Use of a Kramer Shear Cell to Measure Cracker Flour Quality[1]

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ABSTRACT

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A method developed to measure the physical properties of a straight dough with the Kramer shear cell was used to estimate the baking performance of cracker flours. The procedure involved adjusting the pH of a flour-water dough to 3.9 and allowing it to rest for 10 hr. For soft wheat flours, correlation coefficients of 0.89 between shoulder force and cracker weight and of 0.87 between shoulder force and stack height were obtained. A modified procedure that included neutralizing the sponge, adding salt, and remixing gave much better reproducibility. For soft wheat flour, correlation coefficients of 0.97 between shoulder force and stack height and 0.87 between shoulder force and cracker weight were obtained with the modified procedure. Although having more steps, the modified procedure was faster because of its much easier cleanup procedure. Hard wheat flours or blends containing hard wheat gave much higher shoulder forces.

Although cracker baking has been a commercial process for a long time, it is still largely an art. The specifications for cracker flour vary widely between different parts of the country and even between manufacturers in the same area. Both soft wheat flours alone and blends with hard wheat flours are used for saltine crackers. The baking process generally involves a sponge and dough process, with stronger flours used for the sponge and weaker flours for the dough-up. The sponge flour may have 10% protein and a MacMichael viscosity of 90° M, whereas the dough-up flour may have as little as 8% protein and viscosity of 60° M (Johnson and Bailey 1924, Heppner 1959). The chemistry of the cracker making process appears to be complex and poorly understood (Heppner 1959, Pizzinatto and Hoseney 1980a).

The testing of flours for saltine crackers has received much attention (Dunn 1933; Bohn 1934, 1935; Micka 1934, 1955; Reiman 1936, 1938; Brown 1939; Simmons 1940; Loving 1942; Tarnutzer 1942; Hanson 1943a,b). Although those studies are useful, they have not lead to an understanding of cracker flour. A series of new studies on saltine crackers (Pizzinatto and Hoseney 1980a,b; Doescher and Hoseney 1985a,b; Rogers and Hoseney 1987, 1989) describes a laboratory scale test baking procedure, a method to produce a suitable inoculum for laboratory use, and a method to determine optimum absorption for cracker doughs; however, much remains to be understood. Creighton and Hoseney (1990) described a suitable technique to measure the physical properties of cracker doughs. However, it is lengthy because it requires producing a full-formula cracker dough. It was the purpose of this study to use this basic test but with a simpler system with fewer formula ingredients and less fermentation time. We also wanted to determine if such a procedure would be useful for evaluating cracker flours.

MATERIALS AND METHODS

Materials

Commercial cracker flours (Table I) were supplied by ConAgra Flour Milling Co., DCA Food Industries, Inc., Dixie-Portland

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Flour Mills, Inc., Mennel Milling Co., and Nabisco Brands, Inc. For flours C and D, I and II refer to two shipments. Flour X was a hard wheat flour milled at the Kansas State University pilot mill. Flours with the same letters were used in a previous study (Creighton and Hoseney 1990). Red Star compressed yeast was obtained from Universal Foods (Milwaukee, WI). Crisco hydrogenated vegetable shortening was used (Procter & Gamble, Cincinnati, OH). Salt and sodium bicarbonate were supplied by Nabisco Brands. All other chemicals were reagent grade.

Methods

Cracker-making procedures were as described previously (Creighton and Hoseney 1990). The physical properties of cracker doughs were measured using a Kramer shear cell (KSC) attachment (Kramer et al 1951) for the Instron universal testing machine as described by Creighton and Hoseney (1990).

KSC Straight Dough Procedure

The straight dough procedure was tested as a method to predict the baking quality of cracker flours in a shorter time than the KSC sponge and dough method (Creighton and Hoseney 1990) or a test bake procedure. It was hoped that by decreasing the pH of the dough to 3.9–4.0 with lactic acid, a relationship similar to that observed with the traditional sponge and dough procedure would be found. If true, the time savings would be substantial.

