Effect of Pre-Gelatinized Flour on Bread

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Background

- Tang Zhong (water roux) is a gelatinized flour paste made by heating a combination of flour and water.
- Tang Zhong is generally added as a wet ingredient in small scale bakeries, especially in East Asian bread products, which tend to have a softer and moister texture.
- Tang Zhong as a paste does not allow for widespread industrial uses.
- Spray drying, extrusion, and drum drying can be used to produce pre-gelatinized flour as a dry product for industrial scale processing.
- Gelatinized starch are already in use as thickeners in place of gum in baked goods.
- **Objective:** To determine the characteristics of bread made with different combinations of pre-gelatinized flour.

A single-factor design using pre-gelatinized flour at 0%, 25% and 50% substitution for all-purpose flour was used to make a simple yeast roll.

Characteristics analyzed include weight loss, dimensions, moisture content, water activity, color, starch granule size, and texture.

Methodology

Preparation of Pre-Gelatinized Flour → Bake Bread in Single Factor Design → Evaluate Properties

Preparation of Pre-Gelatinized Flour

- One part flour and five parts deionized water were combined and mixed.
- Mixture heated up to 150°F and held for 5 minutes to ensure complete gelatinization.
- Mixture removed from heat, placed onto nonstick dehydrator sheet, dehydrated for 5 hours at 165°F.
- Moisture content of the dehydrated pre-gelatinized flour was verified to achieve between 12-14%, same as the moisture content of normal all-purpose flour.

Single Factor Design of Experiments

Base Recipe: 75% hydration yeast roll, with salt (1.56% Bakers' Percentage) and yeast (1.27% Bakers' Percentage).

Experiment Design: 0%, 25%, and 50% one-to-one substitution of pre-gelatinized flour replacement for all-purpose flour

Mixing: Water at 120°F added to dry ingredients, mixed manually. Samples were mixed for 2 minutes to allow for all ingredients to be hydrated, then fermented for 30 minutes before forming.

Forming: Samples were divided into 4 dough balls, weighing 48.6 grams each. Dough were shaped to be smooth and of similar size and shape. Samples were placed into the oven to proof for one hour at 70 °F, then baked in an oven at 375°F for 25 minutes.

Physiochemical Properties

Color measurements were taken by Konica Minolta CR-400 Chromameter after baking.

The Hardness, Fracturability, Springiness, Cohesiveness, Gumminess, Chewiness, and Resilience of bread was determined using a Texture Technologies texture analyzer with a TA-30 3" aluminum circular disk probe.

The starch granule images were taken from Nikon Model S Epi-Illuminator Microscope of 100x and 400x magnification.

Mass of the bread was measured using an OHAUS® SCOUT™ SPX2201 Portable Balance.

All pictures were taken with a Motorola Edge (2021).

Moisture Contents were measured by a Shimadzu Moisture Balance MOC-120H in baked form.

Water activities were measured with an Aqua Lab 4TE Dew Point Water Activity Meter in baked form.

Results

Physiochemical Properties

Gelatinization of Flour resulted in swelling and decreased amount of starch granule after dehydration (Fig. 1, 2) and had a darker color in appearance (Fig. 3). The surface of yeast rolls appeared rougher as pre-gelatinized flour proportion increased (Fig. 4, 5, 6), and air pockets in the crumb also decreased as pre-gelatinized flour proportion increased (Fig. 7, 8, 9).

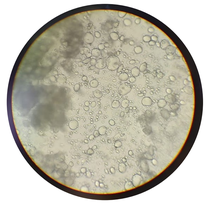

Figure 1
400x Magnification of All-Purpose Flour

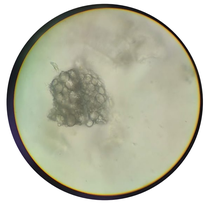

Figure 2
400x Magnification of Pre-Gelatinized Flour

Figure 3
All-Purpose Flour (L) and Pre-Gelatinized Flour (R)

Figure 4
0% Pre-Gelatinized Flour Substitution, Crust

Figure 5
25% Pre-Gelatinized Flour Substitution, Crust

Figure 6
50% Pre-Gelatinized Flour Substitution, Crust

Figure 7
0% Pre-Gelatinized Flour Substitution, Crumb

Figure 8
25% Pre-Gelatinized Flour Substitution, Crumb

Figure 9
50% Pre-Gelatinized Flour Substitution, Crumb

50% Pre-Gelatinized Flour substitution had the darkest color in the crust (Fig. 10), while 0% Pre-Gelatinized Flour had a lightest color in crumb (Fig. 11).

