Effect of Heat-Moisture Treatment on Textural Characteristics of Cassava Flour

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ABSTRACT

Cereal Chem. 60(1):7–8

Modification studies were performed using cassava cultivar Malayan-4. After conditioning, plain and parboiled flours were subjected to open-pan roasting and pressure steaming. Viscosity and textural characteristics of the samples were then compared. Texture improved significantly only in the parboiled flour, which was open-pan roasted after the moisture level was adjusted to 28 ± 2%. A comparative study of plain and parboiled dry cassava cubes showed that compressive strength increased 10 times more in the parboiled cubes than in the plain cubes.

Cassava (*Manihot esculenta* Crantz) is a staple food in India that is usually consumed as tubers or fried wafers. Cassava flour differs from wheat and rice flour in that it becomes rubbery when it is steam-cooked, which limits its use in cereal-based products such as *chappathy* and *puttu*. The effect of heat-moisture treatment on physical properties of potato, wheat, and corn starches was studied by Sair (1964) and Kulp and Lorenz (1981). However, the effect of heat-moisture treatment on the textural and pasting characteristics of cassava flour has not been reported. This study was undertaken with a view to modifying cassava flour so that it may be used in place of wheat and rice flour in cereal-based products.

MATERIALS AND METHODS

Fresh cassava tubers of Malayan-4 (M-4) cultivar were processed into plain and parboiled chips of 9–10% and 7–8% moisture content, respectively. They were then made into flour in a pin-disk pulverizer (Emilia Abraham et al 1979).

Pressure Steaming

Cassava flour was moistened to 14 ± 2% and 28 ± 2% levels, packed in a cloth bag and then steamed in a pressure cooker for 20 min at 15 psi. The material was then dried at 55° C to a final moisture content of 7–8%.

Open-Pan Roasting

Cassava flour samples were conditioned by moistening to 28 ± 2% in a planetary mixer and roasted and stirred in an open pan for 10 min. During roasting, the material attained a maximum temperature of 100 ± 2° C. The moisture content of the fried samples was 1.2–2.6%.

Viscograph Studies

Pasting properties were determined with a Brabender viscoamylograph equipped with a 700-cmg sensitivity cartridge. Bowl speed was 75 rpm. The flour concentration in the slurry was maintained at optimum levels of 7 and 10% in the plain and parboiled samples, respectively. The temperature was raised 1.5° C per min to a maximum temperature of 95° C, allowed to remain for 20 min, and cooled to 50° C (Bhattacharya 1978).

Texturometer Studies

Texturometer studies were performed with a General Food Texturometer (Zonken Co. Ltd., Tokyo). Flour samples (20 g) were mixed with water (1:1) and hand-kneaded into a ball of dough and steamed in a cooker for 20 min. The instrument was set for 1-mm clearance and a current flow of 1 V. The readings of the first two successive "bites" with a V-shaped plunger were recorded as peaks in the chart. The height of the first peak represented the rubberiness of the cooked products. Cohesiveness ('C') of the cooked samples was calculated from the areas of the first and second peak as $C = A_2/A_1$, where A_1 and A_2 are the areas of the first and second peak, respectively.

Organoleptic Evaluation

The steam-cooked products were organoleptically evaluated for their stickiness by a panel of judges.

Compressive Strength Testing

The compressive strength was measured using an Instron Universal Testing machine. Fresh, peeled tubers were cut into uniform pieces and dried in a constant-temperature oven at 60° C to an average final moisture content of 9.6%. Another lot was parboiled by immersion in a boiling water bath for 5 min and subsequent drying. The dried pieces had an average height of 2 cm. The l/b (length–breadth) ratio in all the samples was maintained at 1.5. Studies were conducted at 55% and 25° C. Testing speed was 2 mm/min.

Reflectance Measurement

Percent reflectance at 580 nm was measured using a Carl Zeiss Jena Vsu 2-P spectrophotometer with magnesium oxide as the standard.

RESULTS AND DISCUSSION

The viscogram data in Table I show that paste consistency of untreated, plain cassava flour was highly unstable. Roasting of plain flour did not significantly affect the pasting characteristics under the experimental conditions. The effect of pressure steaming of cassava flour with 14 ± 2% moisture content was marginal. The only distinct effect was that with 28 ± 2% moisture flour, which had a slightly prolonged cooking time and higher paste stability (Fig. 1). Organoleptically pressure-steamed samples are unacceptable, however, because of browning. This is also confirmed by the relatively low reflectance value of pressure-steamed samples (Table I).

