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Proximate composition of wild yam *Dioscorea praehensilis* Tubers flours as Influenced by Boiling Times

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Abstract: The wild yam *Dioscorea praehensilis* is widely consumed as famine food in Côte d'Ivoire and numbers of African countries mainly after boiling. Raw and boiled wild yam tubers (*Dioscorea praehensilis*) flours were analyzed for proximate contents such as ash, crude protein, carbohydrate, Moisture energy s using standard procedures and methods. (YT_0) was used as control compared to tubers boiled for 5 minutes (YT_5), 10 minutes (YT_{10}), 20 minutes (YT_{20}), 30 minutes (YT_{30}) and 40 minutes (YT_{40}). The crude protein contents (9.13 g/100g DM), ash (1.02 g/100g DM), lipid (3.25 g/100g DM), carbohydrate (89.21 g/100g DM) and Moisture (13.04%) were significantly ($p<0.05$) lowered in the boiled tubers. Even boiled, *Dioscorea praehensilis* remained a good energy supply product with about 391 kCal/100g. The evolution of parameters essentially the decrease of moisture content showed that for the storage and nutritional purpose, boiling had both positive and negative effect on yam tuber flours. A cooking time of between 5 and 40 min at 100°C was recommended for *D. praehensilis*.

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INTRODUCTION

About 8 wild edible yams (*Dioscorea praehensilis, Dioscorea hirtiflora, Dioscorea bulbifera, Dioscorea multiflora, Dioscorea burkilliana, Dioscorea dumetorum and Dioscorea togoensis*) are most known in Côte d'Ivoire thanks to studies on proximate composition and starches granules (Sahore and Amani, 2007; Sahore, 2010). The wild yam *D. praehensilis* emerged as the most popular among these species as it seems now in advanced domestication scale with cultivation of some tubers by peasants in fields. The emerging of domestication practices of *D. praehensilis* in many African regions (Tostain et al., 2003**;** Dansi et al., 2013; Djedatin et al., 2017) is a proof that this wild yam met people appreciation standard. This wild yam is used as famine food with a preference to the white variety (Tostain et al., 2003). The top consumption period of *D. praehensilis* tubers occurs while cultivated yams and other foods came out of stock. Miege (1952) estimated this period from June to September. This period corresponds to physiological maturity moment of *D. praehensilis*. Harvesting *D. praehensilis* tubers provide valuable source of starch to populations during these famine periods. The interest of rural population to this wild yam and domestication process in some West African countries like Benin may be due to its relation to highly appreciated cultivated yams of the *D. cayenensis-D. rotundata* complex **(**Dansi et al., 2013).

But *D. praehensilis* tubers are highly perishable. Organoleptic quality depreciation and tubers physical deterioration start immediately the day after its harvest if not consumed. These constraining situations let local people with no trade opportunities since traditional storage method seems inefficient for this yam. In order to give a real meaning to the famine food role assigned to *D. praehensilis* it would be convenient to convert fresh tubers into flour. The making of yam flour is a proven storage technology used to prevent yam tuber raw materials deterioration. In some West African countries like Benin, Nigeria, Togo, the yams tubers are used de make chips and then flour (Bricas, et al., 1997). The advantages of *D. praehensilis* flour would be double: it would fist solve storage purpose of this wild yam and open new economical possibilities to local populations. In fact, it is well known that flours have several applications in food technology. *D. praehensilis* had been reported to contain good amount of starch, minerals and proteins (Sahore, 2010). But the making of yam flours is not as simple as cereals ones which are widely perform in the world. Yam fresh tubers undergo hydrothermal treatment before its conversion into flours (Amandikwa et al., 2015).

This process known as blanching is performed in boiling water. The effect of the boiling treatment on the *D. praehensilis* flours quality had not yet been investigated. The proximate composition of foods includes moisture, ash, lipid, protein and carbohydrate contents. These food components are of interest in the food industry for product development, quality control or regulatory purposes. The purpose of the current study is to investigate the effect of boiling time on the wild yam *D. praehensilis* flours regarding its proximate composition.

MATERIALS AND METHODS

Raw materials

The wild yam *D. praehensilis* was used in the present study. Fresh tubers with variables lengths (20 - 63 ± 4.46 cm) and variable weights (0.5 - 5 kg) were harvested at physiological maturity in six villages (*Hallikro, Ketasso, N'Drikro, Kouassikro, AvocaKoffikro and Diabykro*) in Divo department (5 ° 50'N; 5 ° 22' W), about 204 km from Abidjan, Côte d'Ivoire. Harvested tubers collected from August to November were then carried the same day to Abidjan in jute bags.

