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Physicochemical and pasting properties of flour from Dioscorea schimperiana dried slices sold on local market

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Abstract— This study was carried out to investigate the physiochemical and pasting properties of *D schimperiana* flour in order to find out potential diversity of end uses. Dried slices were randomly purchase from many sellers in Baham, Bamendjou and Bangangté markets in the Western region of Cameroon. Dried slices were reduced into flour of 160µm size. Flour samples were labeled FBah, FBam, FBag for yam bought in Baham, Bamendjou and Bangangté markets respectively. Pasting properties of flours in the presence and absence of alpha amylase inhibitors was tested using a Rapid Visco Analyser (RVA). Results show a variation in chemical composition and pasting properties of flour samples according to purchase location. Three factors appear to determine the RVA hot paste viscosity patterns of yam flours: extend of swelling of the starch granule, the resistance of the swollen granules to dissolution and the tendency towards retrogradation and syneresis during cooling. There was a strong influence of alpha amylase activity on starch gelatinization. FBam flour shows a higher swelling behavior during pasting. This property can be attributed to lower amylase activity. However, FBah and FBag exhibited a restricted swelling pattern which can be due to higher alpha amylase activity.

Index Terms— alpha amylases activities, diversification, dried yam slices, *D. schimperiana*, flour, physicochemical and pasting properties.

Introduction

Dioscorea schimperiana has been a staple food for many decades in Cameroon. So it become concerning when it appears as endangered yam specie [1],[2] due to various factors like scarcity of land, valorization of cash crops, development of off farm activities income generating.... Producing added product from yam flour is a new approach aiming at increasing the production and utilization. Pounded yam is the only dish made from precooked dried yam slices. Bell and Favier [3], in assessing the nutritional value of pounded yam concluded that the double cooking of yam before pounding has an impact on the nutritional quality. Some studies reported the use of yam flours of others species in the production of bakery food, confectionery or baby food etc [4],[5],[6]. By similarity, *D. schimperiana* flour could also be use in many food applications. However, the potential of yam flour to be processed into value added products would be influenced by their physical and chemical properties [7]. The viscosity of starch paste is an important physical characteristic that determines its potential use in various foods [8]. Pasting properties indicate what physical changes may be expected during the processing of starchy foods [8]. Although the physiochemical and pasting properties of the flour or starch of other yam species have been studied by many authors [7], [8],[9],[10],[11],[12],[13], that of *D. schimperiana* have not been investigated. Yam is high in starch and also contains the enzyme alpha amylase which converts starch into sugar as the tuber mature in storage [10]. Flour or starch properties can be influenced by amylolytic activity. Many studies have also shown that flour or starch properties can be influenced by other parameters than amylolytic activity [14],[15]. Differences in proximal composition and structure of starches have been reported to influence the pasting properties. The use of a dual protocol (water and silver nitrate as an inhibitor of alpha-amylase) allows separating the contribution of the starch component and the endogenous alpha -amylases activity on the pasting properties of flour or starch [15]. Study of starch functionality is often preferable in its natural environment like in flours than in pure starch for a better simulation of the reality. Pasting properties is also influence by site of harvest. In general, *D. schimperiana* dried slices are produced after precooking and drying. The products characteristics (diameter, thickness, shape…), the precooking conditions (like peeling before or after cooking) or the drying method (sun or over rank) vary from one locality to another according to the traditional knowledge. This variability can affect the physicochemical and pasting property of yam flour. There is no published information on the effect of difference in processing method on the pasting property of yam flour. The objective of this work is to provide basic information on the property of starch in flours and it potential use. Specifically, it aims at investigating the effect of difference in processing method and amylolytic activity on the physical and pasting properties of *D. schimperiana* flour (as measure by viscosity development). The diversity of end uses will be assessing through a typology.

Materials and Methods

Sample collection

Traditionally dried yam samples

The study was conducted in three localities of the leading dried yam producing region in Cameroon. Traditionally dried yam slices were randomly purchase from many sellers in Baham, Bamendjou and Banganté markets in the West region. The intention was to use purchase location as trial sites in investigating the potential effect of difference in processing method on the properties of starch in flour.

