Effect of Yeast Concentration and Baking Temperature on Quality of Slice Bread

Shrikant Baslingappa Swami¹, N.J. Thakor² and P.R. Murudkar¹

Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri (MS)-415712, India.

Abstract
In the present study the effect of three different yeast concentrations i.e. 2.0, 2.4, and 2.8% and baking temperatures 230, 240, and 250°C on baking time (min), hardness of slice (g), volume expansion (%), and whiteness index of bread was observed. These dependent variables were analysed for optimization of bread for nine treatments. All other ingredients i.e. milk powder (2%), bread improver (0.03%), sugar (10%), salt (1.5%), vanaspati (3%) and oil (4%) water were kept constant. Sensory analysis of prepared bread by the various treatments was performed by coding different samples with market sample by using 9 point hedonic scale to get acceptable concentration of bread. Various sensory parameters of the bread were colour, texture, flavour, taste, mouth feel and acceptability was taken into consideration. Most accepted product from the sensory score was sample having yeast concentration 2.8% and baking temperature 240°C. The desirable quality of slice bread was based on the responses i.e. lower baking time, more volume expansion, more whiteness index, and lower hardness. The optimum zone for acceptability of bread was observed at baking time 20-21 min, volume expansion 665-718%, whiteness index 44-46, and hardness of slice 10.0 - 10.5 g was observed at yeast concentration was 2.5 to 2.8% and baking temperature was 239.5° to 245.62°C. The quality parameters were correlated with sensory score for acceptability of the sliced bread. The bread can be prepared by using yeast concentration 2.5-2.8% and baking temperature 239.5°-245.62°C for lower baking time, more value of volume expansion, more whiteness index, and less hardness of slice.

Keywords: Bread, Yeast, Baking, Whiteness Index, Hardness, Volume expansion, Sensory analysis.

1. Introduction
Bread is a staple food product made from wheat whose worldwide mass manufacture is responsible for significant energy usage and CO₂ emissions. Bread production occurs on a number of different scales, from the artisan bakeries serving the local community, to the large commercial bakeries serving entire nations, as well as in-store supermarket bakeries, small chain outlets and anything in between. There are many types of breads like white bread, brown bread, whole meal bread, wheat germ bread, wholegrain bread, granary bread, rye bread, unleavened bread, sour dough bread, flat bread, hemp bread and crisp bread. Various ingredients used in bread preparation are maida, yeast, sugar, salt, water, vegetable oil, milk powder, bread improver, etc.

The total bread production in the country is estimated to be 3.75 million tons and the baking industry annually growing at a rate of 6 per cent. The organized sector is said to be growing a little higher rate of 8 per cent. In 1977 Government had reserved bread industry for small scale. However, Britannia Industries Ltd (BIL) in private sector as which together accounted for 45 per cent of the total bread production in the country. In the unorganized sector it is said that there are about 75000 bread manufactures spread all over India including some of those operating from even residential premises. South India consumes 32 per cent of the total bread produced in the country followed by north consumes 27 per cent, west 23 per cent and east consumes 18 per cent.

The composition of wheat is responsible for the nutritional properties of bread. The properties of wheat are dependent on climate, soil and genetic variations and therefore vary between wheat types. Wheat has protein content that ranges from 8 to 13% and it also
has a high carbohydrate content of about 83% of the weight of the kernel. Other components of the wheat grain include bran and germ. Bran is the outer coating or “shell”, and is rich in B vitamins and minerals. The wheat germ or “embryo” is a rich source of B vitamins, oil, vitamin E and fat. The wheat germ is removed during milling as the fat tends to become rancid during storage, although it is a valuable ingredients in its own right and is used in many products. Minerals contained in wheat include calcium (151 mg), phosphorous, potassium (100 mg), iron (3.74 mg), magnesium (23 mg) and sodium (681 mg). Vitamins such as thiamine (B1) (0.5 mg), riboflavin (B2) (0.3 mg), folic acid and vitamins B9 and B6 are also distributed throughout the wheat grain.

