FOOD CHEMISTY

Course No.-DTC-321, Credit Hours – 3 (2+1)

Physico-chemical changes during baking

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Several stages can be distinguished during the changes from **dough** to a **baked product.** They are :

- **Enzyme active stage (from 30^0C to 70^0C)**
- **Stage of starch gelatinization (From 55 to 70^0C)**
- **Stage of water evaporation**
- **Stage of browning and aroma formation**

- These changes are different in => outer portion of the dough and in the interior of the crumb.

- This => because in the oven since heat transfer occurs slowly in the dough => there is a steep temperature gradient inward from crust of the dough.

sequences of changes taking place during conversion of foamy texture of dough => spongy texture of bread and other product by baking at a temperature of 220^0C to 250^0C include

Chemical and physical changes:

1. **When dough is put in the oven**

- rate of **fermentation** initially **increases** as heat is conducted through the dough => Upto 50^0C, yeast produces CO_2 and ethanol.

- **viscosity** of dough **falls** rapidly and reaches to minimum at about 60^0C.

- At the same time thermal expansion of gas within each cell result in **rapid expansion of loaf volume**, known as "**oven spring**".

2. As **internal temperature of dough increases above 37^{0}C** => activity of yeast **decreases** and gets inactivated at 54^{0}C.

- beyond 60^{0}C, **viscosity** of dough **again increases rapidly** => caused by **swelling of starch** accompanied by **release of amylose** and by **protein denaturation**.

- As the crumb starch gelatinizes at 65^{0}C => **α and β-amylase** present will attack => starch => amylolytic activity **continues** until their enzymes are **inactivated** at about **74 ^{0}C.**

- optimum amylolytic activity is **desirable** to limit the degradation of gelatinized starch to counteract **staling of bread**.

- At the same time => denatured protein, swollen and partially gelatinized starch forms a **stable crumb network** at about 74^0C => this transformation continues until the end of baking when the internal temp reaches to **93 - 100^0C**.
- During this time **gluten** looses its tough and elastic state and becomes stiff and brittle.
- This stiffens starch structure so that a **firm elastic crumb** is formed => starch granules of crust surface gelatinize almost completely.
- This is specially the case when "oven humidity" is high => resultant starch film produces a **pleasing glaze**.
- This also retards drying and settling of the crust and permits **full expansion** of dough.

3. above process results in => **tremendous increase** in the tensile strength of dough and increase => presence of gas bubbles.

- Consequently membrane gives way and becomes permeable => allowing H_2O, CO_2 and ethanol to evaporate => results => baking weight loss.

- internal temperature never exceeds **100^{0}C,** but the outer temperature reaches nearly oven temperature (~ **200^{0}C**) => water evaporates more from the surface and the crust is formed => results in **weight losses** during crust formation up to **8-14%** of the fresh dough weight.

- At high temperature to which the outer part of the dough is exposed => **Starch degrades** => dextrin, mono and disaccharide at 110^{0}C-140^{0}C.
- Caramelization and non-enzymatic browning also occur at ~140-150^{0}C providing => sweetness and colours to the crust.
- roasted flavors develop at 150-200^{0}C.
- In the crust => heterocyclic compounds pyrroline and pyridine, as well as furanone and 2 and 3 methyl butanal are formed => responsible for the roasty, malty and caramel flavor respectively in the products.
- autoxidation products of linoleic acid => such as methional, and diacetyl are also involved in the aroma of the crumb.

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Changes during storage

Bread quality rapidly changes during storage due to

1) Moisture adsorption - the crust loses its crispiness and glossiness.
2) Aroma compounds of freshly baked bread evaporates => resulting in loss of flavor.
3) Some of very labile aroma compounds decrease rapidly on storage due to oxidation and other reactions.
4) The crumb structure also changes => although at a slower rate.