Dough batch size was based on 500 g (at 14% moisture). The only dough ingredients were flour, water, and lactic acid. Absorption for each flour was the optimum cracker absorption plus 9%. Sufficient lactic acid was added to give a dough pH of 3.8–4.0.

TABLE I
Analytical Data of Flours
(soft wheat except as indicated)

Flour	% Moisture	% Protein (14% mb)	% Ash (14% mb)
Commercial cracker flours			
C-I[a]	13.7	9.2	0.44
C-II[a]	13.5	9.3	0.46
D-I	13.4	8.6	0.43
D-II	13.4	8.5	0.44
E	13.4	8.7	0.50
F	12.2	9.3	0.42
G[b]	12.1	9.6	0.51
H	13.7	8.1	0.33
I	13.2	8.4	0.45
J	12.9	10.1	0.45
K	12.9	8.6	0.48
L	13.5	8.8	0.44
Hard wheat flour			
X	13.8	10.2	0.46

[a] Hard-soft wheat flour blends.

[b] Presumed to be a hard-soft wheat flour blend.

TABLE II
Summary of Kramer Shear Cell Straight Dough Procedure:
Product Stack Height and Weight

Flour	Stack[a] Height (mm)	SD	Stack[a] Weight (g)	SD
Soft wheat				
E	63.27	1.48	30.09	2.06
D-II	63.43	1.65	29.48	2.14
K	64.01	0.81	31.99	1.75
I	70.15	0.67	32.91	1.18
H	70.75	2.03	32.49	1.67
L	71.70	1.04	34.86	1.49
F	72.02	2.32	35.75	1.91
J	73.43	2.05	35.81	1.00
Hard wheat or blend				
G	69.69	0.56	33.41	0.82
C-I	69.44	1.35	34.15	1.21
C-II	71.39	0.87	30.94	1.31
X	78.09	1.67	37.95	1.23

[a] Stack of 10 crackers.

Sufficient lactic acid was added to the dough water, and the mixture was added to the flour in a mixing bowl. The dough was mixed for 3 min. The pH of the dough was measured, and the dough was held at 27°C.

Doughs were tested at various rest times between 0 and 13 hr. Sample pieces of approximately 170 g were sheeted to 4.8 ± 0.15 mm.

The sheeted dough was given a 3-min rest time and measured for thickness. A total of six sample pieces (2.9-mm diameter) was tested from each dough.

KSC Modified Straight Dough Procedure

Sponges made from flour (400 g, 14% moisture), water, and lactic acid were mixed for 3 min. As in the straight dough procedure, water absorption for each flour was the optimum cracker absorption plus 9%. Lactic acid was added to give a pH of 3.9–4.0. Sponges were held at 27°C for 10 hr. Total titratable acidity (TTA) was determined (Rogers and Hoseney 1987) to calculate the amount of soda required to neutralize the dough. One gram of soda was added to the dough from 400 g of flour for each milliliter of 0.10*N* NaOH needed to neutralize the 10-g sponge sample in the TTA procedure. This brought the pH of the mixed dough to pH 7.0–7.2. In addition, 1.8% salt (based on flour) was added to the sponge.

The sponge, soda, and salt were mixed for 1.5 min. Note that no additional flour was added. Approximately 170 g of dough was immediately sheeted to 4.8 ± 0.15 mm. The sheeted dough was rested for 3 min and then tested in the KSC.

TABLE III
Values for the Kramer Shear Cell Straight Dough Procedure and the Modified Procedure: 10-hr Shoulder Force

Flour	Modified Procedure Shoulder Force[a] (g)	SD	Straight Dough Shoulder Force[a] (g)	SD
E	1,735	121	1,173	45
D-II	2,081	44	1,163	294
K	2,087	25	1,509	225
I	2,627	27	1,716	331
L	2,880	122	1,922	401
F	3,052	156	2,083	365
H	3,058	513	1,851	539
J	3,267	267	2,922	174
C-II	3,425	32	4,765	1,013
G	3,648	398	3,168	215
X	4,622	427	6,520	796

[a] Average of at least two determinations.

