Influence of Dough Absorption Level and Time on Stickiness and Consistency in Sugar-Snap Cookie Doughs[1]

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ABSTRACT

Five soft wheat flours and one hard wheat flour were objectively evaluated for sugar-snap cookie dough consistency and stickiness at four widely spaced dough water absorption levels. Evaluations were made immediately after mixing and 1 hr later to observe the influence of time. Change in dough consistency or stickiness after 1 hr was a function of the dough water absorption level. Data suggest a two-phase (initial and time-dependent) requirement for water by flour and sugar, the relative strength of each phase depending on the dough water absorption level. In soft wheat flour doughs, certain dough water absorption levels did not change dough consistency (isoconsistency) after 1 hr. Water absorption levels above and below the isoconsistency level caused doughs of thicker and thinner consistency, respectively, after 1 hr. Other dough water absorption levels caused no change in dough stickiness (isostickiness) after 1 hr. Water absorption levels above and below the isostickiness level caused dough stickiness to decrease and increase, respectively, after 1 hr. In freshly mixed doughs, variation in dough absorption levels had approximately equal influence on dough consistency and stickiness. In doughs rested for 1 hr, changes in dough absorption level exerted twice the influence on dough consistency as on dough stickiness. Holding doughs for 1 hr before measurement and the addition of soy lecithin adversely affected dough-handling properties.

Stickiness measurements of bread dough (Cornford and Coppock 1950; Noguchi et al 1976) and of pie crust (Miller and Trimbo 1970) have been reported and the extrusion consistency of bread dough has been reported (Bennett and Coppock 1953; Stamberg and Bailey 1940). This article compares sugar-snap cookie dough stickiness to dough consistency in doughs of various flours at a wide range of dough water levels.

Sugar-snap cookie dough is prepared in our laboratory by micro-method III (Finney et al 1950) for routine evaluation of soft wheat cultivars. Cookie doughs are rolled to thickness and cut to diameter approximately 1 min after mixing. However, in commercial production, cookie dough may lie in a trough for as long as 1 hr after mixing before machining begins. Dough that is too sticky adheres to mixing and machining equipment, slows laboratory and commercial production, and may require compensating formula changes. This article evaluates cookie dough stickiness and consistency at 1 min and 1 hr after mixing. Lecithin, which is used in some cookie formulations to reduce dough stickiness (Matz and Matz 1978), is evaluated for its influence on stickiness and consistency in micro-method III cookie doughs. The competition between flour and sugar for available

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dough water has been suggested as one explanation for variation in cookie flour quality (Yamazaki 1971). The present paper also examines the relative competitive (equilibrium) strengths of flour and sugar as their competition affects dough consistency and stickiness.

MATERIALS AND METHODS

The six straight-grade flours evaluated for cookie dough stickiness and consistency were: flour A, Argee, a soft red winter variety that is an excellent-quality cookie flour (6.8% protein, 0.39% ash); flour B, a soft white blend with 52.3% sprout damage (7.6% protein, 0.32% ash); flour D, Oasis, a soft red winter variety (11.3% protein, 0.35% ash); flour E, a commercial cracker flour (9.0% protein, 0.42% ash); and flour F, Eagle, a hard red winter variety bread flour (9.6% protein, 0.52% ash).

Cookie doughs were prepared according to micro-method III of Finney et al (1950). The formulation includes 60% sugar, 30% shortening, and a normal range of 12–20% water absorption. Water absorption level is defined as the amount of water (expressed as percentage of flour weight) added to the ingredient formula to make a dough. Doughs of each flour were made using four dough water levels. The creamed mass was not made in a large batch, as is usual at the beginning of the day. The shortening-creamed mass, which was comprised of shortening (Creamtex, Durkee Foods, Cleveland, OH), sugar (C&H Baker's Special, C&H Sugar Co., San Francisco, CA), nonfat dry milk, and sodium bicarbonate, was mixed with a micromixer (National Mfg. Co., Lincoln, NE) in a 200-cc mixing bowl (30 sec and scrape, 15 sec and scrape, 5 sec and scrape) immediately before each dough was made. Doughs that were kept on hand 1 hr were sealed in small plastic bags. Soy lecithin (U.S. Biochemical Corp., Cleveland, OH) (0.25 g per dough, 0.63% based on flour weight, 2.1% based on shortening weight) was added with the shortening to some of the doughs of flours D and E.