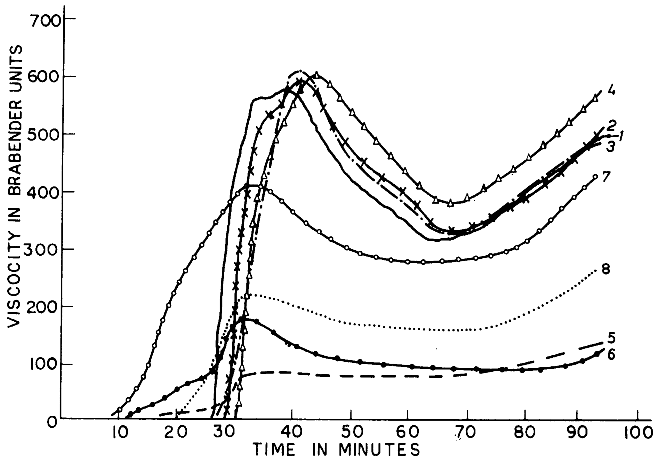
Parboiling of cassava marginally changed the pasting characteristics by reducing the pasting temperature and hot paste viscosity and by slightly increasing the paste stability (Table I). Subsequent treatment of parboiled flour under the experimental conditions by steaming or roasting increased paste stability and changed the set-back value to the positive side, normally observed in wheat (Medcalf and Gilles 1965). The marginal changes observed in the pasting characteristics of parboiled flour might be caused by partial gelatinization of starch. Further improvement in the pasting characteristics of the flour during subsequent heat treatment might be caused by dehydration and conversion of amorphous amylose to helical form, which can act as weak centers of crystallinity in stabilizing the starch granules during cooking (Banks and Greenwood 1975). The textural improvement thus attained was also confirmed by better organoleptic acceptability of the cooked products (Table I).

0009-0352/83/01000702/$03.00/0

TABLE I
Viscograph and Texturometer Data of Cassava Flour

Flour Sample[a]	Viscograph Data: Gelatinization Temperature (°C)	Peak Viscosity (BU)[b]	Hot Paste Viscosity (BU)	Cold Paste Viscosity at 50°C (BU)	Breakdown (BU)	Set-Back (BU)	Texturometer Data: Rubberiness (kg/V)	Cohesiveness (A_2/A_1)	Reflectance at 580 nm	Stickiness Score[c]
Plain	73.5	600	350	460	250	− 140	5.52	0.606	82.5	1.9
Plain, after open-pan roasting[d]	73.5	590	360	500	230	− 90	5.47	0.587	82.0	2.5
Plain, pressure-steamed[e]	70.5	580	330	480	250	− 100	4.08	0.588	69.5	3.6
Plain, pressure-steamed[f]	78.0	610	400	590	210	− 20	2.92	0.672	76.5	4.2
Parboiled	48.0	185	95	125	90	− 60	6.22	0.581	75.5	5.0
Parboiled, open-pan roasted[g]	46.5	410	280	460	130	+ 50	2.75	0.530	75.5	8.2
Parboiled, pressure-steamed[h]	63.0	220	160	280	60	+ 60	···	···	72.5	7.4

[a] Slurry concentration of 7 and 10% maintained for plain and parboiled samples, respectively.
[b] BU = Brabender units.
[c] Scoring scale of 1 to 10 = lowest to highest acceptability.
[d] Moisture-conditioned to 28%.
[e] Moisture-conditioned to 13%.
[f] Moisture-conditioned to 27%.
[g] Moisture-conditioned to 28%.
[h] Moisture-conditioned to 13%.



Viscoamylogram of Tapioca flour samples

Fig. 1. Viscoamylogram of tapioca flour samples. 1, plain Cassava flour; 2, plain Cassava flour, open-pan roasted after moisture conditioning to 28%; 3, plain Cassava flour, pressure-steamed after moisture conditioning to 13%; 4, plain Cassava flour, pressure-steamed after moisture conditioning to 27%; 5, parboiled Cassava flour, 7% slurry concentration; 6, parboiled Cassava flour, 10% slurry concentration; 7, parboiled Cassava flour, open-pan roasted after moisture conditioning to 28%; 8, parboiled Cassava flour, pressure-steamed after moisture conditioning to 13%.

Textural improvement achieved by heat-moisture treatment of plain and parboiled flour samples was also ascertained from texturometer studies. Pressure-steamed, plain flour, preadjusted to 28 ± 2% moisture content, had significantly low rubberiness but the maximum cohesiveness value among the samples. Parboiled flour had increased rubberiness that was signficantly reduced by subsequent heat treatment. A comparative study showed that compressive strength of parboiled cassava cubes increased nearly 10 times as much as that of plain cubes (Table II). This might be due to the partial gelatinization and subsequent hard setting of starch during drying.

TABLE II
Hardness of Plain and Parboiled Cassava

Sample Type	Total Samples Tested	Hardness Value (Newton/mm^2)	Number of Samples
Plain, dried	60	<1	2
		1–3	49
		>3	9
		<15	14
Parboiled, dried	54	15–25	30
		>25	10

Parboiling and subsequent roasting is the most effective method for upgrading the cooking characteristics of cassava flour.

ACKNOWLEDGMENTS

The authors thank K. R. Bhattacharya, Central Food Technological Research Institute, Mysore, for his valuable suggestions during the course of this study and Shri N. S. Mahendrakar of the same institute for his assistance rendered for texturometer studies.

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[Received October 16, 1981. Accepted March 8, 1982]