Influence of Ambient Temperature, Humidity, and Flour Moisture Content on Stickiness and Consistency in Sugar-Snap Cookie Doughs[1]

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ABSTRACT

Stickiness and consistency of sugar-snap cookie dough were evaluated when subjected to varying dry-bulb (room) temperatures in combination with three measures of ambient water vapor content (wet-bulb temperature, relative humidity, and water-vapor pressure deficit). Combinations in excess of approximately 21°C (70°F) dry-bulb temperature, 19°C (67°F) wet-bulb temperature, 54% ambient relative humidity, and 4.89 mm Hg water-vapor pressure deficit caused excessive dough stickiness, even though dough consistency was optimal. Flour moisture content (11.5–14.5%) was also evaluated for effect on dough stickiness and consistency. When dough was at optimum consistency, excessive dough stickiness could not be induced by altering flour moisture content. Stickiness and consistency of doughs made from low-moisture flour were more sensitive to changes in dough water absorption than doughs made from flours of high moisture content. Dough water absorption level was more difficult to adjust in doughs made from low-moisture flours. Dough stickiness was less in dough made from high-moisture flours, and less dough water was necessary to achieve optimum consistency in these doughs.

This laboratory uses micro-method III (Finney et al 1950) to evaluate cookie spread for routine wheat cultivar quality testing. During evaluation, flour moisture content, room temperature, and relative humidity greatly influence the stickiness and consistency of cookie doughs. Compensatory changes are often required in the amount of water necessary to make a dough having proper subjective dough consistency and lack of stickiness during handling, rolling, and cutting. In a previous article (Gaines 1982), we defined the influence of dough water absorption level and 1-hr resting time on stickiness and consistency of sugar-snap cookie dough. This article extends those results to the effects of flour moisture content, dry- and wet-bulb temperatures, relative humidity, and water-vapor pressure deficit (the atmospheric condition that affects the rate of evaporative drying, ie, the difference between the water-vapor pressure of saturated air and the actual water-vapor pressure of the air at that temperature) on the stickiness and consistency of sugar-snap cookie dough.

MATERIALS AND METHODS

Flours

A blended straight-grade soft wheat flour, A, having 11.4% protein, 0.419% ash, and 12.2% moisture (AACC methods 46-12, 8-01, and 44-16, respectively) (AACC 1979) and a commercial soft wheat mix straight-grade flour, B, having 8.4% protein and 0.399% ash, were Miag-milled. Flour B was air-dried to 9.0% moisture, and portions were adjusted to 11.5, 12.5, 13.0, and 14.5% moisture in a humidity cabinet.

Cookie Doughs

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% (based on flour weight) dough water absorption level (the amount of water used to make a dough). The shortening-creamed mass (shortening, sugar, nonfat dry milk, and sodium bicarbonate) was mixed in a dough-mixing bowl (30 sec and scrape, 15 sec and scrape, 5 sec and scrape) immediately before preparation of each dough.

Dough water absorption levels of doughs made from flour B were 16.0, 16.5, 16.9, and 17.5% (based on flour weight) at 11.5% flour moisture; 15.25, 16.0, 16.75, and 17.5% at 12.5% flour moisture; 15.0, 16.0, 16.25, and 17.5% at 13.0% flour moisture; and 12.5, 13.75, 15.0, and 16.0% at 14.5% flour moisture. Flour weights were kept at a constant solids content regardless of flour moisture content.

Consistency and Stickiness Measurements

Dough consistency (seconds of extrusion time) 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 two replicates.

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 (multipled by two) above the 500 line 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 was 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 two replicates. Ambient conditions for the stickiness and consistency measurements of flour B were 21°C (70°F) dry-bulb temperature, 16°C (60°F) wet-bulb temperature, 56% relative humidity, and 8.33 mm Hg water vapor pressure deficit.

Doughs of flour A were prepared and evaluated for consistency and stickiness at 13 combinations of ambient dry-bulb temperature, wet-bulb temperature, relative humidity, and vapor-pressure deficit. Ingredients were allowed to equilibrate to ambient temperature before mixing. Dry-bulb temperatures ranged from 18 to 27°C (64–80°F), wet-bulb temperatures ranged from 13 to 23°C

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(55–74° F), relative humidities ranged from 32 to 83%, and vapor-pressure deficits ranged from 3.29 to 15.64 mm Hg.

Data were converted to multiple regression equations and plotted as contour plots. All multiple regression coefficients of plotted data were between 0.94 and 0.97.

RESULTS AND DISCUSSION

Multiple regression equations for predicting arithmetic and logarithmic dough stickiness and consistency of flour A were calculated using wet-bulb temperature, relative humidity, and vapor-pressure deficit, each in combination with dry-bulb temperature, the most practical of the four variables. The multiple correlation coefficients (Table I) using various combinations of independent variables and stickiness and consistency were similar. Converting stickiness data to logarithms was not advantageous, but log consistency was better correlated with the variables than was arithmetic consistency.

