The Effect of Formula Variations and Dough Development Method on Colombian *Aliñado* Bread Properties[1]

J. E. DEXTER, R. H. KILBORN, and K. R. PRESTON[2]

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ABSTRACT

The most popular bread in the Cali-Palmira region of Colombia is *aliñado* bread, a hearth bread produced by a short process from a formula unusually rich in sugar, shortening, and (optionally) eggs. To determine effects on bread properties, sugar levels were varied from 2.5 to 10%, shortening levels from 2 to 16%, and egg levels from 0 to 13%. The main effect of high sugar content was yeast inhibition during fermentation leading to reduced bread specific volume. Specific volume also decreased when shortening was increased to 16%. The denser nature of high-sugar, high-fat bread caused firmer crumb properties. The lower baking absorption of high-shortening bread also contributed to firmer, less resilient crumb texture because of lower bread moisture content. The high water content of eggs reduced baking absorption and imparted a golden color to the bread, but aside from imparting a slight increase in loaf volume had little effect on bread properties. When doughs were developed by sheeting rolls, which is almost universal in Colombia, bread crumb was finer and softer than when doughs were developed by mixing.

In recent years Colombia has become an increasingly important wheat market to Canada. From 1985 to 1988 Canadian wheat exports to Colombia averaged over 100 thousand tonnes, mainly as Canada Western Red Spring (CWRS) wheat (Canadian Wheat Board statistics).

Colombian bread is predominantly hearth bread of various shapes and sizes. Colombian hearth bread typically is produced by a short process from a formula unusually rich in fat and sugar. In the Cali-Palmira region the most popular bread is a 300–500-g loaf known as *aliñado* bread. Typically, *aliñado* bread formulas include about 10% sugar and 12% shortening, although some bakeries in the Cali area use up to 20% shortening (*personal communications*). Up to 13% eggs may also be included in the formula. Doughs are developed almost universally by sheeting rolls, although high-speed mixers are used occasionally.

An essential part of developing new wheat markets is providing sound technical advice to wheat processors. This requires a thorough understanding of factors that influence end-product quality. Recently we verified that CWRS was the Canadian wheat class best suited for making *aliñado* bread (Dexter et al 1989). In this investigation a CWRS wheat milled to Colombian standards was used to determine the effects of dough development method (sheeting rolls or high-speed mixing), sugar level, fat level, and egg level on Colombian *aliñado* bread properties.

[1]Contribution no. 640 of the Canadian Grain Commission, Grain Research Laboratory, Winnipeg, Manitoba.

[2]Canadian Grain Commission, Grain Research Laboratory, 1404-303 Main Street, Winnipeg, MB R3C 3G8

MATERIALS AND METHODS

Wheat

The wheat was a composite of all cargoes of No. 2 CWRS wheat of 12.5% guaranteed minimum protein content shipped out of Pacific ports between August 1, 1987, and October 31, 1987. Properties determined for this wheat on 13.5% mb were test weight, 81.8 kg/hl; protein content, 13.2%; and falling number, 340 sec.

Milling

The wheat was milled to Colombian standards (Canadian Grain Commission unpublished reports) using the Grain Research Laboratory (GRL) research roll stands (Black et al 1980a) in conjunction with a Bühler Laboratory bran finisher (Bühler-Miag, Don Mills, ON) and GRL sifter units (Black et al 1980b). Grinding rolls are 10 in. (254 mm) in diameter and have an effective grinding length of 5 in. (127 mm). All corrugated rolls have Allis sharp corrugations with a spiral of 0.5 in./ft (41.7 mm/m) of roll length and are set dull to dull at 2:1 differential (fast roll speed 500 rpm). Smooth rolls have a frosted finish and are run at 1.5:1 differential (fast roll 450 rpm). Feed rate to each roll is 0.15 kg/cm roll length per minute.

Wheat is milled to about 78% extraction (dirty wheat basis) in Colombia. Typically about 4% farina (range 0–15%, wheat basis) is removed for pasta production. The mill flow developed for this study (Fig. 1) is not meant to simulate Colombian mill flows, but it does produce a flour with a degree of refinement typical of Colombian flours (Canadian Grain Commission unpublished reports). Flour properties on a 14% mb determined on wheat milled to 79% extraction, clean wheat adjusted to constant moisture basis, with 4% farina (0.38% ash content, 14% mb) removed were as follows: protein content, 12.6%; ash content, 0.64%; color, 2.0 Kent-Jones units; starch damage, 43 Farrand units; farinograph absorption, 67.1%; farinograph development time, 4.5 min; farinograph stability, 5.5 min.

Wheat was prepared for milling and test weight was determined as described by Dexter and Tipples (1987). Three 3-kg lots of wheat were tempered overnight to 16.5% moisture before milling. Mill room conditions were controlled at 21°C and 60% rh.

Break releases, measured as the proportion of stock passing through a 24 wire (678-μm aperture) were set at 20, 65, and 35% for first break (B1), B2, and B3 respectively. Roll gaps for B4, sizings, and reduction passages were set by adjusting rolls to minimum clearance when running empty, then opening the gap slightly (roll gap about 0.3 mm). A portion (4% on clean wheat basis) of the stock proceeding to first middlings from first sizings (Fig. 1) was removed as high-quality (0.38% ash content) farina. The flours from the triplicate millings were blended prior to quality assessment and baking trials.

Wheat and Flour Properties

Wheat and flour tests were performed in duplicate.