Dough consistency (sec) was measured by a research water absorption meter (RWAM) (Henry Simon Inc., Kansas City, MO) using 3 kg added weight (6,407 g = total extrusion weight, including plunger) and a 0.75-in. orifice. Consistency data are the means of duplicate observations.

Dough stickiness measurements were conducted with a Struct-O-Graph (C. W. Brabender, South Hackensack, NJ) fitted with a 2,000-cmg spring and a 30-mm plastic disk plunger. The platen was operated at a rate of 132 mm/min (setting 10.0). The pen arm was zeroed at the 500-Brabender unit (BU) chart line. The pen arm automatic stop was adjusted to the 1,000-BU chart line. On compression of the sample, the pen arm traveled from the zero point (the 500 line) to the 1,000 line. When compression was released, the pen returned to the 500 line and, being spring-mounted, went above the 500 line when the sample adhered to the disk and platen. The distance above the 500 line (multiplied by two) was recorded as dough stickiness in cmg.

A cookie dough was rolled to 6-mm thickness, cut to 60-mm diameter, and transferred to the platen with a spatula. The dough piece was compressed between the disk and platen for 1 min at the 1,000-BU chart line. After 1 min, compression was released and the stickiness measurement taken. This was one compression/stickiness measurement cycle. A series of five cycles was rapidly performed on each dough piece, each cycle having 1 min of compression time. The dough piece was not moved during the five cycles. The platen and disk were wiped with a moist paper towel and dried before each stickiness series began. Stickiness of each dough was reported as the mean of the five measurements. Stickiness data are the means of three replications. Room temperature was approximately 21° C, and the relative humidity was approximately 60% during stickiness and consistency measurements.

The mean pooled standard deviation of the logarithmic transformed data (as variances were proportional to the means) was 0.062 log sec consistency and 0.033 log cmg stickiness. All linear regression coefficients were greater than 0.95 and averaged 0.98.

RESULTS AND DISCUSSION

The micro-method III cookie spread test requires shortening to be mixed first with sugar and other dry ingredients, except flour. Water with some dissolved leavening ingredients is then added and thoroughly mixed before flour is added. Therefore, shortening acts as a partial barrier that separates dough water from flour particles, sugar crystals, and sugar syrup. This separation creates within the dough many microenvironments that have greatly different water vapor pressures and water sorptive capacities. The combined influence on dough of the microenvironments and their tendency toward vapor pressure or sorption equilibrium with time was measured in this study. Consistency measurements of non-Newtonian cookie dough are probably influenced by thixotropic buildup of dough consistency with time. However, the RWAM extrusion apparatus applies stress on dough, extruding it before the extrusion time is measured. Thus, the influence of thixotropic