Preparation of yam flour samples

D. praehensilis flour was produced as described by Bell and Favier (1982) with some changes concerning the boiling time**.** Yam tubers were peeled, thinly sliced, washed and blanched in boiling water for 5, 10, 20, 30 and 40 min. Pieces of precooked yams were left cooling for 25 minutes and cut into chips. Then these chips were dried at 45°C for 48 hours using a dryer made by I2T (Société Ivoirienne de Technologie Tropicale). The dried chips were milled and automatically pass through a 90 µm mesh size sieve to obtain the flour finally stored in plastic bags to prevent moisture re-absorption.

Proximate Composition Analysis

Dry matters were determined by drying in an oven at 105ºC during 24 h to constant weight (AOAC, 1990). Crude protein was calculated from nitrogen (Nx6.25) obtained using the Kjeldahl method by AOAC (1990). Crude fat was determined by continuous extraction in a Soxhlet apparatus for 8 h using hexane as solvent (AOAC, 1990). Carbohydrate content was determined through the method used by Samant and Rege (1989). Total ash was determined by incinerating in a furnace at 550ºC (AOAC, 1990). Method described by Dubois *et al.* (1956) was used to determine total sugars while reducing sugars were analyzed according to the method of Bernfeld (1955) using 3.5 dinitrosalycilic acids (DNS). The crude fibre contents were determined according to standard method (AOAC, 1990). The energy values (kcal/100g) of *D. praehensilis* flour samples were evaluated using formula described by Crisan and Sands (1978).

$EV = (2.62 \times \%P) + (8.37 \times \%F) + (4.2 \times \%C)$

%P = Protein %F = Fat %C = Carbohydrate

pH studies were conducted in the Laboratory of Biocatalysis and Bioprocesses of University Nangui Abrogoua, Abidjan, Côte d'Ivoire.

Statistical analysis

All analyses were carried out in triplicates. Results were expressed by means of ± SD. Statistical significance was established using one-way analysis of Variance (ANOVA) models to estimate the effect of boiling times on some anti-nutritional compounds and some organic acid levels of flour from yam at 5 % level. Means were separated according to Duncan's multiple range analysis ($P < 0.05$), with the help of the software STATISTICA 7 (Statsoft Inc, Tulsa-USA Headquarters) and XLSTAT-Pro 7.5.2 (Addinsoft Sarl, Paris-France).

RESULTS AND DISCUSSION

Results of the proximate composition of raw and boiled wild yam *D. praehensilis* tuber flour samples are as shown in Table 1. The aim of this paragraph is to evaluate the effect of boiling time on the proximate composition of the wild yam *D. praehensilis* tuber flour. For this purpose, six (6) wild yam flours were produced with different boiling times: 5 min (YT_5), 10 min (YT_{10}), 20 min (YT_{20}), 30 min (YT_{30}) and 40 minute (YT_{40}); the raw tuber flour was used as reference control. Results of proximate composition showed that there were significant differences ($p < 0.05$) in proximate parameters (ash, protein, Carbohydrates; fat content, moisture, and calorific energy supply) of the flour samples.

Table 1. Proximate composition of raw and boiled wild yam *Dioscorea praehensilis* flours (mean ± SD; n = 3)

Wild Yam Flours	YT_0	YT_5	YT_{10}	YT_{20}	YT_{30}	YT_{40}
Ash (g/100g DM)	1.02^{a}	1.01^{a}	1.01^{a}	0.88^{b}	0.87^{b}	0.75^{c}
Proteins (g/100g DM)	9.13^{a}	8.52^{b}	8.02^{c}	7.47^{d}	7.09^{e}	6.41^{f}
Carbohydrates (g/100g DM)	89.21^{a}	88.46^{ab}	87.99^{b}	87.29^{b}	86.21^{bc}	85.37^{c}
Fat (g/100g DM)	3.25^{a}	2.89^{b}	2.32^{c}	2.03^{d}	1.94^{e}	1.87^{f}
Energy (kCal/100g)	425.76^{a}	418.04^{ab}	409.98^{b}	403.18^{b}	396.89^{b}	391.00^{b}
Moisture (%)	13.04^{a}	11.41^{b}	11.13^{b}	10.81^{bc}	10.72^{c}	10.62^{c}
pH	5.53^{d}	6.04^{a}	5.88^{c}	5.93^{b}	5.86^{c}	5.85^{c}