Wheat falling number was performed by the standard ICC (1967) procedure. Protein content (% N $\times$ 5.7) was determined by the Kjeldahl procedure as modified by Williams (1973) and ash content was determined by the AACC (1983) procedure. Flour color was determined with a Simon Color Grader Series IV (Henry Simon, Stockport, England) as outlined in the instruction manual. The enzymatic method of Farrand (1964) was used to determine flour starch damage.

Farinograph

Farinograph (C.W. Brabender Instruments, S. Hackensack, NJ) properties were determined by the AACC (1983) procedure with slight modifications (Preston et al 1982).

Baking

Baking trials were performed in duplicate. Duplicate bakes were performed on different days in randomized order.

Baking formula was varied to establish the effects of changing levels of sugar, fat, and eggs. In one series of experiments, all possible combinations of 2.5, 5, and 10% sugar and 2, 8, and 16% Crisco shortening were used with 8% whole eggs and in the absence of eggs (all concentrations proportion of flour weight basis). In a second series of experiments, sugar and shortening levels were held constant at 10 and 16%, respectively, and whole egg levels were adjusted to 0, 6.5, and 13%. Levels of yeast (Fermipan, 1.05%), salt (2%), malt flour (0.1%), ammonium phosphate monobasic (0.1%), potassium bromate (20 ppm), and ascorbic acid (45 ppm) were kept constant.

Information gathered during Canadian Grain Commission technical missions to Colombia (unpublished reports) was used to develop a simulated *aliñado* baking procedure. In the first series of experiments, 400 g of flour, the ingredients listed above, and water to give optimum dough handling properties, were premixed in a GRL-1000 mixer (Kilborn and Tipples 1974a) at 30°C for 3.5 min at slow speed (105 rpm). The dough was divided into two equal portions and bulk fermented for 1 hr at 30°C. Each dough piece was developed by passing through a modified National (National Manufacturing Co., Lincoln, NE) adjustable sheeting unit (Kilborn and Tipples 1974b). The doughs were passed through the sheeting rolls at gaps of 7/32 in. (5.5 mm) and 5/32 in. (4 mm), folded in half, rotated 90°, and the sheeting was repeated; each fold represents two sheetings. The number of folds required for development was assessed subjectively. Properly developed doughs are smooth, nonsticky, and elastic, and when cut exhibit no discernible internal gas cells (Stenvert et al 1979). Energy expended to achieve development was determined as described by Kilborn and Tipples (1974b). Following sheeter development the doughs were rested 20 min at 30°C, hand-rounded, and given an intermediate proof of 20 min at 30°C. Doughs were sheeted with a National adjustable sheeting unit (National Manufacturing Co., Lincoln, NE) and mechanically molded with a GRL molder (Kilborn and Irvine 1963). Work input during sheeting was measured by a force transducer attached to the pivoted frame supporting the movable sheeter roller (Kilborn and Preston 1982).

One molded dough from each pair was placed on a baking tray and given three equally spaced 10-cm oblique slashes with a razor blade. The dough was proofed for 60 min at 33°C. Height at the center of the dough was determined with an adjustable square rule, and an egg wash was applied just prior to baking in an Electro-Grant hearth oven (A.B.D. Distributors, Winnipeg, MB) at 205°C for 30 min. The thermostatic controls in the oven were upgraded to control temperature to ±5°C.

