Food Engineering Progress
Vol. 6, No. 2. pp. 201~207 (2002.5)

A Modified Procedure (One-stage Fermentation) for Evaluating Flour Cracker-making Potential

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Abstract

Cracker products are popular around the world, however there is no standard baking procedure for screening a flours potential for cracker-baking quality. Traditional published procedures involve two fermentation stages, making the evaluation of flour samples a time-consuming process. This study reports a modified procedure (one-stage fermentation) and compares it with a two-stage fermentation procedure for discriminating among flours for making crackers. A wide range of wheat flour samples (19) were used in this study and a set of cracker qualities identified (i.e., weight, moisture, dimension and texture). Results showed that both procedures could discriminate among flours for cracker-making quality. Though differences were found between the two procedures for some measured cracker quality parameters, similar trends among tested flour samples were observed. With one operator, about 15 flour samples could be evaluated for cracker-making potential in a 48 hr period using the modified procedure, as compared to about 6 samples in the same time period when using the two-stage fermentation procedure.

Key words: cracker-making, one-stage fermentation, cracker quality

INTRODUCTION

Snack crackers have become increasingly popular around the world. The largest portion of cracker production consists of the fermented crackers, such as saltine crackers (Lajoie *et al.*, 1994). Traditional fermented crackers are the product of two fermentation stages: sponge and dough (Doescher *et al.*, 1985). During the fermented sponge stage, 60-70% of the total flour, yeast, and water are mixed for 1 to 4 min and then fermented for 16 to 18 hr at 25-30°C and 70-90% relative humidity (Ranhotra *et al.*, 1988). During the fermented dough stage, the fermented sponge, the remaining flour and the other ingredients (e.g., shortening and salt) are mixed together for 3 to 7 min and allowed to ferment for another 6 hr (Creighton, *et al.*, 1990). The fermented dough is then put through a series of rolls to be formed into a continuous sheet of five to seven layers. This laminated sheet is then cut, docked, stamped, and baked (Pyler *et al.*, 1988).

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Although cracker products are popular around the world, a cracker making procedure has not been standardized because of the numerous setting conditions (e.g., temperature, humidity, mixing time, and sheeting number) and formulae (Lajoie *et al.*, 1994; Pyler *et al.*, 1988). This presents a challenge for the researcher attempting to evaluate wheat varieties for their cracker-making potential. In addition, traditional published procedures involve two fermentation stages, limiting the number of flour samples evaluable in a 48 hr period by one operator. The objectives of this study were (a) to develop a modified procedure (one-stage fermentation) enabling more samples be evaluated within a 48 hr period, (b) to compare it with a modified published two-stage procedure, and (c) to use the one-stage procedure for discriminating among flours for cracker-making potential.

MATERIALS AND METHODS

Cracker Ingredients

Nineteen wheat samples were selected for the present study. There were eight commercial flours: cake, cookie, cracker, bread, and hard red spring from Mennel Milling Co. (Fostoria, OH) in 1997; hard red winter, soft red winter, and a blend sample of the hard red winter and the soft red winter (1:1) both from King Milling Co. (Lowell, MI) in 1996; and 11 pure soft wheat cultivars harvested in 1993 from Michigan (Chelsea and Frankenmuth), Ohio (Caldwell, Clark, Dynasty, Excel, and Freedom,), and Washington (Hyak, Lewjain, Madsen, and Tres). These eleven wheat cultivars were tempered to 15% moisture overnight, and then milled on a Bühler experimental mill (Bühler Ltd., Uzwil, Switzerland) to 70% flour extraction. Other ingredients were active dry yeast (Red Star Yeast and Products, Milwaukee, WI), Crisco vegetable shortening (Procter & Gamble, Cincinnati, OH) made from partially hydrogenated vegetable oil, iodized salt (Meijer Inc., Grand Rapids, MI), baking soda (Arm & Hammer, Princeton, NJ), and distilled water.

Physicochemical Analyses of Wheat Flour Samples

Moisture, ash, protein, and optimal water absorption from farinographs of each flour sample were determined according to approved methods 44-15A, 08-01, 46-13, and 54-21 of AACC (American Association of Cereal Chemists, 2000), respectively.

