The Effect of Mixing Time and Ingredient Variation on Farinograms of Cookie Doughs[1]

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ABSTRACT

Physical properties of wire-cut, deposit, and rotary-molded cookie doughs were recorded with a Brabender farinograph. Changes in farinograph consistency (stiffness) and band width (cohesion) were observed with variations in mixing time and ingredient levels in wire-cut, deposit, and rotary-molded doughs. In general, consistency depended on fat distribution and the availability of flour to hydration. Cohesive properties of the dough increased at high sugar/fat ratios.

Cookie doughs are made of four basic components: flour, fat, sugar, and water. A variety of shapes and textures may be produced by varying the proportions of these ingredients. Because desired handling properties are controlled by the type of product and the manufacturing equipment used, accidental variations in ingredient levels may cause serious problems in large-scale production.

Cookie doughs are generally mixed by smearing fat through the flour and sugar and slightly wetting the mixture to form a cohesive mass. During mixing, sucrose and flour compete for the water (Yamazaki 1971). The fat (or shortening) contributes to the plasticity of the dough and acts as a lubricant. Fat also prevents excessive development of flour protein during mixing; some gluten formation is necessary, however, to provide sufficient cohesion for shaping and handling the dough (Berger 1970). The stretching or elastic characteristics appear to be of little importance in cookie doughs, as insufficient water is added to develop a continuous gluten network (Steel 1977).

Depending on sugar level and granulation and mixing procedure, varying amounts of sucrose are included, forming a saturated syrup. Sucrose acts as a hardening agent by crystallizing as the cookie cools, which makes the product crisp. However, moderate amounts of sucrose act as a softening agent in the cookie, due to the ability of sucrose to retain water (Schanot 1981). The effects of ingredient variations on spread and top grain of sugar snap cookies was studied by Finney et al (1950).

The enormous variety of cookie formulations and machining standards used by the baking industry have made studying the physical properties of cookie doughs difficult. A method for measuring consistency and stickiness, as it applies to dough absorption, was developed by Gaines (1982). However, commercial procedures for measuring dough quality and performance are limited to bake tests and the subjective opinion of the baker. The objectives of this study were to: 1) define physical changes during the incorporation of wire-cut, deposit, and rotary-molded doughs by varying mixing time, and 2) describe the effect of major ingredients and their variations on the physical properties of those doughs.

MATERIALS AND METHODS

Cookie Formulas and Ingredients

Three types of cookie doughs, wire-cut, deposit, and rotary-molded, were prepared according to formulas shown in Table I. An unbleached soft wheat flour [protein = 8.9% ($N \times 5.7$), ash = 0.44%, at 14% moisture basis] and nonemulsified all-vegetable shortening were used. In the preparation of wire-cut cookie doughs, sucrose was of fine granulation; for deposit and rotary-molded doughs, powdered sucrose was used.

Dough Mixing and Handling

All doughs were mixed in a Hobart A-200 equipped with a 12-qt bowl and cake paddle. The ingredients were incorporated all at once at 61 rpm. Doughs were mixed for 2, 6, or 12 min, representing "undermixed," "optimally mixed," and "overmixed" conditions, respectively, when studying the effects of mixing time. After each mixing, 300 g of dough was transferred for consistency recording.

The effects of varying the ingredient levels on physical properties were investigated, using the variations in Table II. These doughs were mixed for 6 min.

Recording Physical Properties of Doughs

Dough consistency (stiffness) and band width (cohesion) were recorded with a Brabender farinograph equipped with a 300-g bowl. The lever arm was in the middle position, and the system was zeroed using the large weight opposite the lever arm. Mixing speed was 61 rpm, and tests were run for 10 min. The band width was adjusted by rotating the dashpot lever; widths were arbitrarily set for each type of dough mixed to its optimum consistency: wire-cut $\simeq$ 100 BU, deposit $\simeq$ 40–50 BU, and rotary-molded $\simeq$ 100 BU. Band settings remained constant during subsequent testing of the doughs.

The horizontal position of the band on the chart was considered a measure of consistency (resistance to movement). Larger numbers (BU) indicate a stiffer dough. The band width was considered a degree of tenacity or cohesive properties of doughs. Although the farinograph is not the most appropriate equipment for measuring cookie dough consistency, its universal use as a physical dough testing instrument made it suitable for this study.