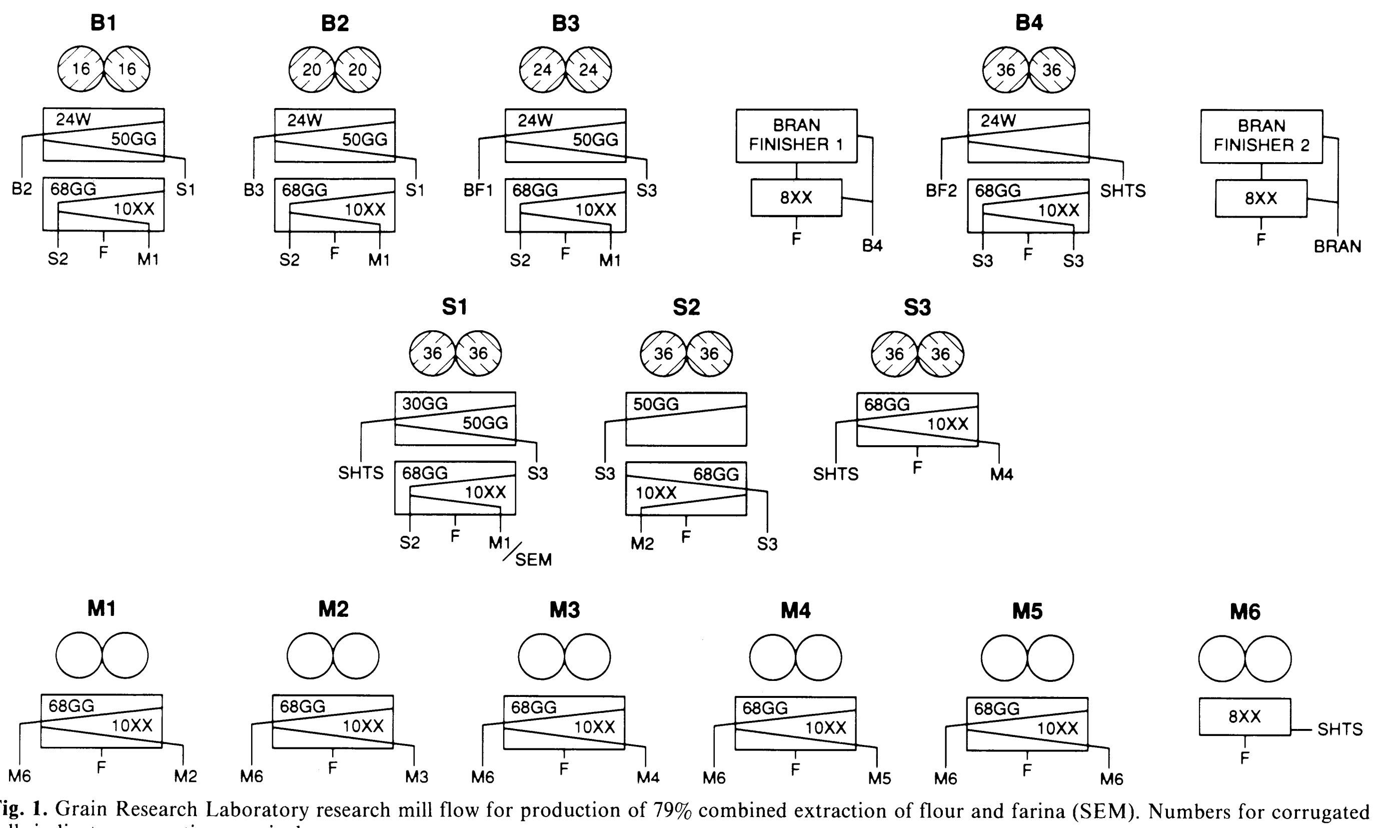

Fig. 1. Grain Research Laboratory research mill flow for production of 79% combined extraction of flour and farina (SEM). Numbers for corrugated rolls indicate corrugations per inch.

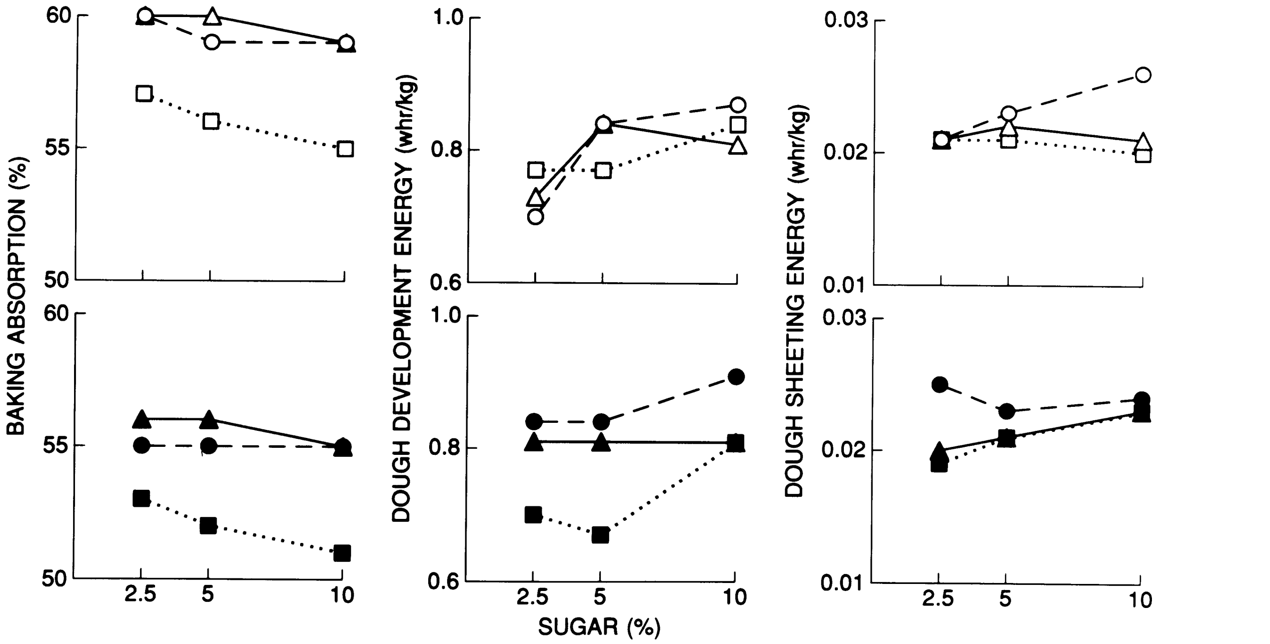

Fig. 2. Baking absorption, energy required to develop dough with sheeting rolls, and energy required to sheet dough prior to molding for doughs containing 2% (○, ●), 8% (△, ▲), and 16% (□, ■) shortening in the absence of eggs (○, △, □) and with 8% eggs (●, ▲, ■) at various sugar levels.

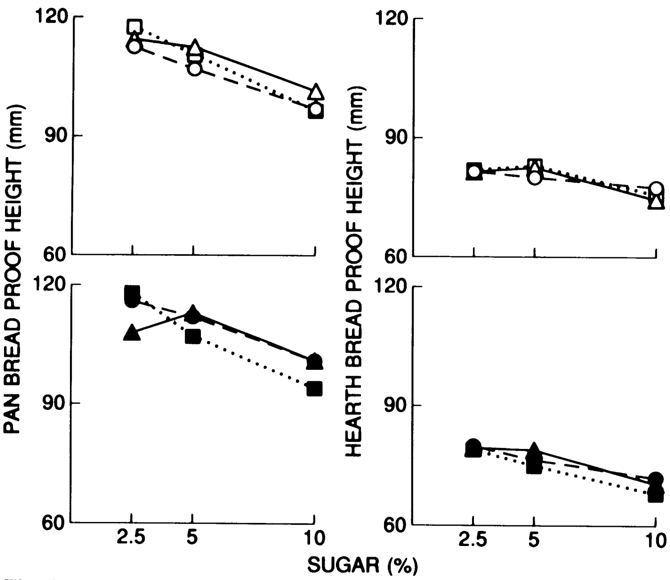

Fig. 3. Proof heights of sheeter-developed pan bread and hearth bread doughs containing 2% (○, ●), 8% (△, ▲), and 16% (□, ■) shortening in the absence of eggs (○, △, □) and with 8% eggs (●, ▲, ■) at various sugar levels.

