Development and Storage Stability of Spinach Chapaties

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Abstract Chapati, an unleavened, hot plate baked product was prepared using fresh spinach paste and permitted level of antimycotic agent like sorbic acid. Chapaties were inpack sterilized and finally packed in PFP packaging materials and stored at ambient room temperature conditions. Initially and at a regular interval; Chapaties were evaluated for physico-chemical changes, sensory attributes, colour values, texture profile and microbiological profile. Chapaties remained stable and acceptable for 12 months of storage studies at ambient room temperature conditions (14-34°C).

Keywords Chapati, Spinach, Shelf-Life, Sensory, Texture, Colour

1. Introduction

Chapati is a flat unleavened, hot plate baked product prepared from whole wheat flour by converting dough with water by adding other ingredients like salt and sugar according to the taste. Though wheat flour is a staple food for half of the world population, still it is not a complete diet which lacks micronutrients. Balanced diets are not accessible to a large population of the world, particularly those in developing countries. In developing countries, multiple micronutrient deficiencies are more common than single deficiencies and the cause for their high prevalence is due to poor consumption and poor bioavailability of micronutrients (Gupta et al., 2011). In India, malnutrition is a major nutritional problem, which possesses a serious threat to the health of vulnerable groups of population. There are food based strategies by which micronutrients status of population can be increased. Food fortification is one such approach along with food production and dietary diversification by which status of micronutrient in food can be increased (Allen et al., 2006).

Green leafy vegetables are one of the most abundant and cheapest potential sources of minor nutrients like vitamins, minerals and proteins (Premavalli et al., 2001; Aletor et al., 2002). The most commonly used green leafy vegetables are spinach, fenugreek, chakota, etc., which are produced in surplus and have short life. Green leaves contain significant amount of iron and leaf concentrates made from fractionating; fresh green is one of the riches sources of this element. It also contains large amount of b-carotene, folic acid and protein as well as a considerable amount of pyridoxine, riboflavin.
and copper. Leaf concentrates can be an excellent dietary factor for the prevention of anemia (Mathur et al., 1989).

In recent years, there is growing concern regarding the nutritive value of foods and to nourish the ever increasing population. A balance of nutrients may be obtained by including whole cereals, vegetables, pulses, milk and milk products etc. Traditional preparations like chapati / paratha when prepared by incorporating with green leafy vegetables could serve a means of enhancing nutritive value of food. Green leafy vegetables have been used as value additives for different products as they are inexpensive, easily available and quickly cook able products. Hence, they can bridge the gap between intake and requirement of micronutrients to overcome the deficiencies prevalent in vulnerable groups of socioeconomic classes. Reports are limited on the enhancement of shelf-life of chapatties prepared by incorporating green leafy vegetable chapatties. Hence, efforts were made to develop chapaties by incorporating fresh spinach and antimycotic agent to enhance the shelf-life of green leafy vegetable chapatties.

2. Materials and Methods

Good quality Banshi wheat (Triticum aestivum), spinach, sugar, salt, milk powder, hydrogenated fat were procured from local market. Sorbic acid was procured from M/s Loba, Mumbai.

A) Wheat Sample and Physical Properties

Wheat procured from local market, manually cleaned and used for the preparation of spinach incorporated chapaties. Test weight and thousand kernel weight of wheat was determined using sample free of foreign material and broken kernels. The kernel length and width were determined by using a Vernier Calliper (ESAL, Scientific Industries, New Delhi, India) according to AACC approved methods (AACC, 2000).

B) Preparation of Whole Wheat Flour

The cleaned wheat was ground to particle size in an emery disc mill (Model No EGM-467 K, diameter: 18 in., (Ganesha & Company, Chennai, India) to obtain whole wheat flour (100% extraction rate) and sieved using 400µm mesh sieve. The ground flour (atta) was packed in PFP and stored at low temperature (4-6°C) till further use.

