CORN FLOUR: USE IN COOKIES[1]

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ABSTRACT

Corn flour treated with water followed by air drying and addition of soybean oil produced cookies with increased diameter and improved top grain compared with cookies produced with untreated corn flour. Reducing the particle size of corn flour led to less cookie spread. In a number of flours from various millstreams, particle size and cookie diameter did not appear to be correlated, suggesting that though particle size in a sample is important, it does not in itself determine cookie size. Starch damage and cookie diameter were essentially unrelated. With flour from certain millstreams, cookie diameter increased as a result of the hydration and drying treatment; with flour from other millstreams, it did not increase. The water-soluble fraction from certain samples increased cookie diameter of the insoluble fraction, suggesting that a component being formed during hydration influences cookie spread.

The majority of U.S. corn is used for feed. Corn for human consumption is processed by wet and dry corn millers, and the products are used in a wide range of foods (1). Grits and coarse meal are the major products of dry corn mills; corn flour is a by-product of the several steps in which large grits are broken into small pieces (2).

In the baking industry, corn flour has been used because of its flavor and because it is economical (especially for developing countries where wheat is an import item) in dry mixes such as muffins, pancake composite flour, and corn bread (3—7). In this study, we attempted to use corn flour as a partial and a total replacement for soft wheat flour in cookie production.

MATERIALS AND METHODS

Corn flour (—50W) experimentally milled as described previously (8) from a commercial sample of yellow corn was used. Flours from 19 millstreams supplied by the Quaker Oats Company were also used. Starch damage was determined by the AACC method (9). The micro cookie baking test that Finney *et al.* (10) described was used, with 0.6% soybean lecithin (based on flour weight) added to the formula (11). All values reported were averages of at least duplicate determinations.

RESULTS AND DISCUSSION

The stock material (—50W corn flour) was hydrated with water (100% based on flour weight) for 6 hr, air dried at room temperature, and ground in the Stein mill

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for 30 sec (treated). That treatment and addition of 0.6% soybean oil were found to be effective in producing cookies with increased diameter and improved top grain (Fig. 1). Stein milling (30 sec) had no effect on cookie diameter, as determined by baking cookies from the stock before and after milling; both cookies had diameters of 8.90 cm. Effects of hydration time and quantity of water are given in Table I. Longer hydration times were slightly beneficial, with only a minor influence from the amount of water used.

Effect of drying temperature was studied by placing the hydrated flour in open containers in a forced-air oven until the product had reached about 10% moisture, a drying temperature of about 90°C was optimum for large cookie diameter (Table II). No appreciable starch gelatinization was noted (microscopic examination) in any of the samples.

Hydrating the stock material (−50W) with water (100%) for 6 hr followed by drying it at room temperature increased the cookie diameter from 8.90 to 9.80 cm. If the stock material was pin milled, however, the hydration-drying treatment did not increase cookie diameter significantly (8.20 untreated; 8.25 treated). Thus, apparently either reduction in particle size or increase in starch damage produced by pin milling was destroying the effectiveness of the hydration-drying system.

To separate the effect of particle size from that of starch damage, the hydrated stock material was wet ground at various settings on a modified Hobart coffee grinder. This treatment would be expected to reduce particle size but have only minor effect on starch damage. The results (Table III) indicated that the reduction in particle size was responsible for the decrease in cookie diameter.

