relationships:

$$Ash\ (\%) = \frac{(W_2 - W_1)}{W_E} \times 100 \qquad (2)$$

Swelling and solubility

The swelling and solubility of the flours were determined according to the method described by Adebooye and Singh [11]. A 1% suspension of flour was placed in a water bath at various temperatures (50 °C to 95 °C) at intervals of 5 °C with maximum stirring for 1 hour. The suspensions contained in tubes were centrifuged at 15000 rpm for 15 min. The Culot (Wcu) and the supernatant were collected in different containers, weighed and dried in an oven at 105 °C for 24 h for the supernatant and 48 h for the culot. Their respective masses were then determined after drying (Ecu and Esu respectively). The supernatant was used to determine the solubility (S) and the culot for the swelling (Sw) according to the following formulas:

$$S\ (\%) = 100 \times (E_{su} - W_{co}) / X_i \qquad (3)$$

$$Sw\ (g/g) = (W_{cu} - E_{cu}) / (E_{cu} - W_{co}) \qquad (4)$$

***S (%)**: solubility expressed as a percentage (%)*
***Sw (g water / g flour)**: swelling capacity (g water / g flour)*
***Esu**: mass of the crucible + supernatant after baking (g)*
***Wco**: mass of the empty crucible (g)*
***Xi**: test portion of the flour (g)*
***Wcu**: mass of the crucible + base (g)*
***Ecu**: mass of the crucible + cap after stoving (g)*

Sensory analysis of yam couscous

Production of yam couscous

In the manufacture of couscous, raw flours have not been taken into account because they do not lend themselves to it. In fact, during the molding process, a paste is obtained in place of granules. The flours preserved in the three types of packaging (thicknesses 80 µm, 90 µm and 100 µm) were transformed into yam couscous. Yam couscous is obtained by manually rolling yam flour cooked with water. This mixture makes it possible to obtain very fine rolled granules which are then dried in the sun and then steamed.

Preparation of the panel and presentation of samples

The different couscous were assessed on the basis of the following criteria: odor, taste, color and overall appreciation by a panel of tasters composed of 50 randomly selected people. The age of these people varies between 30 and 45 years. These panelists or judges were given explanations of the correct understanding of the test and were then trained for two days. The evaluation tests were carried out in an airy room free from odors, as well as auditory and visual distractions. Each panelist received on a plate samples of each variety defined above, coded with alphabetical letters and after tasting has completed a form elaborated for this purpose. To switch between samples, the panelist rinses his mouth with water and consumes a slice of bread. They do not communicate with each other during the evaluation period.

All samples are presented to both tasters to enable them to be evaluated a second time if necessary. The scoring criteria are explained to the evaluators before the start of the event. The notes to be allocated are between 0 and 10. To do this, each taster has a plug[12] which is a scale ranging from 0 to 10 cm. Each centimeter corresponds to a difference in sensitivity. The taster is instructed for this purpose to mark with a cross on the right his assessment of the organoleptic quality of the sample. These different scores are compiled for all subjects to form the data on which ANOVA is applied.

Statistical analysis

The statistical analyzes of the data were carried out using the STATISTICA 7 software.

1. Averages of the physicochemical properties data were analyzed for variance (ANOVA). When a significant difference was observed, pairwise comparisons were made by performing the Duncan test. This test makes it possible to identify the flours which differ significantly from one another. The significance of the mean difference is determined by comparing the probability P associated with the Fischer-Snedecor test statistic to the theoretical threshold of $\alpha = 0.05$. Thus, when $P \geq 0.05$, we deduce that there is no significant difference. On the other hand, when $P \leq 0.05$, there is a significant difference between the different averages.

Results and discussion

Protein content

The protein content of the different flours (Fig. 2) did not show a significant difference ($p \geq 0.05$) during the 90 days of storage for each type of sample (ETCR, ETCU, ENTCR and ENTCU). Similarly, the different thicknesses of bags (80 µm, 90 µm, 100 µm) used for the packing of flours do not influence the protein contents during the 90 days of storage. The protein content of flours from pretreated raw samples (ETCR) with antioxidant (diluted 1% lemon juice solution) was higher in the *Lokpa, Kponan* and *Assawa jaune* varieties. They are respectively about 8.23%, 5.62%, 3.61%. When the samples are precooked, the protein contents of the flours of those treated with antioxidant (ETCU) are the highest. These rates are approximately 5.55%, 5.48%, 3.85%, 3.36% for the ETCU, respectively for the *Lokpa*, *Kponan*, *Assawa blanc* and *Assawa* *jaune* varieties. For ENTCU, the rates are approximately 0.88%, 4.41%, 3.30%, 3.28% for *Lokpa, Kponan, Assawa white,* and *Assawa yellow* respectively. The results indicate a decrease in protein levels during cooking. This decline in rates could be explained by the denaturation of proteins under the effect of heat. However, antioxidant pretreatment better preserves proteins. It therefore reduces the loss of proteins during treatments such as cooking, drying and grinding.