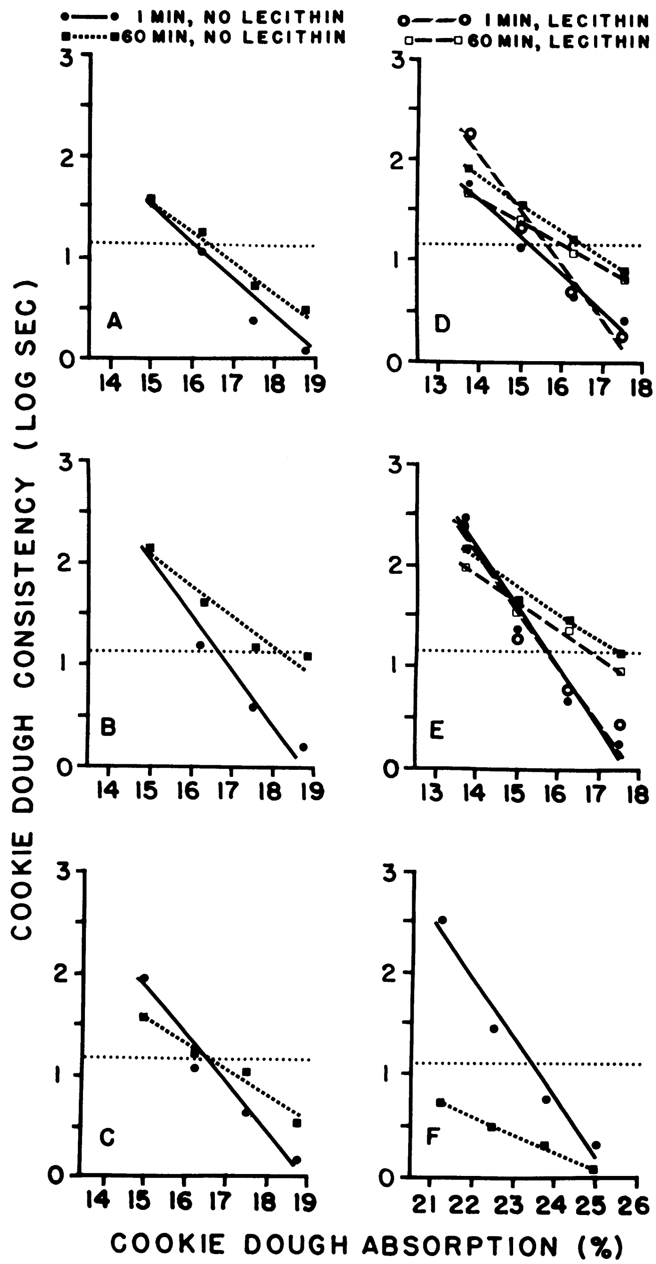

Fig. 1. Relation of sugar-snap cookie dough consistency to dough water absorption levels for six flours measured 1 min and 1 hr after mixing. Dotted line indicates optimum handling consistency (logarithm of 15 sec extrusion time). Absorption level percentage based on flour weight. Flour A–E = soft wheat; flour F = hard wheat; flours D and E also contained lecithin (0.625% based on flour weight, 2.08% based on shortening weight).

consistency buildup with time and its subsequent breakdown by the application of stress before consistency measurements were made is unknown.

The relationship of the logarithm of sugar-snap cookie dough consistency and dough stickiness to dough water absorption level is presented in Figs. 1 and 2, respectively. The subjective optimum dough consistency was approximately 15 sec (log = 1.176) RWAM extrusion time (dotted lines on Fig. 1). The dotted lines in Fig. 2 at log 2.6 (400 cmg) represent the limit of permissible dough stickiness. Above this limit, doughs tended to stick to the rolling pin.

As dough water levels increased, consistency decreased and stickiness increased in 1-min doughs, but the magnitude of change was less in 1-hr doughs. Four flours (A,B,D,E) required more water to achieve optimum dough consistency after 1 hr lay time than did the 1-min doughs. Doughs (A–E) at the lower two or three dough water levels were more sticky at 1 hr. The dough water level, which gave the limit of dough stickiness, decreased for flours B–F at 1 hr of standing. The excellent cookie flour (A) required more dough water to reach the limit of dough stickiness at 1 hr.

At the lower dough water levels, the 1-min and 1-hr consistency regression lines of flours A–E tended to intersect, indicating a dough water level at which competition for dough water did not alter dough consistency at 1 hr. The competing ingredients are probably flour and sugar (Yamazaki 1971). The swelling of flour protein, which should increase as available water increases, also probably increases dough consistency. This article refers to the intersection of the regression lines as the 1-hr isoconsistency dough water level. The dough water level at which dough stickiness was the same at 1 min and 1 hr is referred to as the isostickiness level.

