Effect of Adding Sweet Potato Flour to Wheat Flour on Physical Dough Properties and Baking

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ABSTRACT

From two hybrids of sweet potato, flours were prepared without sulfite treatment, with sulfite treatment, and with sulfite plus ascorbic acid. The effects of adding increments of sweet potato flours to wheat flour (0, 10, 15, 20, 25, and 30 parts per 100 parts) were studied by farinograph, alveograph, and baking tests. Farinograph results showed that additions of all sweet potato flours increased absorption, weakened the dough, and decreased dough development, dough stability, and valorimeter index. Effects on dough strength, absorption, and valorimeter index were increased with sulfite-treated samples but not with those treated with sulfite plus ascorbic acid. Addition of sweet potato flour to wheat flour caused a decrease in extensibility of the dough and an increase in the proportional number. However, addition of non-SO_2-treated sweet potato flour to wheat flour had a lower deleterious effect on the physical properties of the dough than did the SO_2-treated flour. Addition of 0.1% ascorbic acid to mixtures of SO_2-treated sweet potato and wheat flours lessened the deleterious effect on the physical properties of the dough from those mixtures. An increase in the weight of white bread and a decrease in its volume were generally noticed when sweet potato flour was added to wheat flour. Addition of non-SO_2-treated sweet potato flour to wheat flour (extraction 72%) decreased the acceptability of bread more than did SO_2-treated or SO_2-treated plus 0.1% ascorbic acid sweet potato flours. Addition of 10 parts of SO_2-treated sweet potato flour to 100 parts of wheat flour (extraction 93.3%) in "Balady" bread caused an increase in the acceptability of bread, and also increased the yield of loaves nearly 5%. The addition of 10 to 15 parts of sweet potato flour to 100 parts of high extraction wheat flour, i.e., 93.3%, can be recommended for "Balady" breadmaking.

Plaut and Zelzbuch (1) reported that bread baked with 6% sweet potato flour had, on the average, 15% greater volume than did regular bread, and both were similar in taste and appearance. Flour from pressed sweet potato was equally satisfactory. Sweet potato flour prepared after processing starch from sweet potatoes, however, had a slight influence on bread quality. Volume decreased, crumb became gray, and the dough became brittle. Plaut and Zelzbuch found cakes and biscuits baked with flour containing up to 10% sweet potato flour did not differ in quality, taste, smell, or nutritive value from products baked without such additions.

This investigation was undertaken to study the effect of adding sweet potato flour to wheat flour on some physical properties of the dough as well as on the characteristics of bread prepared therefrom. The object was to find the miximum proportion which could be used without lowering bread quality below an acceptable level.

MATERIALS AND METHODS

Materials

The sweet potato varieties and the procedures for preparing flour from them have been described (2). Two preparations of flour were made: one from

untreated sliced sweet potatoes, the other from slices treated with 0.5% sodium metabisulfite for 2 min. prior to dehydration and milling. This flour contained 419 p.p.m. sulfur dioxide (SO_2). To study its effect as an oxidizing agent, 0.1% ascorbic acid was added to part of the flour from treated sweet potatoes. Ten, 15, 25, and 30 parts of well-mixed sweet potato flour were added to 100 parts flour (extraction 72%, protein 12.16%, and ash 0.49%) imported from the U.S. by the Ministry of Supply of the U.A.R., and to flour of 93.3% extraction milled in Egypt. Each mixture was blended on a uniform solids basis and kept in a closed glass container.

Methods

The farinograph (constant flour procedure) and Pekar color tests were performed according to AACC procedures (3). The alveograph test was carried out as described by Kent-Jones and Amos (4). The baking test was applied according to the AACC (3), but absorption was varied according to the degree of dilution of wheat flour with sweet potato flour.

"Balady" bread, the kind generally preferred in the U.A.R., was also baked. Its ingredients are: 100 kg. flour, 70 to 80 liters water, 0.5 to 1.5 kg. salt, and 12 to 17 kg. starter, which consists of fermented dough. Fermentation is brought about by the activity of wild bacteria and yeast.