- crumb becomes firm => its elasticity and juiciness => lost, and it crumbles easily.
- This is known as => **staling defect** of crumb, which is basically a starch retrogradation phenomenon

Determination of gluten content in flour

- **gluten content** determine => loaf volume of bread and an increase in the **loaf volume** of bread is noticed => increase in gluten content of the flour.
- Gluten exhibits properties of => **cohesion, elasticity and viscosity** which are => combined characteristics of its two insoluble component proteins => glutenin and gliadin.
- For good bread flour:
- **wet gluten content** ranges between 30 to 36 % and
- **dry gluten content** ranges between 10 to 12 %.

Apparatus:

1. Mortar
2. Glass rod
3. Hot air oven
4. Desiccator
5. Analytical balance

Principle:

- Gluten is separated out from the flour by washing the dough made using water.

- albumins, globulins and other smaller proteins as well as starch are **washed away** with water leaving behind a cohesive, elastic and rubbery mass called => **crude wet gluten**.

- 65-75% of water present in crude wet gluten is dried out by drying at 100 °C for 24 h and weighed to get a value of **dry gluten**.

Procedure:

25 g of flour + 15 ml of water => mix into a smooth and tight dough using fingers => immerse the dough ball into water for about 1 h to ensure proper hydration => remove the dough ball and place it on a piece of blotting silk cloth having an aperture of 0.5 mm => wash it with a gentle stream of water till the water passing through the silk cloth does not contain starch => collect the residue on the silk cloth and make it free of water by rubbing between dry palms or by using a suitable press => weigh as **wet gluten** => dry this wet gluten in an oven maintained at 100 °C for 24 h.

Observations:

1. Weight of sample taken = W_1g
2. Weight of wet gluten = W_2 g
3. Weight of dry gluten = W_3 g

Calculations:

A. % wet gluten = (W_2/W_1) x 100

B. % dry gluten = (W_3/W_1) x 100

Determination of starch content in flour

- In wheat flour => **starch granules** are embedded in protein matrix.
- major role of starch => act as a water sink and set the system through partial gelatinization.
- Starch is also responsible for **staling phenomenon** since amylose fraction retrogrades rapidly during initial cooling of bread loaves. Slow changes in the amylo-pectin fraction are implicated in the further **firming** of bread during storage.
- Some of normal starches get **damaged** during milling stage => moderate amount of damaged starch is advisable while presence of excessive damaged starch => quite harmful

Apparatus:

1. Conical Flasks
2. Funnel
3. Filter papers
4. Beakers

Reagents:

1. Fehling A and B solutions
2. Methylene blue indicator
3. Concentrated HCl
4. Standard glucose solution
5. 50% NaOH
6. Phenolphthalein indicator

Principle:

- flour => suspended in water and undissociated residue containing starch => allowed to hydrolyze in the presence of dilute HCl.

- glucose produced => filtered out and titrated against Fehling A and B using Lane- Eynon method.

- Value of glucose obtained is multiplied by 0.9 to get value of starch content present in flour.

Procedure: conical flask => 3 g flour sample ✚ 50 ml cold water => stir => keep it aside for 1 hr. => filter it and wash **residue** with sufficient water => **heat** the undissolved residue for 2.5 hrs. in 100 ml of 2.5% HCl solution in a flask equipped with a reflux condenser => Cool, neutralize with NaOH and make up volume of 250 ml and filter it => Fill the filtrate in burette => Take 5 ml each of **Fehling A and B** solutions in a 250 ml conical flask => Add 20 ml of water and few pumice stones => boil on burner => Add sugar solution from burette until a faint blue colours remain => Add 2-3 drops of methylene blue indicator and add sugar solution till red color precipitates of **Cu_2O** is produced => Record the volume of sugar soln used => reduction of Fehling solns.

- Repeat the titration using standard glucose solution.
- Calculate the sugar present in hydrolysate.
- Convert the value of glucose to starch by multiplying with 0.9.

Observations:

1. Weight of sample taken = W gm
2. Final volume of starch hydrolysate = V_1 ml
3. Volume of standard glucose solution used = V_2 ml
4. Volume of starch hydrolysate used = V_3 ml

Calculations:

$$\% \text{ Glucose} = \frac{V_3 \times 2.5 \text{ mg glucose} \times V_1 \times 100}{V_2 \times 1000 \times W}$$

% Starch = % glucose x 0.9

THANKS