Development and optimization of shelf stable ready to eat palak paneer

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Abstract

A convenient ready to eat thermally processed palak paneer has been developed using retort processing. The processing parameters like temperature and time 110 to 125°C for 10 to 25 min respectively optimized on the basis of descriptive sensory evaluation and thermal parameter F0. The processing temperature and time of 116.9°C for 10 min was considered to be the most appropriate for retorting the palak paneer with overall acceptability of 7.81 and desirability 0.719. The developed product was subjected to various chemical, microbial and sensory analyse during storage for 180 days at ambient temperature (17-37°C). Free fatty acid (FFA) thiobarbituric acid (TBA) value and Peroxide value (PV) increased significantly (p<0.01) after 180 days of storage. And the product has good sensory and microbiological profile up to 180 day of storage.

Keywords: Palak Paneer, retort processing, sensory quality, RSM, free fatty acid, thiobarbituric acid value, peroxide value, sensory quality

Introduction

India is the second largest producer of vegetables in the world (rank next to china) and accounts for about 15% of the world’s production of vegetables. The current production level is over 146.55 million tonnes and the total area under vegetable cultivation is around 8494 thousand hectares, which is about 3% of the total area under cultivation in the country (National Horticultural database 2011) [24]. The diverse agro climatic zones of the country make it possible to grow almost all varieties of vegetables in India. Although India is the largest producer of vegetables in the world, the production per capital is only about 100 g per day. However, it is estimated that around 20–25% of total vegetables are lost due to poor post-harvesting practices. Less than 2% of the total vegetables produced in the country are commercially processed as compared to 70% in Brazil and 65% in USA (Sandhya 2010) [15]. Today the demand for processed foods goes beyond the fundamental requirements of safety and shelf life stability. This has resulted in many ready-to-eat items becoming popular during last few years. Ready-to-eat food is one such item, which is gaining popularity in urban areas. Retort processed technology is extensively used for production of long life ready-to-eat products of various types – vegetables, vegetable products, dairy products, food products, fruits etc.

Thermal processing is an important method of food preservation in the manufacture of shelf stable canned foods, and has been the cornerstone of the food processing industry for more than a century (Teixeira, 1992) [29]. In thermal processing, specifically retort processing, has long been used as a common preservation technique in food industry for shelf stable foods. Retort processing also used to produce microbiologically safe products having acceptable eating quality. The commercial retort processing ensures a reduction or inactivation of spore-forming microorganisms sufficient to guarantee commercial sterility (Awuah et al. 2007; Uhler, 1997) [4, 31]. However, there are losses of food product quality during thermal processing and storage.

Thermally processed food has been the focus of research studies in recent years. In view of the immense possibilities, the retort processing using retortable pouches offers long-shelf-life food products. The proposed investigation is to optimize the processes in terms of quality while meeting all the safety requirements. In keeping the above points in present study, attempt was made to develop shelf stable ready to eat palak paneer.
Materials and methods

Raw material and preparation
Palak paneer was prepared using palak, paneer, onion, garlic, ginger, green chilies, cloves, cardamom, cumin, cinnamon, and refined oil. All the ingredients were purchased from local market. For preparation of paneer standardized milk from Parag Dairy was purchased of 6% Fat. Flow chart (Fig. 1) illustrates the method of preparation and retort processing.

Indigenous multilayer laminated retort pouches (Pradeep Laminators, Pune, India) of 20 cm × 15 cm dimension having 4 layer configuration and thickness of 106.0 μm (aluminium foil 9.0 μm, cast poly propylene 70.0 μm, polyester layer 12.0 μm and biaxially oriented nylon 15.0 μm) were used for this study. A semi – automatic paddle objected sealing machine (Sun Ray industries Pvt. Ltd., Mysore, India) was used for sealing of pouches.