These ingredients are mixed for 20 to 30 min. with a mechanical dough mixer. Then the dough is transferred to the dough bowl and left for 30 to 50 min. After that the dough is cut into small portions (about 145 g.), arranged on wooden boards previously sprinkled with a thin layer of fine bran, and left to ferment for 30 to 60 min. The dough is flattened by hand, left for half an hour, and then baked at 350°C. for 2 to 3 min. The moisture content of the resulting bread does not exceed 40%.

Evaluation of Bread Quality

Preference was evaluated in terms of crust and crumb color, taste, and appearance (grain, texture, and symmetry). These attributes were judged subjectively by a panel of ten from the staff of the Food Technology Research Section, National Research Centre. Panel members were asked to give a score from zero to ten for each of the three attributes. Thus the maximum possible score was 30.0; only loaves given scores of 25 or higher were considered acceptable.

RESULTS

Farinograph Tests

Results in Table I indicate that for all prior treatments, addition of sweet potato flour increased absorption; weakened the dough; and decreased dough development time, dough stability, and valorimeter index. Analysis of variance showed these effects to be statistically significant ($P<0.05$). Although trends with increasing concentration were evident over the range of levels tested, differences between levels were generally small and not significant.

The effects on dough strength and valorimeter index were increased by treatment with sulfite alone but not by treatment with sulfite plus ascorbic acid.

Hybrid 266 produced slightly greater absorption values than did hybrid 65.

TABLE I. EFFECT OF ADDING SWEET POTATO FLOUR TO WHEAT FLOUR ON DOUGH PROPERTIES MEASURED IN THE FARINOGRAPH

Parts of Sweet Potato Flour Added to 100 Parts of Wheat Flour	Hybrid 65			Hybrid 266		
	Non-SO_2-treated	SO_2-treated	SO_2-treated + 0.1% ascorbic acid	Non-SO_2-treated	SO_2-treated	SO_2-treated + 0.1% ascorbic acid
			Mixing Tolerance[a]			
0	40	40	40	40	40	40
10	90	100	100	90	100	90
15	90	140	130	90	120	110
20	110	150	130	110	120	110
25	110	160	130	100	180	110
30	110	160	120	90	160	130
			Dough Development (in min.)			
0	2.0	2.0	2.0	2.0	2.0	2.0
10	1.5	1.5	1.5	1.3	1.3	1.5
15	1.5	2.0	1.8	1.5	1.3	1.3
20	1.5	1.8	1.8	1.0	1.5	1.8
25	1.3	1.3	1.5	1.3	1.8	1.8
30	2.3	1.5	1.8	1.5	1.8	1.5
			Absorption (%)			
0	59.3	59.3	59.3	59.3	59.3	59.3
10	61.5	60.7	60.8	61.1	60.4	60.5
15	61.0	60.7	60.7	61.5	61.4	60.9
20	61.3	60.8	60.6	61.6	61.6	61.2
25	61.2	61.2	60.8	62.4	61.8	61.4
30	61.3	61.4	61.0	62.5	62.4	61.5
			Dough Stability (in min.)			
0	3.0	3.0	3.0	3.0	3.0	3.0
10	0.8	1.0	0.8	1.0	0.8	0.8
15	1.3	0.8	0.8	0.8	1.0	1.0
20	0.8	1.0	1.0	1.0	0.8	1.3
25	1.3	0.5	0.8	1.3	1.0	1.0
30	2.0	0.8	1.3	1.0	1.3	1.8
			Valorimeter Index			
0	62	62	62	62	62	62
10	43	43	45	42	42	45
15	46	41	41	44	40	42
20	41	38	42	43	40	46
25	41	36	40	43	36	44
30	50	35	44	43	42	45

[a]Brabender units from leaving 500-Brabender line to middle of curve after 12 min.

Alveograph Tests

Results in Table II indicate that the addition of sweet potato flours to all treatments significantly decreased dough strength and extensibility but increased the proportional number. The effect on resistance depended on prior treatment. Resistance increased with untreated products and with samples treated with

sulfite plus ascorbic acid, but sharply decreased with those treated with sulfite alone.

