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COMPARATIVE STUDY OF PASTING PROPERTIES OF IMPROVED PLANTAIN, BANANA AND CASSAVA VARIETIES WITH EMPHASIS ON INDUSTRIAL APPLICATION

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ABSTRACT

A comparative study of pasting properties of newly developed plantain and banana (*Musa* spp.) and cassava (*Manihot* spp.) varieties were investigated with emphasis on their application in the baking industry. The new varieties were released to farmers in West and Central Africa (WCA) and East and Southern Africa (ESA) in line with the mandate of the Consultative Group on Agricultural Research which aims at reducing hunger and improving the livelihood of Africans. Supplementation of wheat flour with high quality flours from improved plantain, banana and cassava varieties may complement composite baking technology in Africa. This may reduce importation of wheat and other related farinaceous products and consequently enhance industrial development. Results show that BITA 3 had the highest Peak Viscosity (373.1 RVU), Trough Value (304.9 RVU), Final Viscosity (425.2 RVU), Setback Viscosity (120.3 RVU) and Pasting Time (5.2 min) and differed significantly ($P< 0.05$) from other cultivars. PITA 26 had the highest values in Breakdown Value (93.8 RVU) and differed significantly ($P< 0.05$) from other cultivars, while AGBAGBA had the highest values in Pasting Temperature (86.2^{o}C and differed significantly ($P< 0.05$) from other cultivars. TMS 98/0581 had the highest values in Trough Value (188.1 RVU), Final Viscosity (251.6 RVU), Pasting Time (4.7 min), Pasting Temperature (78.8^{o}C) and the lowest in Peak Viscosity (308.4 RVU) and Breakdown Value (120.3 RVU), and differed significantly ($P< 0.05$) from other varieties. TMS 97/2205 was the highest in Setback Viscosity (78.6 RVU) and differed significantly ($P<0.05$) from other varieties. TME 419 was the lowest in Trough Value (116.9 RVU), Final Viscosity (164.0 RVU) and Setback Viscosity (50.9 RVU) and differed significantly ($P<0.05$) from other varieties. New plantain, banana and cassava varieties may find application in the baking and confectionery industry based on their pasting properties. However, a need exists for the establishment of standards for plantain and banana flour by relevant agencies to harness their industrial application.

Key words: *Musa*, *Manihot*, pasting, baking, confectionery

INTRODUCTION

Plantains and bananas (*Musa* spp.) are important staple foods, which make substantial contribution to the nutrition and economy of millions of people throughout the developing world and are grown in some 120 countries [1]. The gross value of plantain and banana production in sub-Saharan Africa exceeds that of several other main food crops, such as maize, rice, cassava, and sweet potato [2]. They are considered the fourth most important global food commodity after rice, milk, and wheat in terms of gross value of production [3], and provide more than 25% of the carbohydrates for approximately 70 million people in the sub-Saharan Africa [4]. Plantain alone account for nearly one quarter of the total world production of banana and plantain, while about 50% of this production is from Africa [5]. Plantain, cooking banana and dessert banana are important sources of carbohydrate [6, 7]. The starch, fat, and total sugars in plantain are adequate for the manufacture of plantain biscuit [8].

Cassava (*Manihot esculenta*) is a major food crop in the humid and sub-humid parts of Africa and a major source of dietary energy for millions of people in these regions [9]. World production of cassava was 160 million tonnes of fresh roots, with 80 million tonnes produced in Africa, out of which 34 million tonnes is coming from Nigeria [10]. Nigeria is the largest producer of cassava in the world going by this estimate. In nutritional terms, cassava is essentially a carbohydrate food with about 75-83% and less than 2% protein [11, 12]. Cassava is emerging as a dominant staple of primary or secondary importance in many developing countries of the humid and sub-humid tropics in Africa and elsewhere. In Nigeria, it is the most important root crop in terms of food security, employment creation, and income generation for crop producing households [13]. In Nigeria, farmers earned more income from cassava production compared to most other major staples [14], and more than 85% of total cassava produced in Nigeria is processed into different products including gari, flour, fermented paste, starch or abacha, among others.