The contour plot of the influence of wet- and dry-bulb temperatures on dough stickiness is shown in Fig. 1. The dotted line indicates the optimum dough-handling consistency (16-sec extrusion time), whereas the 400-cmg line represents maximum permissible dough stickiness. The intersection of these lines (arrow) marks the beginning of combinations of wet- and dry-bulb temperatures, which caused dough of optimum consistency to be excessively sticky. This condition began at 19° C (67° F) wet-bulb temperature and 21° C (70° F) dry-bulb temperature.

TABLE I
Multiple Correlations for Prediction of Sugar-Snap Cookie Dough Stickiness and Consistency Relative to Wet-Bulb Temperature, Relative Humidity, and Vapor Pressure Deficit in Combination with Dry-Bulb Temperature

Prediction Variable Combined with Dry-Bulb Temperature	Stickiness	Log Stickiness	Consistency	Log Consistency
Wet-bulb temperature	0.947	0.940	0.915	0.965
Relative humidity	0.950	0.942	0.927	0.969
Vapor-pressure deficit	0.952	0.942	0.907	0.962

The contour plot of the effect of dry-bulb temperature and relative humidity on dough consistency (Fig. 2) shows stickiness problems developing (arrow) at high relative humidities at 22° C (71° F). The slopes of the lines indicate that stickiness problems began at successively lower relative humidities as the dry-bulb temperature increased above 22° C (71° F).

At the same atmospheric vapor pressure, changes in dry-bulb temperature affect vapor-pressure deficit much more than relative humidity. Because vapor-pressure deficit is the water-vapor pressure in the air relative to the saturated vapor pressure at that temperature, the doughs mixed and measured in a room with low vapor-pressure deficit had a slower rate of evaporative drying. This is evident in the contour plot of dough consistency as influenced by dry-bulb temperature and vapor-pressure deficit (Fig. 3). The intersection of the lines of optimum consistency and maximum permissible stickiness began at approximately 22° C (72° F) when the evaporative drying rate was relatively low (4.77 mm Hg). As the drying rate increased (vapor-pressure deficit, relative humidity, and wet-bulb temperature decreased), warmer room temperatures were required to create a stickiness problem.

In our laboratory, the most desirable ambient conditions for evaluating soft wheat cultivars by the micro-method III procedure are 20–21° C (68–70° F) and 30–50% relative humidity. This allows "standardization" of dough consistency, prevents stickiness problems, and eliminates the detrimental influence of high humidity on cookie top grain (cracking of the cookie surface). Figures 1–3 explain why these conditions are safe.

The influences of dough water absorption level and flour moisture content (flour B) on dough stickiness and consistency are shown in Figs. 4 and 5, respectively. No combination of flour moisture content and dough water absorption level caused stickiness problems at 21° C (70° F) and 50% relative humidity, the ambient conditions of the measurements.

Figure 4 indicates that flours of high moisture content required much larger changes in dough water absorption level to cause the same change in dough stickiness as that which occurred in flours of

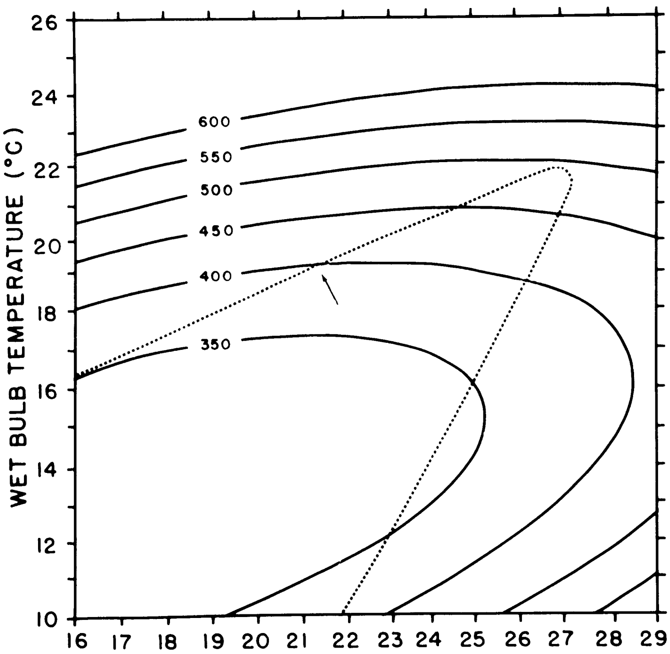

Fig. 1. The influence of dry- and wet-bulb temperatures on cookie dough stickiness (cmg) and optimum dough consistency (16 sec) (dotted line). $S = 762.8 - 55.48W - 10.43D + 3.234W^2 + 0.97D^2 - 1.747WD$ and $\text{Log } C = 8.793 - 0.741W + 0.065D - 0.026W^2 + 0.029D^2 + 0.068WD$, where S = stickiness (cmg), Log C = consistency (Log sec), D = dry-bulb room temperature (° C), and W = wet-bulb room temperature (° C).