The intersection of the 1-min and 1-hr regression lines indicates that flour and sugar have both a mixing, or initial, water sorptive capacity and a time-dependent, or secondary, water sorptive capacity that continues to change after mixing. The relative vapor pressure of water associated with flour and sugar changes with dough lay time and depends on the amount of available water, ie, the dough water absorption level.

At relatively low dough water levels the mixing-water sorptive capacity of flour is greater than that of sugar, and flour successfully

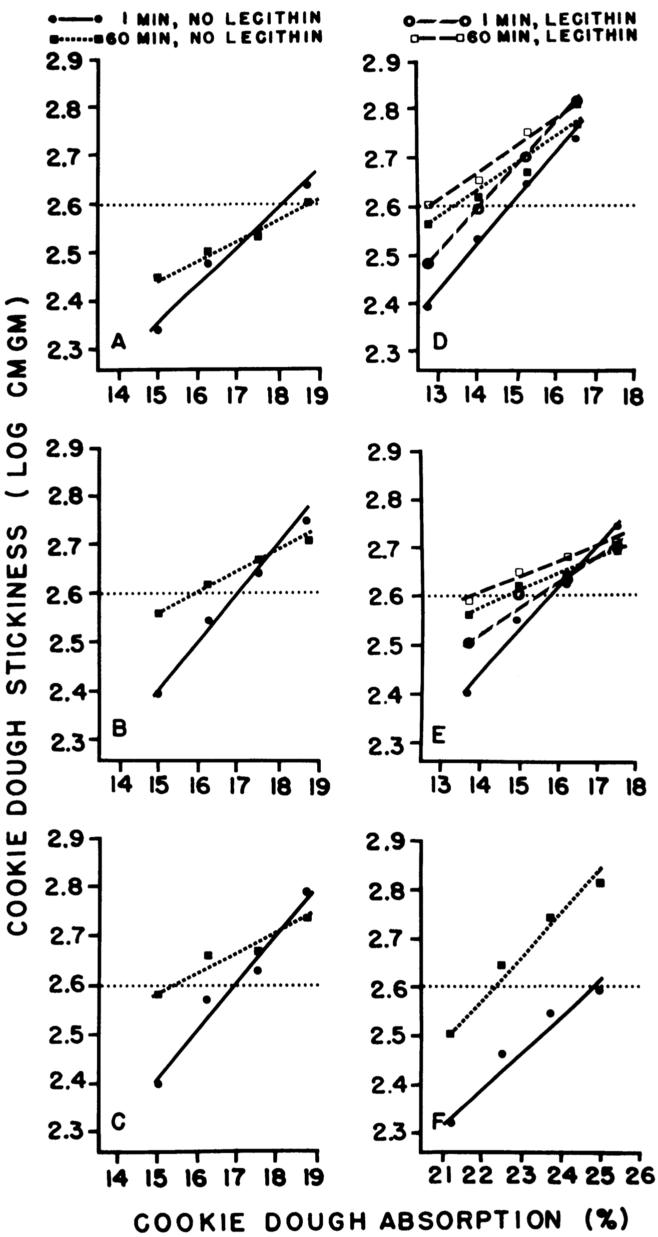

Fig. 2. Relation of sugar-snap cookie dough stickiness and dough water absorption levels for six flours measured 1 min and 1 hr after mixing. Dotted line indicates maximum permissible stickiness (logarithm of 400 cmg stickiness. Absorption level percentage based on flour weight. Flours A–E = soft wheat; flour F = hard wheat; flours D and E also contained lecithin (0.625% based on flour weight, 2.08% based on shortening weight).