Control dried yam samples preparation

Fresh yam tubers were purchased in Baham, Bamendjou and Banganté local markets. Tubers were collected in bamboo bag and bring to the laboratory for flours preparation. They were washed, peeled and cut in small pieces. Slices were spread in a tray and dried in an oven at 50°C for 36 hours. They were kept in plastic bag for flours preparation. The intention of using unprecooked yam flour as control was to better evaluate the influence of processing method on nutrients losses and physical changes in starch properties.

Flour preparation

The dry slices are first reduced into coarse flour using a mortar and pestle, then reduced into fine flour using a hammer mill with a sieve of 1500μm size. The flour is then sieved through a sieve of 160μm. Samples were labeled with four alphabetical digit codes. The first digit code stand for flour and flour samples was labeled FBah, FBam, FBag for flour bought in Baham, Bamendjou and Banganté markets respectively. The raw yam sample flour was labeled FRaw

Chemical analysis

Proximate composition

Moisture, crude protein, total ashes were determined in flour according to the AOAC [16] official methods. Moisture was determined from weight loss after drying in an oven at 105°C for 24 h. Crude protein content of yam flour has been analyzed by kjeldahl block digestion and steam distillation method. Total proteins were calculated by multiplying the evaluated nitrogen by 6.25. Ash was determined after incineration of yam sample in a muffle furnace at 550°C for 24 hours. Lipids content was quantified after hexane extraction for 12 h in a Soxhlet apparatus [17]. Starch and total sugars content were analyzed according to the DNS method as described by Miller [18] using glucose in establishing the standard. Starch was determined after dissolution in DMSO solution (25% (v/v)) and acid hydrolysis while reducing sugars were analyzed directly after dissolution in DMSO.

Minerals analysis

The iron content of dried yam flour was determined by orthophenantroline colorimetric method [19] after acid digestion of ash extracted from yam flour. Phosphorus ions analysis in acid digested ash was done by antimony-phosphomolybdate colorimetric method AOAC [20].

Determination of antinutritional factors

The total phenols analysis was done according to the Folin-Ciocalteu colorimetric method [21] after extraction in ethanol solution (70% (v/v). The total tannins content of dried yam flour were analyzed according to the Bainbridge et al., [22] colorimetric method after extraction in a solvent mixture (acetone: 10% acetic acid (80:20)).

Pasting characteristics determination

Pasting properties of flours was tested using a Rapid Visco Analyser (RVA) (Newport Scientific Pty. Ltd) according to AACC Method [23]. Samples were mixed with distillated water and the water was replaced by $AgNO_3$ solution (0.145mol/l) for the alternative method. Wet sample was inserted into the RVA which was put on during 13 minutes in a programmed heating and cooling cycle at a constant motor speed of 160rpm. The mixture was heated to 50°C and maintained at this temperature for 1min. It was then heated from 50 to 95°C within 4 min, and then at 95°C for 2 min. Slurry was finally cooled to 50°C within 4 min and held at 50°C for 2 min. Pasting curves were recorded on RVA. The starch viscosity parameters measured were pasting temperature, peak time, peak viscosity, breakdown viscosity, final viscosity and setback viscosity. The results are expressed in terms of Pascal second (Pa.s) for all of the parameters with the exception of pasting temperature and peak time, which was expressed in °C and in minute respectively.