The 19 millstreams varied widely in particle size and starch damage. Each flour

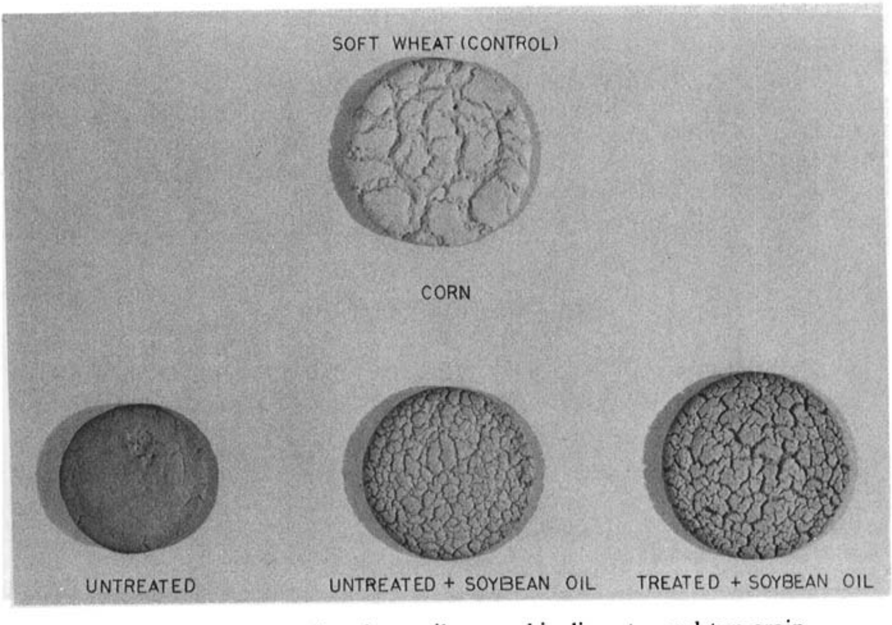

Fig. 1. Effect of treatment and soybean oil on cookie diameter and top grain.

(as received) was baked into cookies (untreated). In addition, each was hydrated with 100% water for 6 hr at room temperature, air dried overnight, and Stein milled for 30 sec (treated) and baked into cookies. Cookie diameter (Table IV) ranged from a low of 7.00 (CR-15) to a high of 9.80 cm (CR-17) for untreated samples. The range for the treated sample was larger, 7.40 (CR-15) to 10.90 cm (CR-18). The increase in cookie diameter as a result of treatment also varied widely, from no change (CR-8) to an increase of 1.5 cm (CR-18).

Starch damage (AACC method) determined on the untreated samples (Table IV), correlated with neither untreated cookie diameter (Fig. 2) nor increase in cookie diameter as a result of treatment (Fig. 3). This was contrary to our original

TABLE I
Effect of Hydration Time and Amount of Water on Cookie Diameter

Hydration		
Time (hr)	**Water[a] (%)**	**Cookie Diameter (%)**
3	50	9.65
3	100	9.73
3	150	9.75
6	50	9.83
6	100	9.80
6	150	9.85
9	50	9.88
9	100	9.90
9	150	9.90

[a]Based on flour weight.

TABLE II
Effect of Drying Temperature on Cookie Diameter

Oven Temperature (°C)	Cookie Diameter (cm)	Oven Temperature (°C)	Cookie Diameter (cm)
25	9.85	80	10.68
40	10.08	90	10.70
50	10.15	100	10.60
60	10.13	110	10.55
70	10.10	120	10.38

TABLE III
Effect of Particle Size on Cookie Diameter

Hobart Setting	Coarse[a] (%)	Cookie Diameter (cm)
5	73	9.28
4	61	8.30
3	60	8.21

[a]Greater than 50 μ by Bacho procedure.

TABLE IV
Effect of Hydration Treatment and Starch Damage on Cookie Diameter

Flour Stream	Cookie Diameter Untreated (cm)	Cookie Diameter Treated (cm)	Increase in Diameter by Treatment (cm)	Starch Damage[a] (%)
CR-1	8.00	8.30	0.30	1.2
CR-2	8.20	8.50	0.30	1.8
CR-3	8.50	8.80	0.30	2.9
CR-4	8.40	8.60	0.20	4.7
CR-5	8.40	8.80	0.40	4.8
CR-6	8.10	9.00	0.90	4.2
CR-7	9.50	10.00	0.50	2.4
CR-8	7.80	7.80	0.00	1.6
CR-9	8.60	9.40	0.80	4.7
CR-10	8.80	9.00	0.20	2.6
CR-11	7.80	8.00	0.20	2.6
CR-12	8.80	9.20	0.40	4.1
CR-13	9.00	9.30	0.30	3.4
CR-14	9.00	9.40	0.40	3.5
CR-15	7.00	7.40	0.40	3.4
CR-16	7.90	8.90	1.00	3.0
CR-17	9.80	10.40	0.60	4.1
CR-18	9.40	10.90	1.50	6.5
CR-19	9.00	10.00	1.00	5.4

[a]On untreated sample.

