USE OF SORGHUM AND PEARL MILLET FLOURS IN COOKIES[1]

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ABSTRACT

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Cookies made from grain sorghum or millet flour did not spread during baking, had a poor top grain character, and were dense and compact. In addition, they were mealy and gritty. Interchanging the lipid between wheat and sorghum flours showed that wheat lipids had components, missing in sorghum-flour lipids, which greatly improved the cookies' top grain. The use of unrefined soy lecithin (0.6%) improved top grain even more than did wheat lipids. When grain sorghum or millet flours were hydrated with water, dried, and supplemented with 0.6% unrefined soy lecithin, they produced cookies with spread characteristics equal to those of soft wheat flour. The grittiness of millet or sorghum cookies was reduced by increasing the pH of the cookie dough. The texture (fragility) of cookies containing part soft wheat flour was much better than the texture of those made from 100% sorghum or millet flour.

Soft wheat is the grain of choice for producing cookies (hard biscuits). Limited areas in the world grow high-quality soft wheat; therefore, there has been increasing interest in the use of coarse cereals as a substitute for wheat in baked products. In producing hard biscuits (cookies) from composite flours containing grain sorghum and millet, Kim (1) found that coherence of the dough could be improved by cooking or fermenting part of the flour before mixing. However, the cookies produced were still dense and compact.

Mustafa *et al.* (2) used ginger to mask the flavor of cookies made with millet or sorghum; however, the cookies were fragile and mealy. Shoup *et al.* (3) and Rooney *et al.* (4) reported producing acceptable cookies when small quantities of wheat flour were replaced with sorghum flour.

This study was undertaken to evaluate millet and sorghum flour for producing cookies, and to develop techniques for producing those cookies with acceptable spread, top grain, texture, and grittiness.

MATERIALS AND METHODS

Flours

A commercially milled, soft red winter cookie flour was used as a control. A commercial sample of mill-run grain sorghum was milled on an experimental mill to a straight-grade flour of 60% extraction. Pearl millet, a random mating population of combine-height plants (5) grown on the KSU Agronomy Farm, was milled with a Buhler mill to a straight-grade flour of 63.4% extraction.

Soybean oil (soy lecithin, oil not removed) and soy lecithin (refined lecithin) were obtained from Nutritional Biochemicals. The monoglycerides (Myverol 18-85) were from Distillation Products, Inc.

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Cookie-Baking Procedures

The micro cookie test described by Finney *et al.* (6) was used for the evaluation of cookie-baking character. The standard deviation for cookie diameter was 0.08 cm. The eating quality of cookies made from treated sorghum flour was studied using a commercial chocolate chip formula (7). The formula included the following:

Items	*g*
1. Brown sugar	681
2. Granulated sugar	681
3. Salt	28
4. Nonfat dry milk solids	85
5. Shortening	908
6. Eggs	681
7. Water	227
8. Baking soda	14.25
9. Vanilla	28.5
10. Flour	1367.0
11. Chocolate chips	1589

Items 1 through 5 were creamed together, items 6 through 9 were added to the creamed ingredients, and then item 10 was blended in, with a minimum of mixing; item 11 was added last.

RESULTS AND DISCUSSION

With the Finney *et al.* microcookie test (6), neither grain sorghum nor millet flour produced acceptable cookies. The cookies had essentially no spread and no top cracks; they were tough, hard, gritty, and mealy in texture and taste.

Working with wheat flour, Kissell *et al.* (8) reported that both polar and nonpolar free lipids were important in obtaining cookie spread and top grain. The free lipids from millet and grain sorghum flours were shown by tlc to differ

TABLE I
Effect of Certain Treatments on Cookie Diameter

Treatment	Cookie Diameter, cm		
	Wheat	Sorghum	Millet
Control flour	8.75	6.29	7.00
Defatted flour	6.38	5.88	...
Reconstituted flour	8.80	6.15	...
Defatted flour + exchanged lipids	6.80	6.80	...
Defatted flour + soy oil (0.6%)	...	7.02	...
Control flour + soy oil (0.6%)	...	7.05	7.78
Control flour + malt treatment and soy oil (0.6%)	...	8.70	9.05
Control flour + hydration treatment and soy oil (0.6%)	...	8.63	9.05

from those in wheats (5). Therefore, cookies were baked from defatted sorghum grain and defatted wheat flour. Cookies from both defatted flours had less spread, no top cracks, and a pale color (Table I and Fig. 1). Exchanging the lipids (defatted wheat flour plus sorghum-flour lipids and defatted sorghum flour plus wheat-flour lipids) gave cookies from sorghum flour with improved top grain and spread. (Table I and Fig. 1). However, cookies made from defatted sorghum flour plus wheat-flour lipids did not approach the quality of the control wheat-flour cookies. Similar results were obtained when wheat-flour lipids were added to nondefatted sorghum flour and baked into cookies. Adding sorghum-flour lipids to defatted wheat flour gave cookies of poor quality.

