Firming Effects in Danish Pastry[1]

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ABSTRACT

The effects of fat, sucrose, water, two surfactants, an α-amylase enzyme, and a fat replacer roll-in on firming and moisture content of Danish pastry crumb were examined. Additionally, starch retrogradation was quantified over a two-week period. Firmness and moisture measurements were obtained on days 1, 8, and 15 after baking. Increased dough fat or water resulted in reduced crumb firmness. Water and the fat replacer roll-in increased crumb moisture content. No direct relationship was observed between firmness and moisture measurements. Firming Danish pastry crumb showed an increase in retrogradation over time.

Manufacturers are becoming increasingly interested in reducing the high costs associated with loss of product due to firming in Danish pastry. Firming, or the loss of crumb softness, is one characteristic of bread staling that is not well understood.

Firming of white pan bread has been studied extensively, but firming has not been reported with Danish pastry doughs. Several agents reduce firming in white pan bread and might affect Danish pastry crumb in a similar manner.

Increased levels of fat in bread crumb are known to reduce firming, although the mechanism is not well understood. Wells (1987) reported that dough fat increased the shelf life of Danish pastry. MacRitchie (1983) suggested that fat molecules surround retrograded starch molecules, decreasing starch-protein interactions. Martin and Hoseney (1991) described the presence of dextrins as interfering with the gluten-starch linkage, thereby reducing firmness. Current theory recognizes the role of starch-protein interactions in firming, but does not explain firming mechanisms.

Rogers et al (1988) found that bread firming rate increased when the moisture content decreased. The authors noted that the direct effect of crumb moisture on crumb firmness was not great.

Monoglycerides have been shown to decrease the firming rate in bread (Krog and Jensen 1970). These authors also found that hydrating the monoglycerides made the antifirming effect more pronounced. Roach (1993) found that bread crumb firmness was reduced significantly by adding powdered and hydrated monoglycerides to a bread dough.

Enzymes that hydrolyze α-1,4 linkages of the starch matrix in bread have been used extensively to reduce the firming rate. A number of workers have reported that bacterial α-amylases significantly reduced bread crumb firming (Bechtel 1953, Miller et al 1953, Martin and Hoseney 1991, Akers and Hoseney 1994).

Baker and Mize (1942) observed that bread with an open grain was more tender than bread with a more fine grain. The same observation is true with Danish pastry. If crumb firmness is measured by compression, a less firm crumb will be one of fine crumb layers and air.

Roll-in fat may be the key to a light, air-filled, Danish pastry. Roll-in is the special type of layering fat that is folded with a Danish dough to form its internal, layered structure. A desirable roll-in isolates itself from the dough layers as it is folded. A roll-in typically contains 12% water (Sultan 1990). When the Danish dough bakes, the water in the dough turns to steam, which lifts the dough layers. At the same time, the roll-in maintains separation of these layers, providing flakiness in the resulting product.

Retrogradation (recrystallization) of starch and firming of crumb both occur over time, but a direct causative relationship between these two phenomena has not been established. Recrystallization may be related to opacity in stale crumb, as indicated by changes in the starch crystal's refractive indices. The amount of crystallization can be quantified using differential scanning calorimetry (DSC) techniques (Zeleznak and Hoseney 1986). That study showed the importance of water in determining the retrogradate rate. Rogers et al (1988) found that bread crumb firming did not occur at the same rate as starch retrogradation. Specifically, they found that starch retrogradation increased at a slow rate in comparison to firming.

The objective of this research was to examine relationships between variations in the Danish pastry dough formula and firming in the resulting crumb. Crumb moisture content was measured during the same testing period. DSC was used to measure recrystallization of starch.

MATERIALS AND METHODS

Danish Pastry Production Method

A basic Danish pastry formulation was used as the control dough (Table I). The flour, containing 11.1% protein, 0.52 ash, and malted barley flour, was donated by Cargill (Wichita, KS). Fermipan dry yeast was provided by Gist-Brocades (King of Prussia, PA). Granulated sugar was obtained from Domino Sugar Corporation (New York).

American Ingredients Company (Kansas City, MO) provided high heat, nonfat dry milk (NFDM). Carey iodized salt was obtained from North American Salt Company (Overland Park, KS). Partially hydrogenated soybean and cottonseed oil used as the dough fat was obtained from Capital City Products (Columbus, OH). All-vegetable puff pastry margarine, the control roll-in, was donated by Bunge Foods (Bradley, IL). Pfizer, Inc. (New York) donated sorbic acid, a mold inhibitor. Two surfactants, a powdered distilled monoglyceride, Amidan ESK (Grinsted

TABLE I
Danish Pastry Dough Formulation

Ingredient	Baker's %
Flour	100.00
Malt	0.14
Yeast	1.50
Sucrose	10.00
Nonfat dry milk	4.00
Salt	1.50
Shortening	10.00
Water	64.00
Roll-in	20% dough weight

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Products, Industrial Airport, KS) and sodium stearoyl lactylate (SSL), Emplex (American Ingredients Co., Kansas City, KS) also were used.

