Laboratory Preparation of Ready-to-Eat Breakfast Flakes from Grain Sorghum Flour[1]

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Grain sorghum (*Sorghum bicolor*) is a staple food in the semiarid tropics, which produces over 55% of the world's supply. Of the total grain sorghum production in the semarid tropics, Asia and Africa contribute about 65%, and about 700 million people are nourished by it (Swindall 1982). Therefore, wise and efficient utilization of the grain is especially important.

Breakfast cereals are of two main classes: those requiring cooking, common in China, Japan, and many African countries, and those precooked, ready-to-eat cereals, common in Europe and the United States (Matz 1970). Breakfast cereal manufacture was originally an art, and quite proprietary, with relatively few publications except for patents (Daniels 1974). A number of different processes are used in the preparation of ready-to-eat cereals, including flaking, puffing, shredding, and granule formation—generally of wheat, corn, and rice, but none of sorghum (Kent 1983). Several grain sorghum processing methods have been reported (Rooney 1985), but not ready-to-eat flakes.

The objective of this study was to develop a process for making ready-to-eat breakfast flakes from grain sorghum flour using simple procedures and equipment suitable for laboratory screening.

MATERIALS AND METHODS

Sample Preparation

Three grain sorghum hybrids were used: yellow (DeKalb DK42Y) and commercial bronze sorghums were obtained from growers in Lancaster County, NE; white (NC+ 271) sorghum was obtained from the local NC+ seed dealer (Lincoln, NE). The grain was cleaned in a model M-2B seed cleaner (A. T. Ferrell & Company, Saginaw, MI), fitted with 0.42-cm diameter round and 1.9×0.32 cm slotted screens.

Two different milling methods were used. In the first, the grain was decorticated in a Udy decorticator (Shepherd 1979). A 25-g sample of grain, initially at 12% moisture, was decorticated for 225 sec at 1,800 rpm. Both whole and decorticated grains were then ground in a Udy cyclone sample mill (Udy Corp., Boulder, CO) with a 1-mm screen, to prepare whole grain and decorticated grain flours. In the second milling method, a 70-g whole grain sorghum sample was fed into the Brabender Quadrumat Junior experimental mill (C. W. Brabender Instruments, South Hackensack, NJ). The internal sifter was not used; the flour was sifted (8-in., 60-mesh testing sieve) for 4 min on a Strand Shaker (Strand Manufacturing Co., Minneapolis, MN). Coarse residues (>60 mesh), consisting largely of bran and germ, were discarded.

The proximate composition of the flours was determined using AOAC (1975) and AACC (1983) methods. A Fisher sub-sieve sizer (Fisher Scientific, Chicago, IL) was used to determine average particle size.

Flake Manufacture

Flour (400 g) was mixed with 160 ml of water, 28 g of sugar, and 4 g of salt in a Kitchen-Aid K5 mixer with a paddle for 1 min at no. 2 speed. The dough was placed in a pasta extruder attachment (Kitchen-Aid, Hobart Inc., Troy, OH) and forced through a die (3-mm thick with 5-mm hole). As the dough was extruded, it was cut into approximately 1.5 cm long pellets, trayed, and steamed at 18 psi for 70 min. After cooking, the pellets were tempered overnight at 5°C, then placed in a circulating air oven at 40°C to reduce the moisture content to 20% (Fig. 1).

The partially dried pellets were flaked through heavily spring-loaded 10-in. diameter steel rollers, with a minimum gap of 0.05 mm. The resulting flakes were toasted on pans at 420°F (215°C) for 3.5. min, cooled, and bagged for storage (Fig. 2). The final moisture was kept below 5% (Lu 1986).

Product Evaluation

Water absorptions in excess water of the experimental sorghum flakes and of commercial breakfast cereal flakes were measured by weighing the water uptake of 10 g at room temperature.

Whole grain, flour, and flake colors were determined with a Hunterlab color difference meter (Hunterlab model D25-9, Fairfax, VA).