Retort processing
The pilot-scale horizontal stationary retorting system (Lakshmi Engineering, Chennai, India) located at the Centre of Food Science and Technology, Banaras Hindu University (BHU), Varanasi (India) was used. For thermal processing, the retort temperature were maintained at 110- 125 ºC for 10-25 min. Pressure was maintained at 20 ± 1 psi throughout the process, using steam- air mixture while heating and water - air mixture was used while cooling. Rapid cooling was accomplished by re-circulating cooling water. The numbers of experimental units were decided using Response Surface Methodology software (Design expert 9x). Central compound rotatable design (CCRD) provided 13 number of trial, which are conducted to obtain combination of selected temp-time for production of best quality of product.

Generation of Heat Penetration Data
For every production trial one of the pouch, transferred to the retort was fitted with thermocouples for measurement of the product temperature every minute during the process. A Cu/CuNi thermocouple (Lakshmi Engineering, Chennai, India) which was capable of measuring temperature in the range of 45 ºC to 135 ºC with an accuracy of ± 0.1 ºC. Thermocouple was placed inside the pouch and the retort was linked to a precision data logging device (Factory Talk ® View Site Edition Client software) which was capable of
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converting the temperature input data into corresponding process lethality values. These process lethality values were expressed as \( F_0 \) values.

**Optimization of product**

Product is evaluated on the basis of \( F_0 \) (given by thermal data analogue) and descriptive sensory quality, judged by panel of 10 judges consisting scientists and research scholars of Centre of Food Science and Technology, BHU, Varanasi. The samples of each trial were evaluated for descriptive sensory analysis on 10 point scale grading intensity of parameter 0-10.

\[
Y_i = \beta_0 + \sum \beta_i X_i + \sum \beta_{ij} X_i X_j + \sum \beta_{ii} X_i^2 + \sum \beta_{jj} X_j^2 + \epsilon
\]

Where, \( Y_i \) was the predicted response, \( \beta_0 \) was a constant, \( \beta_i \) was the \( i^{th} \) linear coefficient, \( \beta_{ij} \) was the \( i^{th} - j^{th} \) interaction coefficient, and \( \epsilon \) were independent variables.

The model F-value of 4.48 implies that the model is significant (\( P<0.0376 \)) (Table 2). The F-value for colour was significant (\( P<0.0376 \)) (Table 2). The model F-value of 4.48 implies that the model is significant. \( R^2 \) was found to be 0.7620, indicating that 76.20 % of the variability in the response could be explained by the model. The adjusted R-Squared of 0.5920.

**Storage study**

The optimized product was stored under ambient temperature (19-39 °C). The samples were analyzed at an interval of 15 days for free fatty acid (FFA) and peroxide value (PV) as per AOAC, 1990 and thiobarbituric acid value (TBA) as per Tarledgis et al. 1960 [20]. The sensory evaluation was done at 25±2 °C temperature. The sensory quality of product evaluated at an interval of 30 days on the basis of 9 point hedonic scale (9- like extremely, 1- dislike extremely) for colour and appearance, aroma, taste, texture, mouth feel and overall acceptability (Amerine et al. 1965) [19].