TABLE I
Cookie Formulas

Ingredient	Cookie Type		
	Wire-Cut	Deposit	Rotary-Molded
Flour	100	100	100
Sugar	45	45	30
Shortening	45	63	27
Water	17	12	13
High-fructose corn syrup	···	···	3.5
Nonfat dry milk	2	2.8	1
Egg albumin	···	1.12	···
Sodium chloride	1.0	0.6	1.5
Sodium bicarbonate	0.2	···	0.2
Calcium phosphate	···	···	0.14
Ammonium bicarbonate	···	···	0.7
Lecithin	···	···	0.4

TABLE II
Ingredient Variations[a,b]

Dough Type	Variation in		
	Sucrose	Fat	Water
Wire-cut	30, 45, 60%	40, 45, 50%	14, 17, 20%
Deposit	35, 45, 55%	58, 63, 68%	9, 12, 13%
Rotary-molded	30, 40, 50%	27, 28, 29%	13, 14, 16%

[a] Levels shown are given in percentage of flour weight. Other components in the formula were kept constant.
[b] Mixing time = 6 min.

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Rotary Molded Doughs

Small amounts of shortening and water in this cookie formula produced dry, crumbly doughs unsuitable for direct farinography. This difficulty was overcome by adding a minimum amount of water (10%, weight of dough) into the farinograph. Smooth and reproducible curves were obtained, which showed a good relationship to the degree of mixing of the dough.

RESULTS AND DISCUSSION

Mixing Time Variations

Wire-cut and deposit doughs mixed 2 min were stiff and produced erratic patterns in the band width (Fig. 1). As the ingredients were blended and the fat more completely smeared over the sugar and flour particles, the dough became slack, as indicated