Results

Physicochemical analysis

Proximate analysis

The chemical composition of yam flours determines their pasting characteristics. Proximate analysis of flour samples is presented in Table 1. The moisture content of sample does not differ significantly. It varies from 12.59 (FBam) to 15.31% (FBah). These values are higher than the acceptable limit of not more than 10% for long term storage [24]. The raw yam flours (FRaw) use as control has the highest content in all the others chemical elements analyzed (starch, reducing sugars, proteins, lipids, ash, iron, phosphorus, total phenols and tannin) in comparison with precooked and dried yam flours FBah, FBam, FBag. This can be attributed to the nutriments losses during precooking and drying process. The starch content of raw yam flour (FRaw) is 45,45g/100g DM and this value is smaller than the value (71.1%) reported by Trèche and Agbor Ebe [25] for *D. schimperiana*. Reducing sugars content is 2,66g/100g. This value is less than the one recorded by Trèche and Agbor Ebe [25] (4.5%) and Tchiegang and Ngueto [2] (28.36 to 29.49%). Among tubers, yams are the most rich in protein [26], [27]. Proteins content of raw yam flours (9,23g/100g) is in agreement with data (8.26 to 8.92%) reported by Bell and Favier [3] for *D. schimperiana*. A range value from 6.25 to 8.98% DM was also reported by Tchiegang and Ngueto [2]. Yams are a poor source of lipids and the raw yam flour content 2,051g of lipid per 100g DM. This value is higher than the value (0.18-0.32%) founded by Bell and Favier [3] but comparable to the value range (1-1.41) reported by Tchiegang and Ngueto [2].

Minerals analysis

Ash content is an indication of mineral level [27]). The ash content of raw yam flour (FRaw) is 1,186 g/100gDM and this value is smaller than the range value (4.53-5.43%) reported by Trèche and Agbor Ebe, [25] but comparable to the values (3.49-7.10%; 2.93%) obtained by Bell and Favier [3] and Trèche and

Agbor Egbe [28] respectively. The level of iron recorded is smaller than the value (2.11-6.45%) reported by Bell and Favier [3] and Trèche and Agbor Ebe [28] (3.43%). Phosphorus content is in contrary higher than the values (119.27-238.71%; 112±13) reported by these authors respectively.

Antinutritional factors

Total phenol content of the raw yam flour is 0,083g/100g. This value is in value ranges (0.0699 - 0.4218g and 0.48-2.82g) reported by Cornago et al. [29] and Lula Nadia et al. [30] for *D. alata* respectively. Tannins have been reported to form complexes with proteins and reduce their digestibility and palatability [24]. However, their contents in foods are known to reduce through cooking by leaching [31],[29]. The tannin concentration of the yam is 0,0169g/100g. This value is lower than the range value (4.40 to 13.20 mg/100g) reported by Polycarp et al. [24] for cultivated and consumed Ghanaian yam (Dioscorea) cultivars.

to swell freely before their physical breakdown [32],[34]. The values ranged between 79 (FBag) to 2288 Pa.s (FBam). The differences observed are partly due to differences in amylases activities. The highest PV recorded for FBam flour is an indication of higher water binding capacity of the starch leading to higher gelatinization despite the amylase activity.

Holding viscosity

The values of Holding viscosity (HV) or paste or though viscosity varies from 75 (FBag) to 1662 Pa.s (FBam) and expresses the minimum viscosity obtained during the holding period. It measures the paste stability during constant shearing in hot temperature [32],[34],[35]. The highest value of holding viscosity for FBam flour proves it highest instability during heating and shearing.

Final viscosity and setback

The final viscosity (FV) is the maximum viscosity recorded after holding cooked flour at 50°C. The value ranged between