Cracker Formula and Preparation

Figures 1 and 2 show the one-stage fermentation and the two-stage fermentation procedures, respectively, for making crackers. In the preliminary studies, the blend flour sample exhibited good potential for cracker making and the optimum amount of water used for making cracker dough from this flour sample was 29%. Thus, the amount of water added to each tested flour was adjusted as follows based on the blend flour sample:

$$\% \text{ water added} = [29\% \times 100 \text{ g of tested flour} \times (100-14)/(100-A)] \times B/C$$

Where A=moisture content of the tested flour
B=optimal farinograph water absorption of blend flour sample
C=optimal farinograph water absorption of flour being tested for cracker making

Cracker Dough Sheeting and Baking

After fermentation (Figures 1 and 2), the dough was flattened by hand to give a uniform piece of dough (7.4 cm diameter×2.3 cm thickness). The dough was then passed through seven different openings of the sheeter (15.91, 12.30, 9.50, 5.65, 2.88, 1.27, and 1.04 mm). The cracker dough was passed through the first four gaps three times each. After the first passage through the 2.88 and 1.27 mm gaps, the dough was folded onto itself once and passed through the same sheeter opening; this was repeated twice for a total of three passes through each of the two gaps. The dough was sheeted three more times through the final sheeter opening without folding.

After the dough had been sheeted, it was cut with a hand-cutter-docker (21 cells of 5.08×5.56 cm), placed on a rectangular rack (40.01×21.59 cm), and then baked at 265°C for 4 min 10 sec in a rotary oven (National MFG Co., Lincoln, NE). Baked cracker sheets were allowed to cool for 30 min and broken into individual crackers.

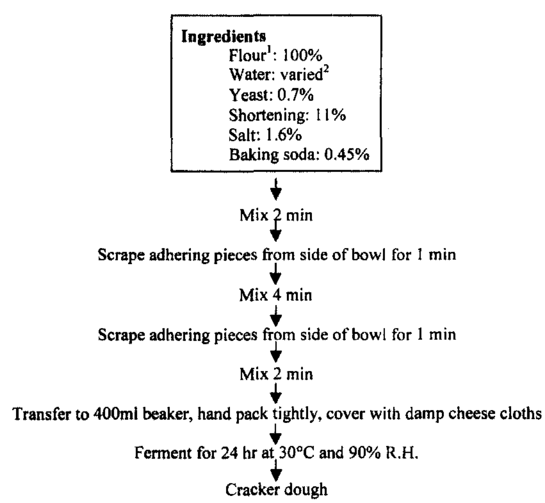

Fig. 1 One-Stage Fermentation Procedure for Making Crackers.

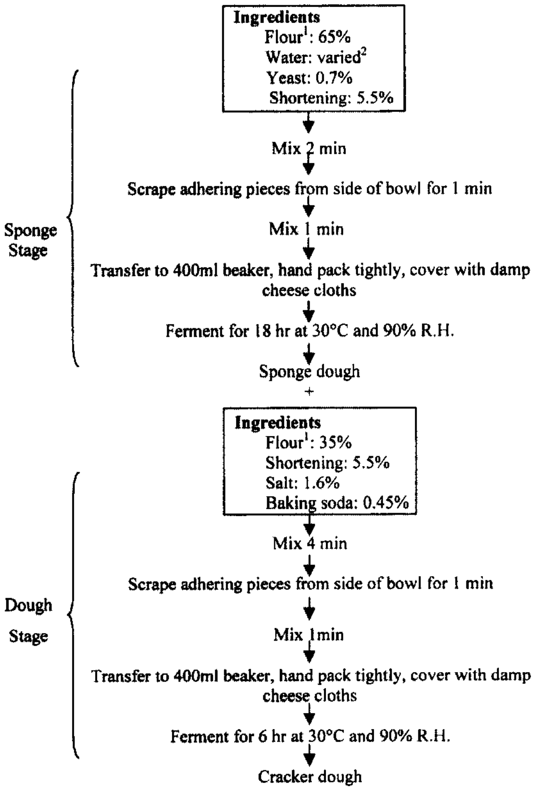

Fig. 2. Two-Stage Fermentation Procedure for Making Crackers[3].

Cracker Quality Analysis

Two commercial saltine crackers (unsalted tops), Meijer Inc. (Grand Rapids, MI) and Nabisco (East Hanover, NJ), were used as references.

Physical Measurements

Weight, length, width, thickness, and volume of crackers were chosen as parameters for evaluating the cracker quality. Length, width, and thickness of each cracker were measured using a vernier caliper manufactured by Glogau & Co. (Germany). Volume was determined by putting an individual cracker into a known-volume container (110 cc) and using rape seeds to measure cracker volume by displacement.

Moisture Measurement

Individual crackers were crushed using a mortar and pestle in a temperature and humidity controlled room and the moisture content of each crushed cracker was immediately determined according to AACC Method 44-15A (American Association of Cereal Chemists, 2000).