To make the Danish pastry dough, the first seven ingredients listed in Table I were mixed on speed 1 for 30 sec, using a two-prong mixing attachment on a 20-quart Hobart mixer with a McDuffee bowl. Water was added to the mixture and mixed on speed 1 for 30 sec. Then the dough was mixed on speed 2 for 4 min.

After mixing, the dough was weighed, placed on a heavy-weight 66- × 46-cm baking pan and retarded at 5°C for 2 hr. The dough was sheeted to 10 mm thickness, using a Rondo sheeter (model S, type AUT 604 sheeter, Sewer AG, Burgdorf, Switzerland). The roll-in was placed onto the dough, then the dough with the roll-in on top was folded in a four-fold turn (McGill 1975). The dough was sheeted and folded a second time using the four-fold turn and was retarded for 30 min. The dough was sheeted to 10 mm thickness, folded by the four-fold turn, retarded for 30 min, and folded again.

Next, the dough was retarded overnight. The following day, it was sheeted to 5 mm thickness. Cylindrical samples, 70 mm in diameter, were cut out of the dough and placed onto a baking pan. Pans were placed into a proofing cabinet and proofed at 85% rh and 38°C, until the dough maintained an imprint when pressed. The dough was baked for 24 min at 190°C in a reel oven (Reed Oven Company, Kansas City, MO).

Immediately following baking, samples were sprayed with a 10% potassium sorbate solution to inhibit mold growth. While still on the baking pans, samples were double-wrapped in polyethylene bags and stored at ambient temperature.

The levels of seven dough ingredients were varied to show their effect on crumb firming. Fat, sucrose, water, and control roll-in were added to three doughs at the control level, a higher level, and a lower level (Table II). Surfactants, enzyme, and the fat-replacer roll-in were added at one level. Each formulaic variation was repeated three times.

Variations

Three separate Danish pastry doughs were mixed with different amounts of dough fat: 7, 10, and 13% (fwb); with different amounts of sucrose: 8, 10, and 12% (fwb); and with different amounts of water: 60, 64, and 68% (fwb).

On three different occasions, two separate Danish pastry doughs were mixed. One dough was mixed with sodium stearoyl lactylate and the other was mixed with a powdered distilled monoglyceride. Powdered surfactants were hydrated by Roach's (1993) method and added to the dough with the shortening at 0.5% (fwb). The resulting Danish pastries were tested to show each surfactant's effect on crumb firming and moisture content.

A bacterial α-amylase (Dexlo-P, Gist-Brocades) with an activity level of 46,500 RAU/g was used. The α-amylase was mixed with water and added to the dough at 0.0001% (fwb) at the time of water addition.

One control Danish pastry dough was mixed and divided into three equal-weight portions. Each portion was spotted with different amounts of the control roll-in: 15, 20, and 25% of dough weight. Folding, retardation, and baking were done as for the control dough.

A control Danish pastry dough was mixed and divided into three equal-weight portions. Each portion was spotted with one of three roll-in variations at 20% (fwb): the control roll-in, and two forms of a fat-replacer roll-in processed in two different ways. The low-shear roll-in was processed by mixing it with a paddle attachment in a Hobart mixer. The high-shear roll-in was processed with the manufacturer's homogenizer at 8,000 to 15,000 psi. Folding, retardation, and baking were done as for the control dough.

Firmness Test

Firmness measurements were taken on days 1, 8, and 15 after baking. A texture analyzer (TA.XT2, Texture Technologies, Scarsdale, NY) was used as the testing instrument. Standard method 74-15A (AACC 1983) was used with the following modifications. One 12.5 mm thick slice of crumb was compressed 5 mm at a rate of 1.7 mm/sec with a 36 mm diameter plunger. Data were obtained and analyzed with the software package (XTRA, version 3.5, Stable Micro Systems, Haslemere, Surrey, England). The peak force value from the force versus time curve was recorded as the firmness measurement.

The bulk density of each crumb sample was calculated and divided into its firmness measurement. The resulting quotients were analyzed to determine whether their standard deviations were less than those of the firmness measurements alone. They were not. Thus, firmness measurements were reported as measured, with no mathematical manipulation.