Total sugar content

Pretreatment of yams with natural antioxidant (1% diluted lemon juice solution) did not significantly ($p \geq 0.05$) influence the total sugar content of the four raw varieties. On the other hand, the results indicate a decrease in the total sugar content of the cossettes of the four varieties of yam after cooking (Fig. 3). However, the loss is less when the cossettes are pretreated with the diluted lemon juice solution (1%). The treatment would therefore have prevented the strong solubilisation of the sugars during cooking. The decrease in total sugars is due to the leaching phenomenon which leads to the diffusion of sugars in the cooking water. Indeed, under the effect of heat, the cell walls of plant tissues are weakened. They burst and thus facilitate the release of sugars. The total sugars of the *Assawa yellow* flour preserved in 100 μm thick bags increased significantly ($p \leq 0.05$) for ENTCR samples and remained stable for ETCR samples. This phenomenon can be explained by the fact that the flours have taken a little moisture, thus causing a resumption of the enzymatic activity of the amylase. The amylase then degrades the starch into single sugar, thus causing the increase in the total sugar content during storage. As for the cooked samples (ETCU), the reduction in total sugars takes place from the first month to the third month of storage. This would be due to the hydrothermal treatment which weakly degraded these sugars[13,14].

Reducing sugar content

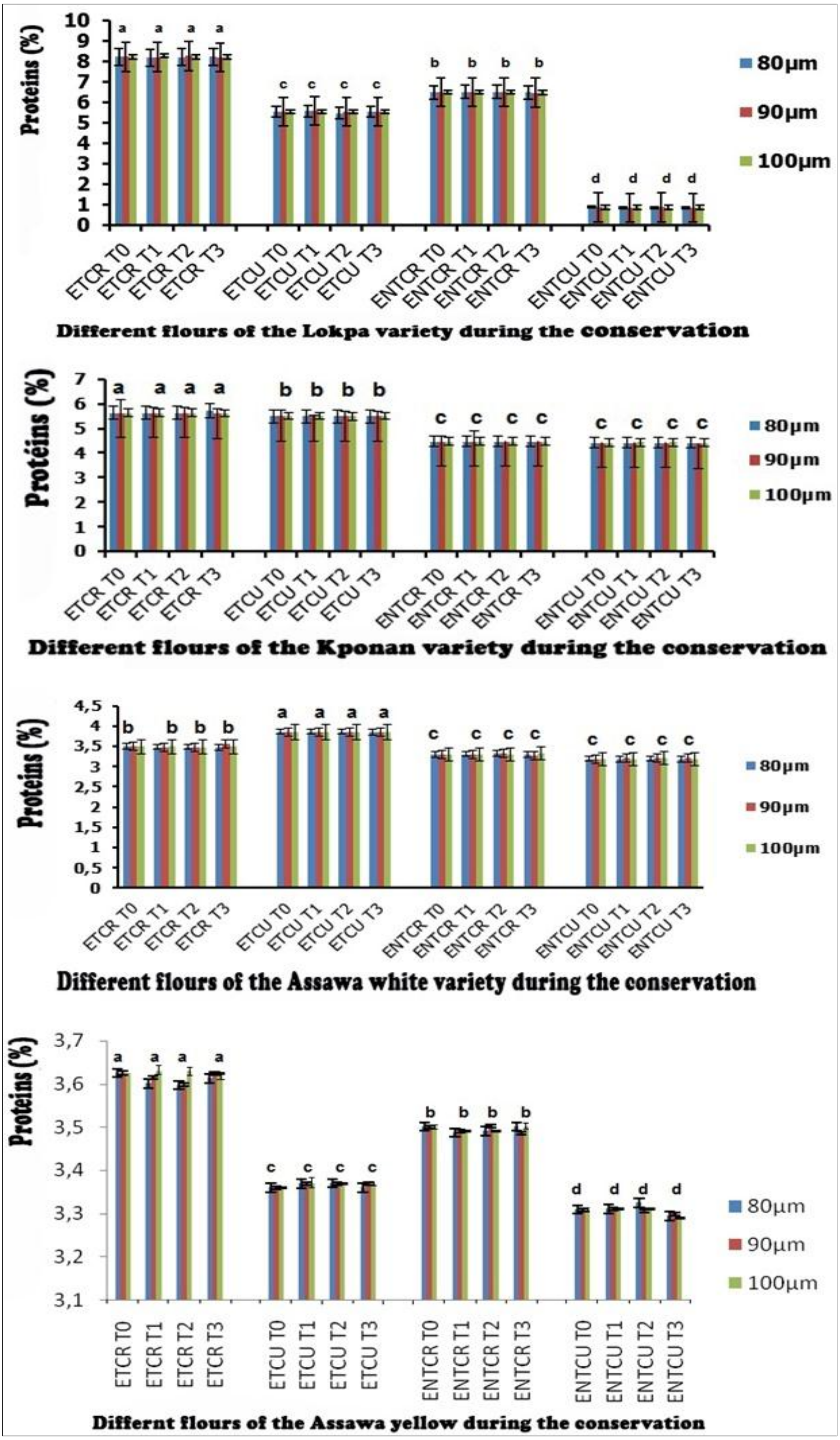
Cooking of the cossettes significantly reduced ($p \leq 0.05$) the reducing sugar contents of the different flours obtained (Fig 4). As with total sugars, the reduction of reducing sugar content is less when the cossettes are treated with the diluted lemon juice solution (1%). The decrease in total and reducing sugars may be due to the simultaneous phenomena of hydrolysis and gelatinization of starch which occur during cooking of the yam cossettes. Indeed, under the effect of heat, the starch grains swell and burst to release their contents composed mainly of amylose and amylopectin[15]. These molecules are then hydrolyzed to total and reducing sugars which are subsequently dispersed in the cooking water, thereby reducing them.

After three months of storage, it is observed that the levels of reducing sugars in the four varieties of yams remain stable. These sugars are thus well preserved when the flours are stored in these three types of sachets whatever the treatment of the yam cossettes.