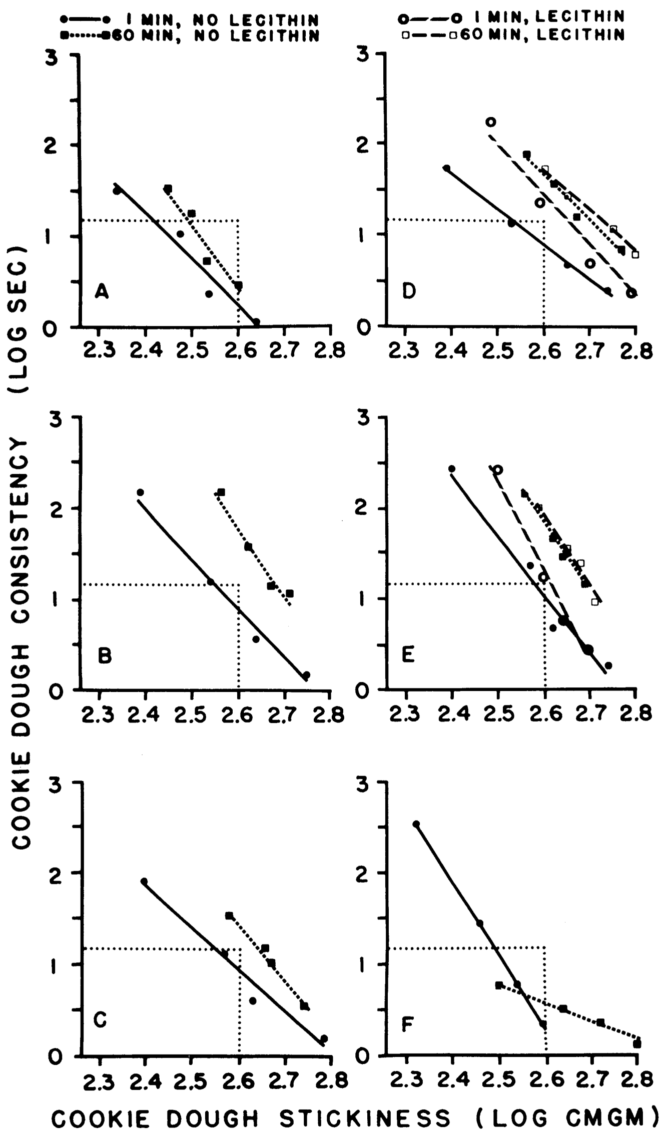

Fig. 3. Relation of sugar-snap cookie dough consistency to dough stickiness for six flours at different dough water absorption levels measured 1 min and 1 hr after mixing. Dotted line indicates optimum handling consistency (logarithm of 15 sec extrusion time). Dotted line indicates maximum permissible stickiness (logarithm of 400 cmg stickiness). Flours A–E = soft wheat; flour F = hard wheat; flours D and E also contained lecithin (0.625% based on flour weight, 2.08% based on shortening weight).

competes for water during mixing. A dough is formed when enough water has been added. This mixing-water sorptive capacity of flour determines the working dough water absorption level for the micro-method III cookie spread test. At higher dough water levels, the mixing-water sorptive requirement of the flour is increasingly met, and more water is available to the sugar, creating more sugar syrup, and thus a stickier dough of thinner consistency.

All doughs had different handling properties after 1 hr because of the secondary water sorptive capacity of flour and sugar. At relatively low dough water levels, the secondary water sorptive capacity of the sugar is stronger but smaller than the secondary sorptive capacity of the flour. The dough becomes less viscous and more sticky at 1 hr of resting time, presumably because sugar syrup increases as the sugar competes for water. As the dough water level is increased, the small but strong secondary water sorptive capacity of the sugar is relatively satisfied and the secondary water sorptive capacity of the flour is increasingly met, with the more abundant water causing an increase in dough consistency (probably due to protein swelling) and a decrease in dough stickiness after 1 hr of lay time. Therefore, whether sugar-snap cookie dough increases or decreases in consistency and stickiness 1 hr after mixing depends on the amount of water added during mixing, specifically whether the dough water level is above or below the isoconsistency or isostickiness (no change after 1 hr) critical absorption level. Only one of six flours, the excellent cookie flour, met desirable handling requirements after 1 hr. The greater change after 1 hr in stickiness and consistency of the hard wheat flour (F) doughs was probably due to the much higher mixing water requirement of the flour, which reflects the greater hydrophilic nature of hard wheat flours.

