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Compositional and Pasting Characteristics of Plain-Dried and Parboiled Cassava (*Manihot esculenta* Crantz)

K. C. M. Raja & S. V. Ramakrishna

Fermentation Section, Regional Research Laboratory (CSIR), Trivandrum—695019, India

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ABSTRACT

Compositional and pasting characteristics of cassava flour samples prepared from plain-dried and parboiled chips of the M-4 variety were examined. Parboiling reduced the levels of amylose, fat, reducing sugars and mineral matter. The profiles of the major fatty acids, palmitic, oleic and linoleic, remained generally similar in both plain-dried and parboiled samples. Modifications in the pasting properties of cassava flour attained as a result of parboiling were reflected in the relatively low peak/maximum paste viscosity, higher paste stability, considerably lower breakdown value (P-H) and higher breakdown ratio (H/P) of the aqueous slurry prepared from the parboiled samples.

INTRODUCTION

Parboiling is a traditional technique, largely applied in the case of rice to improve its nutritional and textural properties. During parboiling, the morphology of starch granules changes due to their swelling and fusion (Bor & Mickus, 1979).

Cassava, a major agricultural crop of tropical regions, is preferred to be consumed in particular forms depending upon the food habits of the region concerned. Two types of dehydrated chips, plain-dried (PD) and parboiled (PB), are commercially prepared for food uses. Studies pertaining to the changes occurring in rehydration properties of cassava chips, as influenced

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by parboiling, have already been reported (Raja & Mathew, 1986). In the present paper, compositional and pasting characteristics of the flour samples prepared from PD and PB chips are discussed.

MATERIALS AND METHODS

Fresh tubers of the M-4 variety were used for the present study. They were of 7–8 months maturity and had a moisture level of 58–60%. Tubers were processed to PD and PB chips, as shown schematically in Fig. 1.

