Effects of Flour Type and Dough Retardation Time on the Sensory Characteristics of Pizza Crust[1]

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ABSTRACT

Pizza doughs were prepared with two commercially available flours: a hard spring wheat blend (13.95% protein) and a hard winter wheat blend (11.2% protein). A standardized formula and lab-scale production method were used. Doughs were retarded at 2–3°C for periods ranging from one to seven days before being processed into pizzas. Trained sensory panelists evaluated freshly baked pizzas to determine the effects of flour and retardation time on crust textural attributes. Statistical analysis of the resulting data indicated that the flour type used in crust production had no significant effect on the sensory attributes under scrutiny. However, dough retardation time had significant effects on several sensory characteristics, including pullapart, crispness, denseness, and cohesiveness.

Pizza, both fresh and frozen, is becoming a significant portion of American diets. The crust constitutes a significant fraction of the product. Its appearance, taste, and, most importantly, texture are important factors for product identification and consumer acceptance. However, because the surge in its popularity has been relatively recent, compared to other baked products, pizza crust quality remains a less researched area. Thus, in industrial production, it has been observed that pizza crust will differ in quality from day to day, even though produced by the same method (M. Morad, *personal communication*). Although this has been attributed to either uncontrolled changes in the flours used in the formulation or the processing steps used in crust production, the ultimate explanation remains unclear.

Flour is the principal ingredient of the crust. Hard red spring wheat flour is the flour of choice in most commercial operations (M. Morad, *personal communication*) because of a belief that it has superior baking quality (final product quality). However, this belief is based on empirical observations of differences in the properties of the pizza crusts. There is no information available stating that the flours result in differences in the ultimate end use or in the eating quality of the pizza crust.

In the production of some bread and pizza crusts, refrigerated storage (retardation) of yeasted doughs (rather than freezing) is used to slow intermediate proofing. In the case of commercial production of pizza crusts, the process has been adopted to facilitate shipping of the intermediate product.

At present, minimal information is available on the effects of flour type and retardation time on the quality of pizza crusts. Likewise, given the importance most pizza processors and consumers place on the sensory attributes of the crust, it is surprising that there is no quantitative data available on the sensory attributes of the crust. Therefore, the objectives of this study were to quantitate changes in pizza crust texture by using sensory methods and to examine how these attributes were affected by two factors: flour type and dough retardation time.

MATERIALS AND METHODS

Pizza Preparation

Two commercially available, hard wheat flours previously found (V. Proctor, J. M. Faubion, and J. G. Ponte, *unpublished*) to produce pizza crusts significantly different in crust volume, percent lift, and bubble area were used for all experiments. The first flour was a blend of hard red spring flours of 13.95% protein (N × 5.7) and 13.0% moisture. The second was a blend of hard red winter flours of 11.2% protein (N × 5.7) and 12.1% moisture. Because protein quantity and quality were confounded in flour type, the flours will be referred to as *spring* and *winter*, respectively.

Thin, bread-type pizza crusts were produced using the standardized, lab-scale production method (V. Proctor, J. M. Faubion, and J. G. Ponte, *unpublished*). The ingredients in the dough formula (flour weight basis) were: flour, 500 g (100%); sugar (1.25%); salt (1.25%); shortening (1.50%); and active dry yeast (0.25%). Formula water was added at a 54% (flour weight basis) for spring wheat flour and 51% (flour weight basis) for winter wheat flour, the optimum as determined with the mixograph.

Formula ingredients were premixed in a 1,000-g mixer (A200, Hobart Mfg., Troy, OH) at speed 1 for 1 min. The formula water was added, and the dough was mixed to optimum in two stages: 5 min at speed 1 and 4 min at speed 2.

The mixed dough was divided into two 242-g pieces, hand-rounded, bagged, and retarded in a walk-in cooler at 2–3°C for one, three, five, or seven days. Two days of retardation is the length of time desired for shipping the intermediate dough product. Therefore, we employed a spring wheat flour dough with two days of retardation (equivalent to commercial production practice) as the control sample for all experiments.