Thus, wheat lipids improve the cookie-baking quality of sorghum flour, apparently because wheat-flour lipids contain a component or components not in sorghum-flour lipids. Several commercially available lipids were investigated to replace the wheat-flour lipids. Unrefined soybean lecithin (0.6%) added to sorghum and millet flours gave cookies with similar top grain and larger spreads than did wheat-flour lipids (Table I, Fig. 2). Refined lecithin was not as effective as the unrefined soybean lecithin. However, refined lecithin plus monoglycerides (3:1) were as effective as the soybean oil. The use of soybean oil greatly improved top grain and cookie spread. However, the cookies from sorghum and millet flours were still mealy and gritty, and did not spread as well as wheat-flour cookies.

Sollars (9) and Sollars and Bowie (10) had shown that damaged starch had a deleterious effect on cookie spread. After we milled sorghum and millet to flour

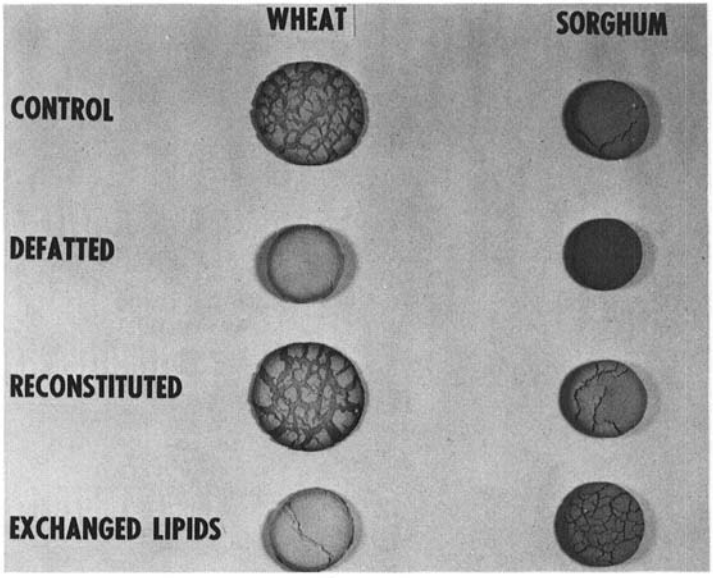

Fig. 1. Cookies made from wheat and grain sorghum flours (control), those flours extracted with petroleum ether (defatted), with their own lipids added back to the flours (reconstituted), and with the lipids exchanged (exchanged lipids).

fineness, considerable damaged starch was noted in scanning electron photomicrographs. To remove some of that damaged starch, the flours were hydrated for 3 hr with 2%, 60° L malt syrup. After air drying, the flours were baked into cookies using the standard formula plus 0.6% soybean oil.

Sorghum and millet cookies with a spread and top grain comparable to those of wheat were obtained (Table I, Fig. 2). The sorghum cookies were slightly darker and were more fragile than the wheat cookies. The grittiness of the cookies was not as objectionable as those from untreated flour. Similarly prepared millet cookies gave a larger spread than wheat cookies and had deeper canals in the top grain. In general, the millet cookies were larger, darker, and more fragile than the sorghum cookies.

Surprisingly, omitting the malt syrup and instead just wetting the sorghum or millet flour with water (100% based on flour weight), then allowing it to hydrate at room temperature for 6 hr and air drying to 12% moisture produced flours that gave cookies essentially equal to those receiving the malt treatment. Thus, removing damaged starch does not appear to be an important consideration. The role of the wetting and drying is not readily apparent, although the treatment reduces the particle size of the flour.

Increasing the pH of the cookie dough by substituting sodium carbonate for

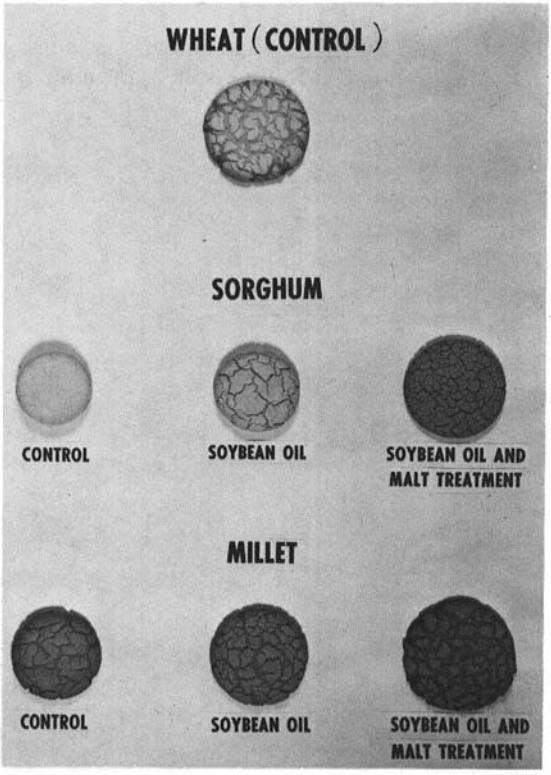

Fig. 2. Cookies made from wheat flour, and grain sorghum and millet flours before and after addition of soybean oil to the formula and before and after malt treatment.

the sodium bicarbonate in the creamed ingredients further reduced the grittiness of cookies baked with either grain sorghum or millet flours. In general, the millet cookies were less gritty than the grain sorghum cookies. Higher levels of sodium carbonate gave progressively darker cookies, presumably because of the effect of the increased alkalinity on the browning reaction.