Texture Analysis

The TA.XT2 Texture Analyzer (Texture Technologies Corp., Scarsdale, NY) was used to evaluate the texture of baked crackers. The peak breaking force (Newtons) of the center part of each cracker was obtained using a 3 mm diameter Warner Bratzler probe at a speed of 2 mm/s with the proprietary software.

Statistics

All experiments were conducted at least four times. Data were analyzed by the one-way analysis of variance (ANOVA) procedure using the Statistical Analysis System version 6.12 (SAS Institute, Cary, NC). Significance was defined at the 5% level.

RESULTS AND DISCUSSION

Table 1 summarizes the results of the physicochemical analyses. It can be seen that there was a wide range of flour protein contents and water absorption values for the chosen flour samples. Thus, the samples should be a good set with which to validate the utility of a proposed cracker-making procedure for discrimination of various cracker qualities.

Comparison of the Two Procedures

Five commercial flours (i.e., bread, hard red spring, cracker, cookie, and cake flours) with different flour properties based on farinograph results (data not shown) were used to compare one-stage and two-stage fermetation procedures. Among these five flour samples, bread and hard red spring flours could not be made into crackers using the one-stage fermentation procedure because the resultant cracker doughs were too dry. These two flours could be formed into crackers using the two-stage fermentation procedure, however, they baked incompletely and had higher weight, moisture content, thickness, and volume, resulting in low crispiness. Therefore, results of these two flour samples are not included in Table 2, which lists the quality parameters of

Table 1. Physicochemical Properties of Wheat Flours

Flour Sample[1]	Moisture (%)	Ash (%, db)	Protein (%, db)	Water Absorption (%, db)
Bread	11.3	0.33	10.2	60.9
Hard Red Winter	12.7	0.51	11.7	62.5
Hard Red Spring	13.2	0.39	12.5	64.6
Blend[2]	12.4	0.50	10.6	59.5
Dynasty	12.1	0.46	7.4	55.7
Clark	11.9	0.50	8.2	59.1
Cracker	13.4	0.25	7.6	51.9
Madsen	11.2	0.43	8.7	64.7
Soft Red Winter	12.0	0.47	9.7	56.3
Cookie	11.6	0.32	7.4	53.7
Lewjain	12.4	0.36	8.2	58.0
Freedom	11.9	0.40	7.2	56.6
Hyak	12.5	0.32	6.3	57.8
Caldwell	11.8	0.33	7.6	56.0
Cake	12.1	0.31	6.8	53.2
Chelsea	10.8	0.49	7.2	56.6
Frankenmuth	11.9	0.50	6.4	53.1
Excel	11.4	0.43	7.6	55.6
Tres	11.2	0.47	8.5	58.6

[1]Samples are ranked from the strongest to the weakest flours based on farinograph results.
[2]Blend of soft red winter and hard red winter (1:1).

baked crackers made with one-stage and two-stage fermentation procedures. It ap-peared that each of the procedure could differentiate flour samples on the basis of cracker qualities (i.e., weight, moisture, length, width, thickness, volume, and peak breaking force). Moreover, both procedures exhi-bited similar trends in quality parameters among the flour samples studied. It was obvious that crackers made with the one-stage fermentation procedure had higher values for weight, moisture content, thickness, volume and peak breaking force; however, there were no significant differences in length and width of crackers from the two different procedures made with the same flour.

When the operator handled the cracker doughs made with both types of procedures, it was found that the cracker dough made with the two-stage fermentation procedure was softer than that made with the one-stage fermentation procedure. This could be due to different amounts of CO_2 generated during fermentation using these two procedures. The amount of CO_2 can affect the density of a dough (Rogers *et al.*, 1989); the more CO_2 present in a dough, the lower the density of the dough. The lower density of a cracker dough could permit faster evaporation during baking and subsequently lower cracker weight and moisture content (Rogers *et al.*, 1989; Pizzinatto *et al.*, 1980). This was also reflected in our findings (Table 2).