### Table 1: Experimental runs and actual values of factors used in central composite rotatable design of Palak paneer

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>Process Temperature °C</th>
<th>Process Time Minute</th>
<th>Sensory attributes scored on 10-point descriptive scale</th>
<th>F0</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>110</td>
<td>10</td>
<td>Colour, Uniformity, Surface Texture of curry, Smoothness, Spicy, Cooked, Texture, Ease of spread, Taste</td>
<td>6.11</td>
<td>9.19</td>
</tr>
<tr>
<td>2</td>
<td>125</td>
<td>10</td>
<td>7.52, 6.49, 6.87, 5.85, 6.11</td>
<td>6.01</td>
<td>43.14</td>
</tr>
<tr>
<td>3</td>
<td>110</td>
<td>25</td>
<td>5.95, 6.21, 6.51, 6.98, 5.46</td>
<td>6.89</td>
<td>42.34</td>
</tr>
<tr>
<td>4</td>
<td>125</td>
<td>25</td>
<td>6.27, 6.28, 6.59, 6.24, 7.64</td>
<td>6.12</td>
<td>32.41</td>
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<tr>
<td>5</td>
<td>106.893</td>
<td>17.5</td>
<td>5.54, 6.26, 6.32, 6.28, 4.51</td>
<td>6.76</td>
<td>55.19</td>
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<td>6</td>
<td>128.107</td>
<td>17.5</td>
<td>7.49, 6.12, 7.39, 7.27, 7.63</td>
<td>7.29</td>
<td>16.16</td>
</tr>
<tr>
<td>7</td>
<td>117.5</td>
<td>6.8934</td>
<td>6.51, 6.12, 6.54, 7.37, 7.47</td>
<td>7.93</td>
<td>22.25</td>
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<tr>
<td>8</td>
<td>117.5</td>
<td>28.1066</td>
<td>7.93, 7.91, 6.28, 6.28, 7.47</td>
<td>8.17</td>
<td>10.58</td>
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<tr>
<td>9</td>
<td>117.5</td>
<td>17.5</td>
<td>7.17, 7.39, 6.27, 6.36, 7.24</td>
<td>7.93</td>
<td>10.33</td>
</tr>
<tr>
<td>10</td>
<td>117.5</td>
<td>17.5</td>
<td>7.17, 7.39, 6.27, 6.36, 7.24</td>
<td>7.93</td>
<td>10.33</td>
</tr>
<tr>
<td>11</td>
<td>117.5</td>
<td>17.5</td>
<td>7.19, 7.52, 6.22, 6.23, 6.16</td>
<td>7.39</td>
<td>11.49</td>
</tr>
<tr>
<td>12</td>
<td>117.5</td>
<td>17.5</td>
<td>7.17, 7.22, 6.28, 7.65, 7.17</td>
<td>7.29</td>
<td>14.81</td>
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<tr>
<td>13</td>
<td>117.5</td>
<td>17.5</td>
<td>6.9, 7.14, 6.49, 7.52, 7.27</td>
<td>7.88</td>
<td>11.31</td>
</tr>
</tbody>
</table>

The optimized product was also analyzed for microbiological tests at an interval of 15 days. Total plate count (TPC) and coliform count were determined using plate count agar (HiMedia, Mumbai, India) and violet red bile agar (HiMedia, Mumbai, India), respectively, after incubation for 48 h at 30 °C. Yeast and molds were estimated with the help of potato dextrose agar (PDA, HiMedia, Mumbai, India) after incubation at 30 °C for 4-5 days by the method of Speck (1992) [20]. Spore formers were determined after killing the vegetative cells by keeping the sample in boiling water bath for 10–20 min and subsequently incubated at 37 °C and 55 °C for 48 h after inoculation by method of Food and Drug Administration (1992) [19]. Pathogen Escherichia coli was also analyzed by the method of Speck (1992) [20].

**Statistical analysis**

The data obtained during present investigation were suitably analyzed by using response surface software (RSM design expert 9x) that was used to optimize the temperature and time combinations. ANOVA was performed to validate the RSM optimization. The experimental data obtained from RSM design were analyzed by the response surface regression procedure using the following second order polynomial equation:

\[
Y_i = \beta_0 + \sum \beta_i X_i + \sum \beta_{ij} X_i X_j + \sum \beta_{ii} X_i^2 + \sum \beta_{jj} X_j^2 + \epsilon
\]