After retardation, the dough ball, taken directly from the cooler, was sheeted to 1.6 mm (Anets Sheeter, Anetsberger Bros., Northbrook, IL) in two stages. Stage 1 reduced dough thickness to 3.2 mm and stage 2 to 1.6 mm. A round pizza cutter was used to cut the dough into a standard 23-cm circle. Sheeted doughs were proofed in a temperature- and humidity-controlled proof box (97°C, 90–95% rh) for 30 min. The surface of the proofed doughs was covered with 63 cc of commercially prepared tomato sauce and 68 g of mozzarella cheese (Dillon's Inc., Hutchinson, KS). The dough samples were baked at 540°F for 8 min on metal screens (Despatch Oven Co., Minneapolis, MN).

Sensory Evaluation

After the baked pizzas were removed from the oven, the sauce and cheese topping were removed, and the crust was cut into 1-in. squares (requiring 15–20 min). The squares were placed in warmed ceramic dishes and served to panelists. Panelists evaluated the inner portion (i.e., the area previously covered by sauce) and the outer portions of the crust separately. Because dynamic changes occur in the textural properties of baked products directly out of the oven, preliminary testing of pizza crusts at a variety of holding times was conducted. Changes stabilized after 15–20 min out of the oven, and panelist evaluation after this holding period reflected the true differences in the crust textural attributes.

A professional, seven-member panel that had been trained in texture evaluation at the Sensory Analysis Center, Kansas State University, evaluated the baked crusts. Panelists were trained according to the principles and practices of the texture profile method of Brandt et al (1963). Panelists were oriented for the

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evaluation of selected pizza crust attributes during five 1-hr sessions. During orientation, panelists discussed the project objectives, determined the definitions and evaluation techniques for selected textural attributes as found in pizza crusts, and became familiar with the texture reference scales developed for pizza crusts under standardized testing conditions.

A generic descriptive scaling method of selected textural attributes (Einstein 1991) was employed to investigate pizza crust texture. Terms deemed appropriate by the panelists and experimenter for description of textural attributes of crusts were determined (Table I). After determining the characteristics in the crust, the panel considered the level at which each characteristic was perceived. Scales developed in previous studies (Szczesniak et al 1963, Civille and Liska 1975, Munoz 1986) were used. Points were indicated on each of the scales for a control sample (spring wheat flour dough with two days of retardation) and two reference products: English muffin (Wonder brand, Continental Baking Co., St. Louis, MO) and bread stick (Pepperidge Farm Italian, Pepperidge Farm, Norwalk, CT). Descriptors and techniques for the evaluation of these baked goods were specific, as stressed by Hansen and Setser (1990). Reference and control samples were provided for the panelists at each session. The control sample placement on the numerical scale for each attribute was indicated by the letter C. Appropriate reference samples were placed on the scale as well (Table I).

Analysis was completed in eight 1-hr sessions. Three randomly selected samples plus a control were evaluated during each session. Panelists required 15 min to complete evaluations of all selected textural attributes for the inner and outer crust of each sample.

Score Sheets

The panel's score sheets consisted of a nine-point category scale for: pullapart (for inner crust only), deformation (inner crust only), crispness-fracturability (outer crust only), firmness, deneseness, cohesiveness of mass, moisture absorption, and chewiness. A vertical mark indicated the panelist's perception of the intensity of the attribute in question, ranging from 0 (none) through 9 (strong).

Statistical Analyses

A split-plot experimental design was used for the study, and a general linear model procedure was performed on the data collected. The experimental design's eight treatments were repeated each three times. Four retardation times (one, three, five, and seven days) were specified as the whole plot treatments. Each whole plot was divided into two subplots, and one flour (spring or winter) was assigned to each. Two treatments were run on each of four days (blocks). Statistical analyses were performed using the Statistical Analytical Software package (SAS Institute, Cary, NC). Standard errors were calculated using type III mean square for replication × flour type × retardation time as an error term.

