African Journal of Food Science Vol. 6(20) pp. 500-505, 26 October, 2012
Available online http://www.academicjournals.org/ajfs
DOI: 10.5897/AJFS12.155
ISSN 1996-0794 ©2012 Academic Journals

Full Length Research Paper

Effect of turmeric *(Curcuma longa* L*)* grates on pasting and some physicochemical properties of cassava starch with and without lactic acid

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Accepted 9 September, 2012

The effects of the addition of turmeric grates (0 to 2.5 g/150 g dry starch samples) on some physicochemical and pasting properties of native cassava starch, with and without lactic acid were studied with a view to examine the possibility of using the active components in turmeric grates as natural product modifying agents for non-fermented and lactic acid fermented cassava starch. Treatment of native cassava starch, with and without lactic acid using turmeric grates exerted cross-linking properties as shown by the increase in peak viscosity: 407 to 433 rapid visco analyzer unit (RVU) vs. 391 RVU for samples without lactic acid; and 350 to 363 RVU vs. 350 RVU for samples with lactic acid. Native cassava starch with lactic acid on treatment with turmeric grates gave improvement in paste stability (BDV = 241 to 251 RVU) in comparison to the breakdown viscosity (BDV = 250 RVU) of native cassava starch with lactic acid. Susceptibility of native cassava starch with lactic acid to retrogradation was reduced on treatment using turmeric grates. Treatment of native cassava starch with and without lactic acid using turmeric grates modifies the pH with a slight improvement in the swelling power of the products. This suggests that components in turmeric grates can be used to modify native cassava starch with and without lactic acid.

Key words: Cassava starch, lactic acid, turmeric treatment, pasting properties.

INTRODUCTION

Nigeria is the world largest producer of cassava, thus cassava is the most economic source of starch in the country. Therefore, cassava starch was the focus for modification in this study. The advantages of modified starches over their native counterparts are explicitly stated in the literature (Bemiller and Lafayette, 1997; Roberts, 1967). Starch modification can be broadly grouped into four classes, namely physical, chemical, enzymatic and biological (Bemiller and Lafayette, 1997). Among the modification methods, the chemical process is most frequently used. The use of synthetic chemicals for production of food grade starches is legislatively discouraged for reasons of consumer and worker safety, environmental concerns and economic reasons. These reasons, in conjunction with appreciation of the fact that the positive attributes of starch can be greatly improved and/or the negative characteristics diminished, by slight and simple modification coupled with the new trends in consumer preference for all-natural foods suggests that attention be shifted towards using natural products, especially those that man has eaten for thousands of years to modify starch.

Phenolic compounds, inherent components of all natural products have been shown to influence the properties of starch (Beta and Corke, 2004). Also, *Curcuma longa* has been shown to contain phenolics. Daramola and Osanyinlusi (2006) have reported the effect of *Zingiber officinale* Roscoe belonging to same botanical family as *C. longa* on cassava starch. These two reasons suggest that constituents of *C. longa* may exhibit an effect on cassava starch, and consequently these constituents were studied in this paper.

This study was designed to determine the effect of turmeric grates on cassava starch with and without lactic acid, with a view to assessing the potentials of *C. longa* for correcting the adverse pasting impacts on cassava starch isolated under conditions that support lactic acid fermentation (George and Moorthy, 1991; Moorthy et al., 1993). Therefore, this paper reports the effects of *C. longa* grates on pasting and other physicochemical properties of cassava starch with and without lactic acid, with a view to using the active components in *C. longa* grates as natural product modifying agents for non-fermented and fermented cassava starch. To my knowledge, this has not appeared in the literature before this research.

MATERIALS AND METHODS

Cassava roots of TME 30572 variety, aged 12 months at harvest were obtained from Igbira farm in the suburb of Federal Polytechnic, Ado-Ekiti, Nigeria. The roots were of an improved variety (low cyanide and high yield). Turmeric (*C. longa)* roots were procured from King's market in Ado-Ekiti, Nigeria. Lactic acid (Milchsaure etwa 90% reinst Merck E. Merck Darmstadt) was obtained from Department of Food Technology Laboratory.