The average effect on Colour score varied from 6.15 to 7.93 (Table 1). Fig 2 shows that with increase in processing temperature and time there was an increase in sensory score of colour and then slight decrease in score in further increase in time and temperature. Effect of time and temperature on sensory score of Colour could be described by the following equation:

\[
\text{Colour} = +7.34 + 0.16*A – 0.21*B – 0.27*AB – 0.50*A^2 – 0.20*B^2
\]
Effect on Uniformity
The average effect on Uniformity score varied from 6.12 to 7.91 (Table 1). Fig 3 shows that sensory score of uniformity increases with increase in processing temperature and time and then decrease in sensory score of uniformity. Effect of time and temperature on sensory score of Uniformity could be described by the following equation:

\[ \text{Uniformity} = 7.44 + 0.16A - 0.29B - 2.50E^{-003}AB - 0.58A^2 - 0.66B^2 \]

The F-value for Uniformity was significant \((P<0.0168)\) (Table 2). The model F-value of 6.16 implies that the model is significant. \(R^2\) was found to be 0.8149, indicating that 81.49 % of the variability in the response could be explained by the model. The "Pred R-Squared" of – 0.0204 is in reasonable agreement with the "Adj R-Squared" of 0.6826.

Effect of Surface texture of curry
The average effect on Surface texture of curry score varied from 6.15 to 7.39 (Table 1). Fig 4 shows that with increase in processing temperature and time there was a decrease in sensory score of Surface texture of curry. Effect of time and temperature on sensory score of Surface texture of curry could be described by the following equation:
Surface texture of curry = +6.31 – 0.083*A – 0.25*B + 0.015*AB – 2.750E-003* A^2+0.25*B^2… (3)
The F-value for Surface texture of curry was significant (P<0.0214) (Table 2). The model F-value of 5.61 implies that the model is significant. R^2 was found to be 0.8004, indicating that 80.04% of the variability in the response could be explained by the model. The "The "Pred R-Squared" of – 0.2260 is in reasonable agreement with the "Adj R-Squared" of 0.6678.

**Effect on Smoothness**
The average effect on Smoothness score varied from 5.01 to 8.05 (Table 1). Fig 5 shows that sensory score of Smoothness decrease with increase in processing temperature and time. Effect of time and temperature on sensory score of Smoothness could be described by the following equation: Smoothness = +6.79 – 0.16*A – 0.080*B + 1.33*AB – 0.42*A^2 + 0.12*B^2…………(4)
The F-value for Smoothness was significant (P<0.0463) (Table 2). The model F-value of 4.11 implies that the model is significant. R^2 was found to be 0.7458, indicating that 74.58% of the variability in the response could be explained by the model. The " The "Pred R-Squared" of 0.0897 is in reasonable agreement with the "Adj R-Squared" of 0.5642.

**Fig 5** Effect of temp-time on smoothness of ready-to-eat palak paneer.

**Effect on Spicy**
The average effect on Spicy score varied from 4.51 to 7.64 (Table 1). Fig 6 shows that with increase in processing temperature and time there was a decrease in sensory score of Spicy. Effect of time and temperature on sensory score of Spicy could be described by the following equation: Spicy= +7.06 – 0.74*A – 0.36*B – 0.31*AB – 0.50*A^2+0.24* B^2………..…….(5)
The F-value for Spicy was significant (P<0.0490) (Table 2). The model F-value of 4.01 implies that the model is significant. R^2 was found to be 0.7410, indicating that 74.10% of the variability in the response could be explained by the model. The "The "Pred R-Squared" of –0.3047 is in reasonable agreement with the "Adj R-Squared" of 0.5560.

**Fig 6:** Effect of temp-time on spicy of ready-to-eat palak paneer.

**Effect on Cooked**
The average effect on Cooked score varied from 5.15 to 7.59 (Table 1). Fig 7 shows that with increase in processing time there was a decrease in sensory score of cooked and there was an increase with increase in processing temperature then slight decrease in sensory score of cooked. Effect of time and temperature on sensory score of Cooked could be described by the following equation: Cooked= + 6.74 – 0.24*A – 0.097*B + 0.54*AB – 0.65*A^2 + 0.14*B^2……………..……(6)
The F-value for Cooked was significant ($P<0.0466$) (Table 2). The model F-value of 4.10 implies that the model is significant. $R^2$ was found to be 0.7452, indicating that 74.52% of the variability in the response could be explained by the model. The "The "Pred R-Squared" of –0.5150 is in reasonable agreement with the "Adj R-Squared" of 0.5633.