YT_0 =fresh wild Yam Flour; YT_5=wild yam with 5 min of Boiling time; YT_{10}= wild yam with 10 min of Boiling time; YT_{20}= wild yam with 20 min of Boiling time; YT_{30}= wild yam with 30 min of Boiling time; YT_{40}= wild yam with 40 min of Boiling time

Results are expressed in a dry weight basis in each line different letters mean significant differences ($p < 0.05$).

The ash content ranged 1.02 to 0.75 g/100g DM with significant decrease (p<0.05) from raw tuber flour (YT_0) to boiled tuber flours YT40 (40 minutes of boiling time). Ash content of *D. praehensilis* tubers flours obtained were comparably lower than reported value (2.93%) for *D. alata* tubers (Ezeocha and Ojimelukwe, 2012). The significant (p<0.05) reduction in ash content of the tubers with increased boiling period is in agreement with the results of Onu and Okongwo (2006), who recorded decrease in ash content of pigeon pea seeds from 5.50% (raw seeds) to 4.00% (30 min boiled seeds). These losses could be as a result of leaching of the minerals into the boiling water. The observed decrease in ash content after cooking implies that the potential ability of these tubers to supply essential minerals has been reduced. This is in accordance with the observation of Onyeike and Oguike (2008) on boiled groundnut (*Arachis hypogaea*) seeds. According to the authors, this may be due to water absorption during boiling leading to dilution and hence, low amount of ash. This wild yam is a good source of minerals such as Ca, P, K, Mg, Na, Fe and Cu with a good Ca/P ratio (Sahoré, 2010).

Proteins content showed significant decrease from raw tuber (9.13 g/100g DM) to 5 minutes of boiling time (8.52 g/100g DM). From there, proteins content continued to decrease as long as the heat treatment continues and reached 6.41 g/100g DM after 40 minutes of boiling at 100° C. This result was in conformity with the findings of Onwueme et al. (1991), Adejumo et al. (2013) and Kouadio et al. (2017) who reported that blanching reduces the protein content of yam flours. The proteins content of raw tuber is similar as values reported by Sahoré (2010) for the same wild yam and higher than those (7.1 g/100g DM) reported by Trèche (1989) in *D. praehensilis* tubers, the *D. alata* content (Wanasundera and Ravindran, 1994), the *D. dumeterum* protein content (Owuamanam et al., 2013) and 3.64% for sweet potato (Alaise and Linden, 1999). This wild yam protein content is also higher than breadfruit (Arinola and Akingbala, 2018)**,** *D. cayennensis* (Koné et al., 2014). The decrease of protein content during the boiling seems to be a proven characteristic of protein content under heat treatment as reported by (Koné et al., 2014; Achy et al., 2017**;** Fashina et al., 2017). This is probably due to the denaturizing of protein caused by the effect of heat on the yam slice samples during blanching (Fashina et al., 2017). The effect of boiling in protein content may be amplified by the loss of free amino acids which took place through leaching (Ezeocha and Ojimelukwe, 2012). The boiling led to the leaching out of soluble proteins and the intensity of this leaching increased with the boiling time (Owuamanam et al., 2013).

Fat content of the raw tuber flour was 3.25 %. The fat content decreases significantly with boiling time from 2.89 % (for 5 min of boiling) to 1.87 % when this heat treatment is performed for 40 minutes. The decrease in fat content during boiling is in agreement with the results of Koné et al. (2014) who inferred that high loss of fat content resulted from longer cooking time. This lower fat content observed at higher boiling times could be associated with the oxidation of fat during blanching (Fashina et al., 2017). There may certainly occur some leaching during boiling as supposed by Amon et al. (2011). The low-fat content noted for longer boiling time flours is an advantage for storage time as this will enhance the storage life of flours due to the lowered chance of development of rancid and unpleasant odorous compounds during storage. However, the reduction in fat content in contradiction with the results of Sahoré (2010) for *D. praehensilis* tubers boiled with the skin. It seems that in this case the fat content increase during boiling. This author attributed this increase to fat migration from yam periphery (skin) to the pulp.

