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Functional and pasting properties of cassava – sweetpotato starch blends

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Abstract

Starch is an important constituent in many foods and plays an obvious role in achieving the desired viscosity in products such as sauces, pie fillings, salad dressings, puddings, etc. Blending different starches has been reported to result in desirable functional properties which help to overcome some end-use limitations of native starches. Therefore, the purpose of this study was to determine the functional and pasting properties of cassava–sweetpotato starch blends with the aim of improving the utilization of these starches in food and non-food applications. Starches were isolated from cassava roots and sweetpotato tubers using standard procedures. The starches were dried, milled, and blended in different proportions. The functional and pasting characteristics of the starch blends were determined using standard analytical procedures and instruments. The functional properties of the starch blends were significantly different ($P<0.05$) from 100% cassava and sweetpotato starches except in bulk density and pH. Bulk density ranged from 0.64 to 0.67 g/ml, Water absorption index ranged from 69.07 to 87.00% and dispersibility from 64.80 to 87.60%. The least gelation concentration ranged between 2.00 and 3.73%. The pH of the starch blends was between 6.70 and 6.80. The swelling power of the starch blends increased with increasing temperature and was considerably higher than that of 100% sweetpotato starch but lower than that of 100% cassava starch. Total titratable acidity of the starch blends was lower than that of 100% cassava and sweetpotato starches. The pasting profile of the starch blends was significantly different from that of the 100% cassava and sweetpotato starches. Peak viscosity (310.05−379.29 RVU), trough (162.67−203.42 RVU), breakdown viscosity (169.13−177.46, RVU), and final viscosity (200.50−274.50 RVU) were lower than those of 100% cassava and sweetpotato starches. Set back viscosity ranged between 66.30 and 82.00 RVU. Time to attain peak viscosity ranged from 4.47 to 4.97 min, while the starches, pasting temperature ranged from 73.65 to 91.60 °C. Blending sweetpotato starch with cassava starch significantly improves some functional properties of sweetpotato starch. The blend containing 75% cassava starch and 25% sweetpotato starch showed higher pasting stability than 100% cassava and sweetpotato starches, due to its low setback viscosity.

Key words*:* cassava, sweetpotato, starch, pasting, functional

Introduction

Starch is not only one of the most abundant biopolymeric assemblies in nature but also a major food component on a world-wide scale and one of the main food ingredients, both in native or modified forms. The range of food products containing starch in one form or another is almost limitless. But the utility of starches is based almost entirely upon their natural or synthesized functional characteristics. The particular physical and chemical characteristics of individual starches are the keys to their commercial success. Starch plays an obvious role in achieving the desired viscosity in products such as sauces, pie fillings, corn starch pudding, etc. In food systems, starch is used to influence or control characteristics such as aesthetics, moisture, consistency, and shelf stability. It can be used to bind, expand density, clarify or opacify, attract or inhibit moisture as well as to stabilize emulsions and act as texturizing agent.

Starches are extracted from several different starchy raw materials, such as barley, maize, rice, sweetpotato, and cassava. Sweetpotato and cassava are two major starchy root and tuber crops used in many tropical countries (Osundahunsi et al 2003). Sweetpotato starch has been used as an ingredient in bread, biscuits, cakes, juice, ice cream, and noodles

or converted to glucose and isomerized glucose syrup (Zhang et al 1999). Cassava starch is used to produce variety of value-added products such as sweeteners, alcohol, acids, and other chemicals (Klanarongs et al 2001). Cassava starch is used in industries due to its high yield, very low cost, and unique characteristics such as a clear viscous paste (Klanarongs et al 2001).

Starches from different plant sources exhibit different varieties of characteristic functional properties such as specific viscosity, flow properties, swelling and resistance to swelling, and gel texture, etc. The functional properties of starch are dependent on the variety, environment, and the extraction process and can also be altered by subsequent enzymatic or chemical modification (Stephen 2008). Cassava starch has a low gelatinization temperature (65-70 °C), a rapid increase in viscosity after gelatinization, and forms a clear, soft gel with better cold stability, but a very cohesive texture. It is ranked very high among starchy staples because it gives a carbohydrate production which is about 40% higher than rice and 25% more than maize (Nyerhorvwo 2004). Sweetpotato starch has been found to be easier to cook, to have a lower potential for retrogradation, but to be less stable during heating than starches from cassava.