Ash contents

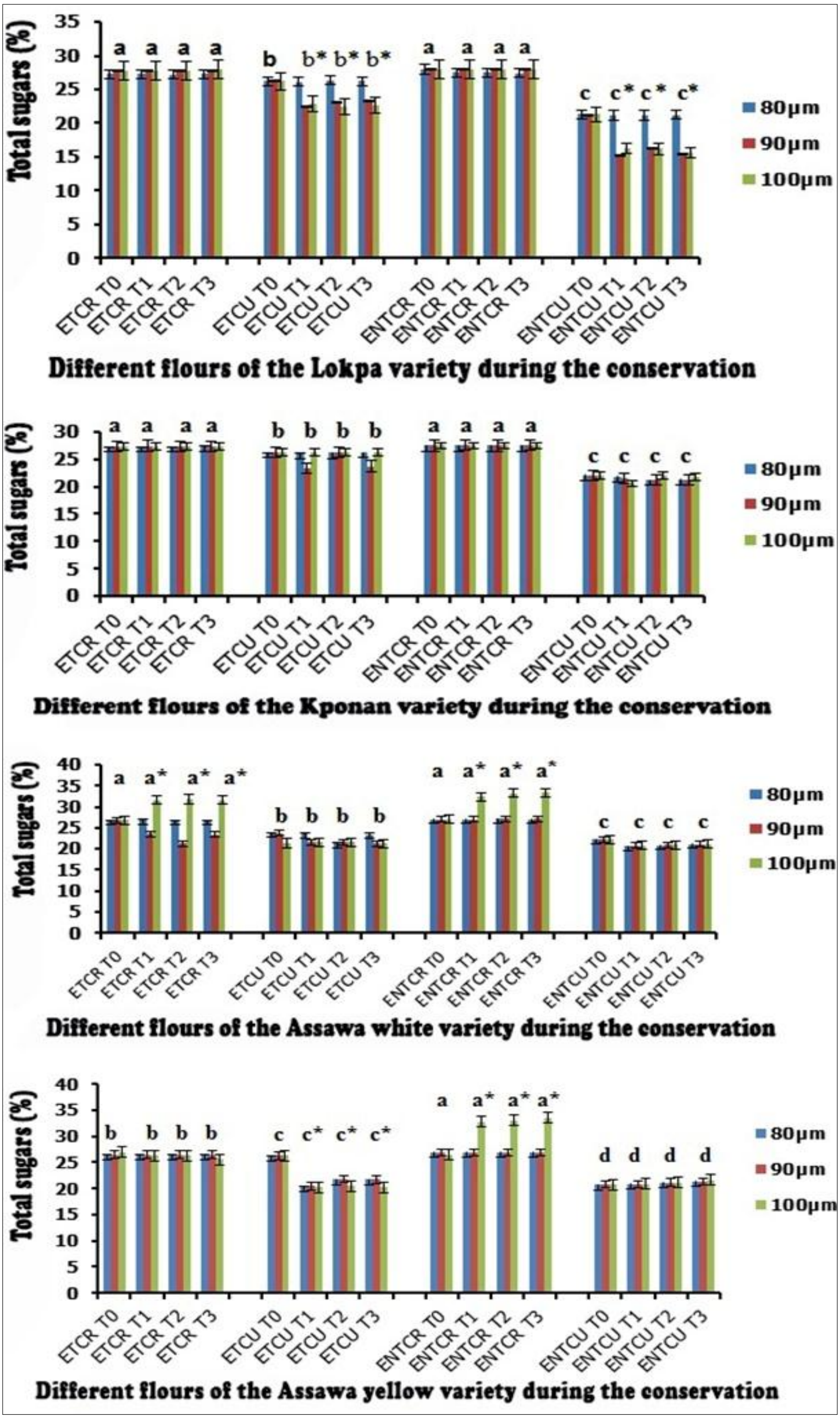
The results of the ash rate are presented below in Fig. 5. These results indicate that the treatment of the yam cossettes with the diluted lemon juice solution (1%) made it possible to increase the ash of the variety *Assawa yellow*. On the other hand, it caused the ash of the three other varieties to fall. Otherwise, cooking yam cossettes decreased significantly decreased ($p \leq 0.05$) the ash levels of the four varieties. This decrease could be explained by the leaching of the minerals in the boiling water during the boiling of the cossettes. At the end of three months storage in 80 μm, 90 μm and 100 μm polyethylene bags, the ash levels of the four yam varieties were not significantly ($p \geq 0.05$) varied.

Fig. 2: Protein content of the four varieties of yam (*Dioscorea cayenensis rotundata)*



