Pastry Lift and Croissant Volume as Affected by Microbial Transglutaminase

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ABSTRACT: Microbial transglutaminase forms nondisulfide covalent crosslinks in proteins and is increasingly being used in foods. We have previously demonstrated beneficial effects of microbial transglutaminase during breadmaking, which are comparable to traditional oxidizing improvers, hypothesized to act via formation of disulfide crosslinks. Transglutaminase substantially improved the lift of puff pastry. It also had a dramatic effect on the volume of yeasted croissants made with both white flour and a blend of wholemeal and white flour. Furthermore, these effects were preserved after the pastry and croissant doughs had undergone frozen storage for periods of up to 90 d. Transglutaminase, therefore, offers a potential solution to the problem of pastry and croissant dough deterioration on frozen storage.

Key Words: transglutaminase, pastry, croissant, flour improver

Introduction

Oxidizing flour improvers are believed to have beneficial effects due to the oxidation of cysteine residues in gluten proteins to form disulfide bridges, which crosslink and strengthen the protein (Lillard and others 1982). The resulting change in protein structure is hypothesized to account for the changes in dough properties (for example, improved gas retention) and the improvement in the quality of the baked loaf (Kauffman 1986). Whether oxidation is exclusively necessary for flour improvement, or whether such benefits are directly due to protein crosslinking, is still uncertain. We are, therefore, exploring methods of introducing crosslinks into gluten proteins without using oxidative methods and evaluating their effects.

Transglutaminase (protein-glutamine γ-glutamyltransferase, E.C. 2.3.2.13) catalyzes acyl-transfer reactions, introducing covalent crosslinks in proteins (Nonaka and others 1989). Crosslinks form between lysine residues and glutamine residues to form an ε-(γ-Glu)-Lys bond without decomposing the nutritional quality of the lysine residue (Seguro and others 1996). The enzyme has no obvious food safety implications and has been approved for food use in Japan (Anonymous 1996). We have previously reported the beneficial effects of transglutaminase in the breadmaking process (Gerrard and others 1998). We report herein the beneficial effects of microbial transglutaminase in pastry and croissant production.

Pastries and croissants are high-value baked goods that are increasingly popular when sold as frozen doughs, to be baked by the consumer or a retail outlet. Unfortunately, freezing of pastry dough and croissant dough leads to deterioration in product quality (Brach and Hanneforth 1995; Inoue and others 1994). We, therefore, decided to explore the possibility of using transglutaminase to alleviate some of the detrimental effects of this frozen storage.

Results

Effect of transglutaminase on pastry and croissant processing and product quality

Initial observations of pastry and croissant doughs to which transglutaminase had been added suggested that they were slightly stiffer than the controls. Lamination was slightly hindered by the decrease in extensibility of the dough sheet. The remainder of the development process could not be distinguished from that of control doughs. On defrosting of the croissant doughs, there was visible damage of crust in the control samples, with a weaker top crust and a visible leaking of butterfat. This was not true for the transglutaminase-treated samples. Control croissant doughs were also flatter than their transglutaminase-treated counterparts.

After baking, the transglutaminase-treated puff pastry and croissants all had excellent texture, mouthfeel, layer, and step structure. The main difference from the control samples was an increase in size. Typical samples are shown in Fig. 1 and 2.

Effect of transglutaminase on puff pastry lift

To quantify the improver response on pastry lift and assess whether the effect was preserved after frozen storage of the pastry dough, we undertook a trial in which control pastry rings were compared to transglutaminase-treated pastry rings, using in-house testing methods developed for assessing pastry quality (Morgenstern and Newberry 1998). Fig. 3 demonstrates that addition of transglutaminase to the pastry dough substantially improves the height of the baked pastry rings and, further, that this effect is preserved on frozen storage of periods of up to 90 d. Indeed, the transglutaminase-treated pastry that had undergone frozen storage had an improved lift, when compared to the transglutaminase-treated
pastry that had not been frozen. This may be due to the extra time that the enzyme had to act, during the thawing process. Transglutaminase would, therefore, seem to have enormous potential as a commercial flour improver for puff pastry production.

**Effect of transglutaminase on croissant volume**

In parallel with our studies on puff pastry, we undertook a trial to assess the effect of transglutaminase on yeasted croissant dough during frozen storage. In addition to their increased size, transglutaminase-treated croissants had a desirable flakiness and crumb texture with very good definition of steps. Fig. 4 shows the effect of transglutaminase on croissant volume as a function of time of frozen dough storage.

Wholemeal croissants have gained recent popularity amongst consumers, since they appear to be both “decadent and healthy”. However, many of the problems associated with commercially produced croissants, such as a high density and a bread-like texture, are exacerbated in wholemeal croissants. We, therefore, investigated the application of transglutaminase to this product. Croissants baked with a 50:50 blend of wholemeal flour and pastry flour were considerably improved by the addition of transglutaminase. Once again, in addition to an improvement in volume, the transglutaminase-treated croissants had a light flakiness, which the controls lacked. The improving effect was preserved on frozen storage, as shown in Fig. 5. The croissant doughs appear to be more prone to deterioration during freezing than the pastry doughs, possibly due to more demanding processing conditions. However, the improvement on addition of transglutaminase was significant after all storage periods.

Transglutaminase clearly has great potential as an additive to both white and wholemeal flour croissant doughs, especially those that are to be baked from doughs that have been previously frozen.