**Effect on Texture**

The average effect on Texture score varied from 5.78 to 7.51 (Table 1). Fig 8 shows that with increase in processing time there was an increase in sensory score of cooked then decrease with further increase and there was an increase in sensory score with increase in processing temperature then constant in sensory score of cooked with further increase in temperature. Effect of time and temperature on sensory score of Texture could be described by the following equation:

$$
\text{Texture} = 7.17 - 0.29A - 0.26B - 0.52AB - 0.11A^2 - 0.41B^2
$$

The F-value for Texture was significant ($P<0.0368$) (Table 2). The model F-value of 4.52 implies that the model is significant. $R^2$ was found to be 0.7631, indicating that 76.31% of the variability in the response could be explained by the model. The "The "Pred R-Squared" of 0.0651 is in reasonable agreement with the "Adj R-Squared" of 0.5946.

**Effect on ease of spread of curry**

The average effect on Ease to spread the curry score varied from 5.57 to 7.71 (Table 1). Fig 9 shows that with increase in processing time there was a slight increase in sensory score of Ease to spread the curry and major increase due to increase in processing temperature. Effect of time and temperature on sensory score of Ease to spread the curry could be described by the following equation:

$$
\text{Ease to spread the curry} = 7.03 + 0.15A - 0.44B - 0.70AB - 0.50A^2 - 0.090B^2
$$

The F-value for Ease to spread the curry was significant ($P<0.0476$) (Table 2). The model F-value of 4.06 implies that the model is significant. $R^2$ was found to be 0.7434, indicating that 74.34% of the variability in the response could be explained by the model. The "The "Pred R-Squared" of 0.5042 is in reasonable agreement with the "Adj R-Squared" of 0.5601.
Effect on Taste
The average effect on Taste score varied from 6.11 to 8.11 (Table 1). Fig 10 shows that with increase in processing temperature and time there was an increase in sensory score of Taste. Effect of time and temperature on sensory score of Taste could be described by the following equation:
\[
Taste = +7.32 + 0.17A - 0.087B - 0.80AB - 0.36A^2 + 0.065B^2
\]  
(9)

The F-value for Taste was significant \((P<0.0423)\) (Table 2). The model F-value of 4.27 implies that the model is significant. \(R^2\) was found to be 0.7529, indicating that 75.29% of the variability in the response could be explained by the model. The "The "Pred R-Squared" of 0.5687 is in reasonable agreement with the "Adj R-Squared" of 0.5765.

Effect on Overall acceptability
The average effect on Overall acceptability score varied from 6.01 to 9.19 (Table 1). Fig 11 shows that there was a decrease in overall acceptability score with increase in processing temperature and time. Effect of time and temperature on sensory score of Overall acceptability could be described by the following equation:
\[
Overall\ acceptability = +7.58 - 0.73A - 0.18B + 0.63AB - 0.36A^2 - 0.042B^2
\]  
(10)

The F-value for Overall acceptability was significant \((P<0.0329)\) (Table 2). The model F-value of 4.74 implies that the model is significant. \(R^2\) was found to be 0.7718, indicating that 77.18% of the variability in the response could be explained by the model. The "The "Pred R-Squared" of -0.0830 is in reasonable agreement with the "Adj R-Squared" of 0.6088.
Effect on $F_0$
The average effect on $F_0$ score varied from 2.81 to 55.19 (Table 1). Fig 12 shows that with increase in processing time there was a slight increase in thermal score of $F_0$ and major increase due to increase in processing temperature. Effect of time and temperature on sensory score of $F_0$ could be described by the following equation:

$$F_0 = 11.64 + 17.95A + 3.18B - 1.07AB + 10.11A^2 + 1.49B^2 \ldots \ldots \ldots (11)$$

The $F$-value for $F_0$ was significant ($P<0.0001$) (Table 2). The model $F$-value of 62.51 implies that the model is significant. $R^2$ was found to be 0.9781, indicating that 97.81% of the variability in the response could be explained by the model. The "The "Pred R-Squared" of 0.8655 is in reasonable agreement with the "Adj R-Squared" of 0.9621.