The corresponding molded dough was panned. Pan bread is not made by this process in Colombia, but we wished to determine whether hearth bread properties could be predicted from pan bread properties. The panned dough was proofed for 70 min at 30°C. Proof height was measured with an adjustable square ruler at the center of the dough prior to baking at 205°C for 30 min in a National revolving oven (National Manufacturing Co., Lincoln, NE) modified to thermostatically control temperature to ±5°C (Kilborn and Tipples 1981a). The egg wash prior to baking was eliminated for pan bread because the pans are standardized, and egg residue on the pans following baking might affect subsequent pan bread results.

In the second series of experiments, dough development by sheeting rolls and high-speed mixing were compared. Two doughs each containing 400 g of flour were prepared for each egg level. One was developed by sheeting rolls as described above. The other was mixed at 30°C in a GRL-1000 mixer until 10% more energy than required to reach peak consistency was recorded by the GRL direct reading energy input meter (Kilborn and Tipples 1973) as detailed by Kilborn and Tipples (1981b). Each of the above doughs was rested 20 min at 30°C, divided into two equal portions, and made into hearth bread and pan bread as described above.

Bread Properties

Breads were cooled for 25 min following baking, weighed, and loaf volumes were determined in a volumeter by rapeseed displacement. Pan bread was scored the next day for appearance, crumb structure, and crumb color as described by Kilborn and Tipples (1981a).

The extent of hearth bread collapse was measured by comparing the heights at the center of the loaf immediately following baking and prior to scoring the following day. Hearth bread was scored for boldness by dividing the maximum height of the bread by the maximum width. Crumb structure of the hearth bread was scored by the pan bread procedure (Kilborn and Tipples 1981a). Hearth bread crumb color was not determined, because the shape of the bread made it difficult to handle and orient properly to score with confidence. It was also assumed that results would be redundant with crumb color scores obtained from pan bread produced from the same dough.

Pan bread crumb firmness and resilience were measured by the GRL compression tester (Kilborn et al 1983). Hearth bread crumb texture was not measured because the tapered dough shape made uniform sample presentation between samples difficult. It was also assumed that results would be redundant with crumb texture measurements obtained for pan bread produced from the same dough.

Statistical Analysis

Statistical analyses were performed with an IBM compatible personal computer (Mind Computer, Winnipeg, MB) using the SAS Stat Release 6.03 statistical program (SAS Institute Inc., Cary, NC). The effects of fat level, sugar level, egg level, development procedure, and bread type (pan or hearth) were determined by completely randomized factorial analysis of variance. Where statistically significant ($P < 0.05$) effects were identified, the significance of differences between treatments was determined from least significant differences.

RESULTS AND DISCUSSION

Properties of Sheeter-Developed Doughs with Variable Levels of Shortening, Sugar, and Egg

Increasing the amount of eggs, sugar, and shortening in the *aliñado* bread formula significantly ($P < 0.01$) reduced baking absorption (Fig. 2). The liquid contribution of whole eggs was reflected by an average 5% drop in baking absorption for doughs containing 8% eggs compared with corresponding doughs without eggs. The effect of sugar levels on baking absorption was too slight to be of practical importance. Pomeranz and Chung (1978) reported a drop in baking absorption of 1–2% when 3% shortening was added to a lean formula. In the current study, when shortening content was increased from 2 to 16%, baking absorption dropped about 3% (Fig. 2).

Energy required for dough development was not significantly ($P > 0.05$) affected by levels of eggs, sugar, or shortening (Fig. 2).

Energy expended at sheeting just prior to molding was not ($P > 0.05$) affected by eggs, but significant ($P < 0.01$) effects attributable to shortening and sugar levels were found (Fig. 2). As shortening level increased, sheeting energy decreased. The effect of sugar level on sheeting energy was complex. A significant ($P < 0.05$) shortening-to-sugar interaction term reflected the inconsistency of the effect of sugar at different shortening levels.

Proof height was strongly influenced ($P < 0.001$) by bread type, sugar level, and egg level (Fig. 3). Shortening had no effect ($P > 0.05$) on proof height.

Pan bread proof heights were higher ($P < 0.001$) than hearth bread proof heights (Fig. 3). The hearth bread proof heights were lower because of spreading in the absence of the side pan support afforded to pan bread doughs, and because of loss of gas from the slashes given to the hearth bread doughs prior to proofing.

Increasing sugar levels had a strong negative effect on proof height (Fig. 3). This corroborates the work of Barham and Johnson (1951), who found that sugar concentrations higher than 6% caused a decrease in both the rate and the amount of gas production in proofing doughs. They attributed fermentation inhibition at high sugar levels to osmotic effects in the yeast cell. In the current study, there was a significant ($P < 0.001$) sugar level to bread type interaction term because the effect of sugar level on proof height was greater in pan bread dough than in hearth bread dough (Fig. 3).

A strong ($P < 0.001$) egg level to proof height interaction term confirmed that the effect of eggs on proof height was solely attributable to lower proof height for hearth bread doughs containing eggs (Fig. 3). Presumably eggs impart greater fluidity to the doughs, resulting in greater spreading of hearth bread doughs in the absence of side pan support.

