Cereal Chemistry

Vol. 50 March-April 1973 No. 2

Preparation and Chemical Composition of Sweet Potato Flour

M. G. E. HAMED, M. F. HUSSEIN, F. Y. REFAI, and S. K. EL-SAMAHY, Food Technology Division, National Research Centre, Cairo, Egypt

ABSTRACT

A study was made to determine a method of preparing sweet potato flour suitable for use as an extender of wheat flour in breadmaking. Flours from peeled and unpeeled sweet potatoes were equivalent in yield and color, but flour from the latter was higher in ash and crude fiber. Treatments with sodium metabisulfite, sodium chloride, and citric acid were compared for the prevention of discoloration during processing. Soaking sliced tubers in 0.5% sodium metabisulfite solution for 2 min. was judged to be the most suitable method. The sulfite content of treated flour gradually decreased during storage. Analyses indicated that total carbohydrates, ash, crude fiber, sugars, total acidity, and amylolytic activity were higher while crude protein was lower in sweet potato flour than in wheat flour. Qualitative paper chromatography of hydrolyzed sweet potato protein showed the presence of lysine, histidine, alanine, glycine, proline, glutamic acid, serine, aspartic acid, leucine, isoleucine, cysteine, arginine, valine, and tryptophan. The amylose contents of starch from two sweet potato hybrids were 16.1 and 13.5%, respectively.

The present work was carried out to study the preparation and chemical composition of sweet potato flour which can be added to wheat flour in breadmaking.

This would be important in countries which lack wheat and must import large quantities of it or wheat flour. The effect of sweet potato flour on dough properties and baking quality is reported separately (1).

Discoloration of sweet potato flour must be prevented for use in white bread. Watanabe et al. (2) reported that white flour from sweet potatoes could be prepared on a laboratory scale by soaking 1 part of sliced sweet potato for 20 hr. in 1.5 parts of 0.2% sulfuric acid solution and then dehydrating by compression. The sulfur dioxide (SO_2) content of sweet potato flour was 140 p.p.m. On the other hand, the flour processed on a factory scale by this method contained 83 p.p.m. SO_2. Legault et al. (3) found that sulfite increased by 1.9 to 5.1 times the length of time required to attain a given degree of browning. Talburt and Smith (4) reported similar results and found that the protection decreased with an increase in content of reducing sugars.

MATERIALS AND METHODS

Materials

Two hybrids of starchy sweet potatoes, namely 65 and 266, selected and grown by the Vegetable Research Department of the Ministry of Agriculture (U.A.R.), were used for the preparation of flour. Wheat flour used was from U.S. flour imported by the Ministry of Supply of the U.A.R. (flour extraction 72%).

Methods

Sweet potato flour was prepared as follows:

Washed sweet potatoes were placed in a wire-mesh basket and immersed in water at 80° to 85°C. for 10 to 15 min. preparatory to lye peeling.

The preheated roots were immediately submerged in 20 to 22% sodium hydroxide solution at 104°C. for 3 to 6 min. The loosened peel and lye were washed away by strong jets of cold water. The roots were then hand trimmed, cut lengthwise, soaked in citric acid solution, and cut to 1.9-mm. slices with a conventional food slicing machine.

To prevent discoloration of sliced sweet potatoes during dehydration and subsequent storage, the following treatments were compared:

(a) Soaking in 0.5, 1.0, 2.0, and 3.0% sodium metabisulfite solution, each for 1, 2, 3, 4, and 5 min.;

(b) soaking in 7% sodium chloride (NaCl) solution for 1, 2, 3, and 4 min.;

(c) soaking in 2% citric acid solution for 2 and 3 min.;

(d) adding of 7% dried NaCl to the prepared and ground tubers;

(e) adding of 6% dried NaCl and 0.25% citric acid to the ground tubers; and

(f) adding of 0.01% dry sodium metabisulfite to the ground tubers.

The prepared tubers were promptly dried in an air oven provided with a motor fan at 60 ± 2°C. for 10 to 12 hr. The dehydrated flakes were milled using a laboratory disc mill, then sieved on an 8xx sieve.

Chemical Determinations

Moisture, ash, crude fat (ether extract), crude fiber, total crude protein, starch, pH, reducing and nonreducing sugars, and diastatic activity were determined as given in AOAC methods (5), and total SO_2 was determined according to Pearson (6).

Total reducing substances were determined as described in AACC procedures (7), and total titratable acidity by Schulerud's (8) method.

Amylose and amylopectin were determined by the method of El-Hadidy (9) using n-butanol and methanol for the separation.