Extraction of native cassava starch

Native cassava starch was extracted according to the classical method described by Osunsami (1987).

Treatment of native cassava starch with turmeric (*C. longa*) grates

Native cassava starch (150 g; 8% moisture content) was treated using turmeric grates (0 to 2.5 g) in accordance with the procedure described by Daramola and Osanyinlusi (2006), with the modification of smaller amounts of turmeric grates in treatments. Fermented cassava starch with lactic acid dominate was mimicked by the addition of lactic acid to cassava starch following the procedure essentially described by Colonna et al. (2001) prior to treatment using turmeric grates.

Methods of analysis

Determination of pasting properties using rapid visco analyzer (RVA)

The pasting properties of native cassava starch samples, with and without lactic acid, treated with turmeric grates were characterized using RVA as described by Delcour et al. (2000). In brief, 5 g starch samples were added to water at a ratio of 1:2 (w/v). The sample slurry was heated from 28 to 150°C at 4°C/min and all the experiments were carried out in triplicate. The RVA-d was operated with 2.5 g of 9.9% starch-in-water suspensions. The temperature profile included a 2 min isothermal step at 50°C, a linear temperature increase to 95°C in 7 min, a holding step (8 min at 95°C), a cooling step (7 min) with a linear temperature decrease to 50°C, and a final isothermal step at 50°C. Measurements agreed within 5 RVU over the entire profile. Pasting peaks and parameters that were of paramount importance were identified and determined for technological interpretation.

Moisture content determination

Moisture content was determined in accordance with the methods of the Association of Official Analytical Chemists (AOAC) (1990).

Measurement of pH

The pH of native cassava starch samples, with and without lactic acid and treated using turmeric grates were determined using an Omega H.HPX digital meter. Standardization of the meter carried out using buffer solutions of pH 9 and 4. A 5 g sample was dispersed in 25 ml of distilled water and the mixture was subjected to stirring until an equilibrium pH was obtained (Smith, 1967).

Determination of swelling power

This was determined in accordance with the method described by Leach et al. (1959) with a modification for small samples, at three temperatures (60, 70 and 80°C).

Pastes clarity determination

This was determined from percent light transmittance (%T) of starch paste as described by Craig et al. (1989).

RESULTS AND DISCUSSION

Pasting properties of native, turmeric (*C. longa*) treated cassava starches, with and without lactic acid

The pasting values of technological importance extrapolated from pasting curves of native, turmeric treated cassava starch, with and without lactic acid, are shown in Table 1. Turmeric treated cassava starch without lactic acid was characterized by high peak viscosities (PV) (407 to 433 RVU) in comparison to the low PV (391 RVU) of the native starch. These findings are similar to previous results (Daramola and Osanyinlusi, 2006) on modification of cassava starch using active components in ginger root (*Z. officinale* Roscoe*),* bearing in mind that *Z. officinale* and *C. longa* used for medication in the tropics belong to the same botanical family, Zingiberaceae (Adeniji, 2003). The higher peak viscosity of turmeric-modified cassava starch in comparison to the native starch may be due to cross linkage of hydroxyl groups of starch molecules with active components in the turmeric which resulted in higher peak viscosities. Cross-linked starch is resistant to loss of viscosities at low pH. This property suggests that the modified starch could be useful as a bodying agent for acid fruit fillings in which the pH is often adjusted to a range of 3 to 4 (Stauffer, 1990).

Cassava starch samples treated with 0.5 g or 2.5 g of turmeric grates showed low set back viscosity (SV_{F-T} = 376 to 498 RVU) compared to native cassava starch with its high set back viscosity (SV_{F-T} = 576 RVU). Lower setback viscosity is an indication of the stability of the cooked paste against retrogradation (Mazurs et al*.,* 1957). The observed reduction in set-back viscosity (an index of retrogradation) is similar to the report of Ou et al.