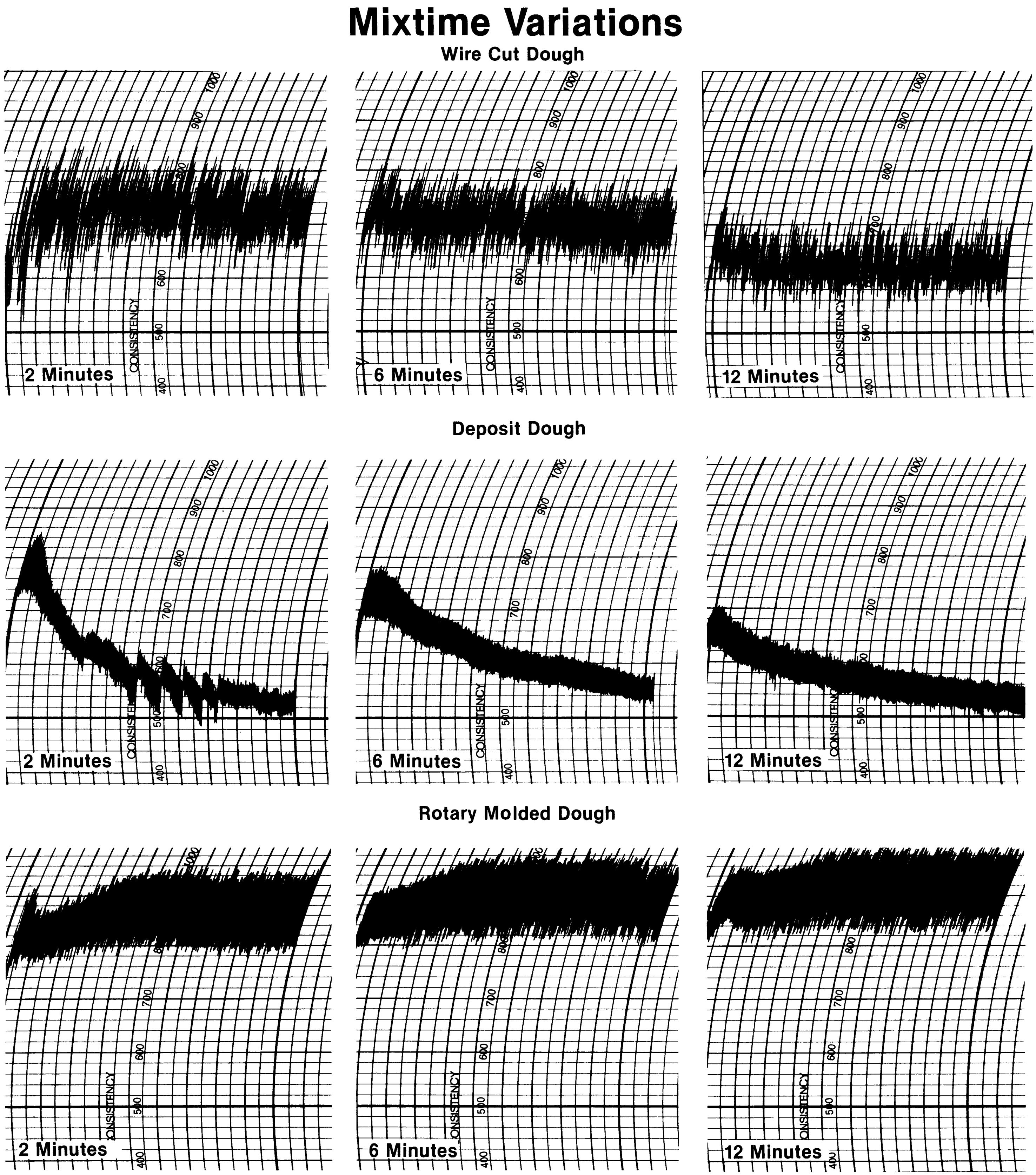

Fig. 1. Effect of mixing time (2, 6, and 12 min) on farinograms of cookie doughs.

by lower consistency values. With increased Hobart mixing time, the band of the wire-cut dough narrowed and that of deposit cookie doughs remained fairly constant. As mixing in the farinograph increased, dough consistency gradually decreased. This trend precluded an appreciable gluten development in the cookie dough system.

Farinograms of rotary-molded cookie doughs showed initial consistency increases, which were related to length of mixing. This indicated that the relatively low level of shortening in this dough permitted a limited degree of gluten formation during mixing in the Hobart mixer. Further mixing in the farinograph during testing with an additional 10% water (dough weight basis) produced