Plantain and cassava processing could offer means of adding value to the crops, while extending the shelf life, expanding the market, and facilitating transportation. Processing also improves product palatability, reduces the cyanide content of cassava product [15, 16] and facilitates fortification with other food products. Diversification of cassava in food product development has been extensively documented [17, 18]. Cassava flour is often used as composite with grains; it is added as a cheaper component, particularly when grains are in short supply [16]. Consumers of boiled green plantain usually prefer cooked fingers with firm and crunchy texture rather than soft and watery pulps. Both unripe and ripe plantain can be cooked and pounded with boiled yam or cocoyam to improve the texture of meal, which is usually smooth, and more elastic when compared to pounded yam or cocoyam alone. Adeniji and Empere [19] reported that the conversion of cooking banana into flour was a means of adding value to the fruit as well as extending shelf life and facilitating transportation. Ogazi [20] earlier reported on the profitability of plantain flour production, where the top of the range of returns was estimated at 64%. The demand for bakery products in

Nigeria is increasing [21], and interestingly, plantain flour is currently being exploited in baking and complementary weaning foods in Nigeria [19, 22, 23]. The application of plantain, cassava, soybean and maize flours has also been exploited in baking [24, 25] and complementary food formulations [26, 23]. The ban on wheat imports by Nigerian government in 1987 and the promulgation into law, effective from July 1, 2006 of the mandatory inclusion of 10% cassava flour in bread produced in Nigeria [18] provide a stimulus for marketable composite bakery goods in Nigeria. There are several research reports on simple and appropriate technologies on the use of cassava flour as a partial replacement for wheat flour in bread making, biscuits, pastries, and snack foods [27-31]. This new project was therefore articulated to promote the application of plantain and cassava flour in the baking industry.

MATERIALS AND METHODS

Materials

Five disease resistant, high yielding *Musa* hybrids being currently distributed to farmers in Nigeria and many parts of West and Central Africa (WCA) and East and Southern Africa (ESA) were investigated in this present study, which included 4 plantain hybrids (PITA 14, PITA 17, PITA 24 and PITA 26) and one cooking banana hybrid (BITA 3), with an African plantain landrace, Agbagba as reference. Top five nationally released cassava mosaic disease resistant (CMD) cultivars (97/2205, 98/0505, 98/0510, 98/0581, and TME 419), including the reference TMS 30572 were also evaluated. Samples were obtained from the experimental station of the International Institute of Tropical Agriculture (IITA), high rainfall station, Onne agro ecology, located on Latitude 04^{o} 43' N, Longitude 07^{o} 01' E and 10m Altitude, near Port Harcourt, Nigeria.

Methods

Flour was produced using the method described by Adeniji *et al*. [28] and Olaoye *et al*. [29]. Bunches were de-handed and individual fruits de-fingered from the hands. Fingers were washed to remove dirt and latex, which exuded from the cut surface of the crown, and allowed to remain in water. Fingers were then peeled manually with the aid of stainless steel kitchen knife and kept in a bowl containing water, and they were allowed to remain in water until the peeling process is completed. Samples were dried in Forced-Air Moisture Extraction Plus II Oven, Sanyo Gallenkamp PLC, United Kingdom, at 65^{o}C for about 48 hours. Milling was carried out using a Retch Muhle, 2850 RPM Hammer Mill, resulting in flour with very fine particle sizes, thus, sifting was not required [30]. Pasting properties of flour was characterised using Rapid Visco Analyser (RVA) Model 3C, Newport Scientific PTY Ltd., Sydney) as described by Delcour *et al*., [31] and Sanni *et al*., [32]. Five gram (5g) of sample was accurately weighed into a weighing vessel. 25ml of distilled water was dispensed into a new test canister. Sample was transferred onto the water surface in the canister, after which the paddle was placed into the canister. The blade was vigorously joggled up and down through the sample ten times or more until no flour lumps remained either on the water surface nor on the paddle. The paddle was placed into the canister and both were inserted firmly into the paddle coupling so that the paddle is properly centred.

The measurement cycle was initiated by depressing the motor tower of the instrument. The test was then allowed to proceed and terminate automatically.

DATA ANALYSIS

The data generated were analyzed using Statistical Analysis Systems version 9.1 SAS [33] software package. Significance of treatment means was tested at 5% probability level using Duncan's New Multiple Range Test (DNMRT).