**Discussion**

Transglutaminase appears to be particularly suitable for use in laminated baked products. Some of the drawbacks associated with its use in other baked products, such as a reduction in the volume of transglutaminase-treated bread (Rohm 1992; Gerard and others 1998), are reversed in pastry and croissants, where the volume is markedly increased. We attribute this difference to the layer structure of laminated products: whereas strengthening a bread dough makes expansion more difficult, strengthening a laminated dough has the reverse effect. Presumably one of the main reasons for loss of potential lift in a pastry dough is incomplete dough layering, resulting in leakage of fat into the dough layers. This problem is exacerbated during the freeze thaw cycle, because the sheets may be ruptured by ice crystal growth during frozen storage. Transglutaminase appears to strengthen the dough sheets and, thereby, reduce this problem. Furthermore, the 2-dimensional nature of the dough in a pastry laminate means that the dough can rise more easily than in the case of bread, where the dough has been strengthened in all 3 dimensions.

**Conclusions**

Transglutaminase shows great promise as a processing aid in the bulk manufacture of pastries and croissants, particularly those that are to be manufactured from a previously frozen dough. The cost of the enzyme is likely to be offset by the increased value and increased shipping and shelf life of the product, and the saving on other flour strengthening ingredients, such as gluten. We are currently exploring the use of transglutaminase in other flour-based products, as well as its mechanism of flour improvement at the molecular level.
Materials and Methods

Materials

Flours (Eagle brand, sold as a pastry flour, and/or wholemeal flour) were purchased from a local mill. Butter (Alaco PB10, 190 × 300 mm × 10 mm, unsalted 500-g pastry butter sheets) and skimmed milk powder were obtained from New Zealand Dairy Ingredients Ltd. (Waitoa, New Zealand.). Fresh compressed yeast was obtained from NZ Food Industries Ltd. (Upper Hutt, New Zealand.). Salt was supplied by Saxa (Cerebos, Auckland, New Zealand.), sugar by Chelsea Sugar Ltd. (NZ Sugar Co., Auckland, New Zealand.), and lard by a local supermarket. Microbial transglutaminase was obtained from Amcor Trading Pty Ltd. (Melbourne, Australia). The powdered preparation was added to the flour and thoroughly mixed before the addition of the other ingredients.

Puff pastry production and assessment

Each dough paste was made from flour (1 kg), salt (18 g), and water (496 mL), according to Morgenstern and Newberry (1998). Where required, transglutaminase was added to the flour at 5000 ppm, based on dry flour weight. All doughs were mixed with a 3-horsepower variable-speed Baker Perkins mixer, using a 1-kg mixing bowl fitted with twin Z-arm blades. The dry ingredients were blended for 15 s, then water was added, and the dough mixed for 1 min at 250 rpm to produce a cohesive, partially developed dough. All pastry preparation was carried out at a temperature of 17 °C. The dough was sheeted on a SINMAG manual pastry brake to a thickness of about 10 mm. A 500-g butter sheet was envelope-folded into the dough sheet and given 1 2-fold and 3 4-folds, reducing the thickness of the sample between each step, to produce a final laminated sheet of pastry, 3 mm in thickness, containing approximately 128 theoretical butter layers. Rest periods between turns were 15 min. Blocks of pastry were either used immediately or stored frozen at −20 °C for the appropriate time period.

After sheeting, rings (61 mm outer and 22 mm inner diameter) were cut for baking. The rings were allowed to rest for 30 min at 17 °C, the thickness measured with calipers, and the rings baked for 11 min at 230 °C. After cooling, baked rings were evaluated for lift by measuring the minimum/maximum height using calipers. To calculate lift, the average height of the rings was divided by the corresponding height of the dough before baking. For each measurement, 10 control and 10 transglutaminase-treated rings were baked and measured.

Croissant production and assessment

Each dough paste was made from flour (1 kg), yeast (40 g), salt (18 g), lard (20 g), sugar (20 g), skimmed milk powder (30 g), and water (594 mL). Where required, transglutaminase was added to the flour at 5000 ppm, based on dry flour weight. Dry ingredients were mixed on a BP mixer, fitted with a temperature-controlled water jacket and cooled with ice, at 86 rpm for 30 seconds. The lard, yeast, and iced water were then added and a further 2 min mixing at 86 rpm was carried out, after which time the dough was rested, covered at 10 °C, for 5 min, before lamination on a SINMAG pastry brake, at 17 °C, using butter sheets (459 g). After 3 3-folds the pastry was rested for 20 min at 10 °C. Pastries were then processed at 17 °C. The pastry sheet of final thickness 6 mm was cut into triangles with a sharp knife to a standard size (length 120 mm, width 135 mm, weight 61 ± 1 g). Each triangle was reduced to 2.4 mm on a hand-driven pastry brake with the rollers set 2.5 mm apart, then formed into croissants with 7 steps. The croissants were either frozen immediately and stored at −20 °C for the appropriate time period, or proved at 29 °C for 55 min, relative humidity 85% and baked at 235 °C for 12 min. After cooling, the length (L), width (W) and height (H) of each croissant were measured using calipers, and the volume calculated according to the formula $V = \frac{1}{3} \pi WHL$.

For each measurement, 5 control and 5 transglutaminase-treated croissants were baked and measured.

Statistical analysis

Data were analyzed using the GENSTAT 5 statistical package, release 3.2, 1996, Lowes Agricultural Trust (U.K.). Significance of differences was defined at $P \leq 0.05$.

References


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