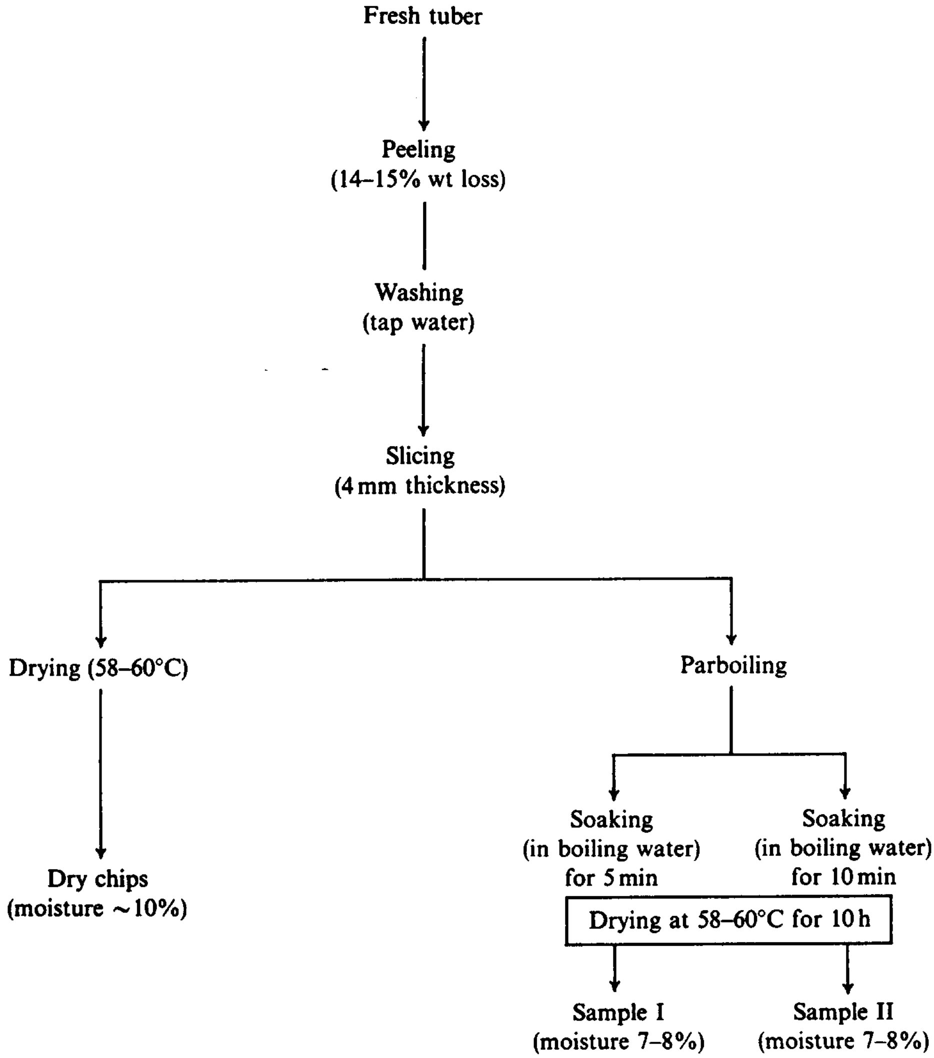

Fig. 1. Flowsheet for parboiling of fresh cassava.

Milling

The dry chips, having moisture content of 7–8%, were milled in a laboratory model grinder (Power Appliances & Co., Bombay, India). The flour sample thus obtained was passed through a sieve of 250 μm mesh size and used for the following experiments.

Compositional analysis

Moisture, starch and reducing sugars were determined by standard procedures (AOAC, 1975; Jacobs, 1958). The mineral matter, i.e. sodium, potassium, iron and calcium, were estimated using a flame photometer (Jackson, 1967). The phosphorus content was analysed by the method of Fiski and Subha Row (1925).

Total and soluble amylose

The procedure recommended by Sowbhagya and Bhattacharya (1971) was followed for estimating total amylose, while hot water-soluble amylose was determined by the method of Hall and Johnson (1966).

Fat content

The free fat was extracted from the flour samples by the AOAC method (1975) and quantified. The total fat, consisting of free and bound, was determined by extracting it in chloroform–methanol (2:1) (Folch *et al.*, 1957).

Fatty acid composition

The fatty acid profile of total fat was studied (Alexandrids & Lopez, 1979) using a gas chromatograph (Hewlett-Packard No. 5840) with SS column (6 ft × $\frac{1}{8}$ in) packed with diethylene glycol succinate. The operational conditions were the following:

Temperature programming	100–200°C
Rate of temperature increase	5°C/min
Detection technique	TCD
Flow rate	20 ml/min
Carrier gas	hydrogen

Fatty acids were identified using methyl ester standards (Sigma Chemicals, USA), and the percentage was computed from the respective peak area.

Pasting characteristics

Experiments were conducted using a Brabender viscograph, essentially following the method of Halik and Kelley (1959), details of which have been reported (Raja *et al.*, 1987).

RESULTS AND DISCUSSION

Results of the present study are presented in Tables 1, 2 and 3.

Starch, reducing sugars and amylose

Among the three constituents, starch, reducing sugars and amylose, the extent of reduction observed in starch as a result of parboiling was the lowest. On the other hand, the percentage of reducing sugars was lowered from 0·99% to 0·23% during parboiling for 5 min (PBI). This virtually accounts for a reduction by 77%. Extension of parboiling time up to 10 min further lowered the sugar content by an additional 7·3% only. It is anticipated that gelatinization and retrogradation, occurring during parboiling, might restrict the solubilization of starch, unlike free sugars, presumably due to complexation of amylose with fatty acids, and of amylopectin with complexed linear component (Priestley, 1977).

Amylose

The total amylose content, 19·8%, observed in the PD sample was lowered to 17·5% by parboiling for 10 min. A corresponding reduction observed in soluble amylose content was from 13·20% to 10·83%.