Table 1: Proximate analysis of flour samples

	Flour samples			
	Precooked flours			Raw yam flour
Nutriments (% DM)	**FBah**	**FBam**	**FBag**	**FRaw**
Moisture content	15.31	12.59	12,66	14,68
Starch(g/100g)	$43.81^{a} \pm 2.633$	$35.68^{b} \pm 3.029$	$34.72^{b} \pm 0.758$	$45.45^{a} \pm 1.96$
Reducing sugars(g/100g)	2.32 ± 0.018	2.65 ± 0.231	2.79 ± 0.011	2.66 ± 0.532
Protein(g/100g)	$5.68^{b} \pm 0.731$	$9.34^{a} \pm 1.156$	$3.01^{c} \pm 1.002$	$9.23^{a} \pm 1.45$
Lipids (g/100g)	$0.531^{b} \pm 0.083$	$0.915^{b} \pm 0.162$	$0.573^{b} \pm 0.162$	$2.051^{a} \pm 0.414$
Minerals				
Total Ash (g/100g)	2.90	2.65	2,34	3,51
Iron (mg/100g)	$0.748^{b} \pm 0{,}126$	$0.729^{b} \pm 0.152$	$0.461^{c} \pm 0{,}105$	$1.186^{a} \pm 0.073$
Antinutritional factors				
Phosphorus (mg/100g)	$555.05^{ab} \pm 105.114$	$246.35^{c} \pm 7.957$	$453.78^{b} \pm 30.261$	$\mathbf{623.59}^{a} \pm 34.236$
Total phenols (g/100g)	0.04± 0.001	0.052 ± 0.012	0.0669 ± 0.04	0.083 ± 0.02
Tannins (g/100g)	0.0000^{c}	$0.0073^{bc} \pm 0.001$	$0.0138^{ab} \pm 0.001$	$0.0169^{a} \pm 0.005$

Value with the same letter in one line showed no significant difference ($p<0.05$)

Pasting behavior

Pasting behavior of flour samples in water

Analysis of viscosities in water allows the expression of endogenous alpha amylase activities. Pasting properties of yam samples without inhibitors are shown in table 2. There were intra and inter variability among the pasting profile of sample recorded by high coefficient of variation (CV) particularly for the raw yam flour (FRaw). All the values obtained for viscosities parameters in this study are in a range values reported by Ikegwu et al [32] for *Brachystegia eurycoma* seed, Acosta-Osorio and Herrera-Ruiz [33] for corn starch, Oke et al. [8] for water yam.

Peak viscosity

Peak viscosity (PV) is the maximum viscosity recorded during the heating phase of the test. It expresses the ability of starch

115 (FBag) to 3543 Pa.s (FRaw). The variation in final viscosity might be due to the kinetic effect of cooling on viscosity and the reassociation of starch molecule in sample [32],[34],[35]. The higher value recorded for FRaw sample indicates a high tendency towards retrogradation.

Breakdown viscosity

Breakdown viscosity (BD) which is the difference between the values of peak (PV) and holding (HV) viscosities ranged between 2 (FRaw) and 804 Pa.s (FBam). It measures the ability of the paste to withstand breakdown during cooking [32],[34],[35]. The highest value of breakdown in viscosity for FBam shows a higher substantial granular breakdown and the lower ability of the sample to resist to breakdown during heating

Setback

The difference in viscosity between the holding and the final viscosities are recorded as setback (SB). Setback value indicates the ability of starches to gel into semi solid pastes [32], [34]. The value ranged between 40 (FBag) to 2826 Pa.s (FBam). The high setback viscosity for FBam is associated with weeping or syneresis [10].

Pasting temperature and Peak time

Among flour samples, FRaw has the highest peak time (5:22-7:12 min) and Fbam the lowest (4:56-5:02 min). The highest Peak time express by FRaw is an indication of highest structural rigidity. The pasting temperature (P_{temp}) (apparent gelatinization temperature) is the temperature at which viscosities first increases. It varies from 63.64 (FBam) to 79.11°C (FRaw). FRaw flour has the highest pasting temperature (78.23-79.11°C) and FBam the lowest (63.64-65.08°C). The highest pasting temperature for FRaw flour indicated a higher resistance to swelling. Indeed, FRaw has the highest content in protein and lipids. The highest pasting temperature and peak time could be attributed to these compounds which obstruct the swelling of granules and thus increase the amount of heat required to reach the final swelling. [9]. FBag with a restricted swelling behavior did not display any pasting temperature. This same behavior was observed by Schoch and Maywald [36] for various legumes starch. The value of raw flour (FRaw) pasting temperature is in a range of value (77.05-86.13 °C) obtained by Oke et al. [8] for *D. alata* raw flour and Aprianita et al. [9].