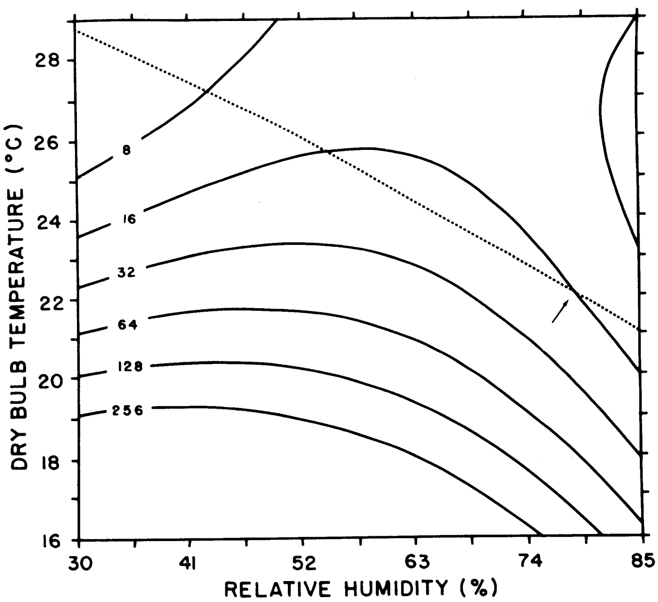

Fig. 2. The influence of dry-bulb temperature and relative humidity on cookie dough consistency (sec) and maximum permissible dough stickiness (400 cmg) (dotted line). $\text{Log } C = 13.32 - 0.017R - 0.811D - 0.001R^2 + 0.011D^2 + 0.003RD$ and $S = 72.98 - 20.82R - 117.7D + 0.066R^2 + 2.102D^2 + 0.677RD$, where Log C = consistency (Log sec), S = stickiness (cmg), D = dry-bulb room temperature (° C), and R = relative humidity (%). Contour plot of consistency was calculated using regression equation for Log consistency (Log sec) and converted to consistency (sec) for plotting.

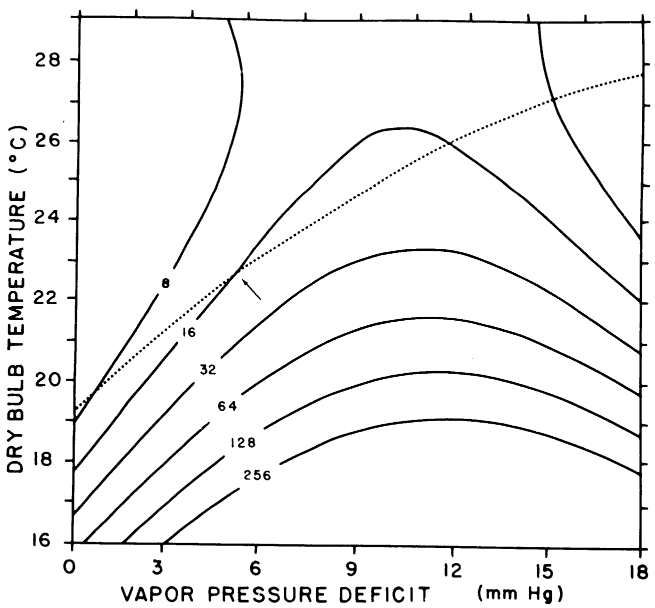

Fig. 3. The influence of dry-bulb temperature and vapor-pressure deficit on cookie dough consistency (sec) and maximum permissible dough stickiness (400 cmg) (dotted line). $\text{Log C} = 10.58 + 347V - 0.792D - 0.011V^2 + 0.015D^2 - 0.004VD$ and $S = 72.98 + 46.46V - 96.86D + 1.458V^2 + 3.33D^2 - 3.632VD$, where Log C = consistency (Log sec), S = stickiness (cmg), D = dry-bulb room temperature, and V = vapor-pressure deficit (mm Hg). Contour plot of consistency was calculated using regression equation for Log consistency (Log sec) and converted to consistency (sec) for plotting.