Yeast is the single-celled fungus. Baker’s yeast is called as *Saccharomycetes cerevisia, “saccharo” meaning sugar and “myces” meaning fungus. Yeast can metabolize simple sugar, such as glucose, sucrose, and maltose. It is used to leaven bread and works by converting sugar into carbon dioxide, which causes the dough to rise so the bread will be light and airy. This makes yeast an extremely important ingredients in the production of the bread. Normally 2% yeast is added to the 100% of wheat flour (Mondal and Datta, 2008). If yeast concentration is increased then volume of dough also increases. So yeast is the main parameter in the bread preparation. Yeast is the driving force behind fermentation, the magical process that allows a dense mass of dough to become a well-risen loaf of bread. The essentials of any bread dough are flour, water, and of course yeast. As soon as these ingredients are stirred together, enzymes in the yeast and the flour cause large starch molecules to break down into simple sugars. The yeast metabolizes these simple sugars and exudes a liquid that releases carbon dioxide and ethyl alcohol into existing air bubbles in the dough. The dough has a strong and elastic gluten network; the carbon dioxide is held within the bubble and will begin to inflate it. This phenomenon resembles blowing up bubble gum. As more and tinier air cells fill with carbon dioxide, the dough rises.

Baking is the final and most important step in bread production, and can be defined as the process which transforms dough, basically made of flour, water and leavening agents, in a food with unique sensory features by application of heat inside an oven. In particular, white or french bread is the most popular type of bread, and is distinguished for having a crunchy and golden-yellow (or brown) crust, a sponge and light crumb with soft texture and intermediate moisture, and a typical flavour. All these quality aspects are the result of a series of physical and chemical changes produced by simultaneous heat and mass transfer occurring within the product during baking (Mondal and Datta, 2008; Purlis, 2010; Sablani et al., 1998; Scanlon and Zghal, 2008; Vanin et al., 2009). Optimization of the bread baking process is a subject of great importance for food industry. On the one hand, bread is a staple food and thus its production is relevant from a commercial point of view, besides its cultural relevance. On the other hand, baking is an energy-intensive process due to water evaporation occurring in the product (e.g. latent heat of water vaporization is 2.257 MJ/kg at 100°C). The energy demand for a conventional baking process is around 3.7 MJ/kg, though it can be higher (up to 7 MJ/kg) depending on specific products and operating conditions (Purlis, 2012).

Each ingredient plays an important role in bread preparation. Mainly volume expansion related to yeast concentration, if it increases or decreases then directly volume of bread increases or decreases. During preparation of bread the yeast concentration and heat supplied should be in appropriate range. Considering all the above points current study has been undertaken with an objective, to study the effect of yeast concentration and baking temperature on quality of slice bread.

2. Materials and Methods

Experiments were carried out in the Bakery Training Centre, Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Konkan Krishi Vidyapeeth, Dapoli. The quality analysis was carried out in NAIP Laboratory of Department of Agricultural Process Engineering.

The study was performed on the three different levels of yeast concentrations (2.0, 2.4 and 2.8%) and three different levels of baking temperature (230°, 240° and 250°C). The experiments were repeated three times for its replications. The results analyzed for optimization of bread quality parameters i.e. colour (whiteness Index, hardness, baking time (min), volume of expansion (%) and sensory evaluation (colour, texture, flavour, mouthfeel, taste and acceptability). The total levels of treatment combinations were 3×3×3=27.

2.1 Process for Preparation of Bread

Fig 1 shows the process flow chart for preparation of slice bread. The bread was prepared by taking wheat flour (1 kg), sugar 100g, milk powder 20g, bread improver 3g, water 550 mL, along varied yeast concentration i.e. 2.0, 2.4 and 2.8% into a planetary mixer. The ingredients are allowed to mix up to 5 minutes for 39 rpm. The dough is allowed to keep as such for natural proofing in the same mixer at normal temperature 20-22 ± 2°C and relative humidity 80-95% for 25 minutes. The dough was added with salt.
15 g and vanspati 30 g and allowed to mix up to 5 minutes for proper mixing of salt and vanspati in the same mixture at 39 RPM. The mixed dough was added with edible oil 40 g and allowed to mix in the same mixer for 20 minutes.