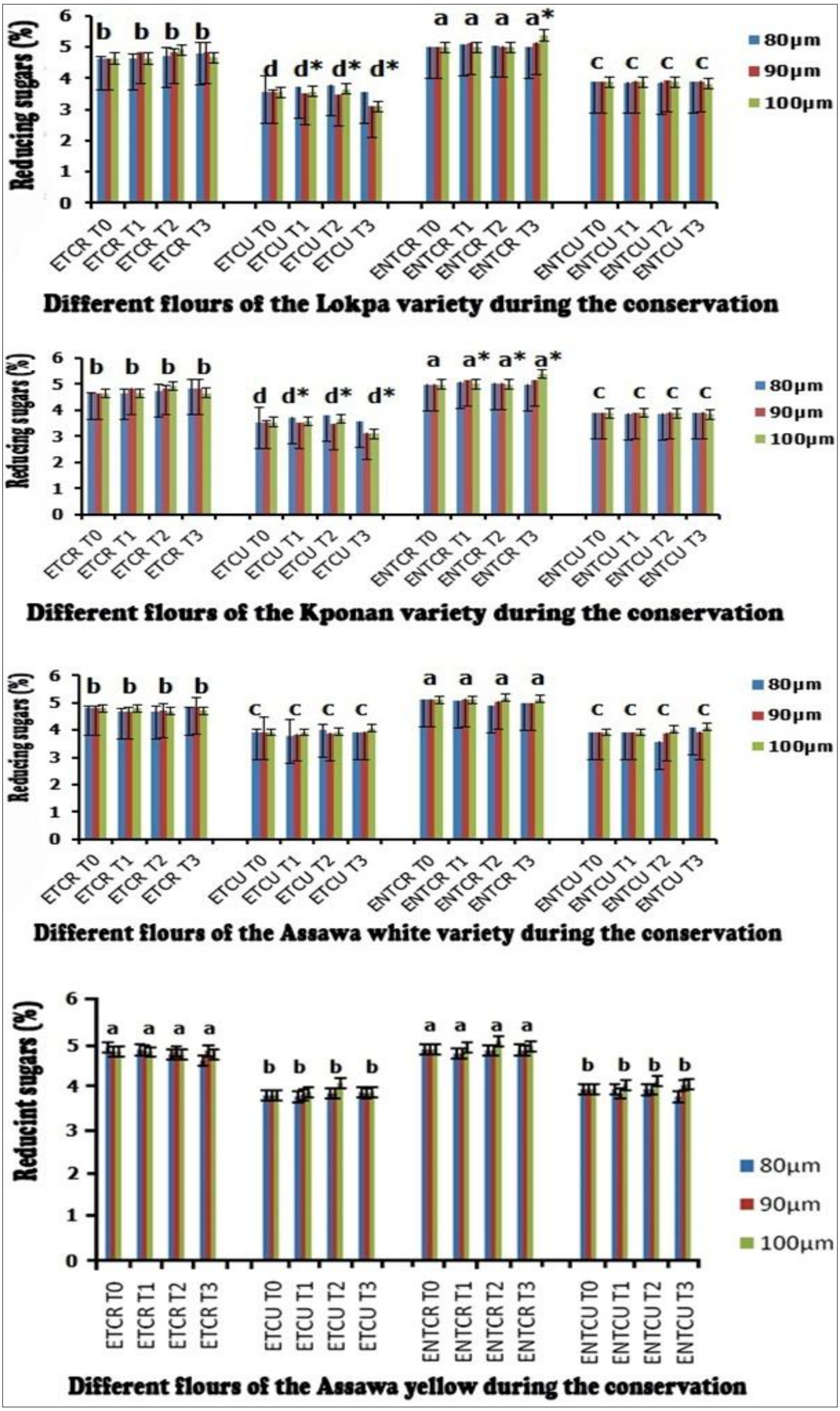
ETCR: raw pretreated flour; ENTCR: untreated raw flour; ENTCU: untreated pre-cooked flour; ETCU: pre-treated pre-cooked flour. T0: 0 months, T1: 1 month, T2: 2 months; T3: 3 months. The averages with the same alphabetic letters are not different.

Fig. 3: Total sugar content of the four varieties of yam (*Dioscorea cayenensis rotundata)*