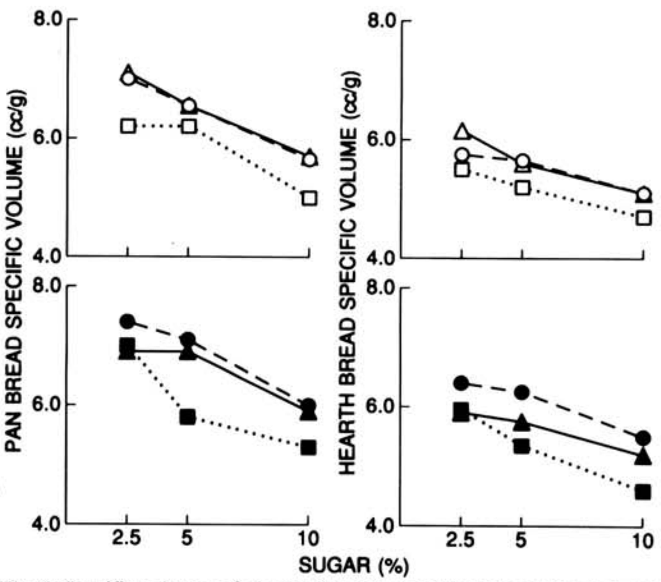

Fig. 4. Specific volumes of sheeter-developed pan bread and hearth bread prepared from formulas containing 2% (○, ●), 8% (△, ▲), and 16% (□, ■) shortening in the absence of eggs (○, △, □) and with 8% eggs (●, ▲, ■) at various sugar levels.

External Properties of Sheeter-Developed Breads with Variable Levels of Shortening, Sugar, and Egg

Bread type, shortening level, sugar level, and egg level all significantly ($P < 0.001$) influenced bread specific volume (Fig. 4). Generally, results were consistent with differences in proof heights discussed above (Fig. 3). The specific volume of the pan bread was larger than the hearth bread for all formulas.

It is well known that addition of 1–3% shortening to a bread formula improves loaf volume by increasing oven spring (Pomeranz and Chung 1978, Moore and Hoseney 1986b). Bell et al (1977) speculated that solid components of shortening facilitate the production of an ordered dough structure that favors gas retention. Moore and Hoseney (1986a) attributed the lower final height of bread prepared without shortening to a rheological change in the dough during baking that restricts expansion once temperature exceeds 55°C.

In the current study, where shortening levels exceeded conventional levels, loaf volume was depressed by additional shortening (Fig. 4). The specific volume of bread containing 8% shortening was slightly lower ($P < 0.05$) than that of bread containing 2% shortening. When shortening was increased further to 16%, specific volume decreased ($P < 0.01$) markedly.

The reduced gas production of dough containing high sugar levels was reflected by a strong negative impact ($P < 0.01$) of sugar level on bread specific volume (Fig. 4).

Addition of eggs to the formula imparted a slight but highly significant ($P < 0.01$) improvement in bread specific volume (Fig. 4). The complex composition of eggs imparts numerous functional effects on baked products. The loaf volume advantage imparted by eggs may relate to increased dough water content and/or the emulsifying, coagulating, and leavening action of whole eggs documented for sweet baked goods (Forsythe 1970).

Colombian *aliñado* hearth bread has an excellent appearance because of the glossy golden color imparted by the egg wash (Fig. 5). The egg wash and the high-fat formula combine to give a soft crust, rather than the crispy crust associated with French hearth bread. Colombian *aliñado* hearth bread is relatively dense, but should have a bold appearance. The boldness of the hearth bread can be measured by determining roundness, or shape, from the ratio of maximum height to maximum width (Fig. 6). Shortening and egg levels had no effect ($P > 0.05$) on hearth bread shape. Increasing sugar levels had a slight ($P < 0.05$) negative effect on hearth bread shape.

An unexplained problem that occurs occasionally in Colombian bakeries is sidewall collapse near the base of the loaf during

Fig. 5. Colombian *aliñado* hearth bread produced from a formula without eggs containing 10% sugar and 16% shortening.

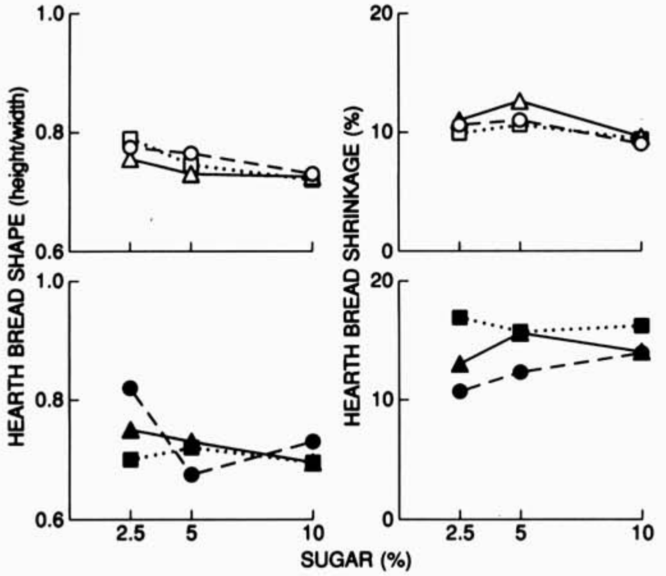

Fig. 6. Shape and shrinkage of sheeter-developed hearth breads containing 2% (○, ●), 8% (△, ▲), and 16% (□, ■) shortening in the absence of eggs (○, △, □) and with 8% eggs (●, ▲, ■) at various sugar levels.

cooling. Shrinkage of hearth breads, measured by comparing the height of hearth bread out of the oven with height the following day, was within acceptable limits for all formulas (Fig. 6). Shrinkage was not influenced ($P > 0.05$) by sugar or fat levels. Inclusion of eggs in the formula significantly ($P < 0.01$) increased shrinkage, but not enough to completely eliminate the loaf volume advantage previously discussed (Fig. 4).