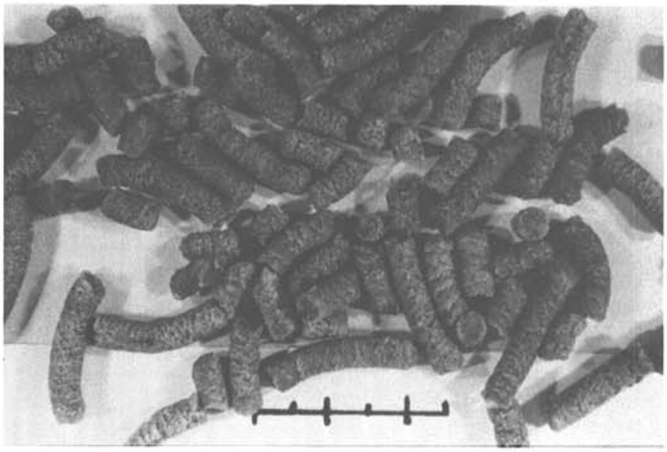

Fig. 1. Sorghum pellets after cold extrusion and cooking (line = 2.5 cm).

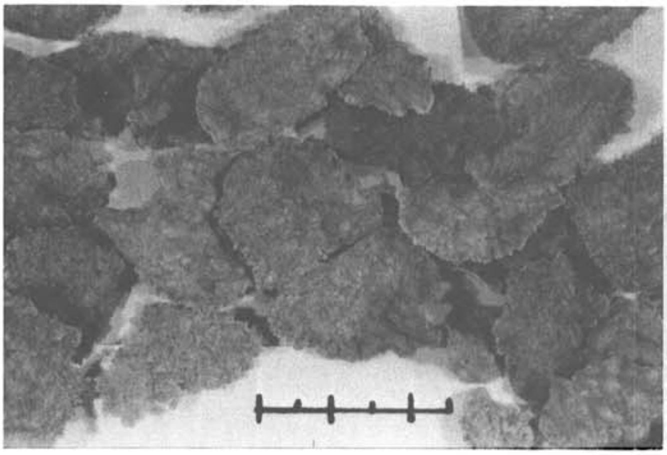

Fig. 2. Toasted sorghum flakes (line = 2.5 cm).

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Sensory evaluation followed the procedure of Larmond (1977). A formal taste panel (white light) was conducted. The panelists were permitted to add milk as desired, but not sugar. Three flake samples were used for the taste panel: 1) 100% sorghum flour with 7% sugar and 1% salt; 2) 75% sorghum flour, 25% soy flour with 7% sugar and 1% salt; and 3) bran flakes (Kellogg's) as the control. The color, texture, and flavor of the flakes were evaluated by 21 North Americans, 11 Latin Americans, and 11 Asians.

In a separate, consumer-oriented evaluation, small (1-oz.) cereal boxes of prototype "Captain Milo" sorghum flakes were distributed to people attending a meeting at York, NE, in February 1986. Each box was accompanied by a questionnaire.

Statistical Analysis

Data on water absorption, color, and taste panels were tested using the analysis of variance procedure of the statistical analysis system (SAS 1979). Duncan's multiple range test was used for mean comparison.

RESULTS AND DISCUSSION

Processing in the Brabender mill reduced flour protein, fat, and ash. Decortication did not result in a major decrease in protein, but there was a decrease in fat and ash content resulting from germ and bran removal (Table I). Flour from the Brabender mill had a larger average particle size than that from the Udy mill (50 and 30 μm, respectively).

All sorghum flakes showed lower water absorption than the control bran flakes (Table II). After 5 min, the sorghum flakes still maintained their crispness, whereas the commercial flakes did not.

Sorghum flake color was compared with that of three commercial flakes (Table III). The bronze sorghum flakes were darker but the Nutri·Grain and corn flakes lighter than the yellow and white sorghum flakes. In agreement with the observations of Rooney and Murty (1982), we found the Hunterlab color difference meter did not easily distinguish between sorghum flours. Steaming and toasting reduced color lightness, *L*, and increased yellow and red hues, probably due to reactions of the sugars with amino acids, or to carmelization, or both.

Volunteer taste panelists, students at the University of Nebraska-Lincoln, represented three different geographic areas: Latin America, Asia, and the United States. Forty-seven percent of the Latin Americans, 64% of the Asians, and 52% of the North Americans preferred flakes made with 100% sorghum flour containing 7% sugar and 1% salt. A darker flake containing 25% soy flour was judged significantly different ($P < 0.05$) from the others. The bran flakes had a soggier texture; the sorghum flakes were crisper. There were no significant differences across the three cultural groups, so only the merged data are presented (Table IV).