C) Rheological Characteristics of Wheat Flour

Rheological characteristics of wheat flour like water absorption, tenacity or maximum pressure required for the deformation (P), extensibility (L), configuration ratio of the curve (P/L) as well as baking strength (W) were determined by Chopin Alveo-Consistograph (Alveolink NG Consistograph; Villeneuve La Garenne, Chopin, France) by using approved Methods of the American Association of Cereal Chemists, AACC, 2000 method (AACC, 2000). The mixing characteristics like mixing time (Time in minutes taken by the curve to reach the peak) and peak height (The height attained by the curve at peak in cm as measured from the centre of the peak to the base line) were measured by using the 10 g moving mixograph (National Mfg, Division, TMCO, Lincoln, USA). Water absorption level used in the mixograph analysis was selected based on moisture and protein content of the sample, which was given in mixograph hand book (first edition 1997, p. 13). Rapid Visco Analyser 4D (Newport Scientific Pvt Ltd, Warie Wood, Australia) was used to measure pasting properties of flours as described by AACC method. The enzymatic activity of wheat flour was determined by using Falling Number (Perten 1500, Sweden) instrument as per AACC procedure (AACC, 2000).
D) Blanching

Spinach was procured from local market, washed in running tap water to remove foreign materials and contaminants. Leaves were chopped into small pieces and blanched in boiling water containing sodium bicarbonate (0.1%), magnesium oxide (0.1%) and sodium metabisulphite (0.2%) for 3 min. Blanched spinach was ground in a mixer and the paste obtained was used in the preparation of spinach incorporated chapaties.

E) Seasoning of Spinach Paste

Known quantity of hydrogenated fat (50g) is taken in a stainless steel tawa. Carom seeds (2.5g) is added to heated oil and required quantities of green chilli (10g), ginger paste (10g), cumin seed (2.5g), Garam Masala (15g, MTR brand) and coriander (5g) were added. Weighed quantity of spinach paste (130g) was added and stirred till the temperature reached 90°C. The seasoned spinach paste was cooled and used in the preparation of chapaties.

F) Preparation of Chapaties

Known quantity of atta (1Kg) was transferred into the dough kneader. Weighed quantity of salt (22g), sugar (30g), sorbic acid (3.0g) and milk powder (20g) was dissolved in measured quantity of water in a stainless steel vessel and added to the dough kneader and mixed for 1-2 minutes. Seasoned spinach paste was added to the dough and mixing was continued. Required quantities (25g) of the hydrogenated fat was melted and added to the dough kneader and the ingredients thoroughly mixed for about 5 minutes. Mixing was continued for about 10-15 minutes to get desired consistency. Dough was set aside for about 10 minutes for conditioning and mixed again for about 5 minutes. The dough was removed from the mixer and divided into round balls of 45 g pieces. Each piece was flattened using a semi automatic flattening machine under 75-100Kg/cm² for 20-30 seconds to have chapatti with a diameter of 150-170mm.

G) Baking of Chapaties

Chapaties were baked on a hot plate (electric/gas). When one side was partially baked, the chapaties were reversed with the help of ladle and melted vanaspati was applied on it. The chapati was reversed again till it attained a creamy baked appearance. The temperature of the hot plate during baking operation was maintained around 240-250°C.

H) Packing and Inpack Heat Sterilization

Four numbers of chapaties were packed in Polypropylene (75µ, PP) pouches, sealed hermetically and inpack sterilized in a hot air oven at 90°C for 2 hrs. Finally they were packed in paper (45 GSM)-aluminum foil (20 µ)-polyethylene (37.5 µ) laminate pouches (PFP) and stored at ambient room temperature conditions (14-34°C) for further storage studies.

I) Chemical Analysis

Moisture, protein, fat, total ash were determined by standard AOAC (1990) methods (AOAC, 1990). Chlorophyll and carotenoid contents were estimated using hexane-acetone solvent mixture and vitamin C by titrometry using 2,6 dichlorophenol indophenols reagent (Ranganna, 1986). Storage changes in spinach chapaties were monitored by determining peroxide value (PV) and free fatty acids (FFA) as per AOCS (1990) methods, while thiobarbituric acid value (TBA) was determined as per the method of Tarledgis et al (1960) initially and after every three months. For measuring the browning intensity, 5 g sample was shaken with 100 ml 70% ethanol for 2 hrs, filtered and optical density was
measured at 420 nm. Microbial profiles of the spinach chapatis were determined using the petri plates methods for standard plate count (SPC) on plate count agar, coliform count on violet red bile agar and yeast and mold counts on potato dextrose agar (Speck, 1992).

J) Colour Values

The colour values in terms of L ,a and b for spinach chapatis were measured using a Hunter Colour Meter (Data Lab; Silvasa, Gujarat, India) with illuminant D_65 and 10^0 observer. A higher L value indicated a brighter or whiter sample. Values of a and b indicated the red-green and yellow-blue chromaticity respectively (Yadav et al., 2008).

K) Statistical Analysis

Experiments were performed using a 2-way factorial design consisting of storage time and attributes studied. All the experiments were performed in triplicate and Analysis of Variance calculated using Statistica Software Version 7.0 of Stat Soft Incorporation, Tulsa OK, USA as per the method given by Snedecor & Cochran (1968).