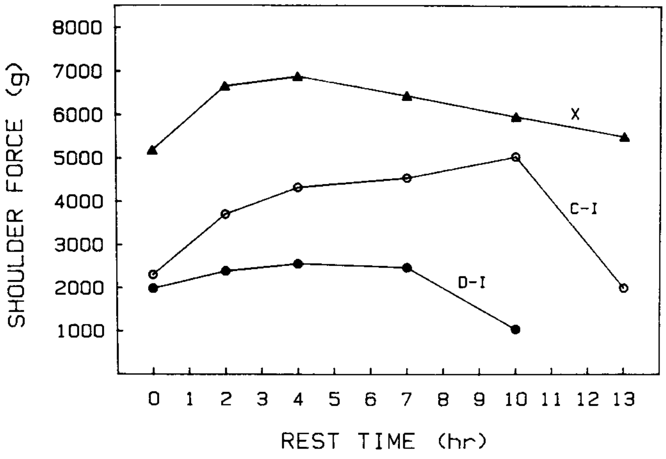

Fig. 1. Shoulder force as a function of rest time for the Kramer shear cell straight dough procedure.

RESULTS AND DISCUSSION

KSC Straight Dough Procedure

An increased absorption was needed to give a dough that could be sheeted and tested at 0 hr and showed the expected changes in shoulder forces in a reasonable time period (perhaps 8–12 hr). Optimum cracker absorption plus 9% proved to be satisfactory. Although slightly dry, doughs at this absorption level could be sheeted fairly easily at zero time.

When several commercial cracker flours were tested using this method, the shoulder force was often greater than the peak force. This was especially true for the C-I (soft/hard flour) and the X (hard flour) doughs. The D-I (soft flour) doughs gave low shoulder forces throughout (Fig. 1), and the force decreased at 7–10 hr of rest time. Dough from C-I flour gave shoulder forces that increased up to 10 hr, then showed a drastic decrease after 10 hr. The X hard flour dough, as was the case with the sponge and dough procedure (Creighton and Hoseney 1990), had the highest shoulder force values and did not show a large decrease after 7 or 10 hr as shown for the other flows.

The shoulder force at 10 hr of rest time was chosen for comparison of the different flours. Some of the soft wheat flour doughs showed decreases between 7 and 10 hr; these flours also gave low stack heights and weights (similar to D-I). Other flours, which gave greater product stack heights and weights, showed little decrease in shoulder force, so the value was still relatively high at 10 hr. A rest period of greater than 10 hr was unsatisfactory, because several of the flours (i.e., D-II, E) became very soft and sticky and could not be sheeted.

All doughs then were tested at a 10-hr rest time in at least two additional trials. Additional test bakes were performed to give at least a total of four replications (4 doughs × 2 cracker sheets per dough). Results of the bake tests are given in Table II, and 10-hr shoulder forces are given in Table III.

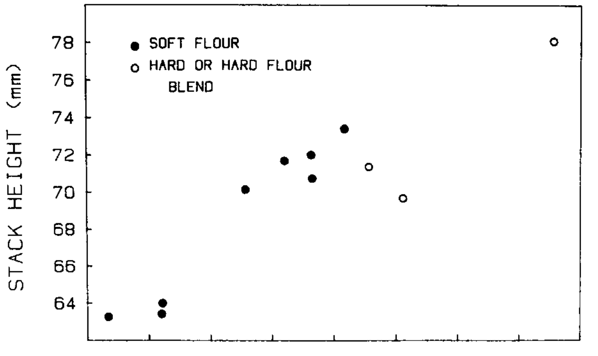

Fig. 2. Cracker stack height as a function of shoulder force determined by the modified Kramer shear cell procedure for soft wheat flours and hard or hard-soft wheat blends.