Amino acids in sweet potato protein were identified by paper chromatography by the method of Rizk (10), summarized as follows:

The protein was hydrolyzed by 6N hydrochloric acid and by barium hydroxide at 118°C. for 24 hr. The hydrolysates were taken up in 10% isopropanol. Two systems of solvents were used for developing the chromatograms. The first system was a mixture of n-butanol:acetic acid:water in the ratio of 4:1:5 v./v., while the second was a mixture of methyl ethyl ketone:pyridine:water in the ratio of 35:7.5:7.5. The chromatograms were developed for 14 hr. The amino acids were detected by spraying with ninhydrin reagent. For detecting tryptophan, Ehrlich's reagent was used.

RESULTS AND DISCUSSION

Preparation of Sweet Potato Tubers for Dehydration

To obtain sweet potato flour which can be successfully used as a substitute for wheat flour in breadmaking, different treatments to prevent discoloration of sweet potato during dehydration were compared.

Addition of 7% dried NaCl, 6% dried NaCl plus 0.25% citric acid, and 0.01% dry sodium metabisulfite to the ground tubers failed to produce a dehydrated product sufficiently light in color. The same was observed when the sliced tubers were soaked in 7% NaCl solution for 1, 2, 3, and 4 min. Shrinkage of the slices took place owing to plasmolysis when they were soaked for 4 min. in the salt solution.

When using 2% citric acid solution for soaking, the final dehydrated product had a red-yellowish tint. This was due to the caramelization of sugars which was accelerated by the citric acid.

The lightest colored product was obtained by soaking sliced tubers in sodium metabisulfite solutions. Treatment for 1 min. with 0.5% metabisulfite was judged to be inadequate but all other combinations of concentration and treatment time gave satisfactory color. Since it is well established that SO_2 has a deleterious effect on the physical characteristics of the dough, the treatment of soaking the sliced tubers in 0.5% sodium metabisulfite solution for 2 min. was chosen. The resulting flour from this treatment contained 419 p.p.m. SO_2 and possessed a suitable bright color.

Dehydration of Sweet Potato with and without Peeling

Peeling sweet potato tubers represents a serious economic problem in the preparation of sweet potatoes for dehydration. Hence a study was made of the possibility of preparing sweet potato flour satisfactory for breadmaking from unpeeled tubers.

To achieve this, 6 kg. of the tubers was divided into two portions. The first portion was dehydrated after washing, peeling, dipping in 0.5% citric acid to prevent discoloration, slicing, and soaking in 0.5% sodium metabisulfite solution for 2 min. For the second the same steps were carried out except peeling.

The dehydration ratio (ratio of the weight of wet material entering the dryer to weight of the material as it leaves the dryer) was 4.7:1 for peeled and 4.1:1 for unpeeled tubers. After milling two times and sieving on an 8xx sieve, the yield ratio of the flour reached 14.7% for unpeeled and 14.0% for peeled sweet potato tubers. The difference in color between samples prepared from peeled and unpeeled tubers was not distinct. Ash and fiber contents of the latter flour were higher than those of the former as shown in Table I.

Changes which Occur in the Moisture and Total SO_2 Contents of Sweet Potato Flour during Storage

Two experiments were carried out to study the changes which occur in the moisture and total SO_2 content during storage of sweet potato flour packed in cloth sacks and kept at room temperature. In the first trial a sample of sweet potato flour containing 1,004 p.p.m. SO_2 and 6.5% moisture was used; in the second the SO_2 content was 823 p.p.m. and the moisture content was 5.1%. The prevailing atmospheric temperature and relative humidity were 28.7°C. and 61.3% in the first, and 21.4°C. and 63.6% in the second trial.

The results given in Table II showed that the moisture content of the samples

TABLE I. EFFECT OF PEELING ON ASH AND CRUDE FIBER CONTENTS OF SWEET POTATO FLOUR AND RESIDUE
(Calculated on dry weight basis)

		Samples from Peeled Tubers		Samples from Unpeeled Tubers	
Content	Type	Flour %	Residue on the sieve %	Flour %	Residue on the sieve %
Ash		3.32	5.34	3.74	4.21
Crude fiber		2.95	5.57	4.01	7.17

TABLE II. CHANGES IN THE MOISTURE AND TOTAL SO_2 CONTENTS OF SWEET POTATO FLOUR DURING STORAGE

Storage Period days	Moisture Content %	SO_2[a] p.p.m.	Loss of SO_2 %	Storage Period days	Moisture Content %	SO_2 p.p.m.	Loss of SO_2 %
		First Trial			Second Trial		
Start	6.5	1,004	...	Start	5.1	823	...
3	7.7	878	12.53	3	6.7	791	3.89
6	8.3	863	14.04	6	7.2	805	2.19
9	8.3	754	24.90	9	8.1	790	4.01
12	8.6	767	23.61	12	8.4	728	11.56
15	8.5	680	32.27	15	8.8	729	11.42
18	8.8	702	30.08	22	8.5	704	14.46
21	8.5	663	33.96	29	8.4	678	17.62
24	8.3	646	35.65	36	8.3	625	24.06
31	8.2	637	35.66				
38	8.7	576	42.63				
45	8.2	446	55.58				
52	8.5	395	60.66				
59	8.1	388	61.35				
66	8.5	410	59.16				
73	8.8	406	59.56				