L) Sensory Evaluation

Sensory quality of spinach chapatis was evaluated by a panel of 15 judges by grading for colour, aroma, texture and taste on a 9 point hedonic scale, with 9 as excellent in all respects and 1 for unacceptable samples (Larmond, 1977). The OAA score was calculated by taking the average of the scores for all the four parameters.

3. Results and Discussion

Chapatis were prepared by fortifying wheat flour with different concentrations of spinach paste keeping all other ingredients constant and evaluated for sensory attributes for their acceptance by a panel of semi trained judges. Chapatis scoring highest in all sensory attributes like colour, taste, texture was taken as standardized recipe for the preparation of preserved spinach chapatis.

Wheat purchased from the local market was analyzed for different parameter like test weight, thousand kernel weight, average kernel length, average grain width before it was grounded. It had a thousand kernel weight, average kernel length, average grain width of 77.0±0.7 Kg hL^-1, 41.2±0.3g, 6.8±0.02 mm, 3.0±0.01 mm respectively. The values of P, L and W were 132, 21 and 151 respectively. The mixing time and peak value of wheat sample was found to be 2.81 min and 52.09 % torque respectively. The pasting properties like final viscosity which shows the baking strength of the product was 155.12 RVU whereas set back which reflects the retro gradation properties of the sample was found to be 65.1 RVU. Falling numbers which is a measure of alpha amylase activity was found to be 430 sec.

The spinach chapatis had 30.81% moisture; 10.52% protein; 12.20% fat and 2.5% ash. The concentration of calcium, iron, sodium, potassium and zinc in fresh spinach chapatis was found to be 13.14, 5.8. 1418, 293, 2.8 mg/100g respectively. However there were no significant changes in mineral constituents of spinach chapatis during storage.

Table 1 shows the physico-chemical changes of spinach chapatis stored under ambient room temperature conditions. It is evident that the during storage the product did not show any significant changes in moisture content attributing to the fact the packaging system based on aluminum foil has been reported to provide barrier against mass transfer, light and micro-organism and thus the moisture content of the product was almost retained till the completion of storage studies (Ghose et
During storage, the rates of autoxidation as measured by PV, FFA and TBA values were significantly increased. The PV increased from 6.68 to 18.15 meqO₂/Kg fat, FFA from 1.42 to 3.21% oleic acid and TBA from 0.086 to 0.121 mg MA/Kg sample after 12 months of storage. The increase in rate of autoxidation may be attribute mainly due to the breakage of long fatty acid chain into individual fatty acid moieties and also increased lipid hydrolysis at elevated temperature. Hydrolysis of lipids during storage is normally brought about by the naturally occurring lipases (Clayton and Morrison, 1972). However, during thermal processing employed for baking, lipase activity was destroyed and therefore formation of free fatty acids in stored chapatis must have resulted from the decomposition of hydroperoxide. Previously Thakur & Arya (1990) have also reported an increase in FFA in the processed cereal products from the decomposition of hydroperoxide rather than that from lipids. The gradual increase in TBA in chapatis during storage is due to the fact that processed chapatis contained only solids and there was no liquid medium in it, hence there has been no dilution of TBA reacting substances and as a result there is a gradual increase on storage. The changes in browning in spinach chapatis were measured as optical density of the alcoholic extract at 420 nm during storage shows significant (p≤0.05) increase in browning indices from 0.65 to 0.98.

Analysis of the colour data like L, a and b of the chapatis from initial samples to the final (after 12 months of storage) was carried out and results are given in Table 2. The L and b values of the samples decreases significantly (p≤0.05), while ‘a’ values increases significantly indicating the samples becomes darker and the redness of the samples has been changed during storage. The changes may be due to the maillard reaction between the sugar and amino acids (Ilkay Tosun, 2004).

Texture of spinach chapatis was carried out initially and at a regular interval of 3 months using food texture analyzer. Different parameters like hardness, cohesiveness, springiness and chewiness were studied and the data presented in Table 3. It is seen from the data that hardness, which is a force necessary to attain a given deformation increases from 6.54 to 18.16 N after 12 months of storage. Cohesiveness which defines how well the structure of a product withstands compression and also chewiness, the energy required to chew a solid food to the point required for swallowing it increases significantly (p≤0.05) from 0.126 to 0.293 N and 0.90 to 2.12 Nmm respectively after 12 months of storage. The increase in all these attributes due to the fact that fresh baked chapatis most of the starch molecules are present in hydrated randomized form and most of the glucose moieties have inter–molecular hydrogen bonding with water and in this form chapatis have a soft and pliable texture. But on starch molecules tend to realign to attain more organized structure having hydrogen bondings between hydroxyl groups of adjacent glucose units. This change is associated with increase in crystallinity and loss in solubility of starch gel leading to hard and brittle texture (Arya et al., 1977). During storage the elastic property represented by springiness in TPA tests decreased significantly (p≤0.05) from 1.10 to 0.40 mm.