TABLE V
Effect of Insoluble and Soluble Fractions on Cookie Diameter

Fraction and Treatment	Cookie Diameter (cm)
CR-11 (control)	7.80
CR-11 treated	8.00
CR-11 insoluble + CR-11 soluble	8.10
CR-11 insoluble	7.70
CR-11 insoluble + CR-16 soluble	8.10
CR-16 (control)	7.90
CR-16 treated	8.90
CR-16 insoluble + CR-16 soluble	8.80
CR-16 insoluble	8.50
CR-16 insoluble + CR-11 soluble	8.70
CR-8 (control)	7.80
CR-8 treated	7.80
CR-8 insoluble + CR-8 soluble	7.70
CR-8 insoluble	7.60
CR-8 insoluble + CR-6 soluble	7.90
CR-6 (control)	8.10
CR-6 treated	9.00
CR-6 insoluble + CR-6 soluble	8.80
CR-6 insoluble	8.45
CR-6 insoluble + CR-8 soluble	8.40

assumption and previous reports that cookie diameter decreases as starch damage increases (10).

Treated and untreated flours from certain millstreams selected to cover the range of increase in diameter as a result of treatment were analyzed for particle size distribution with the Whitby (MSA) procedure. The results show, as would be expected, a rather large variation in particle size of the various streams. The change in particle size as a result of treatment also varied widely—from essentially no change for CR-18 (Fig. 4) to a marked reduction in particle size for CR-6 (Fig. 5). None of the parameters—original particle size, particle size after treatment, or change in particle size as a result of treatment—was related to cookie size.

Effect of Water Solubles on Cookie Diameter

Samples from four streams (CR-6, CR-8, CR-11, and CR-16) were

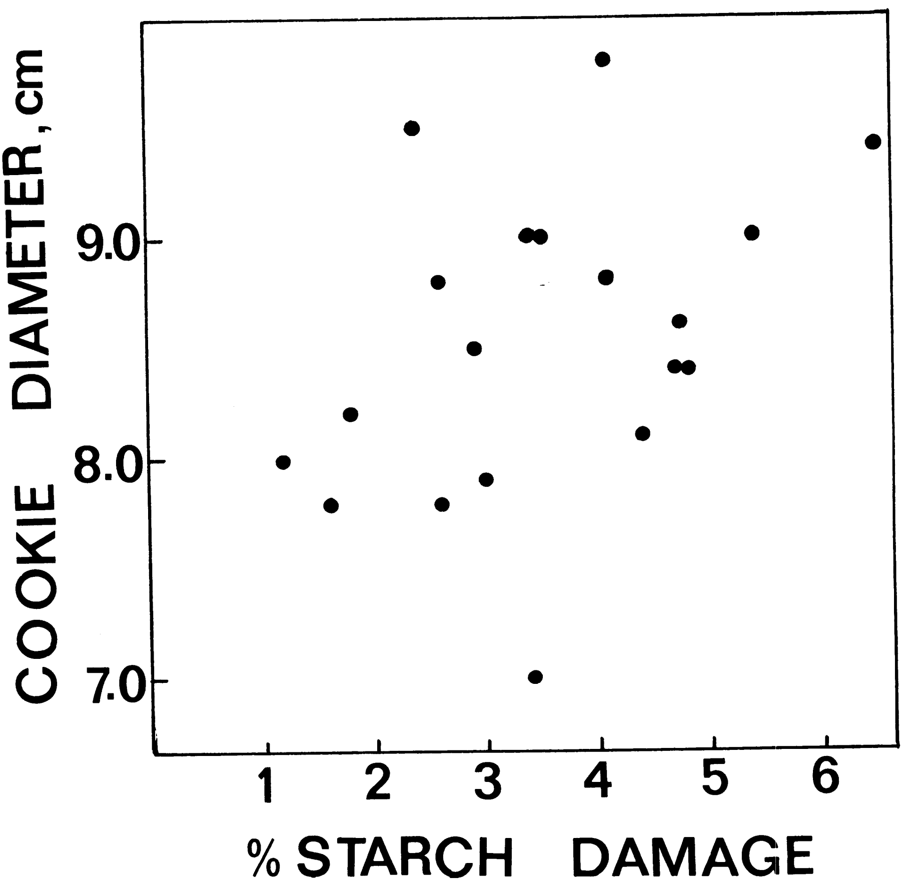

Fig. 2. Relationship of starch damage and cookie diameter.