To prepare Danish pastries for firmness testing, all crust was removed from the sample. Cylindrical samples were placed between two 19 mm high cutting guides, and a smooth-edged knife was moved along the guides, removing the top crust. The sample was turned over, placed between two 12.5 mm high cutting guides, and the bottom crust was removed by moving the knife along the guides. A cylindrical crumb sample was cut out of the remaining crumb with a 40-mm cylindrical die. This die remained around the sample during firmness testing.

Moisture Test

Crumb moisture was determined using standard method 44-15A (AACC 1983). To avoid crumb browning, this method was modified by placing the air-dried samples in a 100°C oven for 1.75 hr or until a constant weight.

Differential Scanning Calorimetry

A calorimeter (DSC-2, Perkins Elmer, Norwalk, CT) with a flexi-cooler and temperature controller (FTS Systems, Inc., Stone Ridge, NY) was used to quantify enthalpy in crumb samples on days 1, 8, and 15 after baking. The calorimeter was calibrated with indium. Data were recorded and analyzed (DARES, version 1.4, Industrial Technology Research Institute, Cambridge, UK).

On the day of testing, crumb of control formulation Danish pastry was measured into aluminum sample pans, using an automatic electrobalance (Cahn Instruments, Cerritos, CA). Excess water was added to the pans at a 3:1 (water-to-crumb) ratio. An empty pan was used as the reference. Enthalpy values were measured near 60°C to indicate the quantity of recrystallized starch in the sample.

RESULTS AND DISCUSSION

Through preliminary tests, dough position on pans was eliminated as a factor causing significant variation in crumb moisture or firmness. Firmness and moisture measurements of Danish pastries that were baked on different locations on the baking pan were insignificantly different.

Effects of Dough Fat Level

On days 1 and 15 after baking, the crumb of dough with the greatest amount (13%) of fat was significantly less firm than the crumb of the other samples (Fig. 1). Fat is known to reduce firmness in bread, so these results are not surprising.

When moisture measurements were taken from the same crumb

TABLE II
Formulaic Variations

	Testing Range, (%fwb)		
Ingredient	**High**	**Control**	**Low**
Fat	13.0	10.0	7.0
Sucrose	12.0	10.0	8.0
Water	68.0	64.0	60.0
Surfactant[a]	...	0.5	...
Enzyme[a]	...	0.0001	...
Roll-in (%dwb)	25.0	20.0	15.0
Fat replacer roll-in[a] (%dwb)	...	20.0	...

[a] Doughs made from these ingredients were compared to a control dough.

samples (Fig. 2), no significant differences occurred in moisture content on days 8 and 15 after baking. On day 1 after baking, however, crumb from the dough with the least amount of fat contained the most moisture. This result is explained easily. The percentage of water in the dough increases as the amount of dough fat decreases, which allows for more moisture in the crumb.

Effects of Sucrose Level

No significant differences occurred in firmness or moisture among the samples that varied in sucrose on any test day after baking. Thus, sucrose did not directly affect firmness or moisture of Danish pastry crumb.

Effects of Water Level

Firmness measurements (Fig. 3) showed that the sample with the highest level of water was significantly less firm than the other samples on day 1 after baking. On days 8 and 15 after baking, no significant differences in firmness occurred among the samples. These results agree with those of Rogers et al (1988) for white pan bread.

Moisture contents on day 15 after baking were highest (Fig. 4) for samples made from doughs with the highest level of added water. Not surprisingly, the sample with the least amount of added water had the lowest moisture content on day 1 after baking. Thus, dough water content affected the final moisture content of the crumb.

Effects of Surfactants and α-Amylase

No significant differences occurred in firmness (Fig. 5) among samples containing either of two surfactants or α-amylase on day 1 after baking. On day 15 after baking, the crumbs of the control and monoglyceride samples were significantly less firm than those of samples containing α-amylase or SSL. These results disagree with those of Roach (1993) and Akers and Hoseney (1994) and many others who have shown that both surfactants and α-amylase significantly reduced firming in bread. One explanation for this difference is that the functionality of ingredients in a Danish pastry dough may be partially masked by its roll-in.

No significant differences in moisture content occurred among the samples. Thus, the surfactants and the α-amylase did not directly affect the moisture content in Danish pastry crumb.

Effects of Roll-In Level

No significant differences in firmness or moisture content occurred among the samples made with different levels of roll-in. Further testing is required to determine whether roll-in does affect firmness or moisture content at levels greater than those used in this study.