TABLE I
Terms for Selected Textural Attributes of Pizza Crusts

Textural Attribute	Definition	Value Scale[a]		
		English Muffin	Bread Stick	Control[b]
Firmness	Force to close molars	. . .	7	7
Crispness-Fracturability	Force and noise with which surface ruptures	. . .	7	7
Denseness	Degree of compactness of cells	4	2	6
Cohesiveness of mass	Degree to which mass holds together	8	5.5	. . .
Moisture absorption	Amount of saliva absorbed by sample	5	. . .	5
Chewiness	Force and time to reduce sample for swallowing	8	5	5.5
Pullapart	Force to separate sample with teeth and fingers	3	. . .	5
Deformation	Amount of change from original form	7	. . .	6

[a]0 = none, 9 = strong.
[b]Spring wheat flour pizza crust with two days of retardation.

TABLE II
F-Values and Probabilities for Sensory Attributes (Inner Crust)[a]

Source	df	Pullapart		Firmness		Deformation		Denseness		Cohesiveness		Moisture Absorption		Chewiness	
		F-Value	$P>F$	F-Value	$P>F$	F-Value	$P>F$	F-Value	$P>F$	F-Value	$P>F$	F-Value	$P>F$	F-Value	$P>F$
Flour (F)	1	0.13	0.7273	0.42	0.5284	0.10	0.7529	0.54	0.4741	0.05	0.8184	0.87	0.3656	1.65	0.2198
Time (T)	3	6.03	0.0074	2.36	0.1152	2.24	0.1287	0.29	0.8297	0.30	0.8247	0.86	0.4860	1.04	0.4058
F × T	3	0.18	0.9060	0.57	0.6437	1.40	0.2855	0.29	0.8346	0.28	0.8383	0.87	0.4775	0.17	0.9147
Panelist (P)	6	6.24	0.0001	7.85	0.0001	6.64	0.0001	9.58	0.0001	1.11	0.3647	2.97	0.0110	1.41	0.2198
P × F	6	0.76	0.6010	0.78	0.5909	1.62	0.1522	1.47	0.1979	0.88	0.5117	1.11	0.3618	0.64	0.7005
P × T	6	0.58	0.9069	0.71	0.7912	1.29	0.2167	1.09	0.3726	1.15	0.3199	0.79	0.7044	0.82	0.6705
P × F × T	18	0.85	0.6344	0.40	0.9842	0.65	0.8511	1.22	0.2607	0.78	0.7189	0.51	0.9490	1.11	0.3609

[a]General linear model procedure for split-plot experimental design.

TABLE III
F-Values and Probabilities for Sensory Attributes (Outer Crust)[a]

Source	df	Firmness		Crispness		Denseness		Cohesiveness		Moisture Absorption		Chewiness	
		F-Value	$P>F$	F-Value	$P>F$	F-Value	$P>F$	F-Value	$P>F$	F-Value	$P>F$	F-Value	$P>F$
Flour (F)	1	1.23	0.2866	1.61	0.2249	0.44	0.5199	1.58	0.2289	1.53	0.2365	0.47	0.5048
Time (T)	3	2.44	0.1078	5.40	0.0111	4.99	0.0147	3.36	0.0494	1.31	0.3107	0.73	0.5536
F × T	3	0.34	0.7934	0.77	0.5307	1.83	0.1874	2.84	0.0759	1.53	0.2510	0.56	0.6473
Panelist (P)	6	4.43	0.0006	4.76	0.0003	17.27	0.0001	2.69	0.0194	9.76	0.0001	3.70	0.0026
P × F	6	1.00	0.4277	0.58	0.7449	0.68	0.6694	1.81	0.1068	2.29	0.0426	1.03	0.4126
P × T	6	0.83	0.6593	1.28	0.2215	1.39	0.1550	1.38	0.1617	0.77	0.7240	1.37	0.1670
P × F × T	18	0.73	0.7758	0.99	0.4772	1.16	0.3092	1.21	0.2697	0.83	0.6614	0.91	0.5641

[a]General linear model procedure for split plot experimental design.