Ninety-three individuals completed a survey form after testing the boxed prototype Captain Milo sorghum breakfast cereal; 76% indicated that they would buy this product, and 77% indicated an "excellent" or "good" overall rating.

CONCLUSION

Prototype grain sorghum ready-to-eat breakfast cereal flakes were produced by a simple, low technology process. Sensory evaluation and a consumer survey indicated that they were palatable and acceptable to many people. Therefore, further development of this breakfast cereal is highly recommended, including larger scale tests in which pellets are prepared with an extrusion cooker, and flaked on commercial-scale rolls.

TABLE I
Proximate Chemical Compositions of Sorghum Flours[a] Obtained from the Udy and Brabender Mills (dry basis)

Sample	Protein[b] (%)	Ash (%)	Fat (%)	Starch (%)	Milling Yield (%)
Yellow					
whole	9.72	1.34	3.34	64.7	100.0
decorticated	9.37	0.43	0.68	77.1	65.6
Brabender	8.25	0.80	1.96	71.6	68.6
White					
whole	10.64	1.73	3.48	65.2	100.0
decorticated	10.15	0.64	1.21	79.3	66.0
Brabender	9.51	0.98	2.16	71.2	64.7
Bronze					
whole	10.87	1.61	3.43	62.8	100.0
decorticated	10.73	0.54	1.41	79.1	58.8
Brabender	9.43	0.98	1.93	71.4	59.1

[a] Average of two determinations.
[b] Nitrogen × 6.25.

TABLE II
Water Absorption of Sorghum and Commercial Flakes[a]

Sample	Time (min) 1	3	5
Sorghum flakes			
yellow	0.74 a	1.23 a	1.69 a
white	0.72 a	1.20 a	1.84 a
bronze	0.81 a	1.41 a	1.80 a
Bran flakes (Kellogg's)	1.53 d	2.61 c	3.04 c
Nutri·Grain (Kellogg's)	1.03 b	1.67 a	2.20 b
Corn flakes (Post)	1.27 c	2.03 b	2.92 c

[a] Average of three determinations, grams of water absorbed per 10 g of dry flakes. Column means followed by same letter are not significantly different ($P < 0.05$) by Duncan's multiple range test.

TABLE III
Colors[a] of Sorghum Flour, Sorghum Flakes, and Commercial Flakes

Samples	Flour *L*	Flour *a*	Flour *b*	Flakes[b] *L*	Flakes[b] *a*	Flakes[b] *b*
Sorghum flakes						
yellow	74.11	−0.34	12.50	48.25 c	4.80	16.12 b
white	73.01	0.07	9.93	45.62 b	4.74	15.61 b
bronze	73.52	0.53	9.56	38.40 a	6.62	14.32 a
Bran flakes (Kellogg's)	···	···	···	44.16 b	7.34	18.35 c
Nutri·Grain (Kellogg's)	···	···	···	54.93 e	6.15	20.69 d
Corn flakes (Post)	···	···	···	52.58 d	7.33	25.00 e

[a] Average of four determinations. Flour and flake colors measured with a Hunterlab color difference meter. *L* measures total light reflected, *a* redness, and *b* yellowness.
[b] Means followed by the same letter in any given column are not signficantly different ($P < 0.05$) by Duncan's multiple range test.

TABLE IV
Flake Hedonic Ratings by Taste Panelists

Sample	Panelists Score Means[a]
Color score	
100% sorghum flour	4.2 a
75% sorghum, 25% soy flour	4.9 b
Bran flakes (control)	4.0 a
Flavor score	
100% sorghum flour	4.3 ab
75% sorghum, 25% soy flour	4.6 b
Bran flakes (control)	3.9 a
Texture score	
100% sorghum flour	4.6 b
75% sorghum, 25% soy flour	4.8 b
bran flakes (control)	2.8 a

[a] Means followed by the same letter are not significantly different ($P < 0.05$) by Duncan's multiple range test, where 1 = light, 7 = dark for color; 1 = none, 7 = strong for flavor; and 1 = soggy, 4 = just right, 7 = crisp for texture. Data were analyzed as one set of samples ($n = 43$), since there were no significant differences among the three culture groups.

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