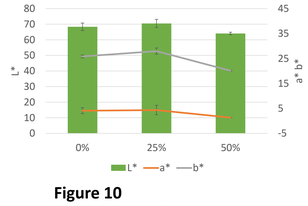

Figure 10
L*a*b* Color of Crust

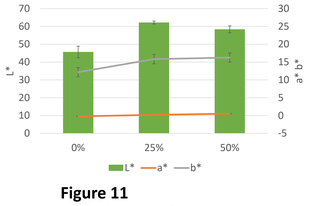

Figure 11
L*a*b* Color of Crumb

Results - Continued

Physiochemical Properties

25% Pre-Gelatinized Flour substitution had the lowest moisture loss based on weight (Fig. 12), while volume gain was proportional to the increased in content of pre-gelatinized flour (Fig. 13). Higher pre-gelatinized flour content led to higher hardness and fracturability (Fig. 14), while springiness and cohesiveness decreased (Fig. 15). Gumminess, chewiness, and resilience were all proportional to the pre-gelatinized flour content (Fig. 16, 17).

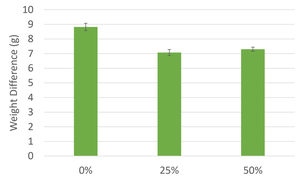

Figure 12 Weight Difference

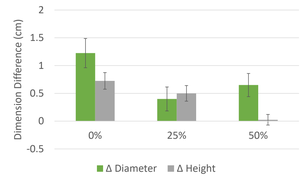

Figure 13 Diameter & Height Difference

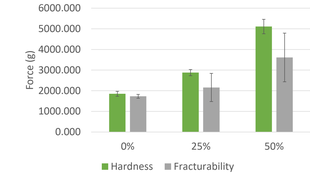

Figure 14 Textual Properties

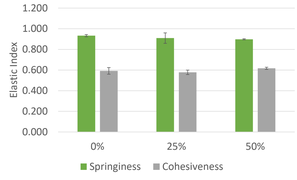

Figure 15 Elastic Properties

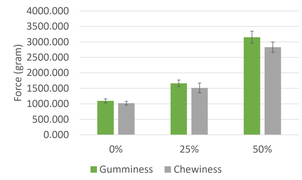

Figure 16 Chewing Properties

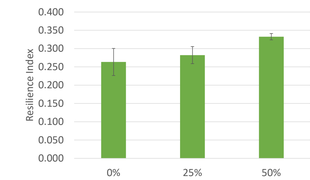

Figure 17 Resilience

Water activity decreased as pre-gelatinized flour content increased, where significant difference was found between 50% Pre-Gelatinized Flour, and 0% and 25% Pre-Gelatinized Flour(Fig. 18). Moisture content remained similar across all samples with no significant difference (Fig. 19).

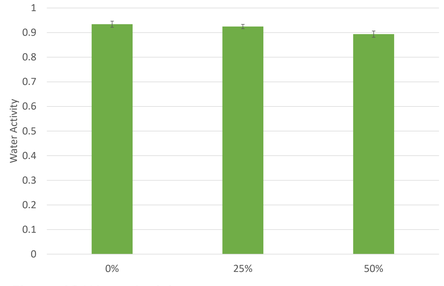

Figure 18 Water Activity

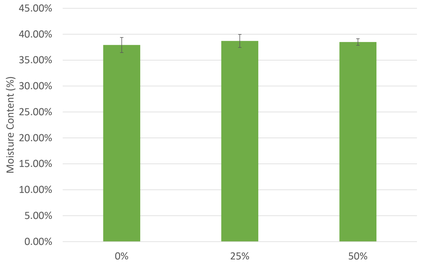

Figure 19 Moisture Content

Conclusion

- Heat applied during gelatinization process can lead to denaturation of gluten in flour, which possibly impacted the ability to form disulfide bonds, associated to stretchiness of gluten
- Roughness of crust showed the lack of a stretchiness in higher pre-gelatinized flour content, and density of crumb showed a lack of air structure
- Maillard reaction could have occurred during the dehydration process, leading to the darker color in pre-gelatinized flour
- Color of crust was darker on samples with the highest amount of pre-gelatinized flour, likely due to partial Maillard reaction occurred during dehydration process, preventing further Maillard reaction on the crust
- Color of crumb was lighter on sample without pre-gelatinized flour, likely due to density of crumb structure
- Higher moisture loss and volume gain in sample without pre-gelatinized flour
- Hardness, Fracturability, Gumminess, Chewiness, and Resilience increased as pre-gelatinized flour content increased
- Despite similar moisture content, water activity was lowered as pre-gelatinized flour content increased