One way to overcome some functional limitations of native starches is by blending different starches. Obanni and Bemiller (1997) reported that a blend of native starches may be formulated to achieve some of the desired characteristics of modified starches. The amount of scientific information available on the functional and pasting properties of cassava and sweetpotato starches cannot be compared with that from the major cereal starches such as wheat and corn starches. A significant amount of research needs to be conducted on the functional characteristics of native as well as modified starches from tropical roots and tubers for them to become competitive with corn and wheat starches, locally and internationally. Therefore, this study was conducted to determining the functional and pasting properties of cassava–sweetpotato starch blends with a view to providing information that will improve the utilization of these starches in food and non-food applications.

Materials and Methods

Cassava and sweetpotato starches were extracted according to the methods described by Oyewole and Obieze (1995) and Lilia and Collando (1999). Five different starch blends were obtained as shown below:

Cassava starch	75%	25%	50%	-	100%
Sweetpotato starch	25%	75%	50%	100%	-

Determination of functional properties. Bulk density was determined by the method of Wang and Kinsella (1976), least gelation concentration by method of Coffman and Garcia (1977), and dispersibility by the method of Kulkarni et al (1991). Swelling power at different temperatures was determined as described by Takashi and Sieb (1988), and water absorption index as described by the modified method of Anderson (1982). Total titratable acidity was determined by Pearson's (1985) method while pH was measured using a digital pH meter (AOAC, 1990).

Determination of pasting properties. Pasting properties were determined using a Rapid Visco Analyser (RVA) (model RVA 3D+; Network Scientific, Australia). The sample was turned into slurry by mixing 3 g of starch powder with 25 ml of water inside the RVA can. This was inserted into the tower, which was then lowered into the system. The slurry was heated from 50 to 95 °C and cools back to 50 °C within 12 min, The contents were rotated at a speed of 160 rpm with continuous stirring with a plastic paddle. Parameters estimated were peak viscosity, trough, setback viscosity, final viscosity, pasting temperature, and time to reach peak viscosity.

Statistical analysis. All data obtained were subjected to One-Way Statistical Analysis of Variance (ANOVA) using SPSS (version 17, 2010). Means were separated using Duncan's Multiple Range Test (DMRT).

Results and discussion

Functional properties of cassava–sweetpotato starch blends. The results from the functional properties of the starch blends are presented (Table 1). The functional properties of the starch blends were significantly different ($P<0.05$) from 100% cassava and sweetpotato starches except in bulk density and pH. Bulk density ranged from 0.64 to 0.67 g/ml. The bulk density is an important parameter that determines the ease of packaging and transportation of powdery or particulate foods. Bulk density is an important functional property in many food applications. For instance, it has been found to affect the sensory acceptability of starch noodles, handling and packaging requirements, as well as transport costs (Nwabueze et al 2009). Water absorption index ranged from 69.07 to 87.00% and dispersibility from

64.80 to 87.60%. The least gelation concentration (LGC) ranged between 2.00 and 3.87%. Dispersibility is a measure of the degree of reconstitution of flour or flour blends in water, the higher the dispersibility the better the flour reconstitutes in water (Adebowale et al 2005). The higher dispersibility value exhibited by all the starches is indicative of their ability to produce smooth or consistent paste. LGC is a measure of the minimum amount of starch or blends of starch powder that is needed to form a gel. The LGC of the starch blends was higher than that of 100% cassava and sweetpotato starches a smaller hence, less amount of the starch blend would be required to form paste during processing (Adebowale et al 2005) compared were 100% cassava and sweetpotato starches. The pH of the starch blends was between 6.70 and 6.80. Total titratable acidity (TTA) of the starch blends was lower than that of 100% cassava and sweetpotato starches; while the pH of the starch blends was similar to that of 100% cassava and sweetpotato starches. The TTA when related with the pH values shows that the starch has the low acid content characteristic of root and tuber starches (Onitilo et al 2007).