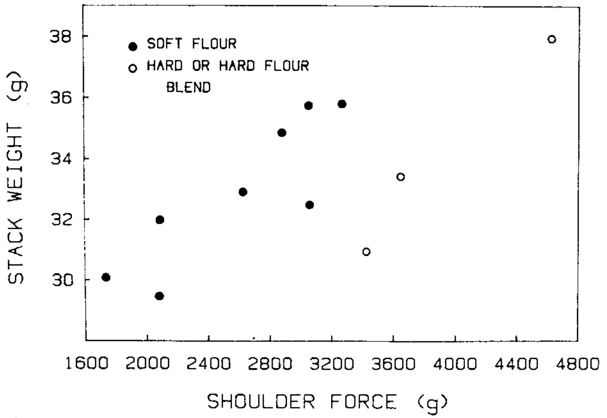

Fig. 3. Cracker stack weight as a function of shoulder force determined by the modified Kramer shear cell procedure for soft wheat flours and hard or hard-soft wheat blends.

Shoulder forces of the C-I and C-II soft/hard flour blends, the G flour, and the X hard flour shoulder forces obviously have a different relationship with the finished product characteristics (Tables II and III). Much greater shoulder forces were seen with these flours than with soft flours that gave similar product stack heights and weights. Thus, the hard flour in the blends had a greater effect on the KSC results than it did on finished product characteristics. This was also seen in the sponge and dough test results (Creighton and Hoseney 1990). The G flour dough gave a much higher shoulder force value than would be expected for a soft wheat flour, considering its product stack height and weight. It was concluded that this flour was probably a blend of soft and hard wheats. Correlation coefficients of the soft wheat flour doughs were 0.89 (significant at < 0.01) for shoulder force versus stack weight and 0.87 (significant at < 0.01) for shoulder force versus stack height. Thus, the shoulder force of the flour-water dough appears to be a useful indicator of cracker properties.

KSC Modified Straight Dough Procedure

A major problem associated with the straight dough procedure was the reproducibility of the 10-hr shoulder force. Another disadvantage was the stickiness of the dough, necessitating a tedious, time-consuming cleaning of the KSC between doughs.

The doughs in that procedure tested at about pH 3.9. Cracker dough is baked into crackers at a pH of 7.0–7.2 after neutralization with soda and after addition of salt. Thus, we theorized that if the acidified straight dough was first neutralized with soda and salt was added, perhaps the reproducibility would improve, as well as the correlation of shoulder force values with the finished product results. The disadvantages of this procedure, which was termed the modified straight dough procedure, would be that pH and TTA would have to be measured on a sponge sample, soda and salt added, and an additional mixing step performed.

Each of the flours then were tested using the modified procedure in at least two trials. The variability of shoulder force within a dough sheet was much lower, and reproducibility between doughs of the same flour was much improved over the straight dough procedure. The average shoulder forces of the doughs are given in Table III, and these values are compared with finished cracker stack height and weight in Figures 2 and 3. Correlation coefficients for the soft wheat flour samples were 0.97 (significant at < 0.001) for shoulder force versus stack height, and 0.87 (significant at < 0.01) for shoulder force versus stack weight. Thus, the shoulder force of the modified procedure appears to be a useful indicator of cracker properties.

An unexpected advantage of this procedure over the initial straight dough procedure was that the extensive clean-up of the KSC was not necessary for this test. After neutralization, the dough was still soft but was not as sticky as the acidified straight dough. Scraping remaining particles from the KSC with a thin metal spatula was all that was necessary. Thus, although pH and TTA measurements and dough mix were necessary, a modified straight dough test could be performed in approximately 35 min, as opposed to about 45 min for the unmodified straight dough procedure.

As with the straight dough test, the hard flour and blends of soft and hard flours gave higher shoulder force values than soft flour doughs of comparable stack height and weight.

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