Reduction in dough strength was enhanced by sulfite-treated flours but the effect was somewhat less in samples treated with sulfite plus ascorbic acid. While sulfite alone did not reduce extensibility, sulfite plus ascorbic acid did.

Pekar Color Test

When the colors of the mixtures from SO_2-treated sweet potato flour and wheat flour were compared with wheat flour alone using the Pekar color test, only slight differences were observed.

Effect of Adding Sweet Potato Flour to Wheat Flour on the Quality of White Bread

The AACC baking test (3) was conducted with flour of 72% extraction imported from the U.S. A study was made of the effect of sweet potato flour on volume, weight, and acceptability of the bread. Results are given in Table III.

TABLE II. EFFECT OF ADDING SWEET POTATO FLOUR TO WHEAT FLOUR ON THE ALVEOGRAPH TEST

Parts of Sweet Potato Flour Added to 100 Parts of Wheat Flour	Hybrid 65			Hybrid 266		
	Non-SO_2 treated	SO_2-treated	SO_2-treated + 0.1% ascorbic acid	Non-SO_2-treated	SO_2-treated	SO_2-treated + 0.1% ascorbic acid
			Strength of Dough (in $cm.^2$)			
0	45	45	45	45	45	45
10	38	15	24	38	22	23
15	36	15	26	34	18	23
20	36	14	32	33	20	28
25	27	18	20	31	16	21
30	32	12	19	27	13	26
			Extensibility of Dough (in mm.)			
0	88	88	88	88	88	88
10	54	73	39	44	66	45
15	39	41	43	46	65	49
20	35	42	41	53	78	39
25	55	51	33	44	46	36
30	42	40	29	35	30	31
			Proportional Number			
0	1.0	1.0	1.0	1.0	1.0	1.0
10	2.2	0.7	3.3	3.0	1.0	1.9
15	3.8	1.8	2.2	2.4	0.8	1.6
20	2.2	1.7	2.9	2.9	0.9	2.8
25	1.7	1.3	2.7	2.5	1.7	3.0
30	3.1	1.6	3.6	3.5	2.6	3.5
			Resistance of Dough (in mm.)			
0	98	98	98	98	98	98
10	117	53	126	130	69	85
15	146	74	96	121	49	79
20	149	70	119	112	68	110
25	94	68	92	112	78	110
30	128	64	105	122	77	107

Volume of Bread

The statistical analysis at 0.05 probability level of the results shown in Table III revealed that no significant decrease in the volume of bread appeared when 10 and 15 parts of sweet potato flour were added to 100 parts of wheat flour. Among the higher addition levels the differences in the volume of bread were not significant.

The addition of sweet potato flour treated with SO_2 or treated with SO_2 plus 0.1% ascorbic acid or nontreated did not show significant differences. Between the two hybrids no significant differences were observed.

Weight of Bread

Addition of sweet potato flour caused a significant increase in the weight of bread. This was to be expected from the increase in absorption observed in the farinograph test. On the other hand, the weight of bread when 10 parts of sweet potato flour were added was significantly lower than that from other levels. Differences in weight of bread from the other mixtures were not significant. No significant difference was caused by the treatment given the sweet potato flour nor by the use of flour from the two hybrids.

TABLE III. EFFECT OF ADDING SWEET POTATO FLOUR TO WHEAT FLOUR ON THE BAKING TEST

Parts of Sweet Potato Flour Added to 100 Parts of Wheat Flour	Hybrid 65			Hybrid 266		
	Non-SO_2-treated	SO_2-treated	SO_2-treated + 0.1% ascorbic acid	Non-SO_2-treated	SO_2-treated	SO_2-treated + 0.1% ascorbic acid
			Volume of Bread (cm.^{3})			
0	380	380	380	380	380	380
10	375	385	375	350	390	365
15	350	380	360	345	375	360
20	350	350	310	310	310	365
25	345	310	310	295	295	350
30	350	300	305	295	285	345
			Weight of Bread (in g.)			
0	136	136	136	136	136	136
10	144	139	139	139	141	139
15	144	142	142	142	145	145
20	145	143	144	144	143	146
25	149	144	143	143	141	148
30	145	144	142	142	145	147
			Acceptability of Bread			
0	30	30	30	30	30	30
10	14	28	28	18	28	28
15	13	21	25	14	27	24
20	11	21	24	9	18	21
25	7	15	19	8	14	21
30	6	13	18	7	14	21

Acceptability of Bread

Addition of sweet potato flour generally resulted in a significant decrease in the acceptability of the resulting white bread as shown in Table III. Moreover, the variations between the individual addition levels were mostly significant.