Whistler (1965) has reported the deposition of an amylose film during the cooling of autoclaved starch owing to retrogradation. Studies carried out in this laboratory (Raja *et al.*, 1987) revealed that steam hydrothermal treatment of fresh cassava causes a noticeable reduction in the total extractable amylose. Extensive studies explaining the mechanism behind the changes of amylose as a result of parboiling are, however, more available for parboiled rice than for any other single starchy crop. Changes occurring of amylose content in parboiled rice have been reported differently by different groups of researchers. Roberts *et al.* (1954) reported a higher amylose content in parboiled rice than raw rice. A similar increase in the amylose content was also noticed by Alary *et al.* (1977) in parboiled, cooked rice. Accordingly, increased firmness, generally noticed in the case of parboiled rice, was attributed to the above increase in amylose content. A

TABLE 1

Analysis[a] of Plain-Dried and Parboiled Cassava Flour (M-4 variety) (particle size 250 μm)

Sample	*Starch* (%)	*Reducing sugars* (%)	*Total fat*		*Total amylose* (%)	*Water-soluble amylose* (%)	*Insoluble amylose* (%)	*Total ash* (%)	*Minerals*				
			Free fat (%)	*Bound fat* (%)					*P* (%)	*Fe* (*mg%*)	*Na* (*mg%*)	*K* (*mg%*)	*Ca* (*mg%*)
Plain-dried flour	92·3	0·99	0·63	0·43	19·80	13·20	5·60	1·830	0·081	1·420	0·453	0·353	40·0
Parboiled (5 min)	92·0	0·23	0·51	0·33	17·60	10·96	6·64	1·249	0·015	1·259	0·142	0·176	24·3
Parboiled (10 min)	91·8	0·16	0·35	0·32	17·56	10·83	6·73	1·247	0·015	1·247	0·141	0·175	24·5

[a] Values expressed on a per cent dry weight basis are the mean of triplicate analysis.

TABLE 2
Fatty Acid Composition[a] of Total Lipids from Cassava Flour (M-4 variety)

Carbon number and unsaturation	*Per cent composition*		
	Plain-dried	*Parboiled*	
		5 min	*10 min*
$C_{6:0}$ (Caproic)	0·15	0·74	0·62
$C_{8:0}$ (Caprylic)	0·22	0·8	0·66
$C_{10:0}$ (Capric)	0·22	0·32	0·10
$C_{12:0}$ (Lauric)	0·25	0·56	1·14
$C_{14:0}$ (Myristic)	0·39	0·26	—
$C_{16:0}$ (Palmitic)	20·51	22·10	20·94
$C_{18:1}$ (Oleic)	52·33	55·52	54·69
$C_{18:2}$ (Linoleic)	13·27	11·27	10·64
$C_{20:0}$ (Arachidic)	1·98	1·17	0·59
$C_{22:0}$ (Behenic)	5·09	2·47	1·29
$C_{24:0}$ (Lignoceric)	0·80	0·66	0·75

[a] Mean of three determinations.

series of experiments conducted by Ali and Bhattacharya (1972), however, revealed that total amylose content shows an increase only when the extraction of parboiled rice flour is carried out below the gelatinization temperature of rice starch ($\ngtr$66°C). Whenever the parboiled samples were extracted at or near the boiling point, the amylose content in parboiled samples remained lower than in raw flour. This was explained as a result of disruption effected in the intact structure of starch granules. Priestley's studies (1976, 1977) on parboiled rice have given a wider and an in-depth explanation in this regard. According to the above, steaming of presoaked paddy (H_2O 35%) results in the formation of an insoluble amylose complex which makes parboiled rice more resistant to solubilization. It was also established that the proportion of soluble amylose decreases with increasing severity of heat treatment (Priestley, 1977). Based on the above enlightening explanations, reduction in total and soluble amylose contents in parboiled cassava flour samples could be attributed to the associative forces in retrograded starch granules, and may also be partly due to complexation of amylose, thereby making it more resistant to cleavage.