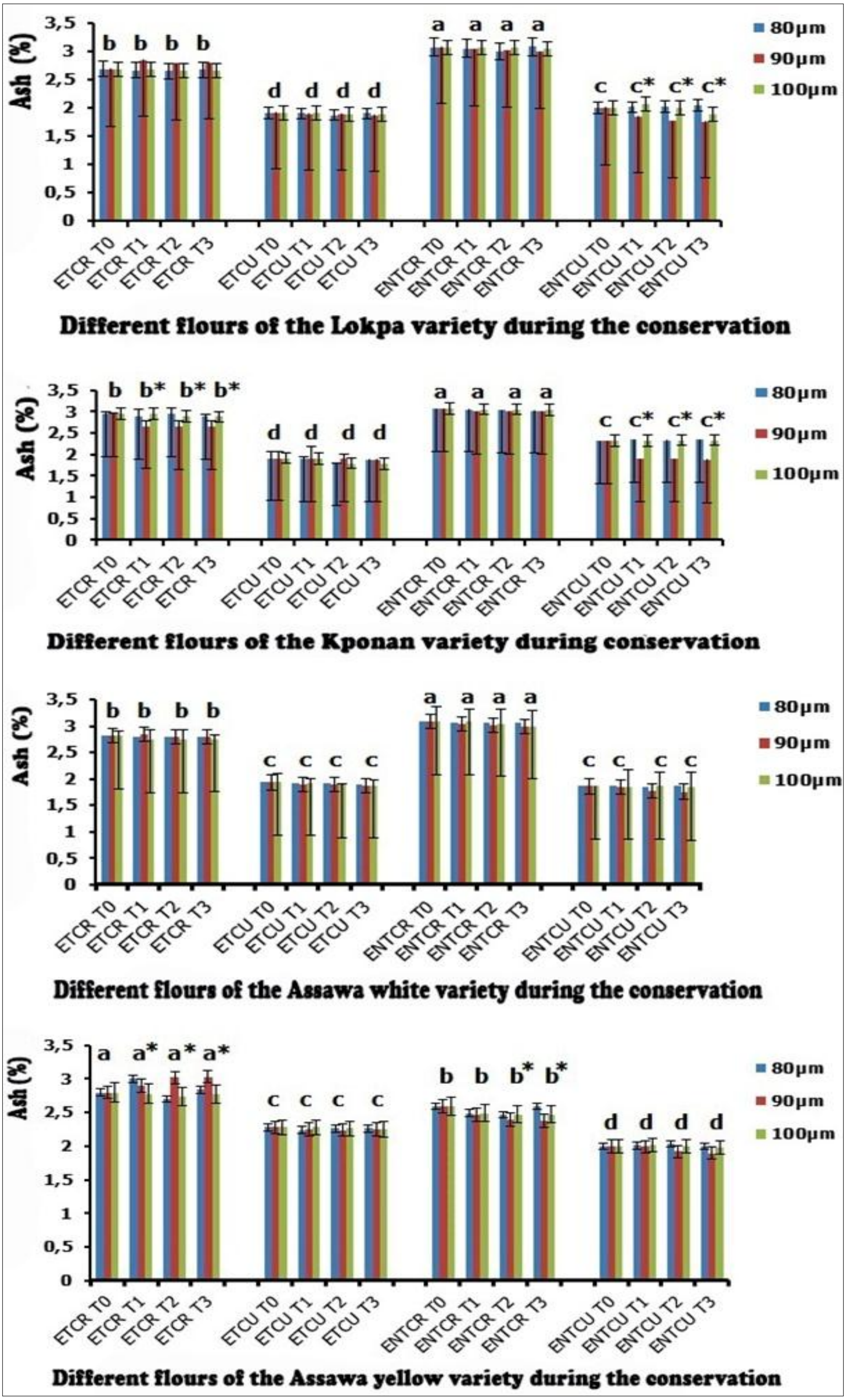
ETCR: raw pretreated flour; ENTCR: untreated raw flour; ENTCU: untreated pre-cooked flour; ETCU: pre-treated pre-cooked flour. T0: 0 months, T1: 1 month, T2: 2 months; T3: 3 months. The averages with the same alphabetic letters are not different.

Fig. 4: Reduced sugars content of the four varieties of yam (*Dioscorea cayenensis rotundata)*



ETCR: raw pretreated flour; ENTCR: untreated raw flour; ENTCU: untreated pre-cooked flour; ETCU: pre-treated pre-cooked flour. T0: 0 months, T1: 1 month, T2: 2 months; T3: 3 months. The averages with the same alphabetic letters are not different.

Fig. 5: Total sugar content of four varieties of yam (*Dioscorea cayenensis rotundata*)



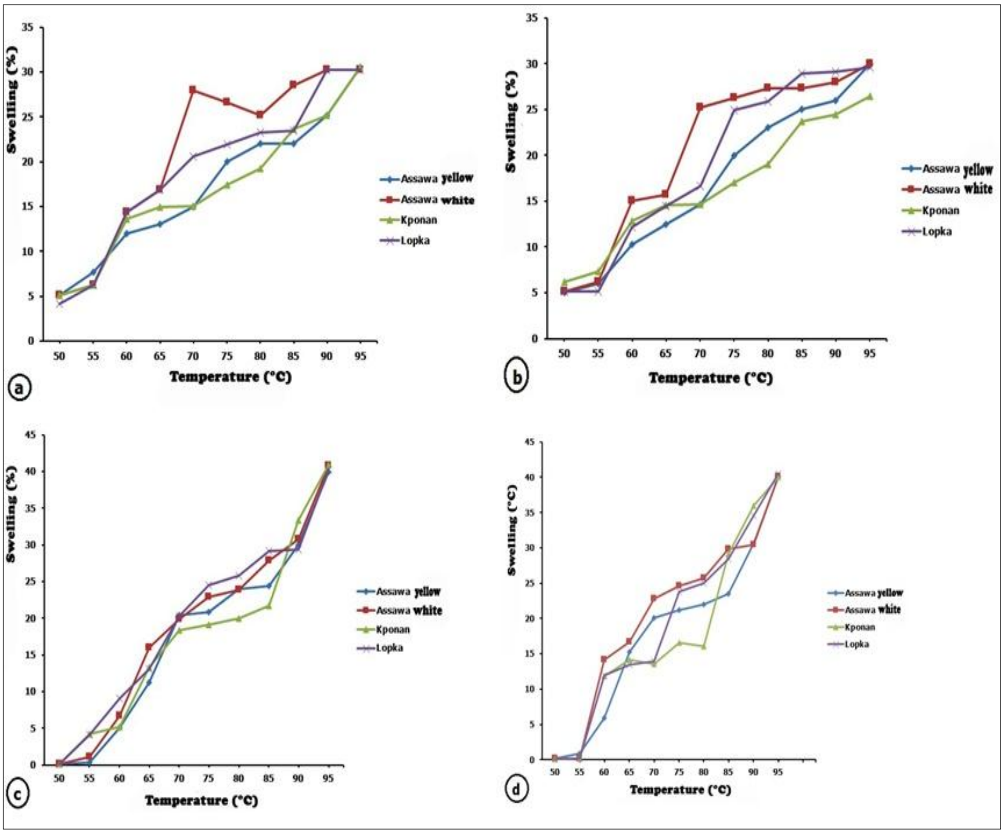
ETCR: raw pretreated flour; ENTCR: untreated raw flour; ENTCU: untreated pre-cooked flour; ETCU: pre-treated pre-cooked flour. T0: 0 months, T1: 1 month, T2: 2 months; T3: 3 months. The averages with the same alphabetic letters are not different.