The carbohydrates content decreases significantly (p < 0.05) during boiling and ranged from 89.21 % (YT_0) to 85.37 % (YT_{40}). This result was in conformity with the findings of Onwueme *et al.* (1991) and Adejumo et al. (2013) who reported that blanching reduces the carbohydrates content of yam flours. Carbohydrates appear to be the most important biochemical component in the wild yam *D. praehensilis* flours. Values in current study are higher than those reported by Oluwamukomi and Akinsola (2015) in yam (*Dioscorea rotundata*), and cocoyam species (*Xanthosoma sagittifolium*) flours and the findings of Koné et al. (2014) for yam "*kponan*" (*D. cayenensis-rotundata*) flours ranged from 72.76 to 79.80 %. However higher carbohydrates content is reported in plantain species (*Musa paradisiaca*) by Oluwamukomi and Akinsola (2015). High carbohydrates content is a particularity of roots and tubers whose dry matter is made of up to about 60 to 90% carbohydrate (Onyenuga, 1968). This is the reason why these products are good energy supply foods. The energy supply of raw *Dioscorea praehensilis* tuber flours was 425.76 kCal/100g and the boiling seemingly reduced the energy potential ranged from 418.04 (YT_5) to 391.00 (YT_{40}). Despite this energy decrease during the boiling, *Dioscorea praehensilis* tuber flours energy is higher than the energy potential of *D. alata* (Ezeocha and Ojimelukwe, 2012), plantain (Oluwatonyin, 2017). In fact, yam is grown and cultivated for its energy-rich tuber.

The moisture content is an important storage parameter for flours as high moisture related to shorter storage ability. Raw tuber moisture was

13.04 %, while boiled one's moisture content were decreasing significantly ranged from 11.41 (YT_5) to 10.62 % (YT_{40}). The decrease of moisture content during boiling showed that this process may improve storage time of flours. But moisture values of this study remained higher than those reported by Koné et al. (2014) yam "*kponan*" (*D. cayenensis-rotundata*) flours and (Amon et al., 2011) for cocoyam (*Colocasia esculenta cv fouê*). Thus, exposure to high temperature may favour moisture loss probably via enhanced evaporation. Furthermore, low moisture content may result in low acid value and free fatty acids, hence high keeping quality (Ejikeme et al., 2010). As would be expected, boiling of tubers may favor keeping quality of flours.

pH of all flours samples of *Dioscorea praehensilis* were ranged from 5.53 to 6.04. These values of pH are similar to finding of Adedeji (2010), analysing pH of 70 % yam flours sold in the Kuto-market Abeokuta, South West Nigeria, ranged from (pH = 6.25) to (pH = 6.93). The lowest pH value of *Dioscorea praehensilis* was recorded for raw flour YT_0, while the highest pH was obtained for the 5 minutes boiling flour YT_5. These values showed that *Dioscorea praehensilis* tubers are slightly acids. This is in agreement with pH values of yam tubers such as *D. alata* and *D. rotundata* (Ogbo and Agu, 2014) and the breadfruit (Arinola and Akingbala, 2018). pH is a variable influencing the speed of chemical and enzymatic reactions during food storage. Extreme values of pH (pH under 2.5 or pH over 8.5) may favor acceleration of reactions catalyzed by acids molecules or bases molecules respectively but are sometime required to inhibition of microbial development and enzymatic processes numbers of molds grow at ($pH<2$ or $pH>9$) while yeasts grow at ($2.5<pH<8.5$) and bacteria scarcely grow at $pH<4.5$ (Cheftel et Cheftel, 1977).

CONCLUSION

Results obtained in this study showed that boiling has both negative effect on wild yam (*Dioscorea praehensilis*). But despite this decrease, Carbohydrates appear to be the most important biochemical component in the wild yam *D. praehensilis* flours. Even if the fat content decrease recorded in current study could be seen as a nutritional loss, it appeared to be an advantage for storage time as it could lower chance of development of rancid and unpleasant odorous compounds during storage. The moisture content decrease with boiling, which is an important storage advantage of flours as high moisture related to shorter storage ability. The decrease of moisture content during boiling showed that this process may improve storage time of flours. pH values showed that *Dioscorea praehensilis* tubers are slightly acids. It is important to avoid overcooking since from the data obtained, it has been shown that the longer the cooking, the higher the loss in nutrients. A boiling time of 20 min was recommended for tuber of *Dioscorea praehensilis*.

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