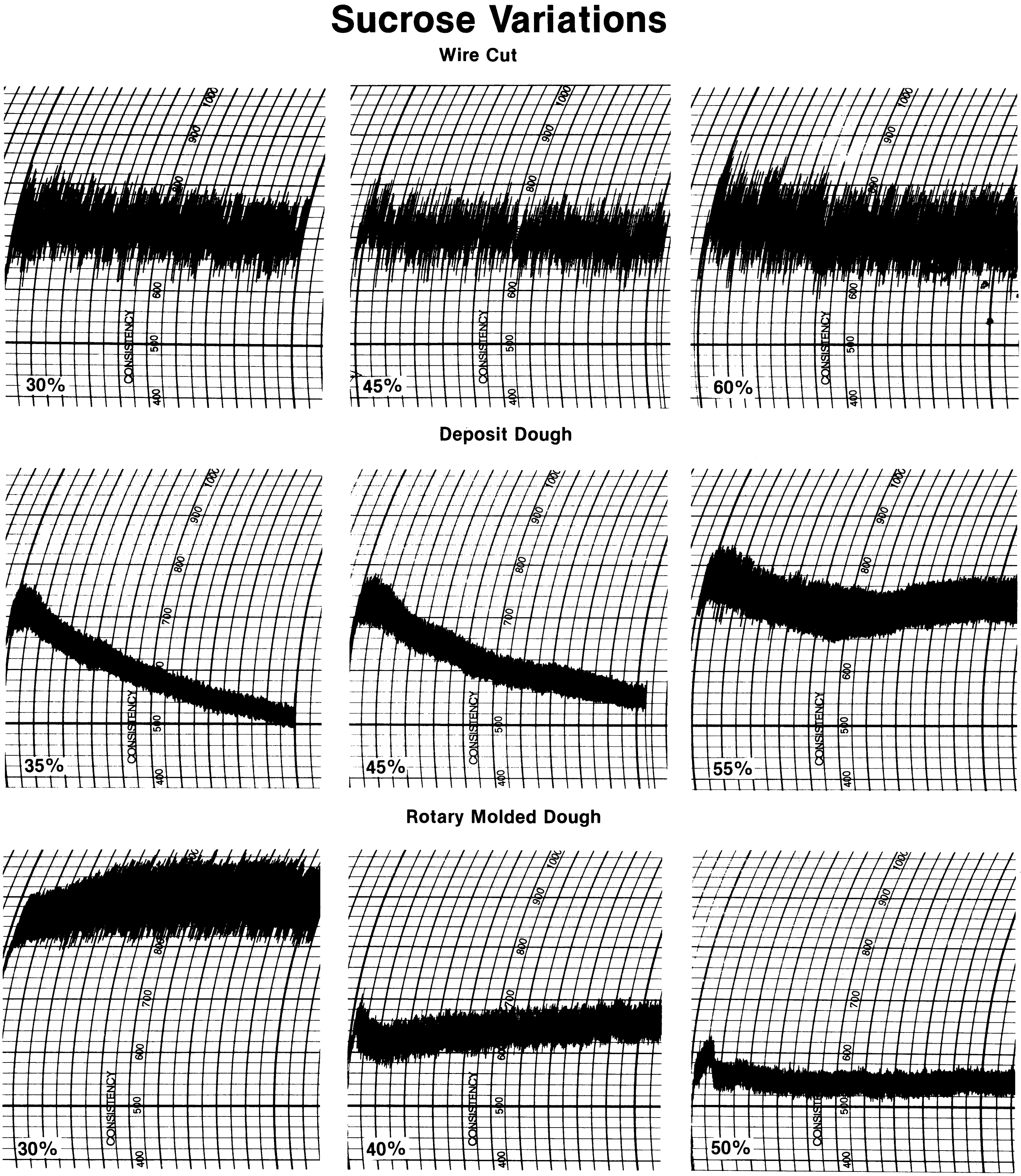

Fig. 2. Effect of sucrose levels on farinograms of cookie doughs.

curves, which indicated different susceptibilities to hydration. The dough that received the shortest mixing time (2 min) produced a curve with an initial rise in consistency, which indicated flour hydration and additional gluten development. This effect was still apparent in the curves for dough mixed for the intermediate period (6 min), but was absent in those prepared with overmixed doughs (12 min). This was attributed to the degree of shortening distribution in the system. When poorly distributed, some flour particles remained accessible to water and more gluten was formed. On the other hand, a uniform distribution of shortening by