fractionated into soluble and insoluble fractions. Samples were hydrated for 6 hr with 200% water and centrifuged; the insoluble fraction was air dired while the water solubles were lyophilized. The fractions were then reconstituted and baked into cookies as outlined in Table V. Each reconstituted flour gave cookie diameters comparable to those from treated flour. Thus, the fractionation and reconstitution technique appeared to be valid.

The difference between CR-11 (low response to treatment) and CR-16 (high response to treatment) appears to be in the insoluble fractions. Inclusion of either CR-11 or CR-16 soluble fractions increased the cookie diameter about 0.4 cm. CR-8 (low response to treatment) and CR-6 (high response to treatment) gave a different picture. The CR-8 soluble fraction was not effective in increasing cookie diameter with either insoluble fraction, while the CR-6 soluble fraction was effective with both insoluble fractions.

When baked without a soluble fraction, the low-response samples (CR-8 and CR-11) produced cookie diameters smaller than those produced with the original

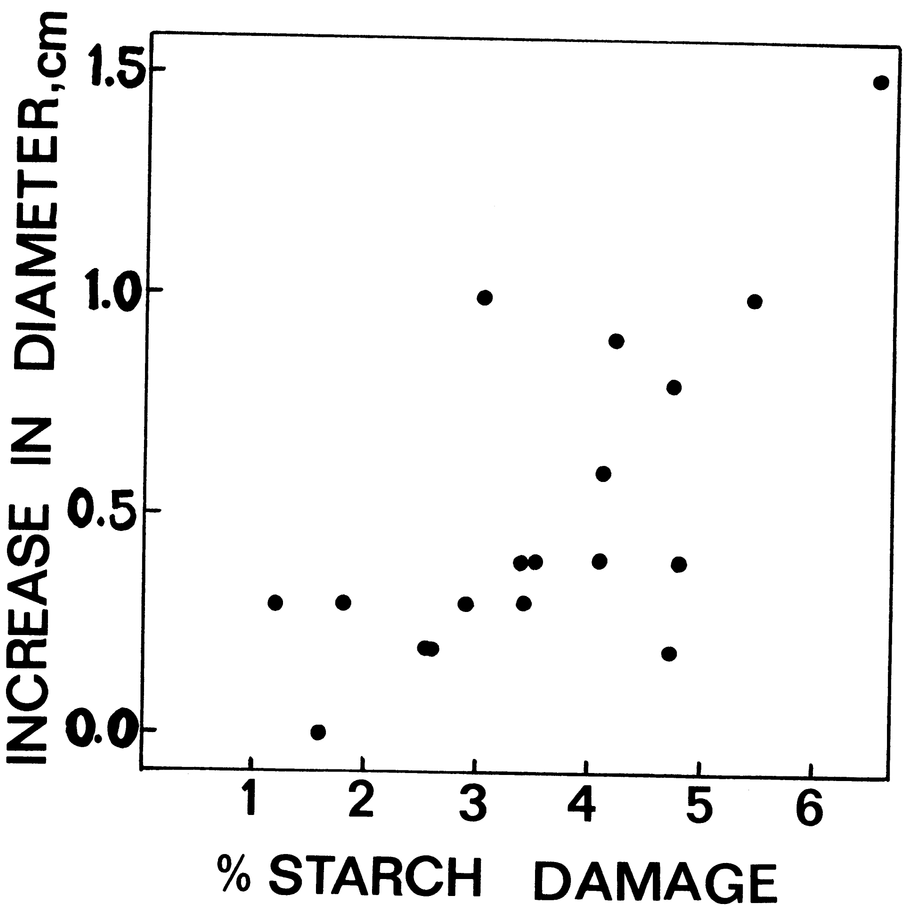

Fig. 3. Relationship of starch damage and increase in cookie diameter.