Wheat flour (1 kg) + Sugar (100 g) + yeast (2.0, 2.4, and 2.8%) + Milk powder (20 g) + Bread Improver (3 g) + Water (550 mL)

Mixing (5 min) in Planetary Mixer at 39 RPM
Proofing (20-30 min)

Addition of Salt (15 g) + Vanspati (30 g)

Mixing (5 min) (39 RPM)

Addition of Edible oil (40 g) & Mixing (39 RPM) (20 min)

Moulding

Proofing (RH 80%; Temperature 40°C)

Baking (Temperature 230°C, 240°C, 250°C)

Cooling (Room Temperature for 2 h)

Slicing and Packaging

Fig 1: Process Flow chart for preparation of bread

The dough was now ready for shaping. 400 g of above prepared dough was taken into the mould. The mould was marked inside to get the change in volume in X, Y and Z direction. The volume of dough in the mould was recorded and treated as initial volume. The moulds were kept in the proofer and allowed to raise at 80% RH and 40°C for 1 h. The moulds were taken out from the proofer and volume expansion was recorded in X, Y and Z direction. The moulds were kept in the deck oven for temperature 230°C. The breads in the moulds were observed continuously for each 2 minutes after 15 minutes interval from initial time when moulds were kept in the oven. The breads should have yellowish colour developed on its crust. When the crust get yellowish colour the time for baking was recorded. The breads after achieving the yellowish colour was taken from the oven and allowed to cool at room temperature 26 ± 2°C for 2 h.

The similar procedure was repeated for 2.4 and 2.8% yeast concentration and at 240°C and 250°C baking temperature. The similar observation i.e. volume expansion and baking time of the breads were recorded.

2.2 Estimation of Quality Parameters for Breads

2.2.1 Moisture Content

Moisture content of bread slice thickness 1 cm was recorded by hot air oven method. 10 g sample was taken in moisture box. Weight of moisture box and sample was recorded. Moisture box without lid was placed in hot air oven at 105°C for 24 h. Then lid was placed over the box and sample was taken out and kept inside the desiccators for 10-15 min. Weight after taking out sample from the dryer was recorded. Moisture content on wet basis was calculated by using Eq. (1). The experiment was repeated thrice for replication. The average moisture content was reported AOAC (2010).

\[
\text{Moisture}(%) = \frac{(w_1-w_2)}{w_1-w} \times 100 \quad \ldots (1)
\]

Where;
- \(w_1\) = weight of sample + moisture box;
- \(w_2\) = weight of sample after drying + moisture box;
- \(w\) = weight of moisture box.

2.2.2 Colour

A colour of bread slice was measured under Hunter Lab calorimeter. The Hunter Lab calorimeter was manufactured by Hunter associates Laboratory, USA. The equipment was standardized with standard black and white tile. The bread slices of 1 cm thickness were kept on aperture of color measuring device. The colour was measured as per 10°/D65 (ASTM) standard. It represents the colour in \(L\), \(a\) and \(b\) value. Degree of lightness or darkness of the samples was represented by “\(L\)” value, redness to greenness by “\(a\)” value and yellowness to blueness by “\(b\)” value on Hunter scale.

The experiment was repeated for 5 times and average values were reported. The whiteness index was calculated as per the procedure described by Purlis (2010) which is given in equation (2).

\[
W_t = 100 - ((100-L)^2 + a^2 + b^2)^{\frac{1}{2}} \ldots (2)
\]
Where;

\[ \begin{align*}
L &= \text{Lightness / darkness} \\
a &= \text{Redness / greenness} \\
b &= \text{Yellowness / blueness}
\end{align*} \]

2.2.3 Texture

The texture of slice bread was measured with QTS texture analyzer. Texture analyzer was made by M/s. Brookfield Engineering Labs, Inc., USA. The above mentioned slices were exposed to compression force with Probe No. TA3/100 and pretest speed was 0.5 mm/s, compression depth was 4 mm, and trigger load was 5 g for slice. For bread pretest speed 0.5 mm/s, compression depth 25 mm, and trigger load is 25 g the force deformation characterization were recorded from the instrument. The peak force for compression was reported. The experiment was repeated for 5 times for its replication and average peak force (g) was reported.

2.2.4 Sensory Analysis

Sensory evaluations of bread prepared by using the combination of different independent variables were tasted by group of twenty-six peoples (sensory panelists). They were from different age groups. Their scores were co-related with the mechanical testing of the product.