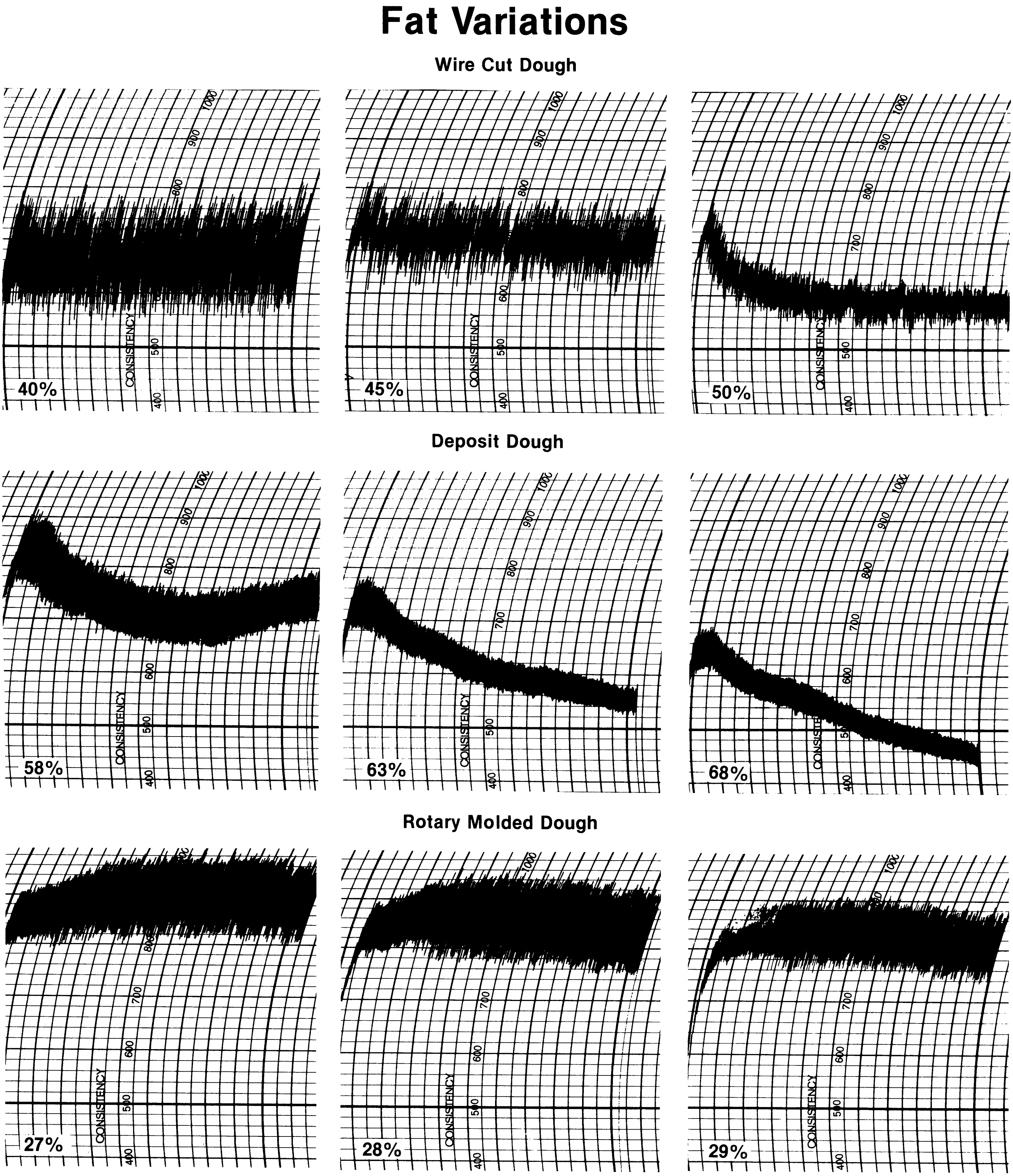

Fig. 3. Effect of shortening levels on farinograms of cookie doughs.

extended mixing prevented additional gluten development.

Ingredient Variations

In the farinograph, wire-cut doughs showed little change between 30 and 45% (flour basis) added sugar (Fig. 2). Dough consistencies remained fairly constant at all three levels, but the farinogram band width increased at the 60% level.

Sugar variations in the deposit cookie doughs were more pronounced. Doughs with a high level of added sugar had sharp increases in consistency and cohesive properties. This is in