RESULTS AND DISCUSSION

Significant treatment effects for flour type, retardation time, and interactions are reported in Tables II and III. Panelist and panelist × treatment interaction effects were examined to determine the quality of the data. The panelist × treatment interactions for all but one of the textural attributes were nonsignificant. Significant panelist effects indicated some differences in the portion of the nine-point category scale being used, which are of no concern when panelist × treatment interactions are not found (Meilgaard et al 1991). This indicates that the panelists were in agreement and that the panel was well-trained.

In the present study, panelist × flour interactions existed only for perceptions of moisture absorption of the outer crust (Table III). This interaction could have resulted from differences in the salivary flows of the individual panelists (Bramesco and Setser 1990). The overall effect of flour type or retardation time makes it difficult to ascertain with certainty whether this type of interaction exists; the pattern of differences depends on the panelists. However, the *F*-value for moisture absorption of the outer crust ($F = 2.29$) was below 3.0. Therefore, the statistical significance of this interaction was probably of limited practical importance (D. Johnson, *personal communication*).

Comparing Spring and Winter Wheat Flour Doughs

Statistical analyses comparing the data from spring and winter wheat flour doughs failed to reveal any significant differences in the selected textural attributes (Tables II and III). Both Larmour (1941) and Finney and Barmore (1948) determined that spring and winter wheat flours were equal in intrinsic breadbaking quality when protein content and quality were equal. However, differences were observed in physical measurements of pizza crusts prepared from spring and winter flours after two days of dough retardation (V. Proctor, J. M. Faubion, and J. G. Ponte, *unpublished*). Specifically, crust weight, specific volume, and specific lift were higher in spring doughs than in winter doughs. Although quantitative differences existed in that study, according to the panelists evaluating the eating quality of the pizza crusts in the present study, the sensory properties between the same two flours did not differ. This suggests that physical differences may not be pertinent to the sensory eating quality of the pizza crusts.

Retardation Time

Differences in selected textural attributes of the baked crusts (Fig. 1) were related to increased dough retardation time. Statistical data for the attributes that were significantly different are presented in Tables II and III.

Figure 1A presents the sensory scores for outer crust denseness of the four dough retardation times. Three days retardation resulted in crusts significantly denser than those with one day retardation. Changes in denseness after three days were inconsistent, and differences were not significant.

Figure 1B shows the sensory scores for crispness of the outer crust. Changes in the crispness of the pizza crusts were not significant from one to three days of retardation. However, crispness of the pizza crusts increased significantly after five days of retardation.

The sensory scores for outer crust cohesiveness of mass are presented in Figure 1C. The *F* value for outer crust cohesiveness ($F = 3.36$; $P = 0.0494$) indicates the existence of significant differences because of dough retardation time (Table III). However, a flour type × retardation time interaction was noted ($P = 0.0759$). Although the *F* value was less than 3.0 ($F = 2.84$), some involvement of interactions seem likely.

Figure 1D shows the sensory scores for inner crust pullapart. Pullapart was not significantly different when pizza crusts were consumed after one and three days of retardation. This attribute increased significantly in the pizza crusts after five and seven days of retardation.

In a study of pizza crust quality (V. Proctor, J. M. Faubion, and J. G. Ponte, *unpublished*) it was determined that pizza crust weight, percent lift, and crust volume from spring and winter flours decreased as a function of retardation time. In the present study, such changes could have produced the changes in the crumb grain and texture of the crust perceived as differences in pullapart and denseness.