Swelling and solubility

The percentages of swelling of the different yam flours are represented by the graphs in Fig. 6. The results show that the swelling rates of the flours from the precooked samples (ENTCU and ETCU) of the four varieties do not differ significantly (a and b). The same result is obtained for raw flours samples (c and d). Swelling of pre-treated pre-cooked flour (ETCU) and untreated pre-cooked flour (ENTCU) of the four varieties is suddenly between 55 °C and 60 °C and increases when the temperature rises to 95 °C. From 50 to 55 °C, the swelling of pre-treated pre-cooked flours (ETCU) are between 4.14% (*Lokpa*) and 7.73% (*Assawa yellow*). Those of untreated pre-cooked flours (ENTCU) is between 5.1% (Assawa yellow) and 7.29% (Kponan) for the same temperatures. In the case of raw pre-treated (ETCR) or raw untreated samples (ENTCR), the swelling also occurs at the same temperatures. But, the rates are low than those of the flours of the pre-cooked samples. The swelling of flours from raw samples ranges from 0.1% (*Assawa white*) to 4.2% (*Kponan*) for the ETCR and from 0.1% (*Lokpa*) to 0, 9% (*Assawa yellow*) for ENTCR. This difference in swelling between the flours of the raw samples and those of the pre-cooked samples is explained by the fact that the pre-cooked cossettes have already undergone a pregelatinization of their starch during cooking. This increases the starch water binding capacity of these flours[16]. The results also indicate that pre-treatment with lemon juice does not influence flour swelling.

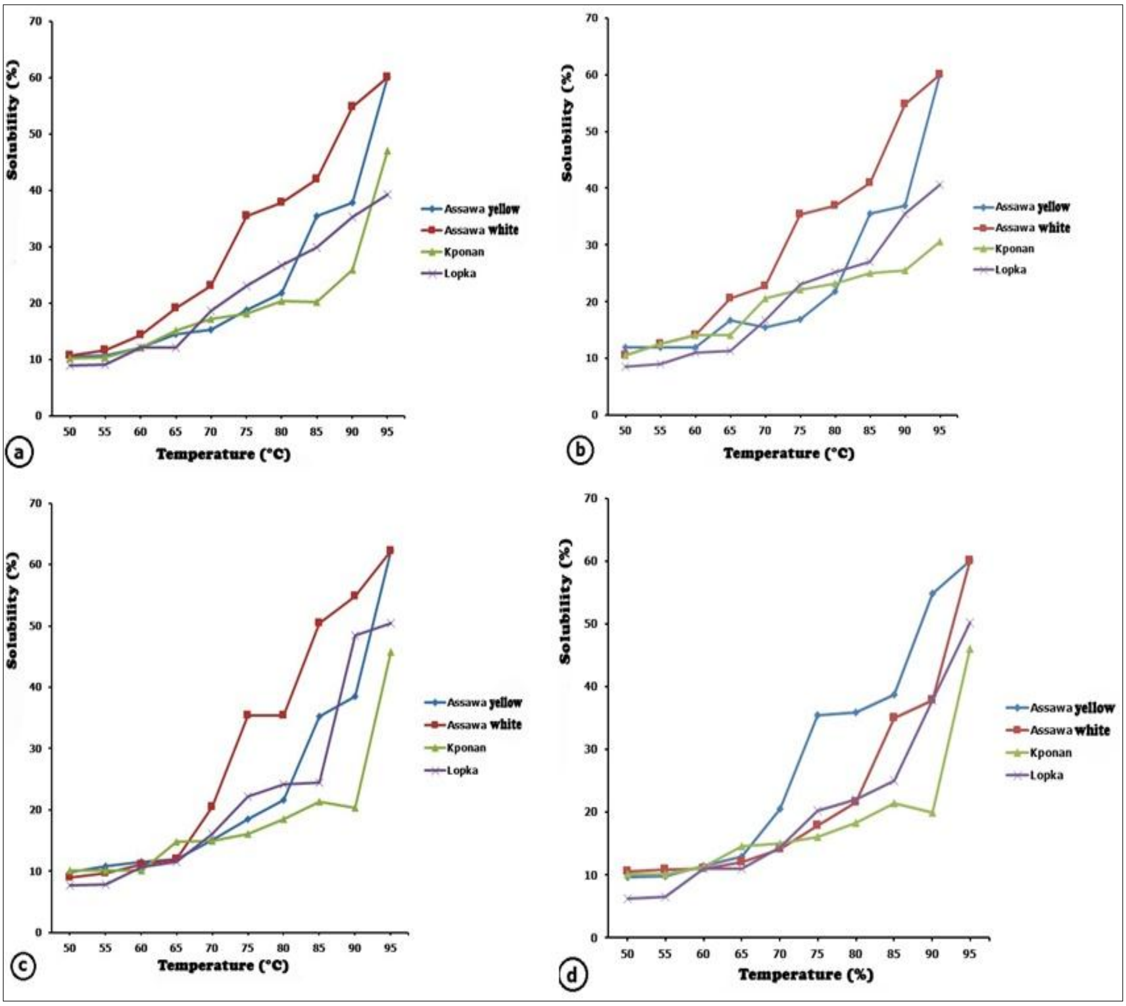
Fig. 6 shows the solubility of the different flours of four varieties of yam. The solubility of the cooked samples of the four varieties of yam has similarities (a and b), with the exception of ETCU flour of the *Kponan* variety which has a low solubility between 90 °C and 95 °C. At the level of the raw samples, the solubility of the flours ETCR and ENTCR of the four varieties of yam have an almost similar evolution (c and d). Pre-treatment with lemon juice does not influence the solubility of the flours of the four varieties of yam.