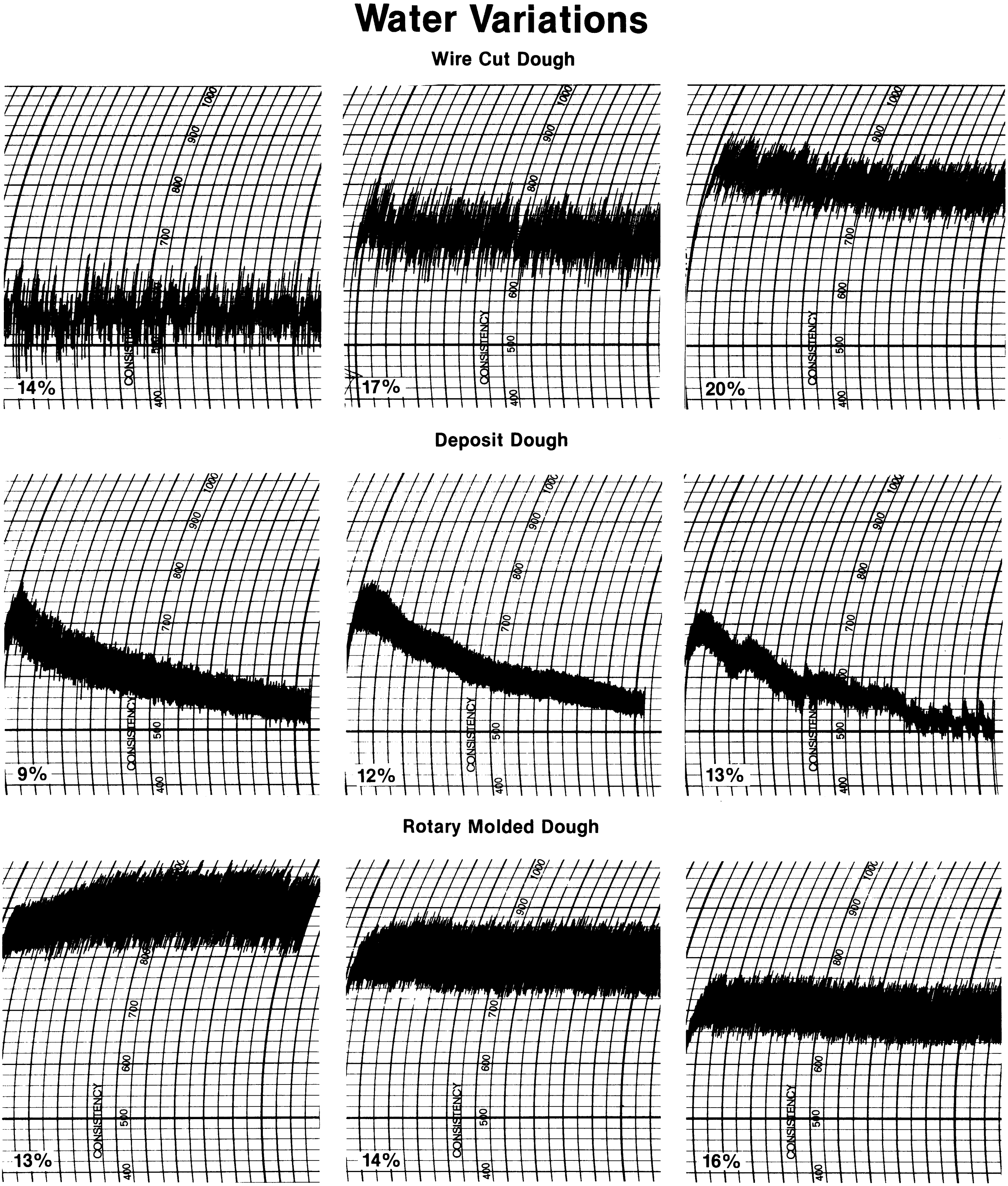

Fig. 4. Effect of water levels on farinograms of cookie doughs.

agreement with the findings of Steel (1979), who observed that increased sugar level causes dough firming.

In rotary-molded doughs, high levels of sucrose caused a sharp reduction in dough consistency and cohesiveness, due to the formation of additional syrups when 10% water was added. The mixing action of this dough prohibited an even distribution of fat throughout the system; therefore, excess sugar was more available in forming a saturated syrup, producing a slack, noncohesive dough mass. Curley and Hoseney (1984) studied the effect of sucrose and high-fructose corn syrup in a cookie system and found that when sugar is added in solution, a sticky, unmanageable dough is formed.

As the amount of fat was increased in wire-cut doughs, consistency of the dough varied within a fairly narrow range; however, band width was considerably reduced (Fig. 3). Deposit doughs had even greater reduction in consistency with increased shortening. The lower level produced a wide band at a relatively high consistency. The intermediate and high levels produced bands that were successively reduced in both consistency and cohesive properties. Rotary-molded doughs followed the previously described patterns.

In wire-cut doughs, a fat film coated the sugar and flour, protecting them from hydration when water was added (Fig. 4). As the water level was increased, the total percentage of fat was reduced, allowing more hydration of the flour and increased gluten formation, as seen by increasing consistency in the farinograms. Varying water levels in deposit cookie doughs had limited effect, due to their characteristic high fat content. Low and intermediate levels of water produced similar curves. Dough with a high water level produced an erratic band width, indicating breaks in the continuous fat phase.

During the mixing of rotary-molded doughs, the smearing of fat over the particles of sugar and flour was retarded, because the dough was dry. The incomplete formation of fat film increased the accessibility of sugar crystals to water, resulting in a faster, more extensive formation of sugar syrup. Dough consistency was reduced as the quantity of water increased from 13, 14, and 16% (flour basis).

CONCLUSION

By using different methods of mixing and adjusting the amounts of fat, sugar, and water in a dough, the baker can control the size, density, and shortness of cookies. However, the physical properties of the dough must conform to the equipment used. Within a specific dough type, ingredient variations can cause significant changes in machining and handling characteristics, as well as in the finished product. A visual description of these changes can be produced with a Brabender farinograph.

The physical properties of cookie doughs depend on the distribution of fat and water in the system. Smearing flour with fat during mixing protects the flour from water and inhibits gluten development. If sugar crystals are not coated with fat during mixing, a slack, noncohesive dough is formed. In general, the band width formed by doughs with high levels of fat increases when sugar is added (ie, in wire-cut and deposit doughs). Increased fat content in all cookie formulations decreased the consistency and band width of the dough.

The effects of water content on dough properties vary with the quantity and relative distribution of fat. Water does not affect deposit doughs very much, due to the dominating effect of fat. In wire-cut doughs, water increased the consistency, due to increased gluten formation. Rotary-molded doughs produced curves with decreasing consistency as water levels increased. The addition of 10% (by weight) excess water to these doughs caused a slackening effect, due to the formation of syrups.

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