Sensory data for spinach chapatis was determined using 9 point hedonic scale and overall acceptability score below 7 was taken as the unacceptable limit for the rejection of sample. Based on this criterion the samples remained stable and acceptable throughout the storage period upto 12 months. The overall acceptability score of chapatis decreased from 8.5 to 7.1 after 12 months of storage and the details are given in Table 4.

There were practically no changes in the microbiological status of spinach chapatis during the entire storage period. The total plate count of freshly prepared chapatis and stored chapatis after 12 months of storage were within the prescribed limits, whereas no yeast and coliforms were found in the fresh and stored chapati samples confirming the adequacy of the process as well as its fitness for consumption.

Changes in chlorophyll, carotenoids and vitamin contents of spinach chapatis during storage are shown in Table 5. It is evident that during storage, concentration of total carotenoids, chlorophyll and
vitamin C decreased considerably affecting the acceptability of the product. Initially chapatis had 21.12 μg/100 g total carotenoids, 6.76 mg/100g chlorophyll and 12.54 mg/100g ascorbic acid. After 12 months of storage samples underwent significant loss in all the above constituents.

Table 1: Changes in Moisture, Peroxide Value, Free Fatty Acid Value, Thiobarbituric Acid Value and Browning of Spinach Chapatis during Storage at Ambient Temperature Conditions (14-34°C)

<table>
<thead>
<tr>
<th>Storage Period (Months)</th>
<th>Moisture</th>
<th>PV</th>
<th>FFA</th>
<th>TBA</th>
<th>Browning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>30.81a</td>
<td>6.68a</td>
<td>1.42a</td>
<td>0.086a</td>
<td>0.065a</td>
</tr>
<tr>
<td>3</td>
<td>30.12a</td>
<td>9.45a</td>
<td>1.16a</td>
<td>0.094a</td>
<td>0.071a</td>
</tr>
<tr>
<td>6</td>
<td>29.45a</td>
<td>14.84a</td>
<td>2.21a</td>
<td>0.106a</td>
<td>0.079a</td>
</tr>
<tr>
<td>9</td>
<td>29.05a</td>
<td>15.02a</td>
<td>2.89a</td>
<td>0.112a</td>
<td>0.087a</td>
</tr>
<tr>
<td>12</td>
<td>28.54a</td>
<td>18.15a</td>
<td>3.21a</td>
<td>0.121a</td>
<td>0.098a</td>
</tr>
</tbody>
</table>

**Values within the same column with different superscripts differ significantly at p≤0.05**

All values are mean of 3 determinations.

Table 2: Tristimulus Colour Values of Spinach Chapatis during Storage at Ambient Temperature Conditions (14-34°C)

<table>
<thead>
<tr>
<th>Storage Period (Months)</th>
<th>L (Lightness)</th>
<th>a (Redness)</th>
<th>b (Yellowness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>52.21a</td>
<td>3.10a</td>
<td>15.23a</td>
</tr>
<tr>
<td>3</td>
<td>48.23b</td>
<td>4.25b</td>
<td>13.10b</td>
</tr>
<tr>
<td>6</td>
<td>43.17c</td>
<td>6.21c</td>
<td>10.21c</td>
</tr>
<tr>
<td>9</td>
<td>40.45d</td>
<td>9.62d</td>
<td>8.38d</td>
</tr>
<tr>
<td>12</td>
<td>35.20e</td>
<td>12.32e</td>
<td>7.10e</td>
</tr>
</tbody>
</table>

**Values within the same column with different superscripts differ significantly at p≤0.05**

All values are mean of 3 determinations.