Differences in pullapart of the inner crust may also have been affected by the physical changes occurring in the outermost (bottom) surface of the crust. During baking, the bottom crust surface is in contact with the pizza screen, and the rate of heat transfer results in a higher degree of moisture loss from the bottom surface. This might result in more force needed to separate a bite from the pizza crust, which would reflect a drier and harder bottom crust. Decreased pizza crust lift and volume might also result in a perceived increase in crust denseness.

Excluding pullapart, no other significant differences were observed for attributes of the inner crust (Tables II and III). Although this was somewhat surprising, initially, it is reasonable to speculate that moisture migration from the pizza sauce to the inner crust during baking has altered some of the crust textural attributes.

SUMMARY AND CONCLUSIONS

Results of this study indicate that differences in the sensory textural properties of pizza crusts were related to the length of dough retardation time. The amount of time the dough was retarded before fabrication and baking had significant effects on denseness, cohesiveness, crispness, and pullapart. Wheat flours, which previously produced pizza crusts of differing physical quality, had no measurable effects on the sensory-textural properties of pizza as eaten. This suggests that physical differences may not be pertinent to the ultimate end use (eating quality of the pizza crusts). The results confirm that processors need to take into account the processing (storage) steps for dough before baking as factors affecting the textural attributes of the crust as it is consumed in the finished pizza.

Although the differences in some of the textural attributes determined by the panelists were statistically significant, it is an open question as to whether or not they are of practical significance when considering consumer acceptance of a baked pizza crust produced from retarded dough. For example, significantly different panelist scores for pullapart (Figure 1D) ranged from 4.5 to 5.8, a relatively narrow range. The panel used in this study was highly trained and sensitive to differences in the product

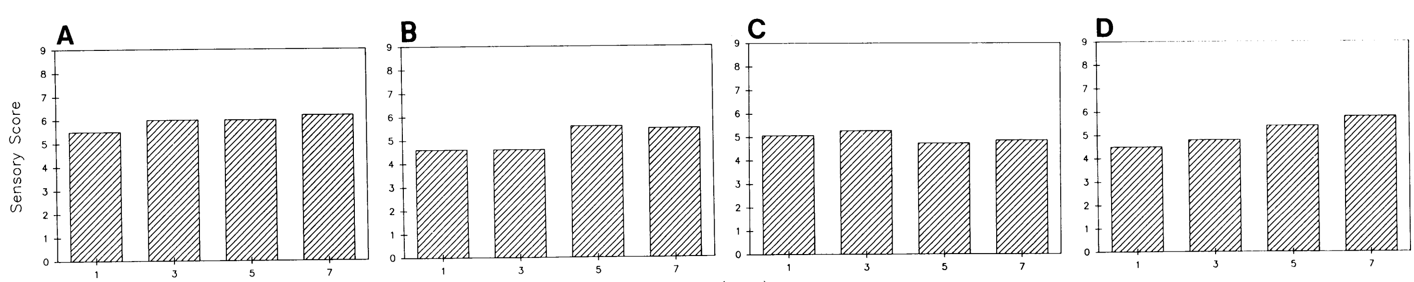

Fig. 1. Effect of retardation time on mean sensory score of selected textural attributes of pizza crust. **A,** denseness (outer crust); **B,** crispness (outer crust); **C,** cohesiveness of mass (outer crust); **D,** pullapart (inner crust). Standard error ranges were 0.19–0.20, 0.30–0.31, 0.18–0.19, and 0.35–0.36, respectively.

that consumers might not detect. Consumers are not highly trained professional panelists, and they might or might not be discriminating at this level. On the other hand, if a highly trained sensory panel did not find differences in some textural attributes of the pizza crust, it is not likely that consumers will detect differences. Further studies to determine how the untrained consumer perceives the differences in these textural attributes could serve as a guide to setting product specifications for consumer acceptability for these attributes in commercially produced pizza crusts.

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