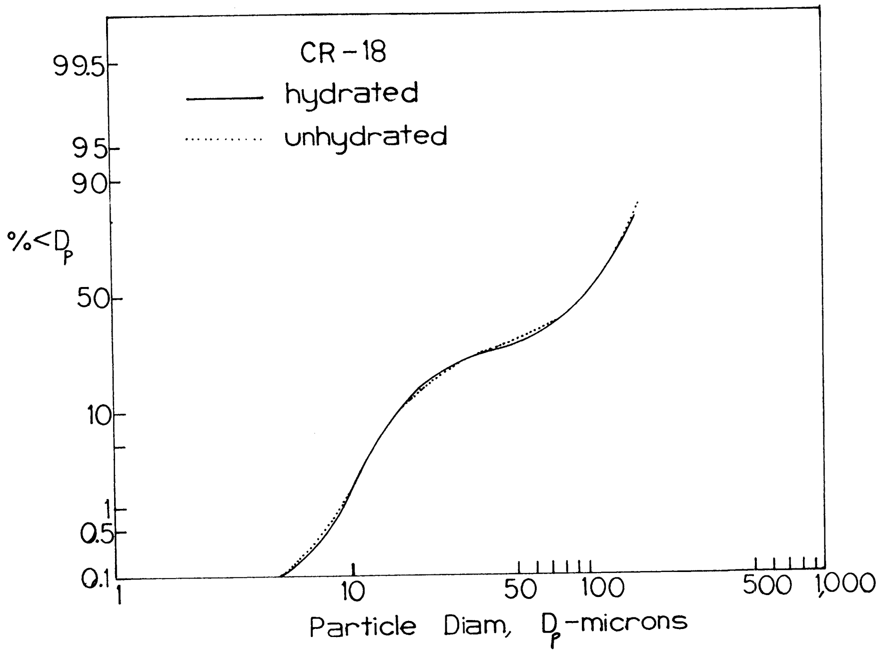

Fig. 4. Particle size distribution of hydrated and unhydrated millstream CR-18.

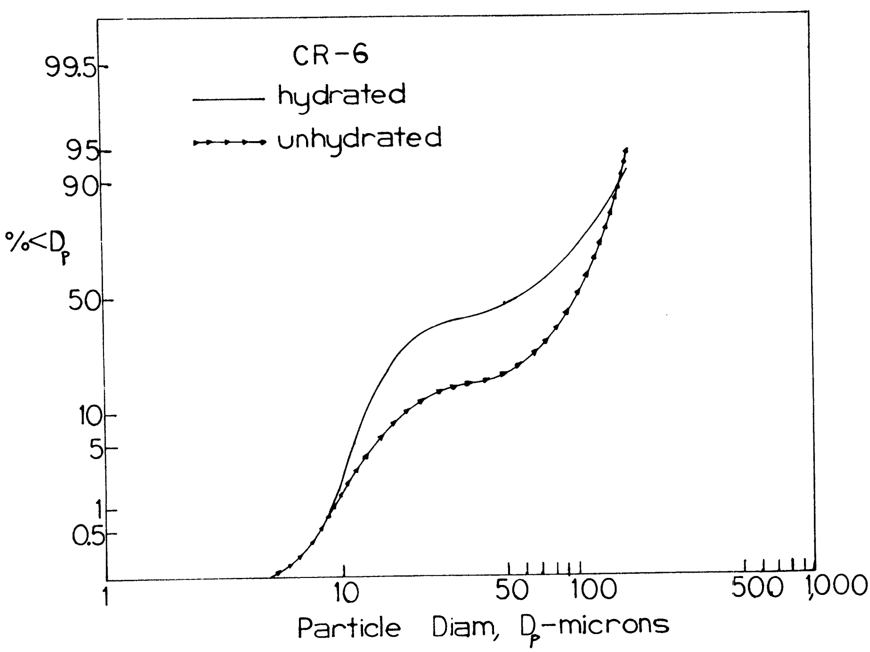

Fig. 5. Particle size distribution of hydrated and unhydrated millstream CR-6.