[a]Calculated on dry weight basis.

increased and the SO_2 content decreased as the storage period progressed. These results are similar to those obtained by Watanabe et al. (11) and Burton (12), who stated that the darkening in color of stored potato flour was accelerated by increase in humidity and temperature. The percentage loss of SO_2 during storage was 42.6 after 38 days in the first trial, and 24.1 after 36 days in the second trial as shown in Table II. This may be attributable to the low atmospheric temperature prevailing during the storage period of the second trial.

As the storage period proceeded, the flour became clumpy and slightly darkened in color. These observations were similar to those of Burton (12).

Chemical Composition of Dehydrated Sweet Potato Flour Compared with Wheat Flour

The experimental results recorded in Table III revealed that the protein content of sweet potato was markedly lower than that of wheat, ranging from 2.3 to 3.0%

(N X 5.7) in sweet potato flour and 12.2% (N X 5.7) in wheat flour (72% extraction). On the other hand, the total carbohydrate content of sweet potato flour was higher than that of wheat flour, i.e., 93.3 to 94.1% and 86.1%, respectively. The fat content ranged from 0.77 to 0.81% in sweet potato flour and was 1.21% in wheat flour. The ash and crude fiber contents were higher for sweet potato flour than for wheat flour.

Reducing and nonreducing sugars were lower in wheat flour than in sweet potato flour. Starch content of sweet potato flour was lower (66.7 to 70.7%) than that of wheat flour (82.4%).

The total reducing substances reached 73.2 and 47.7 mg. iodine per 100 g. flour in the sweet potato flour treated with SO_2 in hybrids 65 and 266, respectively. The wheat flour used in this study was free from reducing substances.

SO_2 content of the sweet potato flour treated with sodium metabisulfite was 460 p.p.m. in hybrid 65 and 408 p.p.m. in hybrid 266.

Titratable acidity and hydrogen ion concentration were generally higher in sweet potato flour than in wheat flour, as the result of soaking the sweet potato slices in citric acid solution to prevent discoloration before dehydration. Furthermore, the acidity of the SO_2-treated sample was higher than the non-SO_2-treated sample.

From the same table it can be noticed that the diastatic activity was lower in wheat flour than in sweet potato flour. This agrees with the results of Gore (13).

Amylose and Amylopectin in Starch Prepared from Sweet Potato Tubers

Noznick et al. (14) showed that starch which contains a high percentage of amylopectin increases the absorption of flour. Since the amylopectin content of the

TABLE III. CHEMICAL COMPOSITION OF WHEAT AND SWEET POTATO FLOURS

Contents (calculated on dry basis)	Wheat Flour	Hybrid 65		Hybrid 266	
		Treated with SO_2	Untreated	Treated with SO_2	Untreated
Crude protein (N X 5.7), %	12.2	2.8	2.3	2.5	3.0
Total carbohydrate, %	86.1	86.1	94.1	94.0	93.3
Ether extract, %	1.21	0.77	0.81	0.71	0.78
Ash, %	0.49	2.81	2.79	2.81	2.94
Crude fiber, %	0.31	2.83	2.85	2.97	3.90
Starch, %	82.4	70.7	70.6	69.1	66.7
Reducing sugars, %	0.03	4.79	3.80	10.35	7.75
Non reducing sugars, %	1.56	6.43	6.53	4.89	5.77
Total reducing substances[a]	0.0	73.2	0.0	47.7	0.0
Diastatic power[b]	211	380	393	371	338
Total SO_2, p.p.m.	...	460	...	408	...
Total titratable acidity[c]	1.36	5.87	3.51	6.76	3.38
pH	6.09	5.26	5.79	5.24	5.85

[a]Total reducing substances = mg. iodine per 100 g. flour.

[b]Diastatic power = mg. maltose per 10 g. flour.

[c]Total titratable acidity = ml. of N per 10 NaOH per 10 g. flour.

sweet potato starch might thus affect its breadmaking properties, the proportion in the starch from the two sweet potato hybrids used in this study was determined.