Optimization for retorting
Optimization of retort process time and temperature for the development of palak paneer was based on sensory score and thermal quality $F_0$ using RSM. Out of 7 suggested solutions, the solution No.1 had better overall acceptability of 7.81 than all other solutions and also the desirability was 0.719, highest amongst all other solutions (Table 3). Hence the solution with processing temperature and time of 116.9°C for 10 min was considered to be the most appropriate for retorting the palak paneer. The optimized palak paneer was having predicted scores of 7.31 for colour, 7.05 for uniformity, 6.81 for surface texture of curry, 7.09 for smoothness, 7.68 for spicy, 7.03 for cooked, 6.99 for texture, 7.31 for ease of spread, 7.39 for taste, 7.81 for overall acceptability and 8.60 for $F_0$ (Table 3). The optimized product thus prepared scored 8.79 for colour and appearance, 8.44 for aroma, 8.66 for taste, 8.62 for texture, 8.80 for mouth feel and 8.88 for overall acceptability (Table 7).

Table 2: ANOVA for the different predicted models for responses of Palak Paneer

<table>
<thead>
<tr>
<th>Source</th>
<th>Degree of Freedom</th>
<th>Colour</th>
<th>Uniformity</th>
<th>Surface texture of curry</th>
<th>Smoothness</th>
<th>Spicy</th>
<th>Cooked</th>
<th>Texture</th>
<th>Ease of spread of curry</th>
<th>Taste</th>
<th>Overall Acceptability</th>
<th>$F_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>5</td>
<td>4.48</td>
<td>6.16</td>
<td>5.61</td>
<td>4.11</td>
<td>4.01</td>
<td>4.10</td>
<td>4.52</td>
<td>4.06</td>
<td>4.27</td>
<td>4.74</td>
<td>62.51</td>
</tr>
<tr>
<td>A-temp</td>
<td>1</td>
<td>1.74</td>
<td>1.16</td>
<td>1.52</td>
<td>0.50</td>
<td>10.77</td>
<td>1.89</td>
<td>4.51</td>
<td>0.64</td>
<td>1.31</td>
<td>12.42</td>
<td>238.78</td>
</tr>
<tr>
<td>B-time</td>
<td>1</td>
<td>2.85</td>
<td>3.72</td>
<td>13.95</td>
<td>0.12</td>
<td>2.48</td>
<td>0.31</td>
<td>3.42</td>
<td>5.89</td>
<td>0.33</td>
<td>0.73</td>
<td>7.49</td>
</tr>
<tr>
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<td>1</td>
<td>2.38</td>
<td>1.370E-004</td>
<td>0.025</td>
<td>16.60</td>
<td>0.94</td>
<td>4.71</td>
<td>6.94</td>
<td>7.29</td>
<td>14.17</td>
<td>4.64</td>
<td>0.42</td>
</tr>
</tbody>
</table>
The free fatty acids (FFA) are the primary products of microbial or enzymatic lipolysis of lipids present in food during storage. During storage, FFA content increased significantly from 0.124 to 2.337 % as oleic acid and which was due to the breakdown of long chain fatty acid into short individual fatty acid molecules and also lipid oxidation increased (Table 5). Increase in FFA in retort processed black clam meat was also observed by Bindu et al (2007) [6]. Similar results have been reported in retort processed shelf stable chapatis (Khan et al. 2011) [21], radiated and retort processed vegetable pulav (Kumar et al. 2011) [22], thermally processed pearl spot fish curry (Jayakumar et al. 2007) [13] and retort processed ready to eat tender jackfruit (Lakshamana et al. 2013) [23]. The increase in free fatty acid can be due to hydrolysis of triglyceride, triggered by infusion of moisture from the food into oil followed by oxidation (Fritsch 1981) [10]. Thioobarbituric acid (TBA) and Peroxide values (PV) of palak paneer analyzed periodically over the period of 180 days. The data showed in Table 5 shows a gradual increase during the period of storage of 180 days. TBA value is key index of secondary lipid oxidation, increased significantly from 0.143 to 2.125 mg O2/Kg of sample during storage (Table 5). A significant increase in Peroxide value (PV) from 1.632 to 19.187 meq O2/kg fat (Table 5). Similar results of increasing PV and TBA value reported by Bindu et al. 2004 [4] in ready to eat mussel meat, Bindu et al. 2007 [6] in retort processed black clam and shelf stable chapatis by Khan et al. 2011 [21], Dhanapal et al. (2010) [8], Jha et al. (2011) [17] and Gautam et al. (2013) [11] have also reported significant increase in TBA values with increase in storage time in ready to eat tilapia fish curry, long life kheer, Chhana kheer and chhana roll respectively.