Crumb Properties of Sheeter-Developed Breads with Variable Levels of Shortening, Sugar, and Egg

Bread crumb structure was not significantly ($P > 0.05$) affected by level of eggs or shortening (results not shown). Crumb structure of bread made from 10% sugar was slightly ($P < 0.05$) superior to crumb structure of bread prepared with less sugar (0.2 units on average), but the magnitude of the effect was too slight to be of practical importance (results not shown).

Bread crumb was significantly ($P < 0.001$) brighter (mean score 8.5 with eggs compared to 7.9 without eggs) when eggs were included in the formula. Neither shortening nor sugar levels affected ($P > 0.05$) crumb color (results not shown).

Bread crumb maximum compression force, a measure of firmness (Kilborn et al 1983) was not affected ($P > 0.05$) by eggs, but increased significantly ($P < 0.001$) with increasing shortening level and increasing sugar level (Fig. 7). The greater denseness (lower specific volume) of bread prepared from high-shortening, high-fat formulas (Fig. 4) likely accounts for the greater crumb firmness (Fig. 7). The lower moisture content of the high-

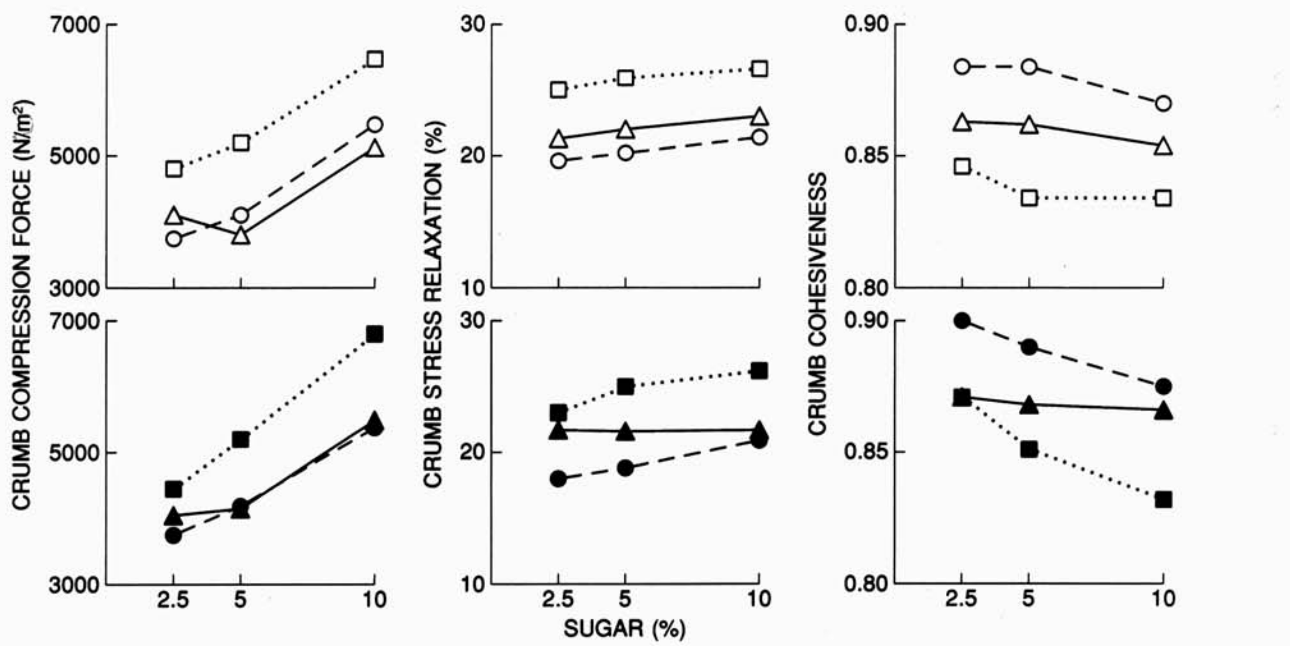

Fig. 7. Textural measurements of crumb from sheeter-developed pan bread prepared from formulas containing 2% (○, ●), 8% (△, ▲) and 16% (□, ■) shortening in the absence of eggs (○, △, □) and with 8% eggs (●, ▲, ■) at various sugar levels.