Mineral matter

Although constituents other than starch are relatively low in cassava, their loss due to parboiling was found to be noticeably high. Further, the chief loss

TABLE 3

Pasting Characteristics of Cassava Flour (particle size 250 μm) (M-4 variety) at Different Slurry Concentrations

Sample	*Per cent slurry concentration*	*Pasting temperature*[a] *(°C)*	*Peak viscosity (P)*[a] *BU*	*Hot paste viscosity (H)*[a] *BU*	*Cold paste viscosity (C)*[a] *BU*	*Breakdown P-H*	*Setback C-P*	*Breakdown ratio H/P*	*Setback ratio C/P*
Plain-dried flour									
(i)	5·0	70·5	330	150	300	180	−30	0·454	0·909
(ii)	6·0	70·5	440	280	420	160	−20	0·636	0·954
(iii)	7·0	70·5	700	400	640	300	−60	0·571	0·914
(iv)	8·0	72·0	1 010	500	760	510	−510	0·495	0·752
Parboiled I (5 min)									
(i)	8·0	45·0	120	110	300	10	180	0·916	2·500
(ii)	9·0	43·5	170	140	530	30	360	0·823	3·117
Parboiled II (10 min)									
(i)	8·0	46·5	110	90	520	20	410	0·818	4·727
(ii)	9·0	42·0	180	120	520	60	340	0·606	2·888

[a] Mean value of three determinations: P, peak viscosity; H, hot paste viscosity; C, cold paste viscosity; BU, Brabender units.

of minor constituents occurred during the initial phase of parboiling, i.e. during soaking for 5 min. Thus, for example, loss of phosphorus reached up to 82% in PBI. In a similar way certain elements, viz. sodium and potassium, also showed reductions of 69% and 50%, respectively. Extension of parboiling time up to 10 min did not produce any further appreciable quantitative change. This obviously indicates that parboiling of deskinned fresh cassava slices disadvantageously leads to faster leaching of water-soluble constituents, due to direct heat transfer and consequent rupture of the cells.

Fat content and fatty acid composition

Total extractable fat in plain-dried cassava flour was at a level of 1·06%, of which the free fat that could be removed by extracting with a nonpolar solvent, viz. *n*-hexane, was 0·63%. The remaining portion could be extracted only by using a solvent system consisting of chloroform–methanol (2:1). It should, therefore, be presumed that a portion of total fat exists in bound form. Hudson and Ogunsua (1974) observed this and suggested that the bound lipids, mostly consisting of polar lipids, might exist as inclusion complexes with amylose. Hence, they are not so easily released when extracted with solvents such as petroleum ether or hexane.

Parboiling for 10 min (PB II) brought down the total fat by approximately 36%. However, the fatty acid profiles of PD and PB samples did not differ much, especially in their levels of the three major fatty acids, i.e. palmitic, oleic and linoleic (Table 2). Therefore, it is possible that heat penetration during parboiling caused cell rupture and facilitated leaching of intact fat. A similar heat-induced reduction, in potatoes, has been reported by Mondy and Mueller (1977), when tubers were baked in conventional as well as microwave ovens.

Among the total fatty acids identified, oleic and linoleic acids together accounted for 64–65%, suggesting the unsaturated nature of cassava fat. The fact that parboiling did not affect the fatty acid levels supports the idea of complex formation of fatty acids by amylose.

Pasting characteristics

Results of a comparative study on pasting properties of plain-dried and parboiled flour samples are presented in Table 3. Viscograph data of PD cassava flour showed a high peak viscosity (p) depending on the initial flour concentration (% w/v), followed by a sharp fall in the paste viscosity when the gel is held at 94°C for 30 min. This indicates faster swelling of the native cassava starch granules, but their inability to retain the swollen structure at cooking temperature (94°C) for a prolonged time (30 min). The PB sample, on the other hand, showed a low pasting temperature indicating a faster absorption of water, but it possessed a lower paste viscosity suggesting less swelling. The hot gel, however, did not evince any fall in viscosity, unlike the PD sample, and showed a relatively lower breakdown value (P-H) and higher breakdown ratio (H/P). A more or less similar pasting behaviour for parboiled rice flour has been reported (Ali & Bhattacharya, 1980; Unnikrishnan & Bhattacharya, 1981). In the case of parboiled cassava flour it might be anticipated that the higher resistance to swelling is due to associative forces of retrograded starch as inferred for parboiled rice (Priestley, 1977).

Thus the present studies have enabled us to explain the improved texture of PB cassava flour in terms of the changes occurring in its starch at granular levels, leading to modifications in their functional characteristics.

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