The starch viscosity depends on two interrelated factors: the starch gelatinization and the enzymatic attack of starch by alpha amylases [37]. Recording the viscosity in the presence of alpha amylase inhibitors ($AgNO_3$ solution) is a method which allows the expression of starch component in the gelatinization properties. It is the measurement of the viscosity potential of starch in the absence of alpha amylase.

Impact of amylase in reducing the viscosity

In order to assess the impact of endogenous alpha amylases in reducing the viscosity during the first phase of the RVA heating cycle, the difference between the peaks viscosities recorded in the presence (PV_2) and in the absence of $AgNO_3$ inhibitors (PV_1) was calculated (PV_1-PV_2). A relative amylase reduction factor dPV/PV_1 was calculated in order to better assess the impact of amylase activity on the maximal viscosity (Fig 1). The values range between 24.49 for FBag to 0.59 for FBam showing a higher alpha amylase activity this flour.

Table 2: Pasting characteristics of yam flour samples in water and in $AgNO_3$ solution as alpha amylase inhibitors

	Viscosity (Pa.s)						
Samples	PV	HV	BD	FV	SB	P_{time} (min)	P_{temp} (°C)
Gelatinization pattern in water							
FRaw	734-1861	732-1065	2-796	1470-3543	738-2478	5:22-7:12	78.23-79.11
CV (%)	61.42	26.21	140.71	58.48	76.52	20.63	0.79
FBag	79-79	75-75	4-4	115-115	40-40	6:34-6:34	
CV (%)	0.00	0.00	0.00	0.00	0.00	0.00	
FBah	661-727	657-720	4-19	1101-1014	357-389	5:56-6:00	68.79
CV (%)	6.72	6.47	92.23	5.82	6.07	0.79	1.18
FBam	2236-2288	1432-1662	626-804	2755-2826	1164-1323	4:56-5:02	63.64
CV (%)	0.25	10.51	17.6	1.8	9.04	1.42	1.89
Gelatinization pattern with $AgNO_3$ as alpha amylase inhibitor							
FRaw	429	424	5	670	246	7:12	78.2
FBag	2014	824	1190	2733	1909	4:50	63.19
FBah	3006	1054	1952	3497	2442	4:34	61.93
FBam	3631	1005	2626	3941	2936	4:26	56.25

PV= Peak viscosity; HV= Holding viscosity; BD= Breakdown; FV= Final viscosity; P_{time}= Peak time, P_{temp}= Peak temperature

Pasting behavior of flour samples in $AgNO_3$ as alpha amylase inhibitors

Viscosity parameters

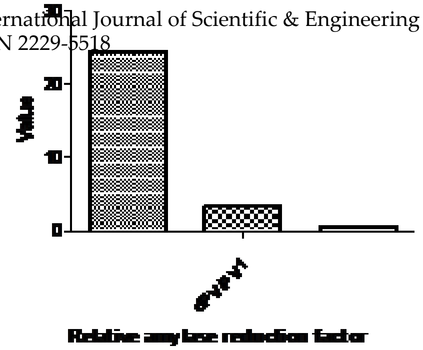

Fig 1: Relative amylase reduction factor (dPV/PV_1) in peak viscosity after treatment of FBag, FBah and FBam yam flour with $AgNO_3$ solution (0.145M).

Key: **FBah** = flour bought in Baham market, **FBam** = flour bought in Bamendjou market, **FBag** = flour bought in Banganté market, **FRaw** =raw yam flour sample

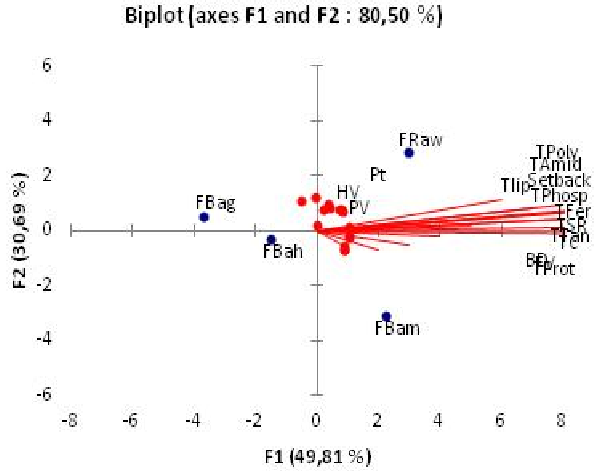

Fig 2: RVA and chemical variables plot for the principal component analysis of the chemical characteristics of the yam flour samples