**Microbiological analysis**

The microbiological profile of retort processed ready to eat palak paneer was done at regular interval of 15 day (table 6). The microbiological data showed that no total plate count and yeast mould count in processed product up to 180 days of storage. The pathogen tests of E. coli were also found negative in the samples during entire period of storage. The data showed on growth on commercial sterility test of spore formers at 37 and 55°C temperature. Khan et al. 2011 [21] reported the similar results on shelf stable chapatis and Kumar et al. 2011 [22] on ready to eat vegetable pulav. Dhanapal et al. (2010) [8] reported the similar results of no growth immediately after processing and at the end of storage study of 1 year, which indicates that the thermal processing given was sufficient to attain sterility in thermally processed Tilapia fish curry at 116°C and F0 value of 7.0. Rajan et al. (2014) [33] also reported the similar results of no detection of total bacterial count including E. coli, Salmonella spp., Clostridium spp., Staphylococi spp., yeast and mould during storage period of 180 days in retort processed chilli chicken, corresponding F0 value of 5.2.

<table>
<thead>
<tr>
<th>Storage Period</th>
<th>FFA</th>
<th>TBA</th>
<th>PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 days</td>
<td>0.124±0.004</td>
<td>0.143±0.002</td>
<td>1.632±0.174</td>
</tr>
<tr>
<td>15 days</td>
<td>0.340±0.0182</td>
<td>0.285±0.020</td>
<td>2.692±0.167</td>
</tr>
<tr>
<td>30 days</td>
<td>0.455±0.020</td>
<td>0.415±0.020</td>
<td>4.055±0.121</td>
</tr>
<tr>
<td>45 days</td>
<td>0.537±0.022</td>
<td>0.540±0.029</td>
<td>5.340±0.409</td>
</tr>
<tr>
<td>60 days</td>
<td>0.662±0.027</td>
<td>0.720±0.008</td>
<td>7.097±0.060</td>
</tr>
<tr>
<td>75 days</td>
<td>0.765±0.007</td>
<td>0.982±0.001</td>
<td>9.045±0.069</td>
</tr>
<tr>
<td>90 days</td>
<td>0.935±0.004</td>
<td>1.103±0.001</td>
<td>10.635±0.108</td>
</tr>
<tr>
<td>105 days</td>
<td>1.147±0.035</td>
<td>1.221±0.008</td>
<td>12.110±0.037</td>
</tr>
<tr>
<td>120 days</td>
<td>1.339±0.010</td>
<td>1.323±0.010</td>
<td>13.590±0.137</td>
</tr>
<tr>
<td>135 days</td>
<td>1.555±0.026</td>
<td>1.432±0.015</td>
<td>14.460±0.111</td>
</tr>
<tr>
<td>150 days</td>
<td>1.750±0.031</td>
<td>1.615±0.012</td>
<td>16.80±0.119</td>
</tr>
<tr>
<td>165 days</td>
<td>1.927±0.0170</td>
<td>1.866±0.032</td>
<td>17.880±0.064</td>
</tr>
<tr>
<td>180 days</td>
<td>2.327±0.022</td>
<td>2.125±0.026</td>
<td>19.187±0.038</td>
</tr>
</tbody>
</table>

Each value is represented as the mean ± SD of n=4.