The experimental results showed that the amylose content was 16.1 and 13.5% in hybrids 65 and 266, respectively. These results are lower than those obtained by Wang and Lin (15), who found that the amylose percentage was 20.5, but similar to those given by Chaudhury (16), who found that 15.2% of the starch of sweet potato is amylose.

Identification of Amino Acids in the Proteins of Sweet Potato Flour

The two sweet potato hybrids used to prepare the flour contained the same amino acids. The chromatogram developed with the n-butanol:acetic acid:water system showed that the following amino acids could be identified with certainty: cysteine, lysine, histidine, arginine, alanine, proline, leucine, and isoleucine. From the chromatograms developed by the methyl ethyl ketone:pyridine:water solvent system, aspartic acid, glutamic acid, glycine, serine, alanine, valine, isoleucine, and leucine were identified. The fifth spot, from the start line, proved to be a mixture of aspartic acid, glycine, and serine (having nearly the same R_f value) by using the n-butanol:acetic acid:water system. The sixth spot might be a mixture of glutamic acid and threonine. From the second system, i.e., methyl ethyl ketone:pyridine:water, it was noticed that threonine was not present. Tryptophan was identified in a chromatogram of alkaline hydrolysate.

It can be therefore concluded that the two hybrids of sweet potato examined did not contain methionine, threonine, tyrosine, and phenylalanine. The absence of the last two suggests that sweet potatoes may be of value in feeding persons with the disease phenylketonuria.

These results were similar to those obtained by Yamamato (17) who identified the following amino acids in an acid hydrolysate of sweet potato proteins: aspartic acid, glutamic acid, serine, glycine, threonine, alanine, lysine, tyrosine, histidine, arginine, valine and/or methionine, proline and/or isoleucine, cysteine, and tryptophan.

Literature Cited

1. HAMED, M. G. E., REFAI, F. Y., HUSSEIN, M. F., and El-SAMAHY, S. K. Effect of adding sweet potato flour to wheat flour on physical dough properties and baking. Cereal Chem. 50:140 (1973).
2. WATANABE, T., YOKOZAWA, I., and KOIZUMI, U. White flour from sweet potatoes treated with sulfurous acid, Rep. Food Res. Inst. (Tokyo) 2: 2. [Chem. Abstr. 47: 7134C (1953).]
3. LEGAULT, R. R., NERDEL, C. E., TALBURT, W. F., and POOLE, M. F. Browning of dehydrated sulfited vegetables during storage. Food Technol. 5: 417 (1951).
4. TALBURT, W. F., and SMITH, O. Potato processing. Avi. Pub. Co.: Westport, Conn. (1959).
5. ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. Official methods of analysis (10th ed.). The Association: Washington, D.C. (1965).
6. PEARSON, D. The chemical analysis of foods (3rd ed.). Churchill: London (1962).
7. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. AACC Approved methods (7th ed.). The Association: St. Paul, Minn. (1962).
8. SCHULERUD, A. Determination of acidity in flours. Cereal Chem. 9: 128 (1932).
9. EL-HADIDY, Z. A. Physico-chemical studies of some carbohydrate extractions from plant sources. M.Sc. Thesis, Ain-Shams Univ., Cairo (1967).

10. RIZK, A. M. Chemical investigation of certain species of Egyptian desert plants. Ph.D. Thesis, Faculty of Science, Cairo Univ. (1963).
11. WATANABE, T., YOKOZAWA, I., and HAVAKAWA, A. Problems concerning the utilization of sweet potato flour. Rep. Food Res. Inst. (Tokyo) 6: 59. [Chem. Abstr. 47: 7134C (1953).]
12. BURTON, W. G. Storage life of a sample of sweet potato slices dried in a sugar-beet factory. J. Soc. Chem. Ind. 64: 85 (1945).
13. GORE, H. C. The value of sweet potato flour in breadmaking. Ind. Eng. Chem. 15: 1238 (1923).
14. NOZNICK, P. P., MERRITT, P. P., and GEDDES, W. F. Staling studies on breads containing waxy maize starch. Cereal Chem. 23: 297 (1946).
15. WANG, Y., and LIN, H. Potentiometric titration of amylose in starches. Prov. Agr. Coll. Chem. (Taiwan) 263-70 (1956). [Chem. Abstr. 52: 4011H (1958).]
16. CHAUDHURY, A. K. R. Starch from sweet potato. J. Proc. Inst. Chem. (India) 17: 134. [Chem. Abstr. 41: 2263D (1947).]
17. YAMAMATO, Y. Studies on sweet potato from standpoint of nutritional chemistry. I. Isolation of sweet potato protein and examination of its amino acid composition. Eiyo To Shokuryo 7: 112. [Chem. Abstr. 53: 7457H (1959).]

[Received October 24, 1969. Accepted July 20, 1972]