For evaluation of bread the sensory parameters i.e. colour, texture, flavour, taste, mouth feel, and acceptability. There are total ten breads were placed, out of which nine were from the treatments and one was control (Market sample- M/s Aiyangar Bakery). The samples were coded A-J. The sensory panel was trained. The rating was based of nine point hedonic scale. The standard format for sensory score sheet is given in Appendix II. The average scores were reported for each treatment including the control sample (Market sample).

2.3 Optimization

The desired quality of bread slice should have more whiteness, less baking time, more volume of expansion, and less hardness. The desirable quality of bread were correlated with the response of whiteness, baking time, volume of expansion, and hardness with the sensory scores for different treatments of yeast concentration (2.0, 2.4 and 2.8%) and baking temperature (230, 240 and 250°C) using superimposed contour plots.

3. Results and Discussion

3.1 Effect of Yeast Concentration and Baking Temperature on Moisture Content

Table 1 shows the effect of yeast concentration and baking temperature on moisture content of bread at crust, crumb and bottom portion. Moisture content of the bread at top (crust), crumb, bottom portion of the bread showed that the moisture content at top (crust) was 46.08 ± 1.10% db, crumb 66.63 ± 0.94% db, and bottom 42.76 ± 2.50% db. Effect of yeast concentration and baking temperature on bread has no much variation in the final moisture content of the crust, crumb, and bottom portion of bread.

3.2 Effect of Yeast Concentration and Baking Temperature on Baking Time

Fig 2(a) shows the effect of yeast concentration and baking temperature on baking time of bread. It was observed that as baking temperature increases from 230-250°C the baking time decreases 29 to 20 min. Similarly as the percent yeast concentration of bread increases the baking time decrease. It is also clear from contour plots Fig 2(b). The effect of yeast concentration and baking temperature on baking time of bread is represented by equation (3)

\[
B_T = 7.291\varepsilon_1^2 - 83.750\varepsilon_1 + 0.011\varepsilon_2^2 - 6.267\varepsilon_2 + 0.187\varepsilon_1\varepsilon_2 + 904.22 \quad (3)
\]

\((R^2= 0.998)\)

From equation (3) and contour plot it is clear that the combined effect of percent yeast concentration and baking temperature will also reduce the Baking time.

Table 2 shows the ANOVA of baking time. It was observed that effect of yeast concentration (%) and baking temperature on baking time is highly significant either at \(p \leq 0.05\) or \(p \leq 0.01\).

3.3 Effect of Yeast Concentration and Baking Temperature on Volume Expansion

Fig 3(a) shows the effect of yeast concentration and baking temperature on volume expansion (%) of bread. It was observed that as percent yeast concentration increases from 2.0 to 2.8% the volume expansion increases from 520.0-770.7%. Similarly, as the baking temperature of bread increases the volume expansion increases. It is also clear from contour plots Fig 3(b). The effect of yeast concentration and baking temperature on volume expansion of bread is given by equation (4)

\[
V_g = 12.812\varepsilon_1^2 - 1569.29\varepsilon_1 - 0.145\varepsilon_2^2 + 55.166\varepsilon_2 - 5.375\varepsilon_1\varepsilon_2 - 4923.07 \quad (4)
\]

\((R^2= 0.997)\)
From equation (3) and contour plot it is clear that the combined effect of percent yeast concentration and baking temperature will also increases the volume expansion. Table 3 shows the ANOVA of volume expansion. It was observed that effect of yeast concentration (%) and baking temperature on volume expansion is highly significant either at $p \leq 0.05$ or $p \leq 0.01$. 

Fig 2(a): Surface plot of effect of Yeast concentration (%) and Baking Temperature (°C) on Baking time (min) of slice bread.

Fig 2(b): Contour plot of effect of Yeast concentration (%) and Baking temperature (°C) on Baking time (min) of slice bread.
2.1 Yeast Concentration, %
2.2 Baking Temperature, °C

Fig 3(a): Surface plot of effect of Yeast concentration (%) and Baking temperature (°C) on Volume expansion (%) of slice bread.

Fig 3(b): Contour plot of effect of Yeast concentration (%) and Baking temperature (°C) on Volume expansion (%) of slice bread.