RESULTS

The pasting properties of the flour from different *Musa* hybrids and plantain landrace are presented in Table 1, showing that BITA 3 had the highest Peak Viscosity (373.1 RVU), Trough Value (304.9 RVU), Final Viscosity (425.2 RVU), Setback Viscosity (120.3 RVU) and Pasting Time (5.2 min) and differed significantly (P< 0.05) from other cultivars. PITA 26 had the highest values in Breakdown Value (93.8 RVU) and differed significantly (P< 0.05) from other cultivars, while AGBAGBA had the highest values in Pasting Temperature (86.2^{o}C and differed significantly (P< 0.05) from other cultivars. Data on pasting properties of CMD varieties summarised in Table 2 show that TMS 98/0581 had the highest Trough Value (188.1 RVU), Final Viscosity (251.6 RVU), Pasting Time (4.7 min), Pasting Temperature (78.8^{o}C) and the lowest in Peak Viscosity (308.4 RVU) and Breakdown Value (120.3 RVU), and differed significantly (P< 0.05) from other varieties. TMS 97/2205 was the highest in Setback Viscosity (78.6 RVU) and differed significantly (P<0.05) from other varieties. TME 419 was the lowest in Trough Value (116.9 RVU), Final Viscosity (164.0 RVU) and Setback Viscosity (50.9 RVU) and differed significantly (P<0.05) from other varieties.

DISCUSSION

Pasting properties is an important index in determining the cooking and baking qualities of flours [34]. Starch when heated increases in viscosity as a result of the swelling of the starch granules and in their difficulty in moving past one another. Plantain absorbs water during cooking, which results in softening of the pulp. The amount of water absorbed depends on the duration of cooking, starch content and the cultivar [35]. In the present study, differences exist in the pasting properties of various *Musa* spp. hybrids flour, and are in consistent with the values reported in plantain-soy flour mixes [36] and yam starches [37]. The pasting properties of flour produced from new CMD varieties (308.4-324.5 RVU) are in consistence with those reported in starch and tapioca derived from 39 different cultivars of cassava [38] and cassava starch residue flour fortified with different levels of soybean [39]. High value of peak viscosity was found in different *Musa* and *Manihot* varieties investigated, apart from AGBAGBA, which implies high water binding capacity. Peak viscosity is an indicator of the strength of paste formed during processing [40]. It shows the viscosity of the cooked starch and reflects the ability of the starch to swell freely before their physical breakdown [41]. Sanni *et al.* [32] and Charoenrath *et al.* [42]

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reported higher levels of peak viscosity in cassava grits (tapioca) made from CMD cassava varieties obtained from South Western Nigeria, and starch from cassava roots, respectively. These high values in peak viscosity are probably due to the presence of interfering non-starch components, and also as a result of amylose activity in starch, which have the tendency to cause changes in viscosity. Starch produces a viscous paste when heated in the presence of water, and this viscosity accounts for the application of starch in textiles, paper, adhesives and food industries. Cassava is well known for its high viscosity [43] and may constitute an important raw material in these applications. Fairly higher value of breakdown viscosity has been recorded [38] in cassava starch in comparison with the present data. Daramola and Osanyinlusi [44] reported a much higher values of breakdown viscosity (115.42-487.92 RVU) in six varieties of banana in Ekiti state compared to those found in the new *Musa* hybrids. Products with low levels of breakdown viscosity have the tendency for better resistance to heating and shear-thining. Moorthy *et al*. [45] postulated that the cohesiveness of starch is attributed to the breakdown viscosities of starch molecules during heating and stirring. Starch may be predisposed to breakdown due to early gelatinisation because it undergoes a longer period of shear. Setback viscosity obtained in the present study for various new *Musa* spp. flour is lower than those reported in plantain flour [36], in consistence with those reported in some banana varieties [44], but higher than the values obtained in *Dioscorea alata* [46]. Lower setback viscosity indicates higher potential for retrogradation in food products [40] and gives an idea about retrogradation tendency of starch [47]. High set back value is associated with a cohesive paste and has been reported [48] to be significant in domestic products such as pounded yam, which requires high set back, high viscosity and high paste stability. New *Musa* varieties may be widely accepted in many African countries due to their high levels of set back viscosity, especially cooking banana hybrid, BITA 3 and plantain hybrids, PITA 17, PITA 26 and PITA 14. The production and utilisation of flour from unripe cooking banana and plantain has been reported [49]. Final viscosities of flour mixtures are important in determining the ability of a sample to form a gel during processing [40]. It is an indication of whether the starch material forms a gel or a paste on cooling, and also indicates the strength of cooked paste [46]. It has been reported that starches with low paste stability or breakdown have very weak cross-linking within the granules [48]. The temperature at which the first detectable viscosity is measured (when the stirred starch suspension begins to rise) is the pasting temperature of a sample, which gives an indication of the minimum temperature to cook a given sample [50, 46]. This can have implication on stability of other components in a formulation and also influence energy cost. It is essential that product attain its pasting temperature during processing to ensure swelling, gelatinisation and subsequent gel formation. TMS 98/0581 and BITA 3 had the highest pasting time compared to other cultivars. This is due to the gelatinisation of flours, which would have made the starch cells to swell and consequently increasing the time the product would require to form a paste. The shortest cooking time observed in this present research was 4.8 min (PITA 14 and PITA 26 flours), 5.1 min (whole PITA 14 flour) and 3.7 min (TME 419 flour), which suggests that these varieties have low cost implication regarding processing.