Table 1. Rapid visco analysis readings of native cassava starch, with and without lactic acid treated using turmeric grates.

Sample treatment	PV (RVU)	TV (RVU)	BDV (RVU)	FV (RVU)	$SV_{F.T}$ (RVU)	SV_{f-p} (RVU)	PT (min)	Pt (°C)
C_NS	391	211	180	268	58	-123	4.40	72.80
C_NS-T_1	409	194	215	251	57	-157	4.10	72.10
C_NS-T_2	433	321	202	268	58	-165	4.47	72.05
C_NS-T_3	407	200	207	248	37	-157	4.27	73.55
C_NS_{LA}	350	100	250	127	27	-223	3.73	72.80
C_NS_{LA}-T_1	350	109	242	148	39	-202	3.73	71.90
C_NS_{LA}-T_2	362	111	251	156	44	-206	3.73	72.05
C_NS_{LA}-T_3	363	121	242	166	452	-196	3.87	71.95

C_NS, Native cassava starch without lactic acid; C_NS-G_1, C_NS treated using 0.1 g turmeric grates; C_NS.T_2, C_NS treated using 0.5 g turmeric grates; C_NS.T_3, C_NS treated using 2.5 g turmeric grates; C_NS_{LA}, native cassava starch with lactic; C_NS_{LA}.T_1, C_NS_{LA} treated using 0.1 g turmeric grates; C_NS_{LA}.T_2, C_NS_{LA} treated using 0.5 g turmeric grates; C_NS_{LA}.T_3, C_NS_{LA} treated using 2.5 g turmeric grates. PV, peak viscosity; TV, trough viscosity from trough (final; viscosity-trough viscosity); PT, pasting time; Pt, pasting temperature; SVF-P, setback viscosity from peak (final viscosity-peak viscosity); RVU, rapid visco analyzer unit.

(2001) that reported lower retrogradation for starch ferulate, a product of starch and ferulic acid (a phenolic compound). These inherent components of *C. longa* are phenolic compounds and they occur in many natural products. The lower set back viscosities of turmeric treated starch samples indicate that active components in turmeric grates might function by formation of a complex with amylose, thereby preventing re-alignment of the amylose that results in a delay in retrogradation in starch. Turmeric treated cassava starch could function as starch-additive in products such as pie-fillings where good thickening and stability are required.

Native cassava starch treated with turmeric grates appeared to have a short gelatinization time (4.1 to 4.3 min) when compared to the longer gelatinization time (4.4 min) of the native cassava starch. Cooking time has energy-cost consequences. A cursory examination of the effects of turmeric on the cooking properties of cassava starch in comparison to other treatments showed that turmeric was most effective at a concentration of 0.5 g of the turmeric grates.

Pasting values of technological importance of fermented cassava starch lactic acid dominate were simulated by addition of lactic acid to each starch prior to treatment with turmeric grates, and are presented in Table 1. Native cassava starch to which lactic acid had been added showed a reduction in peak viscosity (350 RVU) in comparison to the high peak viscosity (392 RVU) of the native starch. The reason for the viscous degradation of the lactic acid treated cassava starch is obvious in that acidity accentuated hydrolysis of starch polymers by disrupting the glycoside linkages, thereby lowering the final viscosity of the cassava starch products (Belitz and Grosch, 1999). Kerr (1950) reported a decrease in the viscosity of starch with acid treatment. Treatment of native cassava starch with lactic acid using turmeric grates improved the cooking properties of the treated starch. Peak viscosities were generally increased from 350 RVU for the native cassava starch to 350 to 363 RVU for the turmeric treated native cassava starch with lactic acid. The effect was probably due to the cross linking properties of the active components in turmeric grates with starch molecules. The trough viscosities (109 to 120 RVU) of the turmeric treated native cassava starch with lactic acids samples were higher than the trough viscosity (100 RVU) of the native cassava starch with lactic acid. Final viscosities (148 to 166 RVU) of turmeric grates treated cassava starch with lactic acid samples were higher than the final viscosity (127 RVU) of the native cassava starch with lactic acid. This again suggests that turmeric might contain components that can stabilize the viscosity of fermented cassava starch. This conjecture was informed by the observation that the acidic properties of starch products decreased as the proportion of turmeric grates added was increased as revealed by the pH of the products, irrespective of treatment (Table 2). Thus, some components possessed alkaline properties. Belitz and Grosch (1999) stated that, in the presence of alkali, the helical conformation of starch becomes more extended, and Beta et al. (2001) added that the peak viscosity of such starch will be increased.