Although satisfactory cookies were made from treated sorghum and millet flours, they were more fragile than wheat cookies. No conditions were found to improve the fragility. Therefore, blends of wheat flour with treated sorghum or millet flour were used. Pictures of the cookies and their diameters are given in Fig. 3 and Table II.

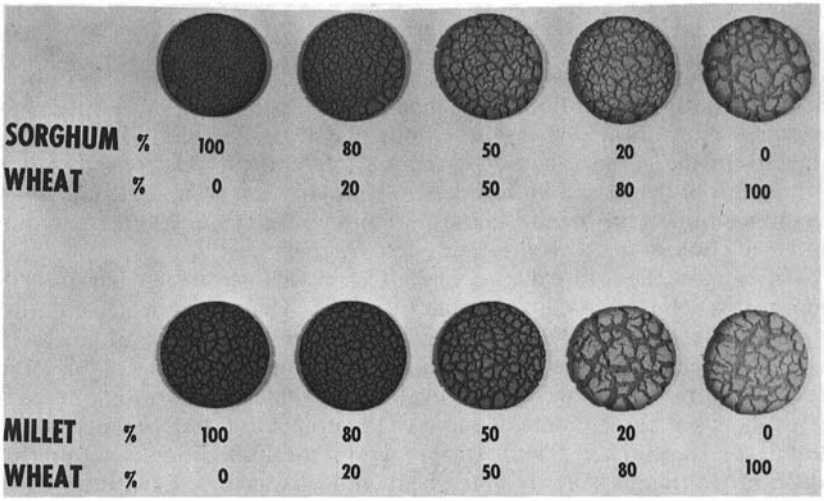

Fig. 3. Cookies made from certain blends of treated grain sorghum flours and wheat flours, and treated millet flours and wheat flours.

TABLE II
Effect of Blends of Sorghum Grain and Millet Flour with Wheat Flour on Cookie Diameter[a]

% of Wheat Flour in the Blend[b]	Cookie Diameter, cm	
	Sorghum	Millet
0	8.75	9.00
10	8.60	9.05
20	8.62	8.93
30	8.63	8.90
50	8.55	8.88
70	8.33	8.70
80	8.55	8.80
90	8.40	8.60
100	8.73	8.76

[a]Sorghum and millet flour treated with malt and containing 0.6% soybean oil based on sorghum and millet-flour weight.
[b]Cookie containing over 50% wheat flour baked with $NaHCO_3$; less than 50% wheat flour baked with Na_2CO_3.

TABLE III
Taste Panel Evaluation of Chocolate Chip Cookies Made from Soft Wheat Flour and Cookies Made with Part, or All, of the Soft Wheat Flour Replaced with Treated Grain Sorghum Flour[a]

Flour	Appearance	Taste	Texture	Off-Flavor	Grittiness
100% Soft wheat	4.25	4.75	4.50	1.25	1.25
100% Soft wheat	4.00	4.25	4.00	1.50	1.50
25% Grain sorghum	3.25	4.12	4.25	1.75	1.75
50% Grain sorghum	4.25	4.12	4.00	2.25	1.50
75% Grain sorghum	3.70	3.50	3.75	2.25	2.25
100% Grain sorghum	4.00	3.75	3.75	1.50	2.75
LSD 0.05	1.524	1.243	0.802	1.247	1.355

[a]Scale for judging appearance, taste, texture: 1 = poor, 5 = excellent. Scale for off-flavor: 1 = no off-flavor, 5 = pronounced off-flavor. Scale for grittiness: 1 = not gritty, 5 = very gritty.

Cookies made from blends of wheat flour and treated sorghum flour were generally slightly smaller than those made from either 100% wheat flour or 100% treated sorghum flour. With wheat flour and treated millet flour blends, the diameters of the cookies had essentially a straight line relationship based on composition of the blend. Differences in color and top grain varied largely with the composition of the blend. As the amount of wheat flour was increased in the blend, the cookies were progressively less fragile.

To investigate the eating quality of cookies made from treated sorghum flour, a commercial chocolate chip formula was used. The test panel (five untrained members) was individually given coded cookies and asked to evaluate them for five attributes: appearance, taste, texture, off-flavor, and grittiness. Six samples (duplicated on different days) were evaluated (Table III); two were made from 100% soft wheat flour (controls), and in the other four, part, or all, of the soft wheat flour was replaced with treated grain sorghum flour. The only result significantly different from the soft wheat cookies was for the grittiness attribute with 100% treated grain sorghum flour.

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