untreated sample; when baked without a soluble fraction, the high-response samples (CR-6 and CR-16) produced cookies with a larger diameter than those baked from the untreated samples. Thus, apparently in certain samples something was changed in the insoluble fraction as a result of the treatment. The change results in cookies with a larger diameter. In other samples, that change did not occur. Also, for certain samples from the 19 streams baked with or

TABLE VI
Effect of Hydration Treatment and Removal of Water Solubles on Cookie Diameter of Corn Flours From Different Millstreams

Millstream	Cookie Diameter			Increase by WS[b] (cm)
	Unhydrated (cm)	Hydrated (cm)	Insoluble[a] (cm)	
CR-1	8.00	8.30	7.95	0.35
CR-2	8.20	8.50	8.20	0.30
CR-3	8.50	8.80	8.45	0.35
CR-4	8.40	8.60	8.40	0.20
CR-5	8.40	8.80	8.40	0.40
CR-6	8.10	9.00	8.40	0.60
CR-7	9.50	10.00	9.50	0.50
CR-8	7.80	7.80	7.80	0.00
CR-9	8.60	9.40	8.60	0.80
CR-10	8.80	9.00	8.80	0.20
CR-11	7.80	8.00	7.80	0.20
CR-12	8.80	9.20	8.80	0.40
CR-13	9.00	9.30	8.90	0.40
CR-14	9.00	9.40	9.00	0.40
CR-15	7.00	7.40	6.95	0.45
CR-16	7.90	8.90	7.90	1.00
CR-17	9.80	10.40	9.75	0.65
CR-18	9.40	10.90	10.30	0.60
CR-19	9.00	10.00	8.95	1.05

[a]Separated and air dried after 6 hr of hydration.
[b]Hydrated minus insoluble.

TABLE VII
VII
Effect of Certain Soluble Fractions on Cookie Diameter

Fraction and Treatment	Cookie Diameter (cm)
CR-6 (control)	8.10
CR-6 insoluble – 0 hr	8.20
CR-6 insoluble – 6 hr	8.40
CR-6 insoluble – 0 hr + soluble – 0 hr	8.60
CR-6 insoluble – 6 hr + soluble – 6 hr	8.90
CR-6 insoluble – 0 hr + soluble – 6 hr	8.90
CR-6 insoluble 6 hr + soluble – 0 hr	8.50
CR-6 insoluble 6 hr + 2(soluble – 6 hr)	9.40

TABLE VIII
Effect of Boiled Water Solubles on Cookie Diameter

Treatment	Cookie Diameter (cm)
6 hr hydrated	9.90
Water soluble + insoluble	9.85
Boiled water soluble + insoluble	9.20
Insoluble	9.20

without the water solubles, the water-soluble component or components increased the cookie diameter; in other samples, the water soluble had no effect (Table VI).

The CR-6 sample was treated with water and immediately centrifuged to give essentially a zero-time treatment. The fractions produced were reconstituted or interchanged with the 6-hr treated and centrifuged fractions and baked into cookies (Table VII). The insoluble fraction from the 6-hr treatment yielded only a slightly larger cookie than did that from the zero-time treatment. The soluble fraction from the 6 hr treatment, however, was much more effective in increasing the cookie diameter than that from the zero-time treatment. Thus, apparently a water-soluble component created during the 6 hr treatment was effective in increasing cookie diameter. Further evidence was furnished when the amount of the 6 hr water-soluble component was doubled and the increase in cookie diameter also doubled (Table VII).

As noted earlier (Table I), longer hydration times and higher drying temperatures increased cookie diameter slightly (Table II) which indicated the possibility of enzymatic activity. Hydration times longer than 6 hr gave no appreciable increase in cookie diameter. A zero-time water-soluble fraction of corn flour was boiled, cooled, and recombined with the insoluble fraction and then allowed to hydrate for 6 hr. After being dried, it was baked into cookies. The cookie diameters (Table VIII) were essentially equal to those obtained with the insoluble fraction. Therefore, changes normally found during hydration were not found when the water-soluble fraction was boiled, which also would suggest enzymatic activity.

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