Treatment of the cassava native starch with lactic acid using turmeric grates gave a product with slight improvement in breakdown viscosity (Table 1). As stated earlier, an increase in breakdown viscosity signifies stability of the cooked paste to heat and shear thinning. The effectiveness of the active components in turmeric in stabilizing paste viscosity was more pronounced in native cassava starch with lactic acid samples, which were characterized by a relatively low breakdown viscosity (BDV = 241 RVU) in comparison to that (BDV = 250 RVU) of the native cassava starch with lactic acid.

Similarly, native cassava starch with lactic acid samples treated using turmeric grates showed lesser tendency to retrogradation as shown by the low set back of the final viscosity from the peak viscosity (SV_{F-T} = -196 to -206 RVU) in comparison to the high set back viscosity

Table 2. Some physicochemical properties of cassava starch, with and without lactic acid treated using turmeric grates

Sample	pH	Paste clarity (% T)	Moisture content (% T)	Swelling power (g paste/g dry sample)		
				60°C	60°C	60°C
C_NS	4.67	8.30	8.40	11	12	15
C_NS-T_1	4.60	11.75	8.35	11	13	18
C_NS-T_2	4.72	40.54	9.00	13	17	16
C_NS-T_3	5.00	30.19	9.05	14	15	15
C_NS_{LA}	3.24	74.13	8.45	12	12	17
C_NS_{LA}-T_1	3.41	27.54	8.30	10	14	13
C_NS_{LA}-T_2	3.40	1.70	8.35	12	17	14
C_NS_{LA}-T_3	3.65	8.71	8.00	14	14	17

C_NS, Native cassava starch without lactic acid; C_NS-G_1, C_NS treated using 0.1 g turmeric grates; C_NS-T_2, C_NS treated using 0.5 g turmeric grates; C_NS-T_3, C_NS treated using 2.5g turmeric grates; C_NS_{LA}, Native cassava starch with lactic; C_NS_{LA}-T_1, C_NS_{LA} treated using 0.1g turmeric grates; C_NS_{LA}-T_2, C_NS_{LA} treated using 0.5g turmeric grates; C_NS_{LA}-T_3, C_NS_{LA} treated using 2.5g turmeric grates.

(SV_{F-P} = -223 RVU) of the native cassava native cassava starch with lactic acid. Thus, components in turmeric grates appeared to diminish retrogradation, the major undesirable attribute of cassava starch paste upon cooking (Abraham, 1993). The native cassava starch with lactic acid was characterised by a lower pasting temperature compared to turmeric treated native cassava starch with lactic acid. This attribute may be useful in the preparation of foods where some additives are heat labile, flavourings for example.

Some physicochemical properties

Values for the physicochemical properties of pH, moisture content, paste clarity and swelling power are shown in Table 2.

pH

Treatment of native cassava starch using turmeric grates tended to raise the pH (4.60 to 5.00) of the treated cassava starch samples relative to the pH (4.67) of the native cassava starch. This suggests that components in the turmeric grates can modify acidity, most likely by esterification of components in cassava starch. For example, shagoal and gingerol in ginger belonging to the same botanical family, as turmeric has been reported (Kikuzaki and Nakatani, 1993) to esterify acidic group. The pH of native cassava starch with lactic acid and treated with turmeric grates was generally lower than corresponding samples without lactic acid treated using turmeric grates. This finding is plausible because of the addition of lactic acid, which reduced pH of the samples. The pH (3.41 to 3.65) of turmeric treated native cassava starch with lactic acid was higher than the pH (3.24) of native cassava starch with lactic acid. This corroborates the previous assertion that components in turmeric root probably modify acidity, probably by esterification.