Key: **RVA variables**: **PV** = Peak viscosity; **HV** = Holding viscosity; **BD** = Breakdown; **FV** = Final viscosity; $\mathbf{P_{time}}$ = Peak time, $\mathbf{P_{temp}}$ = Peak temperature; $\mathbf{P_t}$: Pasting time

Chemical variables: **TProt** = protein content, **TFer** = iron content, **Tlip** = lipids content, **Tc** = ash content, **Tpoly** = polyphenol content, **Tan** = Tannin content, **Tamid** =starch content, T**RS** = reducing sugar content, **Tphosp** = phosphorus content,

FBah = flour bought in Baham market, **FBam** = flour bought in Bamendjou market, **FBag** = flour bought in Banganté market, **FRaw** =raw yam flour sample

Potential utilization of yam flours

Chemical composition of flour samples varies from one sample to another as the viscosity parameters. Analysis of variability and classification of flours according to their physicochemical composition and their viscosity pattern was done using Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA). Fig 2 shows representation of variables and flours samples according to the first two principal components F_1 and F_2 which explain 80,5 % of variance. The first Principal Components (PCs) were able to explain 49.81 % of the total variance. The variables well correlated on this axis are RVA parameters (PV, HV, BD, FV, Setback) and ash, protein, iron and lipids content. The second axis F_2 which explain 30.69% of the total variance is highly correlated with Peak time, total phenol and phosphorus content. Spatial distribution of samples well differentiates the precooked flour sample FBag (on the left hand of F_1 axis) from control sample FRaw (on the right hand of F_1 axis). FRaw sample is characterized by highest values of RVA parameters (PV, HV, BD, CV, Setback), protein, iron and lipids contents while FBag has the lowest. FBam flour (on the negative side of F_2 axis) stands out with low peak time and low content in total phenol and phosphorus. It position on the positive side of F_1 axis shows also that it RVA parameters are higher. By taking in account the principal component F_3, FBah flour is characterized by a low content in tannins and reducing sugars and a high content in starch.

Fig 3 shows the cluster dendogram which group samples into three classes according to the degree of similarity in chemical and RVA profile. FRaw and FBam with a similar profile form a single class. Their chemical and RVA profiles are different to the precooked flour sample FBag and FBah which form another class. FRaw and FBam have the highest value for all the physicochemical and RVA parameters analyzed and FBag and FBah the lowest. FBam having a closer similarity with FRaw means that the pretreatment have had a lower influence on the nutrients content of the yam. High peak viscosity of starch in flour are often related to high content in starch, [32],[34],[35] minimizing the effect of alpha amylase on starch breakdown. Precooked flours are often observed to have lower peak viscosity than raw flour because of low content in starch due to leaching during the precooking process [11],[38]. FBam is precooked flour characterized by a low content in starch and a higher peak viscosity as the raw yam flour (FRaw). In addition, it is less subjected to enzyme hydrolysis as shown by results on the impact of endogenous alpha amylases activities on the liquefaction of starch pastes. The behavior of this precooked flour clearly confirms that the higher swelling is due to the lower activity of alpha amylase. It also demonstrates that misleading interpretation in pasting behavior can come from not integrating alpha amylase activity during interpretation of RVA profile. The flour from dried yam slices sold in Bamedjou (FBamAg) and Baham (FBahAg) markets when treated in $AgNO_3$ solution formed the third class with lower amylase activity. The gelatinization pattern of FBah in water shows that it is restricted swelling yam flour. The classification of this flour when treated with $AgNO_3$ (FBagAg) in the same class as FRaw and FBam with a higher swelling properties is another proof that the alpha amylase activity is the drawback for starch gelatinization in precooked flour rather than flour components.