The isoconsistency dough water level was at a relatively dry dough water level, and the isostickiness level was at a relatively wet dough water level. One explanation is that, although dough consistency is involved to some extent in stickiness measurements and vice versa, flow properties of an extruded dough piece involve the entire dough piece, whereas stickiness measurements result mainly from a combination of adhesion and cohesion only a few molecules deep in the dough. Stickiness measurements were, therefore, not as sensitive to changes (different dough water levels) within the entire dough system as were extrusion measurements.

The addition of lecithin to doughs of flours D and E caused a decrease in consistency and an increase in stickiness. Lecithin also decreased the liquid level of optimum consistency and maximum permissible stickiness in 1-hr doughs. Increased stickiness and decreased consistency probably resulted from the shortening sparing effect of lecithin (Matz and Matz 1978). Increased stickiness and decreased consistency are not desirable dough-handling characteristics for the laboratory cookie spread test.

Cookie dough consistency was compared to dough stickiness at different dough water levels (Fig. 3). Some dough water levels satisfied the handling conditions for all flours when measurements were made 1 min after mixing. However, after 1 hr of lay time, only flour A, the excellent cookie flour, satisfied the dual requirements of optimum consistency and acceptable stickiness. The addition of lecithin resulted in unacceptable dough properties for flours D and E, both at 1 and 60 min. All hard wheat (F) doughs were too thin in consistency after 1 hr, resulting from their relatively high mixing water sorption capacity. In relation to all other doughs, no conspicuous evidence existed of the effect of wheat sprouting damage on dough handling properties, as measured in this study.

The slope angles (data composite of soft wheat flours A–E, no lecithin) of 1-min doughs were 46° and 43° for dough consistency and stickiness, respectively, compared with dough water absorption levels. Slope angles of the 1-hr doughs were 34 and 21° for dough consistency and stickiness, respectively. Therefore, changes in liquid level had approximately an equal effect on consistency and stickiness in freshly mixed doughs, but in 1-hr doughs the effect of dough water level on consistency and stickiness was reduced 26 and 51%, respectively. Therefore, when dough water level is chosen for proper handling properties in doughs that are to be rested for as long as 1 hr before use, consistency is twice as likely as stickiness to cause handling problems.

LITERATURE CITED

BENNETT, R., and COPPOCK, J. B. M. 1953. Dough consistency and measurement of water absorption on the Brabender farinograph and Simon "Research" water absorption meter. Am. Assoc. Cereal Chem. Trans. 11:172.

CORNFORD, S. J., and COPPOCK, J. B. M. 1950. Measuring the physical characteristics of bread. Research 3:558.

FINNEY, K. F., MORRIS, V. H., and YAMAZAKI, W. T. 1950. Micro versus macro cookie baking procedures for evaluating the cookie quality of wheat varieties. Cereal Chem. 27:42.

MATZ, S. A., and MATZ, T. D. 1978. Cookie and cracker technology. 2nd ed. Avi Publishing Co., Inc., Westport, CT.

MILLER, B. S., and TRIMBO, H. B. 1970. Factors affecting the quality of pie dough and pie crust. Bakers Dig. 44(1):46.

NOGUCHI, G., SHINYA, M., TANAKA, K., and YONEYAMA, T. 1976. Correlation of dough stickiness with texturometer reading and with various quality parameters. Cereal Chem. 53:72.

STAMBERG, O. E., and BAILEY, C. H. 1940. Plasticity of doughs. Cereal Chem. 17:37.

YAMAZAKI, W. T. 1971. Soft wheat products. Page 749 in: Wheat Chemistry and Technology. Y. Pomeranz, ed. Am. Assoc. Cereal Chem. St. Paul, MN.

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