Moisture content

The moisture contents of turmeric treated native cassava starch with or without lactic acid and native cassava starch were similar. This was because the starch samples were dried under similar conditions, thus giving rise to same amounts of total solids in the samples. Shildneck and Smith (1967) reported that the moisture content of starches is usually related to a large extent to the type of starch and the method and conditions of drying.

Paste clarity

The paste clarities (% T) of native cassava starch samples treated with turmeric grates were not similar. Turmeric treated native cassava starch with lactic acid showed relatively high % T which decreased as the amount of turmeric increased. This observation was thought to be due to the optical interference caused by the water soluble colourant inherent in turmeric. Pastes' clarity is an importance attribute of commercial starches. However, there are products, such as spoonable salad dressings, where the starch used in its manufacture should be opaque (Craig et al*.,* 1989).

Swelling power

Swelling power increased as the quantity of turmeric grates added was increased within the temperatures (60, 70 and 80°C) of the heating profile. Swelling power is a measure of hydration capacity, because the determination

Table 3. Correlation coefficient and regression equations between some physicochemical properties and selected pasting properties of native cassava starch with and without lactic acid treated using turmeric grates.

X	Y	R	R^2	Regression equation
Samples without LA*				
T (%)	SV_{F-P}	0.87	0.76	Y = -128.90 - 2.34X
T (%)	PV	-0.72	0.52	Y = 427.00 - 1.798X
pH	PV	0.019	0.00	ND
pH	SV_{F-P}	0.257	0.06	ND
pH	T (%)	0.665	0.44	Y = 134.23 - 26.28X
Samples with LA*				
T(%)	PV	-0.689	0.47	Y = 416.24 - 1.741X
T(%)	SV_{F-P}	0.99	0.98	Y = 1910.02 + 61.47X
pH	PV	0.703	0.49	Y = 225.88 + 293X
pH	T(%)	-0.91	0.83	Y = 548.19 – 149.99X
pH	SV_{F-P}	-0.91	0.83	Y = 420.297 – 62.27X

All viscosity in RVU; PV, Peak viscosity; TV, trough viscosity from trough (final; viscosity-trough viscosity); PT, pasting time; Pt, pasting temperature; SVF-P, setback viscosity from peak (final viscosity-peak viscosity); RVU, rapid visco analyzer unit. *Lactic acid; R, correlation coefficient; R^2, variance; ND, not determined.

is a weight measure of swollen starch granules and their occluded water. Food eating quality is often related to retention of water in swollen starch granules (Rickard et al., 1992). Generally, swelling power increased as heating temperatures increased.

A comparison of the swelling power of native cassava starch with and without lactic acid treated using turmeric grates showed that the treatment (with lactic acid) resulted in lower swelling power. This observation can be explained by the fact that acid weakens the integrity of starch granules which allows the amylose/amylopectin content to leach out resulting in comparatively lower swelling power.

Table 3 shows the relationship between some physicochemical properties (X) and selected pasting properties (Y) of native cassava starch with or without lactic acid treated using turmeric grates. Regression equation was not determined (ND) for correlation coefficient that is nominally less than 0.5. Based on the fact that the physicochemical methods are rapid in comparison to the pasting method, therefore, an insight into changes in pasting properties of turmeric treated cassava starch can be gained using the regression equations.

Conclusions

Active components in *C. longa* modified the pasting and some other physicochemical properties of native cassava starch with and without lactic acid. The active components of turmeric grates could be used to produce specialty starches with cross-linked properties characterized by reductions in negative attributes. The active components in *C. longa* could also be used to modify the pasting and other physicochemical properties of fermented cassava starch lactic acid dominate, although, this is a preliminary study on modification of cassava starch using *C. longa*. Therefore, it should create interest in more intensive work in this area.

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