The thickness, volume, and peak breaking force are related to the strength of a dough (Rogers *et al.*, 1989; Pizzinatto *et al.*, 1980). The stronger (or harder) doughs generally produced thicker, bigger, and harder crackers than the weaker (or softer) doughs. It was observed that cracker dough made with the two-stage fermentation procedure was softer than that made with the one-stage

Table 2. Cracker quality by comparison of two different cracker-making procedures (One-Stage and Two-Stage)[1]

Flour Sample[2]	Weight (g)	Moisture (%)	Length (cm)	Width (cm)	Thickness (cm)	Volume (cc)	Peak Breaking Force (N)[3]
One Stage							
Cracker flour	3.26b±0.12	4.80c±0.24	5.44ab±0.04	5.02a±0.04	0.49a±0.01	18.0a±0.5	10.4a±1.4
Cookie flour	3.73a±0.07	7.21a±0.37	5.41bc±0.12	4.97bc±0.07	0.45b±0.02	18.5a±0.5	9.3b±1.2
Cake flour	3.65a±0.06	6.01b±0.29	5.35cd±0.07	4.87d±0.05	0.41c±0.02	16.3b±0.5	10.1a±1.0
Two Stage							
Cracker flour	2.64d±0.13	1.81e±0.04	5.41bc±0.05	5.02a±0.03	0.37d±0.02	16.0b±0.5	8.9b±0.9
Cookie flour	2.87c±0.12	2.91d±0.07	5.40bc±0.06	5.00ab±0.04	0.33e±0.02	16.0b±0.9	6.1c±0.6
Cake flour	2.68d±0.07	1.45f±0.03	5.33d±0.06	4.87d±0.04	0.28f±0.03	14.3c±0.5	6.4c±0.5

[1]Values in the table are: means ± standard deviation. Different letters within the same column designate significant differences among the samples at α=0.05.
[2]Samples are ranked from the strongest to the weakest flours based on farinograph results.
[3]From texture analyses of the crackers. N = Newtons.

Table 3. Cracker quality using a one-stage fermentation procedure[1]

Cracker Sample[2]	Weight (g)	Moisture (%)	Length (cm)	Width (cm)	Thickness (cm)	Volume (cc)	Peak Breaking Force (N)[3]
Blend[4]	3.59ef±0.11	5.19h±0.23	5.37ef±0.07	4.77i±0.03	0.52ab±0.01	19.6d±0.5	11.9c±2.0
Dynasty	3.53fg±0.11	6.30ef±0.29	5.45a±0.11	4.97bc±0.04	0.52ab±0.03	20.2c±0.4	7.5jk±0.9
Clark	3.72cd±0.14	7.59c±0.32	5.43abcd±0.09	4.92def±0.03	0.54a±0.02	20.7b±0.5	9.3fg±0.8
Cracker	3.26j±0.12	4.80ij±0.24	5.44ab±0.04	5.02a±0.04	0.49cde±0.01	18.0g±0.5	10.4d±1.4
Soft Red Winter	3.46gh±0.08	4.58j±0.03	5.40cde±0.07	4.92cdef±0.06	0.46fg±0.02	17.0h±0.8	6.4l±0.6
Cookie	3.73c±0.07	7.21d±0.37	5.41bcd±0.12	4.97bcd±0.07	0.45g±0.02	18.5ef±0.5	9.3fg±1.2
Lewjain	4.02b±0.15	9.17a±0.58	5.43abc±0.07	4.85h±0.02	0.48cdef±0.03	20.4bc±0.9	9.0gh±1.0
Freedom	3.63e±0.10	7.35cd±0.36	5.35f±0.06	4.88fgh±0.04	0.50bc±0.03	20.7b±0.5	7.9ij±0.6
Hyak	4.02b±0.18	7.58c±0.36	5.40de±0.06	4.79i±0.04	0.52ab±0.02	19.3d±0.5	8.8gh±0.9
Caldwell	3.63e±0.10	6.54e±0.28	5.41bcd±0.12	4.93cdef±0.03	0.52ab±0.03	18.6e±0.9	9.8ef±1.3
Cake	3.65de±0.06	6.01fg±0.29	5.35ef±0.07	4.87gh±0.05	0.41h±0.02	16.3i±0.5	10.1de±1.0
Chelsea	4.22a±0.14	8.64b±0.48	5.40cde±0.09	4.84h±0.02	0.48def±0.01	21.3a±1.0	8.4hi±1.1
Frankenmuth	3.37i±0.08	6.37e±0.23	5.44ab±0.07	4.93cde±0.02	0.40h±0.03	18.0g±0.9	6.2l±0.7
Excel	3.47gh±0.10	5.71g±0.33	5.38ef±0.06	5.01ab±0.03	0.45g±0.02	19.2d±0.4	6.8kl±0.8
Tres	3.40hi±0.08	4.16k±0.22	5.36f±0.09	4.91efg±0.01	0.47efg±0.02	18.5ef±0.6	9.1fg±1.1
Nabisco	3.01k±0.02	4.58j±0.14	5.07h±0.04	4.87gh±0.04	0.52ab±0.03	18.3efg±0.5	14.5a±1.6
Meijer	2.86l±0.02	5.10hi±0.16	5.13g±0.04	4.93cdef±0.04	0.48cdef±0.03	18.0fg±0.0	13.1b±2.4

[1]Values in the table are: means±standard deviation. Different letters within the same column designate significant differences among the samples at α=0.05.
[2]Ranked according to farinograph dough strength results; Nabisco and Meijer are brand name commercial crackers used for comparison.
[3]From texture analyses of the crackers. N=Newtons.
[4]Blend of soft red winter and hard red winter (1:1).

fermentation procedure, and that the baked crackers made with two-stage fermentation had lower values of thickness, volume, and peak breaking force.