Effects of a Fat Replacer Roll-In

No significant differences in firmness were found among the samples made with commercial pastry roll-in (control), a fat replacer roll-in processed at high shear, and the same fat replacer

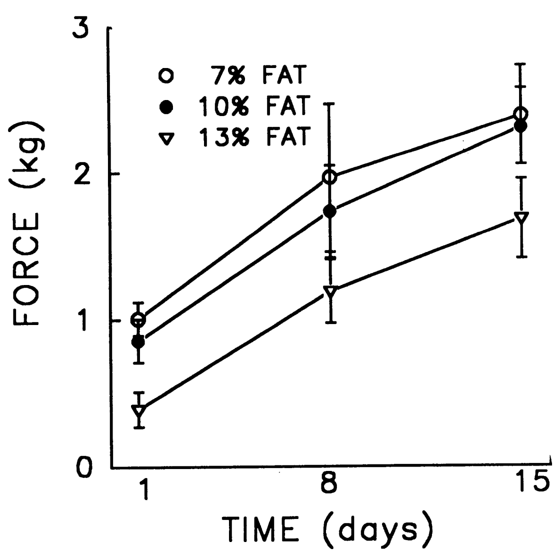

Fig. 1. Effect of dough fat on Danish pastry firmness.

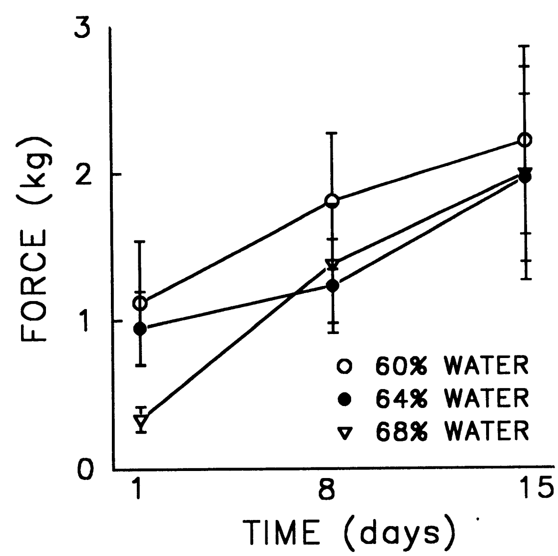

Fig. 3. Effect of water on Danish pastry firmness.

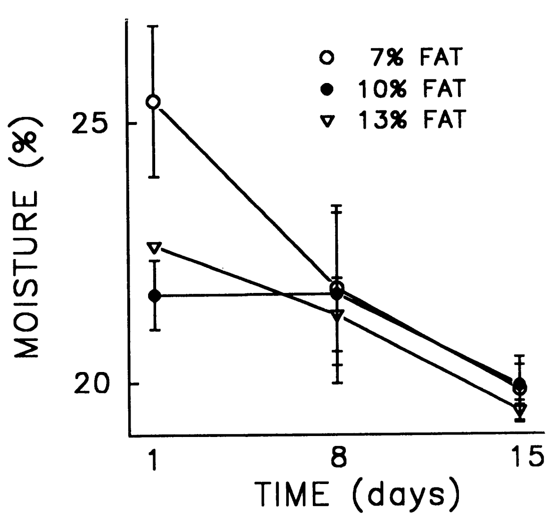

Fig. 2. Effect of dough fat on Danish pastry moisture.

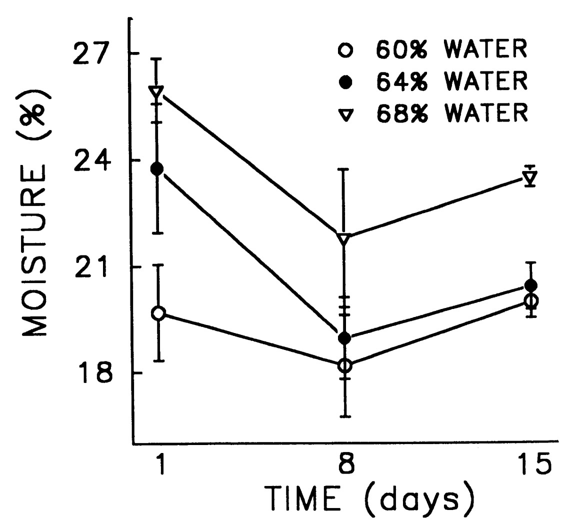

Fig. 4. Effect of water on Danish pastry moisture.