The swelling power of the starch samples at different temperature is presented (Fig 1). The swelling power of the starch blends increased with increasing temperature and was considerably higher than that of 100% sweetpotato starch but lower than that of 100% cassava starch. All the starches showed a gradual increase in swelling power with the increase in temperature and this suggested that these starches had weaker internal associative forces maintaining the granule structure.

Pasting properties of cassava–sweetpotato starches. The pasting properties of cassava– sweetpotato starch blends are presented (Table 2). The pasting profile of the starch blends was significantly different from that of the 100% cassava and sweetpotato starches. Peak viscosity (310.05–379.29 RVU), trough (162.67–203.42 RVU), breakdown viscosity (169.13–177.46, RVU) and final viscosity (200.50–274.50 RVU) were lower than those 100% cassava and sweetpotato starches. Peak viscosity is the maximum viscosity attained during or soon after the heating portion of the amylograph pasting test. Peak viscosity indicates the water binding capacity of the starch or mixture. It is often correlated with final product quality (Maziya-Dixon et al 2007). The peak viscosity occurs at the equilibrium point between swelling that causes an increase in viscosity and rupture and alignment that cause its decrease. Setback viscosity ranged between 66.30 and 82.00 RVU. Setback has been correlated with the texture of various products and high setback is also associated with syneresis or weeping during freeze/thaw cycles (Maziya-Dixon et al 2007). The higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the products made from the starch (Adeyemi and Idowu 1990). The setback viscosity of the blend of 75% cassava with 25% sweetpotato starch was considerably lower than 100% starches, indicative of the potential of the blend to form a much more stable starch paste than 100% cassava and sweetpotato starches. The time to attain peak viscosity ranged from 4.47 to 4.97 min; the starches, pasting temperatures ranged from 73.65 to 91.60 ^{o}C. The ability of starch to imbibe water and swell is primarily dependent on the pasting temperature. The higher the pasting temperature, the faster the tendency for a paste to be formed (Dreher and Berry 1983). The starch blends exhibited a higher pasting temperature than to 100% cassava and sweetpotato starches.

Table 1: Functional properties of cassava–sweetpotato starch blends

Sample	Bulk density (g/ml)ns	Water absorption index (%)	Dispersibility (%)	pHns	Least gelation concentration (%)	Total titratable acidity
100% cassava	0.65	86.80^{d}	85.40^{b}	6.80	2.00^{a}	2.07^{b}
75% cassava : 25% sweetpotato	0.67	69.07^{a}	84.80^{b}	6.78	2.00^{a}	2.07^{b}
25% cassava : 75% sweetpotato	0.65	77. 60^{c}	64.80^{a}	6.70	3.38^{b}	1.38^{a}
50% cassava : 50% sweetpotato	0.67	70.40^{b}	87.60^{b}	6.70	3.73^{b}	1.73^{ab}
100% sweetpotato	0.64	87.00^{d}	71.80^{a}	6.75	2.07^{a}	2.07^{b}

Values are means of three replicates.
Mean values having different superscript within column are significantly different ($P<0.05$)
ns not significantly different ($P>0.05$)

Table 2: Pasting properties of cassava – sweetpotato starch blends.

Sample	Peak (RVU)	Trough (RVU)	Break Down (RVU)^{ns}	Final Viscosity (RVU)	SetBack (RVU)	PeakTime (min)^{ns}	Pasting temperature (°C)
100% cassava	379.29^{d}	201.83^{d}	177.46	274.50^{c}	72.67^{ab}	4.47	81.68^{b}
75% cassava : 25% sweetpotato	310.05^{a}	134.21^{a}	175.84	200.50^{a}	66.30^{a}	4.77	73.65^{a}
25% cassava : 75% sweetpotato	360.21^{c}	187.84^{c}	172.38	269.84^{c}	82.00^{b}	4.90	88.88^{c}
50% cassava : 50% sweetpotato	331.79^{ab}	162.67^{b}	169.13	239.50^{b}	76.83^{ab}	4.97	91.60^{d}
100% sweetpotato	376.29^{d}	203.42^{d}	172.75	273.50^{c}	70.09^{ab}	4.57	82.55^{b}