3.4 Effect of Yeast Concentration and Baking Temperature on Whiteness Index

Fig 4(a) shows the effect of yeast concentration and baking temperature on whiteness index of bread. It was observed that as percent yeast concentration increases from 2.0 to 2.8% the whiteness index first increases then decreases. Similarly, as the baking temperature of bread increases whiteness index first increases then decrease and again increase. It is also clear from contour plots Fig 4(b). The effect of yeast concentration and baking temperature on whiteness index of bread is given by equation (5).
Table 1: Moisture Content at Crust (top), crumb (middle) and bottom of bread

<table>
<thead>
<tr>
<th>Yeast Concentration (%)</th>
<th>Temperature (°C)</th>
<th>Moisture Content (% db.)</th>
<th>Top</th>
<th>Middle</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>230</td>
<td>42.67</td>
<td>66.59</td>
<td>42.68</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>230</td>
<td>42.79</td>
<td>66.62</td>
<td>42.79</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>230</td>
<td>42.84</td>
<td>66.66</td>
<td>42.85</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>240</td>
<td>42.65</td>
<td>66.59</td>
<td>42.65</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>240</td>
<td>42.74</td>
<td>66.63</td>
<td>42.73</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>240</td>
<td>42.81</td>
<td>66.65</td>
<td>42.82</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>250</td>
<td>42.70</td>
<td>66.67</td>
<td>42.71</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>250</td>
<td>42.78</td>
<td>66.64</td>
<td>42.78</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>250</td>
<td>42.85</td>
<td>66.66</td>
<td>42.85</td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>42.08 ± 1.10</strong></td>
<td><strong>66.63 ± 0.94</strong></td>
<td><strong>42.76 ± 2.50</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Analysis of Variance for Baking time

<table>
<thead>
<tr>
<th>Responses</th>
<th>Degree of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>6</td>
<td>4718.810</td>
<td>786.468</td>
<td>8.94</td>
<td>27.9</td>
</tr>
<tr>
<td>Residual</td>
<td>3</td>
<td>6.194</td>
<td>2.064</td>
<td>8.94</td>
<td>27.9</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4725.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at p ≤ 0.01; p ≤ 0.05**

Table 3: Analysis of Variance for Volume expansion

<table>
<thead>
<tr>
<th>Responses</th>
<th>Degree of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>6</td>
<td>3734090.0</td>
<td>622348.0</td>
<td>8.94</td>
<td>27.9</td>
</tr>
<tr>
<td>Residual</td>
<td>3</td>
<td>8767.910</td>
<td>2922.640</td>
<td>8.94</td>
<td>27.9</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>3742860.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at p ≤ 0.01; p ≤ 0.05**

\[
W_i = 21.241\epsilon_1^2 + 21.554\epsilon_1 - 0.035\epsilon_2^2 + 18.066\epsilon_2 - 0.514\epsilon_1\epsilon_2 + 2250.030 \quad \text{... (5)}
\]

\[W_i = 21.241\epsilon_1^2 + 21.554\epsilon_1 - 0.035\epsilon_2^2 + 18.066\epsilon_2 - 0.514\epsilon_1\epsilon_2 + 2250.030 \quad \text{... (5)}
\]

\[(R^2 = 0.998)\]

From equation (5) it is clear that the effect of percent yeast concentration on whiteness index shows that, the whiteness index increases initially followed by decreases gradually. As baking temperature increases the whiteness index decreases gradually followed by increase in whiteness index.

Table 4 shows the ANOVA of whiteness index. It was observed that effect of yeast concentration (%) and baking temperature on whiteness index is highly significant either at p ≤ 0.05 or p ≤ 0.01.

3.5 Effect of Yeast Concentration and Baking Temperature on Hardness

Fig 5(a) shows the effect of yeast concentration and baking temperature on hardness (g) of slice of bread. It was observed that as baking temperature increases from 230°C to 250°C the hardness increases. Similarly as the percent yeast concentration of bread increases the hardness gradually decrease. It is also clear from contour plots Fig 5(b). The effect of yeast concentration and baking temperature on slice of bread is given by equation (6).

\[
H_R = 44.416\epsilon_1^2 + 169.775\epsilon_1 + 0.066\epsilon_2^2 - 28.270\epsilon_2 - 1.636\epsilon_1\epsilon_2 + 3222.23 \quad \text{... (6)}
\]

\[(R^2 = 0.991)\]

From equation (6) it is clear that the combined effect of percent yeast concentration and baking temperature will also decreases the hardness of slice of bread. Table 5 shows the ANOVA of Hardness. It was observed that effect of yeast concentration (%) and -
baking temperature on hardness is highly significant either at \( p \leq 0.05 \) or \( p \leq 0.01 \).