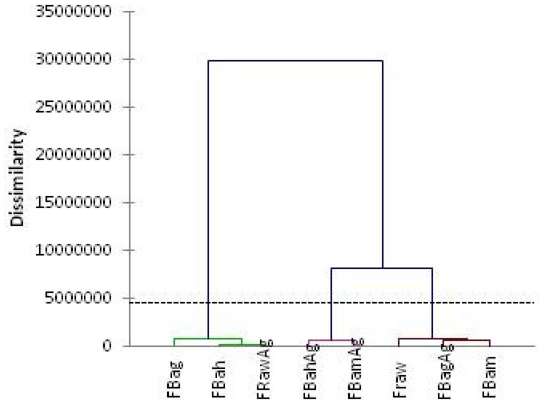

Fig 3: Cluster observation dendogram grouping yam flour samples in different classes

Key: **FBag** = flour bought in Banganté market, **FBagAg** = flour bought in Banganté market treated with $AgNO_3$ solution (0.145M), **FBah** = flour bought in Baham market, **FBahAg** = flour bought in Baham market treated with $AgNO_3$ solution (0.145M), **FBam** = flour bought in Bamendjou market, **FBamAg** = flour bought in Bamendjou market treated with $AgNO_3$ solution (0.145M). **FRaw** = raw yam flour sample, **FRawAg** = raw yam flour sample treated with $AgNO_3$ solution (0.145M)

