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COMPARATIVE RHEOLOGICAL PROPERTIES AND BREAD QUALITIES OF WHEAT FLOUR DILUTED WITH TROPICAL TUBER AND BREADFRUIT FLOURS

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ABSTRACT Cereal Chem. 55(1): 1-6

The effect of adding 10, 20, and 30% tropical tuber flour (yam, cocoyam, and cassava) and breadfruit flour to wheat flour was studied with the falling number apparatus, farinograph, extensograph, amylograph, and baking tests. Addition of the different percentages of yam, cocoyam, cassava, and breadfruit flours to wheat altered the rheological properties. The diastatic activity in terms of falling number, the water absorption, and the tolerance index of the farinogram increased with increasing amounts of nonwheat flours while dough development time and stability decreased. The dough area, extensibility, and the peak of the curve in the amylogram decreased significantly while the resistance and proportional number increased with increases in the nonwheat flour of the blends. However, the area under the curve of the 10% yam-flour blend and the extensibility of the 10% yam- and cocoyam-flour blends were higher than the corresponding values for 100% wheat flour at 45- and 90-min intervals. The 10% flour blends in all cases gave results comparable to the control and produced better quality bread than the 20 and 30% flour blends. Sources of the nonwheat flours and increased addition of these nonwheat flours to wheat flour significantly affected the proportional number ($P < 0.5$). The specific volume of the bread and the total acceptability score were also significantly different ($P < 0.5$). Loaves of bread from 100% wheat flour and 10% flour blends were very similar, whereas bread from 20% flour blend (excluding the 20% yam-flour blend) was definitely poorer than that of the 100% flour blend. The 30% flour blends were unsatisfactory. Generally, cocoyam-flour blends gave bread which scored the closest to bread made from 100% wheat flour.

In many parts of Africa, advancing national prosperity and urbanization coupled with a tremendous increase in population in recent years have led to an increase in the consumption of wheat-based products, especially bread. However, the production of wheat in African countries is alarmingly low and far below domestic consumption. Most African countries thus import tremendous quantities of wheat or flour. The worldwide inflation in commodity prices has resulted in considerable loss in foreign currency, which most African countries cannot sustain.

The recent development of composite flours for making bread and other products may help in providing new areas in which to use tropical raw materials and to reduce importation of wheat, thereby helping to conserve foreign exchange.

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Some useful information can be found in literature (1–5) concerning work done in other parts of the world on the production of bread and bread products from composite flours consisting of wheat and nonwheat flours. Comparable information on some tropical tubers and breadfruit is scarce or unavailable.

This paper reports the comparative rheological assessment and baking qualities of a commercial wheat flour diluted with 10, 20, and 30% tropical tuber and breadfruit flours.

MATERIALS AND METHODS

Wheat flour, sold under the trade name "Golden Penny" flour (GPF), was obtained from Flour Mills of Nigeria. Cocoyam, yam, and cassava tubers were bought in the local market. Breadfruit was obtained from a village near Lagos.

Preparation of Flours

The yam, cocoyam, breadfruit, and cassava were peeled, washed, sliced into small bits, dried in an air dryer at 65°C for 24 hr, and milled separately in an Apex Mill. The throughs of an 80-mesh wire were classified as flour.

Blends of 10, 20, and 30% each of the tuber and breadfruit flours were prepared with the wheat flour. Moisture and gluten contents were determined by methods Nr 110 and Nr 106, respectively, in ICC Standard methods (6). Falling numbers, farinograms, extensograms, and amylograms were also determined by AACC methods 56-81A, 54-21, 54-10, and 22-10, respectively (7).

Baking Test

Baking tests were performed using a standard-test baking procedure established at the Federal Institute of Industrial Research, Oshodi, Lagos, using the straight-dough method. The baking formula used was as follows:

Flour	100%
Yeast	1% of flour weight
Salt	2% of flour weight
Sugar	6% of flour weight
Fat	1% of flour weight
Water	As determined by the farinograph

The mixing time was 5 min for all the composite flours and 7 min for GPF. Dough was fermented for 3 hr at 30°C, scaled at 700 g, and proofed at 35°C under constant relative humidity (85%). Baking was at 204°C for 30 min and the loaf volumes were measured by millet displacement after cooling and used in the calculation of specific volume.