Fig. 6 : Swelling of flours of Assawa yellow, Assawa white, Kponan and Lokpa varieties



a: flours of pre-cooked untreated samples (ENTCU); b: flours of pre-cooked pre-treated sample (ETCU); c: flours of raw pretreated samples (ETCR); d: flours ot raw untreated samples (ENTCR)

Fig. 6 : Solubility of flours of Assawa yellow, Assawa white, Kponan and Lokpa varieties



a: flours of pre-cooked untreated samples (ENTCU); b: flours of pre-cooked pre-treated sample (ETCU);
c: flours of raw pretreated samples (ETCR); d: flours ot raw untreated samples (ENTCR)

Sensory analysis of couscous

Sensory analysis was done on couscous made from cossette flour, pretreated or not, with the diluted solution of lemon juice and precooked (ETCU and ENTCU), sotred for three months.

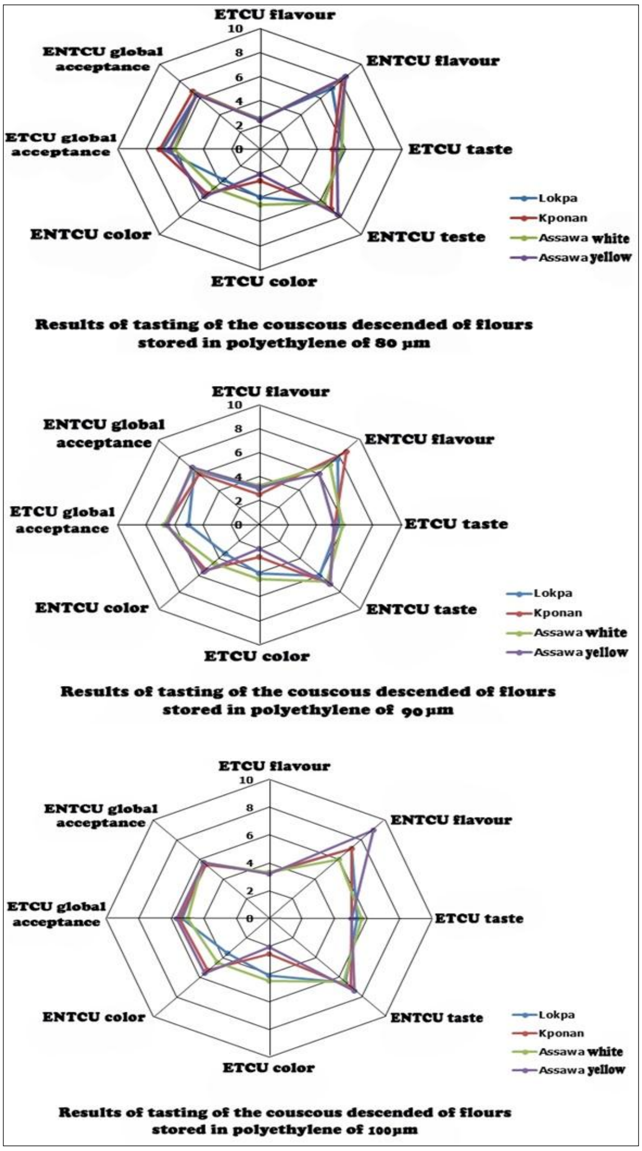
The flavour of yam couscous from treated samples is different from that of untreated samples. Pretreatment had a significant impact ($P \geq 0.05$) on the flavour of couscous. Indeed, the tasters had difficulties in perception of the yam flavour of couscous from pretreated samples. It was quite the opposite with those of the untreated samples. This result has been confirmed with those reported by the International Cooperation[12] who observed the difficulty of tasters to smell yam flavour, because flours were significantly influenced by temperature, the duration of the conversation and the method of cooking.

The taste of couscous from pretreated samples of the *Lokpa* and *Assawa white* varieties was more appreciated than that of the *Kponan* and Assawa yellow varieties. As for the taste of couscous from unprocessed samples of the Kponan and *Assawa yellow* varieties, it was more appreciated than that of *Lokpa* and *Assawa white*. It is to be understood that the taste of the yam was difficult to perceive at the level of the couscous originating from the pretreated samples. In general, these couscous were judged not to have a repulsive aftertaste. Many consumers have found the taste of these yam couscous very pleasant and quite distinctive from the current couscous on the market. On the other hand some consumers say not enough smelled the taste of the yam in the preparations. Thus, the different technological operations should make it possible to preserve the taste of the basic material. This result is close to those of Gravoueille[17].

Regarding the color of couscous, it varies according to the varieties of yam. It is yellow for *Assawa yellow* and *Kponan*, white for *Assawa white* and off-white for *Lokpa*. However, statistical analysis reveals a difference in color between couscous from pre-treated cossette flour and from untreated cossette flour. Couscous made from flour of cossettes pretreated with natural citric acid has a lighter color than those obtained from cossette flour which has not undergone pretreatment. Indeed, the antioxidant treatment makes it possible to block the enzymatic browning reactions during subsequent processing operations[12].