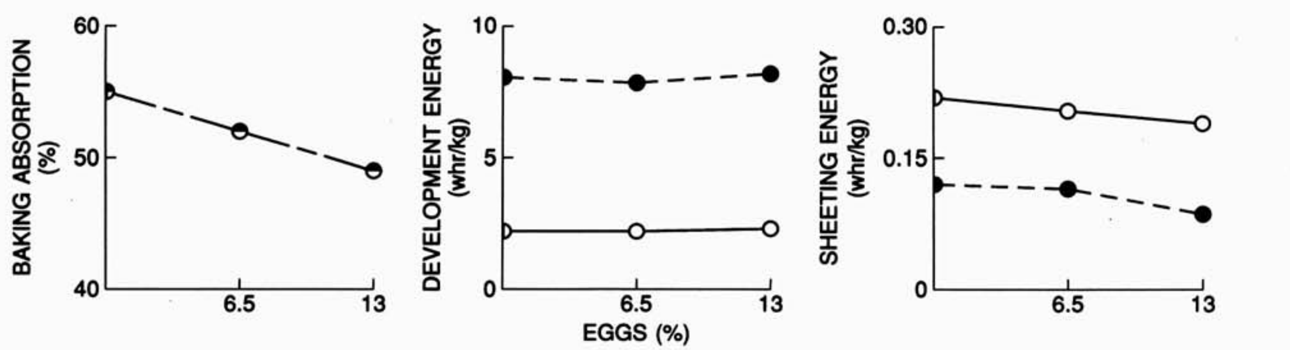

Fig. 8. Baking absorption, energy required to develop dough, and energy required to sheet dough prior to molding for mixer-developed (●) and sheeter-developed doughs (○) containing 10% sugar, 16% shortening, and various levels of eggs.

shortening bread, verified from bread weights following baking, also would increase bread firmness, negating the tenderizing effect of the shortening (Rogers et al 1988).

Crumb stress relaxation and crumb cohesiveness, measures of crumb resilience (Kilborn et al 1983) were significantly ($P < 0.001$) influenced by egg, shortening, and sugar levels (Fig. 7). The effects of egg and sugar were too slight to be of practical importance. The reduced resilience (greater stress relaxation and lower cohesiveness) of bread crumb at high shortening levels may reflect lower bread moisture content.

Development of Doughs Containing High Shortening, High Sugar, and Variable Egg Levels by Sheeting Rolls and by Mixer

Colombian bakeries almost universally employ sheeting rolls to develop dough, although a few new model bakeries use high-speed mixers. The large capital investment required to switch to high-speed mixers makes the imminent abandonment of sheeter-development by Colombian bakers unlikely. Nevertheless, we thought it advisable to compare mixer development and sheeter development using rich Colombian formulas. At the same time, additional information on the effects of adding eggs, an optional *aliñado* bread ingredient, was obtained while holding sugar and shortening levels constant at 10 and 16%.

To facilitate dough handling at the dough development stage, sheeter-developed doughs must be processed at lower absorption than mixer-developed doughs (Kilborn et al 1981). In the current study, about 3–5% more water could have been added to the mixer-developed doughs. However, it was decided to process all bread at the optimum absorption for sheeter-development to avoid the effect of differing moisture content on dough and bread properties (Fig. 8). The liquid contribution of eggs reduced baking absorption by 3% for each additional 6.5% eggs (Fig. 8).

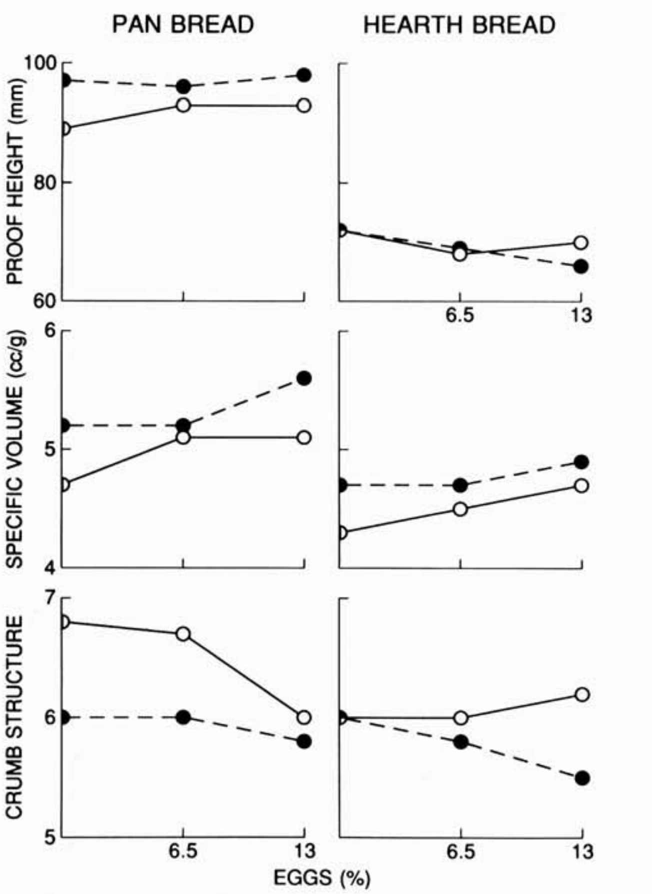

Fig. 9. Proof height, specific volume, and crumb structure of hearth bread and pan bread using mixer development (●) and sheeter development (○) for formulas containing 10% sugar, 16% shortening, and various levels of eggs.

Kilborn and Tipples (1974b) reported that developing doughs by sheeting required only 10–15% of the energy required to reach peak development by mixing. Similar results were obtained in the current study (Fig. 8). Egg level had no significant ($P > 0.05$) effect on energy required to achieve development by either procedure.

The doughs developed by sheeting rolls were tighter and less elastic following the initial fermentation. As a result sheeter-developed doughs required significantly ($P < 0.001$) more energy to sheet prior to molding than mixer-developed doughs (Fig. 8). However, it should be borne in mind that energy input at this stage was more than 10 times less than that used to develop the dough initially by sheeting rolls (Fig. 8). Egg level had no effect ($P > 0.05$) on sheeter energy regardless of development procedure.