### Table 5: Changes in chemical characteristics of ready to eat Palak paneer during storage period under room temperature (14-35°C)

### Table 6: Microbiological profile of retort processed ready to eat Palak paneer during storage period.
Sensory analysis
Table 7 showed the Sensory attributes of ready to eat palak paneer analyzed using a 9-point hedonic scale score revealed that the product scored 8.83 ± 0.108 for colour and appearance, 8.79±0.106 for aroma, 8.77±0.114 for taste, 8.84±0.115 for texture, 8.79±0.078 for mouth feel and 8.82±0.091 for Overall acceptability (Table 4.7) during initial day of storage. On storage, there is significant decrease in sensory scores and also with in acceptability limit. The sensory scores decreased to 6.15±0.126 for colour and appearance, 6.08±0.150 for aroma, 6.10±0.104 for taste, 6.13±0.108 for texture, 6.17±0.088 for mouth feel and 6.14±0.097 for Overall acceptability during storage period of 6 months under ambient (17-37°C) conditions and thus clearly indicating the effect of storage conditions on the quality attributes of the product. However, the samples stored at ambient (17-30°C) were acceptable up to 6 months of storage as the Overall acceptability score of the product remained in good.

Table 7: Sensory attributes of shelf stable ready to eat palak paneer during storage at ambient temperature (17-37⁰C) on 9-point hedonic scale

<table>
<thead>
<tr>
<th>Days</th>
<th>0 day</th>
<th>30 day</th>
<th>60 day</th>
<th>90 day</th>
<th>120 day</th>
<th>150 day</th>
<th>180 day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour &amp; Appearance</td>
<td>8.83±0.108</td>
<td>8.31±0.070</td>
<td>7.86±0.105</td>
<td>7.43±0.111</td>
<td>7.11±0.060</td>
<td>6.66±0.056</td>
<td>6.15±0.126</td>
</tr>
<tr>
<td>Aroma</td>
<td>8.79±0.106</td>
<td>8.38±0.128</td>
<td>7.86±0.105</td>
<td>7.44±0.136</td>
<td>7.02±0.112</td>
<td>6.52±0.179</td>
<td>6.08±0.150</td>
</tr>
<tr>
<td>Taste</td>
<td>8.77±0.114</td>
<td>8.28±0.102</td>
<td>7.81±0.136</td>
<td>7.35±0.127</td>
<td>7.06±0.120</td>
<td>6.60±0.085</td>
<td>6.10±0.104</td>
</tr>
<tr>
<td>Texture</td>
<td>8.84±0.115</td>
<td>8.33±0.097</td>
<td>7.85±0.099</td>
<td>7.42±0.108</td>
<td>7.11±0.056</td>
<td>6.62±0.135</td>
<td>6.13±0.108</td>
</tr>
<tr>
<td>Mouth feel</td>
<td>8.79±0.078</td>
<td>8.31±0.098</td>
<td>7.93±0.120</td>
<td>7.41±0.104</td>
<td>7.11±0.064</td>
<td>6.64±0.186</td>
<td>6.17±0.088</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>8.82±0.091</td>
<td>8.32±0.112</td>
<td>7.79±0.139</td>
<td>7.45±0.089</td>
<td>7.08±0.104</td>
<td>6.63±0.101</td>
<td>6.14±0.097</td>
</tr>
</tbody>
</table>

References