The results of the acceptability test show that the different couscous were judged to be good. In general, flour results from pre-cooked untreated cossettes of the four varieties did not differ ($p \geq 0.05$). The significant difference ($p \leq 0.05$) is found in the pre-cooked pre-treated flours. In general, the most accepted couscous is that of the *Assawa yellow* variety, then comes the *Kponan* variety, then the *Assawa white* variety and finally that of *Lopka*.

Fig. 7: Sensory analysis of couscous prepared from yam flours from sachets of different thickness (80 µm, 90 µm, 100 µm), after 3 months of storage



ENTCU: flours of pre-cooked untreated samples; ETCU: flours of pre-cooked pre-treated sample;
ETCR: flours of raw pretreated samples; ENTCR: flours ot raw untreated samples

CONCLUSION

The objective of this work was to provide producers with other forms of yam utilization. From this point of view, we have experimented the methods for the production and conservation of flours of four varieties of local yams. At the end of this study, results show that the chemical characteristics of the samples depend on the variety of yam and the type of treatment undergone by the cossettes. In general, cossette flours that had been treated with the dilute solution of lemon juice (1%) had their nutrients preserved significantly in subsequent operations. However, cossettes boiling leads to a significant decrease these elements whatever the type of pretreatment operated. During storage, the variation of the different chemical components of the flour was also a function of the yam variety, the type of treatment undergone by the cossettes and the thickness of the polyethylene film used (80 .mu.m, 90 .mu.m and 100 .mu.m). From the point of view of the overall sensory appreciation of the processed products, the couscous which has been better appreciated by the panelists are those made from the pre-cooked cossette flour and packed in the 100 µm bags.

REFERENCES

1. Coursey, D.G., "Yam, an account of the nature, origine, cultivation and utilisation of the useful members of the *Dioscoreacea*", *Tropical agriculture* series, tropical products institute, Longmans; London, (1967).
2. Dansi "Caractérisation des principaux cultivars d'ignames cultivées du complexe Dioscorea cayenensisrotundata du Nord-Est du Bénin", DEA de biotechnologie et amélioration des productions végétales, Université d'Abidjan, pp. 41, (1995).
3. Dansi, D., "Ressources génétiques des ignames cultivées du complexe Dioscorea cayenensis-Dioscorea rotundatadu Bénin", Thèse de doctorat. Université d'Abidjan, pp. 210, (2000).
4. Kouakou, A.M., Zohouri, G.P., Dibi, K.E., N'zué, B., Foua, B., Emergence d'une nouvelle variété d'igname de l'espèce Dioscorea alata L., la C18, en Côte d'Ivoire", *Journal of Applied sciences*, 57: pp. 4151-4158 (2012).
5. Faostat, Mise à jour du 30/08/2002, Statistiques démographiques de la Côte d'Ivoire, 2002.
6. FIRCA (Fonds Interprofessionnel pour la Recherche et le Conseil Agricoles), "Répertoire des Technologies de conservation et transformation de l'igname et de la banane plantain", COTIM, Tunisie, pp. 155, (2010).
7. AOAC, "Official Methods of Analysis of the Association of Official Analytical Chemists", 15th ed., AOAC, Arlington, Virginia, USA, (1990).
8. J. Martinez-Herrera, P. Siddhuraju, G. Francis, G. Davila-Ortiz, K. Becker, "Chemical composition, toxic/ antimetabolic constituents and effects of different treatments on their levels, in four provenances of J. curcas L. from Mexico", *Food Chemistry*, **96:** pp. 80-89 (2006).
9. Dubois, M., Gilles, K.A., Hamilton, J.K., Roben, F.A., Smith, F., Colorimetric method for determination of sugar and related substances, *Analysis chemical*, no. **28:** pp. 350-356 (1965).
10. Bernfield, P., Alpha and beta-amylases, In, Methods in Enzymology, Colowick S.P. and Kaplan N., eds. Academic Press, New York,1, pp. 149-158 (1955).
11. Adebooye, O.C., Singh, V., Physico-chemical properties of the flours and starches of two cowpea varieties (Vigna unguiculata L. Walp), *Innovative Food Science and Emerging Technologies*, **9:** pp. 92-100 (2008).
12. Watts, B.M., Ylimaki, G.L., Jeffery, L.E., Elias, L.G., Méthodes de base pour l'évaluation sensorielle des aliments, Ottawa, Ont., CRDI, Canada, pp. 145 (1991).
13. Trèche, S., Guion, Ph., Etude des potentialités nutritionnelles de quelques tubercules tropicaux au Cameroun, *Agronomie tropicale*, **2:** pp. 127 – 156. (1979).

14. Dadié, A.T., Etude de quelques propriétés physico-chimiques de l'amidon et de la farine de patate douce (Ipomea Batatas)", DEA, Université nationale de Côte d'Ivoire, (1993).
15. Bjorck, N.G. Asp, D. Birkhe, Lunquist, I., Effects of processing on starch availability *In vitro* and *In vivo*. II. Drum-drying of wheat flour, *Journal of Cereal Science* **2(3):** pp. 165-178, (1984).
16. Whistler, R.L., Paschall, E.F., Starch chemistry and technology, **2:** Industrial aspects. New York et Londres, Academic Press. (1967).
17. N. Bricas, T. Ferré, "Tester l'acceptabilité de nouveaux produits", In TPA Bulletin du réseau Technologie et partenariat en agroalimentaire, **18:** pp. 21, (2000).