Table 3: Changes in Texture Profile of Spinach Chapatis Stored Under Ambient Temperature Conditions

<table>
<thead>
<tr>
<th>Storage Period (Months)</th>
<th>Hardness (N)</th>
<th>Cohesiveness (N,mm)</th>
<th>Springiness (N,mm)</th>
<th>Chewiness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.54a</td>
<td>0.126a</td>
<td>1.10a</td>
<td>0.90a</td>
</tr>
<tr>
<td>3</td>
<td>8.31b</td>
<td>0.153b</td>
<td>0.90b</td>
<td>1.15b</td>
</tr>
<tr>
<td>6</td>
<td>11.01c</td>
<td>0.193c</td>
<td>0.72c</td>
<td>1.55c</td>
</tr>
<tr>
<td>9</td>
<td>15.21d</td>
<td>0.221d</td>
<td>0.51d</td>
<td>1.91d</td>
</tr>
<tr>
<td>12</td>
<td>18.16e</td>
<td>0.293e</td>
<td>0.40e</td>
<td>2.12e</td>
</tr>
</tbody>
</table>

**Values within the same column with different superscripts differ significantly at p≤0.05**

All values are mean of 3 determinations.

Table 4: Changes in Overall Acceptability* of Spinach Chapatis Stored Under Ambient Temperature Conditions

<table>
<thead>
<tr>
<th>Storage Period (Months)</th>
<th>Colour</th>
<th>Aroma</th>
<th>Taste</th>
<th>Texture</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8.5a</td>
<td>8.5a</td>
<td>8.5a</td>
<td>8.5a</td>
<td>8.5a</td>
</tr>
<tr>
<td>3</td>
<td>8.1b</td>
<td>8.2a</td>
<td>8.2a</td>
<td>8.1a</td>
<td>8.1b</td>
</tr>
<tr>
<td>6</td>
<td>7.9c</td>
<td>7.9a</td>
<td>7.9a</td>
<td>7.8a</td>
<td>7.8c</td>
</tr>
<tr>
<td>9</td>
<td>7.5d</td>
<td>7.5a</td>
<td>7.5a</td>
<td>7.4a</td>
<td>7.4d</td>
</tr>
<tr>
<td>12</td>
<td>7.1e</td>
<td>7.2a</td>
<td>7.3a</td>
<td>7.1a</td>
<td>7.1e</td>
</tr>
</tbody>
</table>

**Values within the same column with different superscripts differ significantly at p≤0.05**

*(n=15)
Table 5: Changes in Total Carotenoids, Total Chlorophyll and Vitamin C in Spinach Chapaties during Storage at Ambient Temperature Conditions (14-34°C)

<table>
<thead>
<tr>
<th>Storage Period (Months)</th>
<th>Total Carotenoids</th>
<th>Total Chlorophyll</th>
<th>Vitamin C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>21.12a</td>
<td>6.76a</td>
<td>12.54a</td>
</tr>
<tr>
<td>3</td>
<td>18.15b</td>
<td>5.21b</td>
<td>10.31b</td>
</tr>
<tr>
<td>6</td>
<td>14.31c</td>
<td>4.01c</td>
<td>8.71c</td>
</tr>
<tr>
<td>9</td>
<td>11.68d</td>
<td>3.11d</td>
<td>7.45d</td>
</tr>
<tr>
<td>12</td>
<td>8.86e</td>
<td>2.20e</td>
<td>6.30e</td>
</tr>
</tbody>
</table>

**Values within the same column with different superscripts differ significantly at p≤0.05**

All values are mean of 3 determinations.

4. Correlation Analysis

The chemical changes and overall acceptability scores were found to be negatively correlated (r<0.96) during storage. The correlation between PV & OAA, FFA & OAA, TBA & OAA and BI & OAA were found to be -0.96, -0.98, -0.99, -0.99 respectively. The negative correlation indicated that with the increase in PV, FFA, TBA and BI, the overall acceptability of chapaties during storage decreased. Significant correlation (p≤0.05) was observed between the textural properties like hardness, springiness, stiffness and chewiness and overall acceptability scores, and it ranged from -0.99 to -0.97. Correlations between colour values obtained by using hunter colorimeter and their effect on sensory scores of chapaties during storage were analyzed. It was found that lightness and yellowness were negative correlated (r=0.91, p≤0.05) overall acceptability, while redness was positively correlated (r=0.93, p≤0.05) with overall acceptability of chapaties during storage. Total carotenoids and T. Chlorophyll contents also played significant effect on the overall acceptability scores and found that they exhibit significant positive correlation with sensory scores of chapaties during storage.

5. Conclusion

It is evident from the study that highly acceptable and nutritious spinach Chapaties can be prepared by incorporating fresh spinach paste and their shelf-life can be extended up to 12 months by using antimycotic agent like sorbic acid, subjecting to inpack sterilization and storing them in PFP packaging materials.

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References