Discussion

Precooking treatment and drying have an influence on nutrients levels. This justifies the highest nutrient values recorded in raw yam flour compare to the precooked yam flours. However, the influence of precooking and drying on nutrient loses varies according to the type of flour (purchase location) and the type of nutrient. These treatments have little effect on starch, iron and phosphorus levels in flour bought in Baham local market (FBah) because these values are higher than those of others pre-cooked flour. Flour from dried slices purchased in Bamendjou market (FBam) have the highest and significant levels of protein than the others precooked yam flours; showing a low influence of pre-cooking and drying process on protein level. These treatments are harshest for flour samples (FBag) obtained from dried slices bought in Baganté markets because of highest nutrients losses (starch, iron, protein). The FBag flour is also characterized by high contents in total phenols and tannins. The lowest value in starch, protein and iron and the higher content in total phenol and tannins reduce the nutritional value of this flour and will surely have an impact on the pasting behavior since the present of protein along with starch are very important for the establishment its paste which influences the texture of food products [29]. From the above results, three factors appear to determined the RVA hot paste viscosity patterns of yam flours: The extend of swelling of the starch granule, the resistance of the swollen granules to dissolution by heat or fragmentation by shear and the tendency towards retrogradation and syneresis during cooling. In this context, the viscosity pattern of flours samples varies from one locality to another. It clearly discriminate flour sample bought in Bamedjou local market (FBam) against flour sample from Baganté (FBag) even thought their starch content do not differ significantly. FBam shows a higher swelling of starch granules during cooking with lower resistant of the swollen granules to dissolution by heat or fragmentation by shear. This flour appears to have a high tendency toward retrogradation and syneresis during cooling. In contrary, FBag has a lower swelling of starch granules during cooking. The starch of this flour resists to fragmentation during shear and develops a lower tendency toward retrogradation and syneresis. The pasting behavior of flour sample from Baham market (FBah) and raw yam flour (FRaw) seem to be between the two. After treatment of pre-cooked flours (FBag, FBam and FBah) in $AgNO_3$ solutions (table 2), all the values of viscosity parameters (PV, HV, BD, FV, SB) increase. This result shows a strong influence of alpha amylase activity on starch gelatinization. The trend of however depends on the type of flour sample. The raw yam flour (FRaw) expresses a different pasting behavior. The values of the viscosity parameters decrease after $AgNO_3$ treatment. This result suggests that alpha amylase activity have a little even no influence on pasting properties of the raw starch flour. Indeed, alpha amylase does not attack raw starch. It degrades the starch during gelatinization process until the enzyme is inhibited at 70 °C. This could partially explain the difference in pasting behavior between raw and precooked yam flour. Another plausible reason could be, as stated by many authors, a particular behavior of raw flour components (composition and structure) mainly starch responsible for the gelatinization properties. The optimal activity of endogenous amylase is usually between 60 and 70 °C [37]. This corresponds to the first phase of the RVA heating cycle where the parameter recorded is the peak viscosity (PV). Analysis of table 2 shows variability in peak viscosities (PV_2) for all the precooked flour samples analyzed even treated in water or in $AgNO_3$ solution. After treatment with $AgNO_3$ solution, FBam flour continues to show the high swelling behavior with the highest intrinsic peak viscosity and FBag flour the restricted-swelling behavior with the lowest intrinsic peak viscosity. The contrasts in intrinsic peak viscosities observed during treatment in water (in presence of amylase activity) or in $AgNO_3$ solution (in absence of amylase activity) are mainly due to differences in composition and structure of starch responsible for viscosity upon cooling heating cycle. The highest relative amylase reduction factor value (dPV/PV1) recorded for FBag shows a higher alpha amylase attack in flour during gelatinization in water and justifies the lower peak viscosity recorded. In contrary, the higher peak viscosity recorded for FBam is due to the lower alpha amylase activity since the relative amylase reduction factor value is the lowest. A very strong activity of the endogenous alpha amylase results in a decrease of the gel strength which influences the quality of the final manufactured product. This property is however beneficial when making products such as bread because alpha amylase will rapidly hydrolyzed starch in maltose and this will increase it use by yeast as substrate for fermentation with production of CO_2 increasing by this, the bread volume [37]. The viscosity of starch paste is an important physical characteristic that determines its potential use in various foods. Differences in processing method influence the pasting properties. An attempt was made to draw a typology of potential end uses of traditionally dried *D. schimperiana* slices according to purchase location. Results of multivariate analysis show that the viscosities patterns of starch in flour can be roughly classify into two types: High-swelling flour and Restricted- swelling flour. FBam appears to be high- swelling flour. With this property it can be use in many food applications. According to Burke and Johnston [14], this type of flour may be suitable for product required high gel strength and elasticity like fufu or pounded yam. With it low gelatinization temperature and it high viscosity it can also be use as thickener in soups and sauces or for application in "instant" products (dry product reconstituted in boiling water). Product prepared from batter required a controlled pasting temperature and high peak and through viscosity [14]. FBam have this potentiality. Flour from Baganté (FBag) or Baham (FBah) are Restricted- swelling flour. They are mostly desirable for the manufacture of value added food such as noodle. The higher alpha amylase activity makes them suitable in application for bread making. Weaning foods require low viscosity and paste stability at low temperatures [7]. Low viscosities of the pre-cooked flour FBag or FBah make them suitable for infant baby food formulation.

Conclusion

The objective of this study was to screen the uses of *D. schimperiana* yam flour derived from dried yam slices sold in local markets. The results of the study show that precooking and drying treatment have an influence on nutrients levels and the trend of varies according to the type of flour, the type of nutrient and the locality. The main factor which influences the pasting characteristic of flour resulting in decrease RVA parameters is alpha amylase activities. FBam may be suitable for product required high gel strength and elasticity like fufu or pounded yam. They can also be use as a thickener in soups and sauces... FBam with a lower gelatinization temperature combine with high viscosity can be use for application in "instant" products. It can also use as batter. A restricted type of swelling like FBag or FBah is mostly desirable for the manufacture of value added food such as noodle. The higher alpha amylase activity makes them suitable in application for bread making. Low viscosities of the pre-cooked flour FBag or FBah make them appropriate for infant baby food formulation. The result of physicochemical and pasting properties obtained indicate that flour from dried yam slices sold in local markets have useful technological properties for many food application.

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Conflict of interest

No potential conflict of interest relevant to this article was reported.

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