Bread quality was evaluated in terms of crust and crumb color, grain (cell structure), appearance (shape, size, break, and shred), texture (evenness of vesiculation), crumb stability (degree of hardness or softness when toughed with the finger), and taste. These parameters were judged by a panel of not less than eight members of the staff of the Federal Institute of Industrial Research, Oshodi, Lagos. Panel members were asked to give a score from zero to 40 for appearance, zero to 20 for crust and crumb color, and zero to ten for each of the other four parameters.

RESULTS AND DISCUSSION

The moisture and gluten contents, falling number and farinograph data of the composite flours are shown in Table I. The moisture content of the various flour blends ranged from 10.6 to 13.5%. The gluten content of 12.3% for the GPF was higher than that of the composite flours. There was a gradual decrease in gluten content as the percentage of wheat flour in the blends decreased. The nonwheat flours analyzed did not contain gluten.

The falling number values showed a progressive increase with increases in percentage of dilution. The 10% flour blends were similar to the control GPF. Kent-Jones and Amos (8) stated that flours with high falling number values stand the risk of diminished bread volume and dry bread crumb. Similar results were obtained in this study in that the 30% flour blends with high falling numbers resulted in decreased volume and dry bread crumb (Table II).

The results in Table I indicate that the addition of tuber and breadfruit flour decreased dough development time and dough stability. Hamed *et al.* (1) showed that, in addition to the fact that potato flour contains no gluten, it was more acidic than wheat flour. Watanabe *et al.* (9) stated that when the pH of flour decreased, development time decreased, causing the dough to weaken. These reasons and especially the reduction in gluten content might be responsible for decreased development time in the composite flours investigated in this study. The tolerance indices of the different composite flours were also affected. There were increases in the tolerance indices, especially at 30% flour blends. The first 20% addition has little effect on the tolerance indices.

TABLE I
Moisture, Gluten, Falling Number, Water Absorption, Dough Stability, Tolerance Index, and Development Time of Wheat and Composite Flours

Flour	Blend %	Moisture Content %	Gluten Content on Dry Basis %	Falling Number sec	Water Absorption min	Dough Stability min	Tolerance Index BU	Dough Development Time min
Control	...	14.0	12.3	443	57.9	12.5	20	8.5
Yam	10	11.6	11.2	474	58.9	8.0	30	6.5
	20	11.8	9.4	595	59.1	7.5	30	4.0
	30	11.0	8.4	750	59.3	6.5	35	4.0
Cocoyam	10	11.2	11.3	431	60.0	10.0	25	5.5
	20	11.3	9.4	455	60.2	10.0	30	5.5
	30	10.6	8.6	468	61.4	8.0	50	4.5
Cassava	10	12.6	11.2	439	59.8	9.0	25	4.5
	20	11.3	9.5	462	59.9	7.5	30	4.0
	30	10.9	8.5	474	60.6	7.5	65	3.5
Breadfruit	10	13.5	11.2	437	60.2	10.0	30	5.5
	20	11.9	9.4	548	60.7	9.0	30	5.0
	30	13.2	8.4	666	61.3	9.0	35	4.0

Slight increases in water absorption were observed in all the flour blends. Table III shows the effect of the different flour blends on area under the curve, extensibility, resistance to extension, proportional number, highest gelatinization temperature (temperature at peak viscosity), and peak viscosity (peak of curve).

Areas under the curves showed that the strength of the flour decreased with increase in the percentage of tubers. The 10% flour blends gave higher values than the 20 and 30% blends, respectively. The areas of the GPF were higher than the composite flour values with the exception of the 10% yam blend at the 45- and 90-min readings.

As the amount of the wheat flour decreased, the extensibility decreased, whereas the resistance to extension increased (Table III). The proportional numbers obtained by dividing resistance by the extensibility showed significant increases with increased nonwheat flour in the blends. The proportional numbers obtained for GPF were lower than those for the flour blends. The proportional numbers for cocoyam- and breadfruit-flour blends were lower than the other dilutions tested in this experiment and gave better bread as shown by the total acceptability score (Table II).

The differences in the temperature at maximum gelatinization for all the flours vary and the values obtained for peak heights (Table III) results differed significantly ($P < 0.5$). The trend was an increase in peak heights with increased nonwheat flour in the blends.