3.6 Optimization of Dependents (Baking time, Volume expansion, Whiteness index, and Hardness)

Desirable qualities of bread are lower baking time, more volume expansion, more whiteness index, and lower hardness. Fig 5 shows the superimposed contour plots for effect of yeast concentration and baking temperature on baking time, volume expansion, whiteness index, and hardness of slice of bread.
It was observed that the lower value of baking time 20-21 min, more value of volume expansion 665-718%, more whiteness index 44-46 and hardness of slice 10-10.5 g was observed in optimum zone where the yeast concentration was 2.5 to 2.8% and baking temperature was 239.5° to 245.62° C. The optimum zone of lower baking time, more volume expansion, more whiteness index and lower hardness is shown in Fig 5.

### 3.7 Sensory Evaluation
Table 6 shows the sensory scores for the slice bread. It was observed that eight breads having scored
Table 4: Analysis of Variance for Whiteness index

<table>
<thead>
<tr>
<th>Responses</th>
<th>Degree of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P at 5%</td>
</tr>
<tr>
<td>Regression</td>
<td>6</td>
<td>17744.2</td>
<td>2957.360</td>
<td>8.94</td>
<td>27.9</td>
</tr>
<tr>
<td>Residual</td>
<td>3</td>
<td>30.905</td>
<td>10.301</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>17775.10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Significant at p ≤ 0.01; p ≤ 0.05

Table 5: Analysis of Variance for Hardness

<table>
<thead>
<tr>
<th>Responses</th>
<th>Degree of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P at 5%</td>
</tr>
<tr>
<td>Regression</td>
<td>6</td>
<td>3509.34</td>
<td>584.890</td>
<td>8.94</td>
<td>27.9</td>
</tr>
<tr>
<td>Residual</td>
<td>3</td>
<td>29.576</td>
<td>9.858</td>
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<tr>
<td>Total</td>
<td>9</td>
<td>3538.920</td>
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</table>

** Significant at p ≤ 0.01; p ≤ 0.05

Table 6: Average Sensory scores for various samples (Sample A - J)

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeast Concentration (%)</td>
<td>2.0</td>
<td>2.4</td>
<td>2.8</td>
<td>2.0</td>
<td>2.4</td>
<td>2.8</td>
<td>2.0</td>
<td>2.4</td>
<td>2.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Baking Temperature (ºC)</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensory Attributes</th>
<th>Colour</th>
<th>Texture</th>
<th>Flavour</th>
<th>Taste</th>
<th>Mouth feel</th>
<th>Acceptability</th>
<th>Overall Acceptability</th>
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<tr>
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more than forty-five. Sample A and B are near about the acceptability limit but best score was observed at sample code F (yeast concentration 2.8% and baking temperature 240°C). Sample J was market sample which is not much accepted by judges. It had less concentration of yeast (10%).

3.8 Correlation of Objective (Baking time, Volume expansion, Whiteness index, and Hardness) and Subjective (Sensory evaluation) Tests

It was observed from Fig6 the optimum zone was observed in yeast concentration 2.5-2.8% and baking temperature 239.50-245.62°C. From the sensory scores it was observed that the best score was observed at yeast concentration 2.8% and baking temperature 240°C. This is lying within the optimum zone of the superimposed contour plot.

Therefore it is recommended that the bread can be prepared by using yeast concentration 2.5-2.8% and baking temperature 239.50-245.62°C for the samples lower baking time 20-21 min, more value of volume expansion 665-718%, more whiteness index 44-46, and lower hardness of slice 10.0 - 10.5 g.

4. Conclusions

Following conclusions were drawn from the present investigation are as follows:

1. Bread can be prepared by using yeast concentration 2.5-2.8%.

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2. Baking temperature should be 239.5-245.62°C

3. Optimum baking time 20-21 min., volume expansion 665-718%, whiteness index 44-46 and hardness of slice 10.0 - 10.5 g.

References