Values are means of three replicates.
Mean values having different superscript within column are significantly different ($P<0.05$)
ns not significantly different ($P>0.05$)

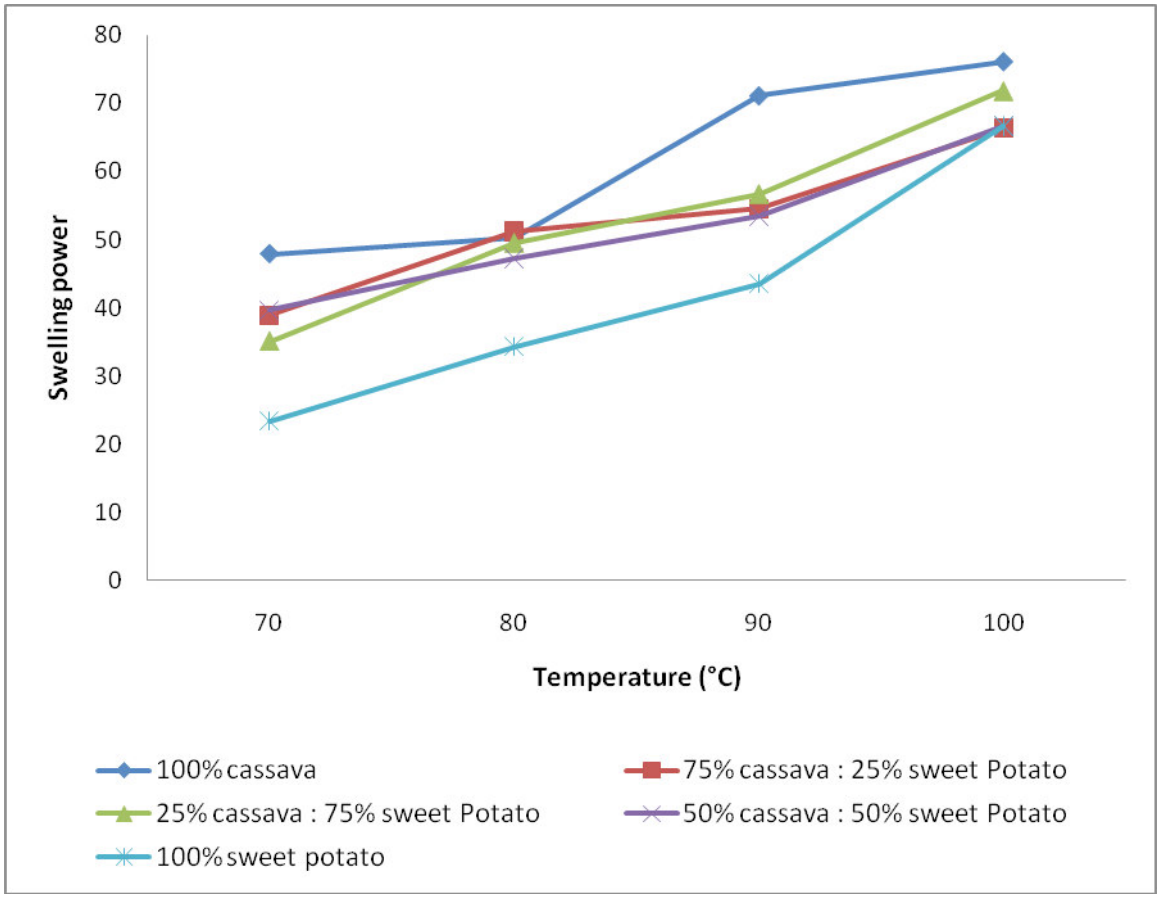

Figure 1: Swelling power of cassava-sweetpotato starch blends at different temperatures.

Conclusion

In conclusion, blending sweetpotato starch with cassava starch significantly improves some functional properties of sweetpotato starch. The blend containing 75% cassava starch and 25% sweetpotato starch showed a higher pasting stability than 100% cassava and sweetpotato starches.

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