Replacing wheat flour with nonwheat flour affects the specific volume and the six parameters considered under the organoleptic tests (Table II). The specific

TABLE II
Effect of Adding Yam, Cocoyam, Cassava, and Breadfruit Flours to Wheat Flour on the Baking Test

Bread	Blend	sp vol	Appearance	Crust and Crumb Color	Texture	Grain	Crumb Feel	Taste	Total Acceptability Score[a]
Control	...	3.9	40	20	10	10	10	10	100
Yam	10	3.6	34	15	8	10	8	6	81
	20	3.4	24	8	6	8	7	3	56
	30	2.7	12	5	4	6	5	2	34
Cocoyam	10	3.7	38	18	9	9	9	9	92
	20	3.5	29	14	8	8	8	7	74
	30	2.9	23	12	5	5	6	5	56
Cassava	10	3.5	35	16	8	10	9	8	86
	20	3.3	26	12	6	8	7	6	65
	30	2.6	12	8	4	6	5	3	38
Breadfruit	10	3.5	37	18	9	8	9	9	89
	20	3.2	28	13	7	7	5	5	65
	30	2.3	18	9	4	5	4	4	44

[a]81–100 = Acceptable; 65–74 = slightly acceptable; and 56 and below = not acceptable.

TABLE III
Dough Area, Extensibility, Resistance, Proportional Number, Highest Gelatinization Temperature, and Peak of Amylogram Curve of Wheat, Yam, and Cocoyam Flour Blends

	Blend	Time	Area Under the Curve cm^2	Extensibility mm	Resistance BU	Proportional Number	Highest Gelatinization Temperature °C	Peak of Curve Viscosity AU
Control	...	45	140	148	520	3.5	...	...
	...	90	147	139	650	3.7	85	390
	...	135	161	135	700	5.2		
Yam	10	45	162	140	650	4.6		
	10	90	176	144	780	5.4	84	470
	10	135	128	115	740	6.4		
	20	45	126	109	765	7.0		
	20	90	133	100	920	9.2	86	540
	20	135	105	103	760	7.4		
	30	45	96	78	955	12.2		
	30	90	102	79	1040	13.2	86	640
	30	135	87	77	895	11.6		
Cocoyam	10	45	136	148	520	3.5		
	10	90	135	142	585	4.1	84	400
	10	135	133	126	665	5.3		
	20	45	136	142	560	3.9		
	20	90	133	119	730	6.1	84	520
	20	135	129	110	820	7.5		
	30	45	104	135	585	4.3		
	30	90	109	115	640	5.6	84	520
	30	135	93	104	630	6.1		
Cassava	10	45	120	130	520	4.0		
	10	90	131	124	690	5.6	84	510
	10	135	117	112	760	6.8		
	20	45	105	97	750	7.7		
	20	90	96	83	930	11.2	85	680
	20	135	94	86	890	10.3		
	30	45	77	78	730	9.4		
	30	90	78	75	880	11.7	86	1000
	30	135	64	65	805	12.4		
Breadfruit	10	45	132	145	550	3.8		
	10	90	137	135	640	4.7	85	390
	10	135	115	112	655	5.8		
	20	45	122	126	550	4.4		
	20	90	103	115	630	5.5	84	530
	20	135	89	108	680	6.3		
	30	45	103	117	590	5.0		
	30	90	90	97	650	6.7	84	630
	30	135	75	97	695	7.2		

volume and organoleptic characteristics of the bread decreased with increased nonwheat flour in the flour blends. Similar results with other nonwheat flour blends have also been reported (1,3). During proofing it was observed that doughs with 30% nonwheat flour behaved abnormally. The gluten strands did not have enough strength and elasticity to withstand the sudden extra production and expansion of gas; consequently, the loaves collapsed and adversely affected their crust appearance and volume. These effects were slightly observable in the 20% flour blends. The panel unanimously indicated that the bread made from 100% wheat flour and 10% flour blends gave very good bread and scored between 81 and 100%. The 10% cocoyam-flour blend with a total score of 92 was closest to the 100% wheat bread. The 20% flour blends also gave acceptable bread, except the 20% yam-flour blend which, like the 30% flour blends, was unacceptable. The crumb of the 20% yam-flour-blend breads was black and had a slight off-flavor, a characteristic of the nonwheat flour source used, which was similar to the other 20% blends. It is worthy to note that, in all the 30% blends, the characteristic odor of the individual nonwheat flour source was dominant and contributed greatly to the unacceptability of the bread. The 10% dilution values were nearest the value for the GPF and gave better bread than the other flour blends. Cocoyam and breadfruit flours gave comparable values to GPF.

The results of this study have indicated that wheat flour could be diluted with tropical tuber and breadfruit flour to the level of 10% without a great change in the rheological dough properties and bread quality. Kim and de Ruiter (3) have shown that it was possible to increase the level of nonwheat flour (cassava and corn flour) above 10% provided certain bread improvers are used.

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