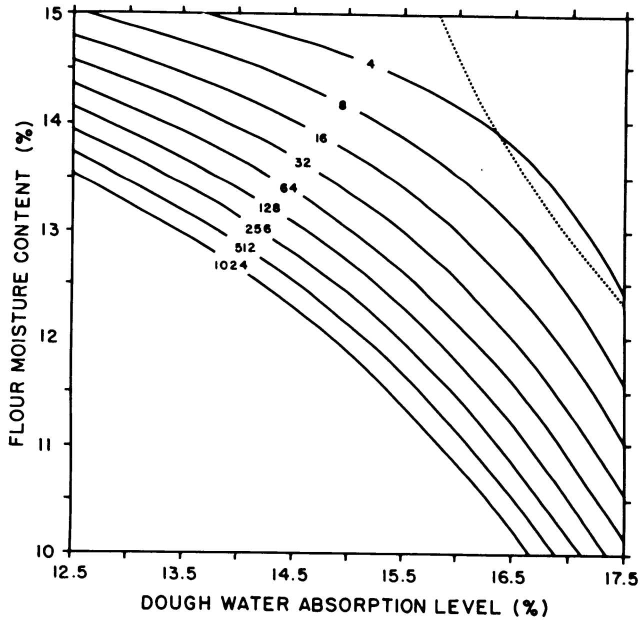

Fig. 5. The influence of flour moisture content and dough water absorption level on cookie dough consistency (sec) and maximum permissible dough stickiness (400 cmg) (dotted line). $\text{Log C} = 53.08 - 3.251M - 2.721A + 0.164MA$ and $S = -1551 + 296.7M - 133.4A - 8.768M^2 + 6.648A^2 - 0.341MA$, where Log C = consistency (Log sec), S = stickiness (cmg), M = flour moisture content (%), and A = dough water absorption level (percent of flour weight). Contour plot of consistency was calculated using regression equation for Log consistency (Log sec) and converted to consistency (sec) for plotting.

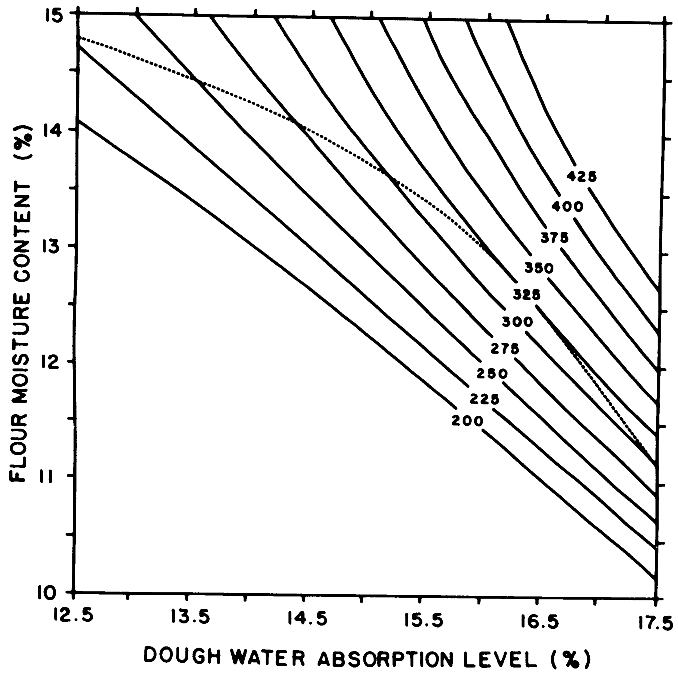

Fig. 4. The influence of flour moisture content and dough water absorption level on cookie dough stickiness (cmg) and optimum dough consistency (16 sec) (dotted line). $S = -1551 + 296.7M - 133.4A - 8.768M^2 + 6.648A^2 - 0.341MA$ and $\text{Log C} = 53.08 - 3.251M - 2.721A + 0.163MA$, where S = stickiness (cmg), Log C = consistency (Log sec), M = flour moisture content (%), and A = dough water absorption level (percent of flour weight).

low moisture content. Dough consistency also changed much less with changes in dough water absorption level in doughs made with flours of high moisture content. Therefore, adjusting dough water absorption levels in flours of low moisture content is much more difficult because relatively small changes in dough water absorption levels cause relatively large changes in dough stickiness and consistency.

At any dough water absorption level, when the flour moisture content is reduced, dough stickiness is reduced and dough consistency is increased (thickened). The relative amount of water necessary to revive optimum consistency becomes less if doughs are made from relatively dry flour. At higher flour moisture levels, considerably less dough water is necessary to achieve optimum handling consistency. This would be an advantage because the water must be baked out to obtain a constant cookie moisture content or weight. Therefore, at optimum dough consistency, doughs made from flours having high moisture contents are less sticky and easier to work because they better tolerate changes in dough water absorption level. However, flour moisture contents above 14% are detrimental to micro-method III cookie top grain.

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