Bread from the mixtures with sweet potato flour treated with SO_2 plus 0.1% ascorbic acid had the highest acceptability while that from the nontreated mixtures had the lowest. The differences in acceptability scores were significant between the mixtures from the SO_2 and SO_2 plus ascorbic acid treatments. Between the two hybrids the difference was not significant.

Effect of Adding Sweet Potato Flour to Wheat Flour on the Palatability of "Balady" Bread

Two experiments were carried out to study the effect of adding sweet potato flour to wheat flour on the organoleptic characteristics of "Balady" bread.

In the first experiment 10 and 15 parts of SO_2-treated sweet potato flour (hybrid 65) were added to 100 parts of wheat flour of 72% extraction, then baked by a professional baker.

In the second trial 10 parts of SO_2-treated sweet potato flour from hybrids 65 and 266 were separately mixed with 100 parts of wheat flour (flour extraction 93.3%) and baked in the same manner.

Addition of sweet potato flour to wheat flour increased the yield of loaves by approximately 5%. Moreover, the test panel judged bread from the mixtures of sweet potato and wheat flours to have improved taste, appearance, and crumb color, especially when the high extraction flour (93.3%) was used. The scores were 20.6, 23.3, and 24.7 for bread from wheat flour (72% extraction), wheat flour plus 10 parts sweet potato flour, and wheat flour plus 15 parts sweet potato flour, respectively. When the local milled flour (extraction 93.3%) was used, the scores were 19.3, 23.5, and 23.6 for bread prepared from wheat flour, wheat flour plus 10 parts sweet potato flour hybrid 266, and wheat flour plus 10 parts sweet potato flour hybrid 65.

DISCUSSION

As expected, sweet potato flour had an adverse effect on most dough properties measured in the farinograph and alveograph (Tables I and II) although absorption increased. In addition to the fact that it has no gluten, sweet potato flour is somewhat more acid than wheat flour (2). Watanabe and Uemura (5) showed that when pH of flour decreased, development time, valorimeter index, and width of farinograms decreased while dough weakening increased.

The adverse effects of sulfite on dough were reported by Hlynka (6), Prentice et al. (7), and Bennett and Coppock (8). More recently the mechanism of the reaction between sulfite and proteins has been elucidated by Swan (9) and Kolthoff et al. (10). Thus the large adverse effect of bisulfite-treated sweet potato flour is not surprising. It is encouraging to find that 0.1% ascorbic acid at least partly reversed these adverse effects in agreement with the findings of Melville and Shattuck (11), who reported its value as an oxidant in dough.

The effect of sweet potato flour in decreasing the volume of bread made by the AACC procedure (Table III) was not great until the proportion exceeded 15 parts per 100 parts of wheat flour. It is interesting that up to that same proportion it gave bread with high acceptability scores when the sweet potato flour was treated with sulfite or sulfite plus ascorbic acid. Bread with untreated

sweet potato flour had low acceptability when only 10 parts were used per 100 of wheat flour.

In "Balady" bread an alveograph proportional number no lower than 0.7 is required. The wheat flour used in these studies had a proportional number of 1.0. Table III shows that the sweet potato flour did not reduce the proportional number. It can therefore be recommended in making "Balady" bread.

Sweet potatoes thrive best on sandy loam but can be grown on a wide range of soils. They are adapted to regions having a growing period of at least 4 months, warm days and nights, plenty of sunshine, and moderate rainfall. For countries having these conditions and a shortage of wheat, addition of sweet potato flour to wheat flour for breadmaking will decrease the amount of wheat imported and will be of economic advantage.

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