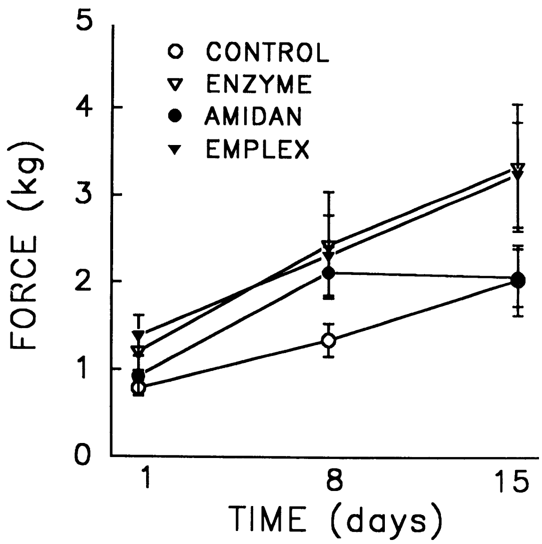

Fig. 5. Effect of an enzyme and surfactants on Danish pastry firmness.

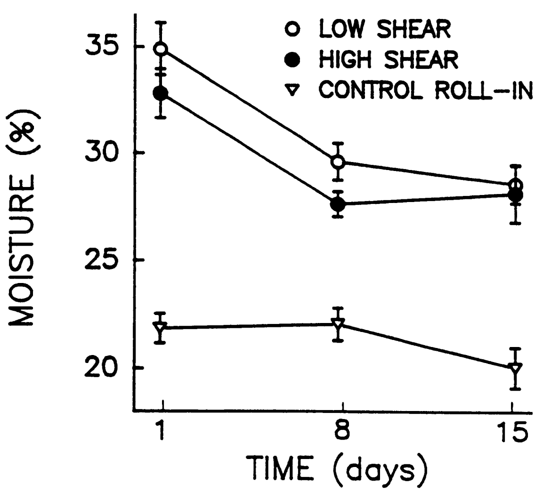

Fig. 6. Effect of a fat replacer roll-in on Danish pastry moisture

roll-in processed at low shear.

Moisture measurements also were taken for those dough variations (Fig. 6). Pastries made with the fat replacer roll-ins had significantly more moisture than the pastry made with the control roll-in. On day 8 after baking, the pastry made with low-shear, fat replacer roll-in contained significantly more moisture than the pastry with high-shear fat replacer roll-in.

There is a simple explanation for these results. The fat replacer roll-ins contained approximately 30% water, whereas the control roll-in contained approximately 16% water. The low-shear roll-in crumb showed a higher moisture value on day 8 than crumb from the high-shear roll-in because the greater amount of shearing allowed the formula's water to be more bound to the larger surface area of the roll-in's starch component. Thus, the water in the dough with the high-shear roll-in was not as available as that water in the dough with the low-shear roll-in. This resulted in lower moisture values.

Effects of Retrogradation

As expected, our results showed a trend of increasing crystallization with time (Fig. 7). The rate of increasing enthalpy was greatest between days 8 and 15 after baking. However, the greatest increases in firmness occurred between days 1 and 8 after baking. Comparison of these results indicates that, although retrogradation of starch and firmness in crumb both occur after baking and with storage, these phenomena are not the same.

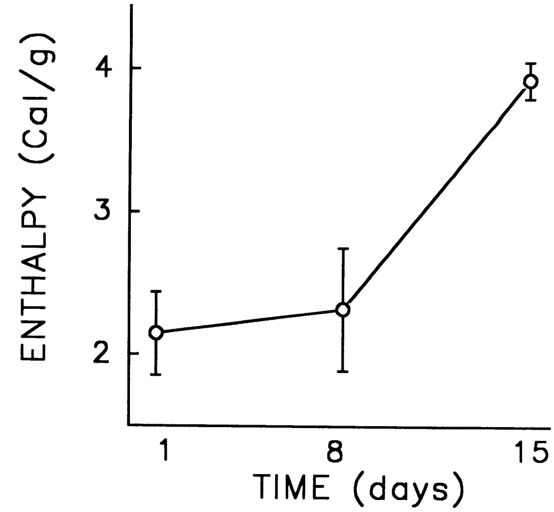

Fig. 7. Change in starch recrystallization in Danish pastry crumb

CONCLUSIONS

This study has shown the effects of different formulaic variations on the firming of Danish pastry crumb. Increased levels of dough fat and water resulted in decreased crumb firmness. Neither a bacterial α-amylase nor either of two surfactants (monoglyceride or SSL) were effective as antifirming agents. This presumably was because of the high level of fat in the dough. Increased levels of water and one type of fat replacer roll-in resulted in increased moisture content. No direct relationship between firmness and moisture content was observed. Starch retrogradation was shown to increase with time.

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