CONCLUSION

Genotypic variations were observed in the pasting properties of different cultivars of plantain, banana and cassava. Following the dissemination and acceptance of plantain and cassava in Nigeria, West and Central Africa and East and Southern Africa, coupled with Nigerian government's initiative on cassava-wheat bread, it is strongly anticipated that demand for plantain and cassava flour will definitely outstrip supply. Considering their pasting characteristics, improved varieties of plantain and cassava may find application in the baking and confectionery industries. A need, therefore, exists for increasing production of disease resistant, high yielding varieties of plantain, banana and cassava in anticipation of their industrial requirement. Industrialisation of plantain and cassava may serve as intervention programmes to reduce importation of wheat and other related farinaceous products in Nigeria. Developments in the down stream sector through processing and product development will activate the emergence and growth of small and medium scale agro enterprises, which could significantly improve the socio-economic status of Nigeria.

RECOMMENDATION

An innovation can be adopted but still remains confined in the area where it has been introduced. An expanded diffusion programme is therefore indispensable to take this innovation beyond the shores of Africa, where many Africans resident overseas could benefit.

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Table 1:Pasting properties of flour made from plantain and banana hybrids

Cultivars	PV	TV	BV	FV	SV	PTi	PTe
	RVU					min	°C
PITA 14	320.3^{bc}	236.6^{bc}	83.7^{b}	344.2^{b}	107.6^{c}	4.8^{c}	85.25^{d}
PITA 17	297.0^{d}	221.6^{d}	75.4^{c}	336.6^{b}	115.0^{b}	4.9^{b}	85.3^{c}
PITA 24	311.1^{c}	239.3^{b}	71.8^{cd}	320.3^{c}	80.9^{d}	4.9^{b}	83.7^{f}
PITA 26	324.1^{b}	230.3^{c}	93.8^{a}	342.2^{b}	111.9^{b}	4.8^{c}	84.8^{e}
BITA 3	373.1^{a}	304.9^{a}	68.2^{d}	425.2^{a}	120.3^{a}	5.2^{a}	85.7^{b}
AGBAGBA	229.9^{e}	149.5^{e}	80.5^{b}	205.4^{d}	55.9^{e}	4.9^{b}	86.2^{a}

PV=Peak Viscosity, TV=Trough Value, BV=Breakdown Value, FV=Final Viscosity, SV=Setback Viscosity, PTi=Pasting Time, PTe=Pasting Temperature, RVU=Rapid Visco Unit.

Values in the same column with different letters are significantly different at $p<0.05$

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Table 2:Pasting properties of flour made from cassava mosaic disease varieties

Cultivars	PV	TV	BV	FV	SV	PTi	PTe
	RVU					min	°C
TMS 97/2205	324.5^{a}	173.9^{c}	$150.6^{a\ b}$	252.5^{a}	78.6^{a}	4.4^{c}	76.9^{c}
TMS 98/0505	320.1^{a}	173.8^{c}	146.3^{b}	233.9^{b}	60.0^{c}	4.2^{d}	76.4^{d}
TMS 98/0510	321.4^{a}	166.8^{d}	154.6^{ab}	227.4^{c}	60.6^{bc}	4.2^{d}	77.2^{b}
TMS 980581	308.4^{b}	188.1^{a}	120.3^{c}	251.6^{a}	63.5^{bc}	4.7^{a}	78.8^{a}
TME 419	324.4^{a}	116.9^{e}	161.8^{a}	164.0^{d}	50.9^{d}	3.7^{c}	69.3^{e}
TMS 30572	323.4^{a}	180.2^{b}	143.2^{b}	246.4^{a}	66.2^{b}	4.6^{b}	77.2^{b}

PV=Peak Viscosity, TV=Trough Value, BV=Breakdown Value, FV=Final Viscosity, SV=Setback Viscosity, PTi=Pasting Time, PTe=Pasting Temperature, RVU=Rapid Visco Unit.

Values in the same column with different letters are significantly different at $p<0.05$

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