Development procedure significantly ($P < 0.001$) affected proof height. A significant bread type to development procedure interaction term ($P < 0.01$) arose because the effect was entirely due to higher proof height of mixer-developed pan bread (Fig. 9). Hearth bread proof height was not influenced ($P > 0.05$) by development procedure. Egg level had no effect ($P > 0.05$) on proof height.

Hearth bread shape and shrinkage were not significantly affected ($P > 0.05$) by either egg levels or development procedure (results not shown).

In agreement with results from the first series of experiments (Fig. 4), eggs imparted a slight but significant ($P < 0.001$) increase in bread specific volume (Fig. 9).

Regardless of bread type, mixer development produced bread with significantly ($P < 0.001$) greater specific volume than sheeter development (Fig. 9). Previously, using more conventional formulas, Kilborn et al (1981) reported a 5% lower loaf volume for sheeter-developed bread than for mixer-developed bread. The volume advantage of mixer-developed bread may reflect beneficial oxidative effects of air incorporation during mixing (Marston 1986).

Rather than incorporating air into dough, sheeting removes gas inclusions in the dough, favoring a fine interconnected protein structure that leads to fine bread crumb structure (Kilborn and Tipples 1974b, Stenvert et al 1979, Kilborn et al 1981). The beneficial ($P < 0.01$) effect of sheeter-development on Colombian *aliñado* bread crumb structure was readily apparent in the current study for both pan bread and hearth bread (Fig. 9). An example of the crumb grain of sheeter-developed Colombian *aliñado* hearth bread is shown in Figure 10. The incorporation of eggs in the formula did not benefit crumb structure (Fig. 9). At 13% eggs, crumb structure deteriorated ($P < 0.01$). In these experiments neither eggs nor development procedure influenced ($P > 0.05$) crumb color.

Bread crumb firmness (maximum compression force) and resilience (stress relaxation and cohesiveness) were not significantly ($P < 0.05$) affected by egg level (Table I).

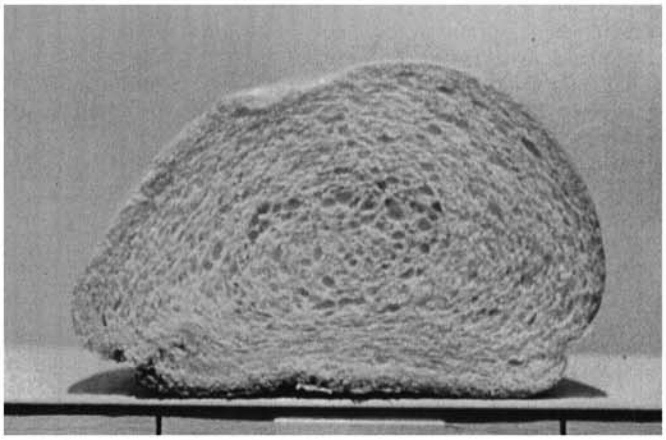

Fig. 10. Internal view of Colombian *aliñado* hearth bread produced from a formula without eggs containing 10% sugar and 16% shortening.

TABLE I
Effects of Development Procedure and Egg Level on Bread Crumb Texture[a]

Procedure	Maximum Force (N/m^2)	Stress Relaxation (%)	Cohesiveness
Mixer developed			
No eggs	8,650	27.2	0.82
6.5% eggs	7,350	26.9	0.83
13% eggs	7,980	25.7	0.83
Sheeter developed			
No eggs	6,490	27.2	0.83
6.5% eggs	6,520	25.3	0.84
13% eggs	5,980	26.3	0.83

[a] Mean values from duplicate bakings.

Despite the lower specific volume of sheeter-developed bread, sheeter-developed bread crumb was softer ($P < 0.001$) than mixer-developed bread crumb (Table I). This was consistent with the finer, thinner cell walls of the crumb in sheeter-developed bread. Development procedure did not affect ($P > 0.05$) bread crumb resilience.

CONCLUSIONS

This study shows how sugar, shortening, and eggs contribute to Colombian *aliñado* bread properties. High sugar levels imparted sweetness to the bread. In addition, sugar reduced proof height and specific volume by inhibiting fermentation. Specific volume of high-sugar bread might be increased by prolonging proofing, although this would be offset to some extent by increased spreading. In addition, Colombian bakeries typically are small and labor intensive, and longer proof times would disrupt production schedules.

High levels of shortening also depressed loaf volume. The greater denseness of high-sugar, high-shortening breads contributed to increased crumb firmness. The low baking absorption associated with high-shortening formulas also contributed to firmer crumb by lowering bread moisture content. The high shortening levels combined with an egg wash produced the soft crust preferred by Colombian consumers.

Eggs are an optional ingredient in Colombian *aliñado* bread, and, nutritional considerations aside, appear to contribute little to bread properties aside from flavor and color. Bread specific volume increased slightly when eggs were added to the formula, but this may be offset by increased bread shrinkage during cooling. The liquid contribution of eggs also reduced baking absorption.

Dough development by sheeting rolls is almost universal in Colombia. Mixer-development would reduce labor, allow higher baking absorption, and impart slightly greater loaf volume, although none of these factors seem to be a priority to Colombian bakers. The advantage of sheeter-development is a fine, soft crumb texture which is preferred not only in Colombia, but in all markets where sheeter-development is traditional.

An interesting aspect of this work that has implications in market development research was the confirmation that hearth bread properties can be predicted from pan bread results. As a result, equipment requirements are reduced, and familiar bread production and scoring methods can be used. There were no obvious anomalies in the trends observed for the two bread types, and trends observed for some properties, notably specific volume, were actually more readily observed for pan bread. Pan bread has the added advantage of being easier to score for crumb appearance and texture.

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