It should be noted that the one-stage fermentation procedure was simple and allowed 15 flour samples to be evaluated in a 48 hr period by one operator, as compared to six flour samples in the same time period when using the two-stage fermentation procedure. In addition, both procedures could distinguish cracker quality, and results demonstrated similar trends for the different flour samples examined. Accordingly, the one-stage fermentation procedure was further evaluated with a larger set of flour samples.

Differentiation of Cracker Quality by the One-Stage Fermentation Procedure

Among the 19 flour samples, bread, hard red winter, hard red spring, and cv. Madsen could not be made into crackers using the one-stage fermentation procedure. These were strong flours with high water absorption (Table 1), and the resultant cracker doughs were too dry to process. Therefore, the following results do not include these four flour samples. Quality parameters of baked crackers are listed in Table 3. Data are ranked from the strongest to the weakest doughs based on farinograph results (data not shown). It appeared that the one-stage fermentation procedure could significantly differentiate baked cracker qualities (e.g., weight, moisture, length, width, thickness, volume, and peak breaking force) among the different flour samples. Baked cracker weight varied from 3.26 g for those made from cracker flour to 4.22 g for those from cv. Chelsea flour. In general, the heavier the baked cracker, the higher the moisture content. The moisture contents of baked crackers from blend, cracker, and soft red winter flours and of commercial crackers were not significantly different (Table 3).

The size of each cracker was 5.56 cm long and 5.08 cm wide after cutting the dough sheet but prior to baking. However, after baking, the length and width of crackers had decreased 1.9-3.8% and 1.2-6.1%, respectively, due to contraction of the cracker dough (Pizzinatto *et al.*, 1980). Stronger flours (e.g., blend flour) resulted in greater contraction. These observations are in general agreement with previously published reports (Creighton *et al.*, 1990; Levine, *et al.*, 1994).

The thickness of crackers after baking ranged from 0.40 to 0.54 cm. Crackers made from blend, and cvs. Dynasty, Clark, Hyak, and Caldwell flour samples were the thickest, whereas those made from cv. Frankenmuth sample were the thinnest. The thickness of the baked crackers appears to correlate with the dough strength of the flours studied. Similar findings were also obtained by (Pizzinatto *et al.*, 1980; Rogers *et al.*, 1994).

The volume of baked crackers varied from 16.3 to 21.3 cc. It was assumed that there would be a relationship between the thickness and volume. However, some thinner baked crackers did not exhibit smaller volumes due to their smaller degree of shrinkage and the presence of blisters on the top surface of the baked cracker. Based on the volume, the crackers made cv. Caldwell, cv. Frankenmuth, and cv. Tres flour samples could produce crackers most similar to commercial crackers.

The peak breaking forces measured by texture analysis were significantly different (6.2-11.9 N) among baked crackers. Baked crackers made from blend, cracker, and cake flour samples had the highest peak breaking forces, and those from soft red winter, cv. Frankenmuth and cv. Excel samples had the lowest. Baked crackers made from stronger flours (e.g., blend flour) had higher peak breaking forces than those from weaker flours (e.g., cv. Frankenmuth flour). Overall, it appeared that the cracker flour sample could be used to make the best quality of crackers, as compared to commercial crackers.

SUMMARY

This study demonstrated that both one-stage and two-stage cracker-making procedures could be used to distinguish differences among flours for cracker-making potential, and yielded similar trends in their results of measured cracker qualities (i.e., weight, moisture, length, width, thickness, volume, and peak breaking force). Using the one-stage fermentation procedure, the cracker flour sample could produce crackers most similar to commercial crackers for the measured quality parameters. The one-stage procedure has the potential to be successfully used for screening flours for cracker-baking quality, with an operator efficiency factor of 2.5 times more than the two-stage procedure.

ACKNOWLEDGEMENTS

We gratefully acknowledge the partial financial support from the Michigan Agricultural Experiment Station for this research.

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