

Development and Evaluation of Long Shelf-Life Ambient Stable Chapatias Without The Use of Chemical Preservatives

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Abstract

Convenient, ready-to consume thermally processed chapatias with natural sensory attributes were developed. Chapatias were packed in indigenously developed retortable pouches and processed in an air-steam retort. The time-temperature history was recorded during heat processing using an Ellab data cum F_0 recorder. The total processing time was 20min with a F_0 value of 3.0. Chapatias remained stable and acceptable even after storage for one year under ambient temperature (15-35°C) conditions. During storage, chemical parameters like peroxide, thiobarbituric acid and free fatty acid values increased with concomitant decrease in sensory score. After 12 months of storage, the overall acceptability score of chapatias decreased significantly ($p < 0.05$) from 8.5 to 7.2 on a 9 point hedonic scale with an increase in peroxide and free fatty acid values from 4.94 to 15.10 meqO₂/kg fat and 0.46 to 1.79 % oleic acid respectively. Microbiologically chapatias were found to be safe during entire period of storage.

Keywords: Processing effects; Packaging material; Lipid oxidation; Sensory evaluation; Thermal processing; Shelf-life; Texture profile

Introduction

More than 80% of wheat produced in India is consumed in the form of chapatias a flat unleavened baked product and other traditional foods such as parothas, poories etc [1] and relished by all the segments of population. Chapatias also form a major component of the staple diet for Indian Armed Forces. Chapatias preserved in ready-to-eat form is ideally suited for operational situations where cooking facilities become limited or non-existent. Despite huge marketing potential, commercial marketing of chapatias has not picked up due to high perishability. The shelf-life of freshly baked chapatias is 24-36 h and they become unfit for consumption due to development of mold growth, ropiness and texture deterioration depending upon storage conditions [2]. Various attempts have been made to preserve chapatias with the use of antimycotic agents like propionic acid, sorbic acid and other ingredients for more than 6 months [3-6]. However, during storage the chapatias developed slight bitter after taste due to preservative. Recently long shelf-life chapatias were developed by lowering the concentration of sorbic acid in combination with bio preservative nisin [7]. Though these chapatias were liked by the civilian consumers as well as Indian Armed Forces during large scale trials, demand still persists for the chapatias without any chemical preservatives. Therefore, attempts were made to develop shelf-stable, no preservative chapatias using thermal processing and evaluate their storage stability in flexible retort pouches.

Materials and Methods

Food and packaging materials

Good quality Bansi wheat (*Triticum aestivum*), salt (Tata ionized salt) and Vanaspati (Hydrogenated fat) were procured from local market. Retort pouches were procured from M/s Pradeep Lamination, Pune.

Physical properties of wheat kernels

Wheat procured from local market was manually cleaned and used for the preparation of retort pouch processed chapatias. 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 using a Vernier Calliper (ESAL, Scientific Industries, New Delhi, India) according to approved methods [8].

Preparation of whole wheat flour

The cleaned wheat was ground to 400µm particle size in an emery disc mill (Model No EGM-467 K, diameter: 18 inch, Ganesha & Company, Chennai, India) to obtain whole wheat flour (100% extraction rate). The ground flour (atta) was packed in paper (45 GSM)-aluminium foil (20µ)-polyethylene (37.5 µ) laminate pouch and stored at low temperature (4-6°C) till further use.

Rheological properties of wheat flour

Rheological properties 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) using approved Methods [8]. The mixing characteristics like mixing time (time in minutes taken by the curve to reach the peak) and peak height (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 10g mixograph (National Mfg, Division, TMCO, Lincoln, USA). Rapid Visco Analyser 4D (Newport Scientific Pvt Ltd, Warie Wood, Australia) was used to measure pasting properties of flour by standard methods [8]. The enzymatic activity of wheat flour was determined using Falling Number (Perten 1500, Sweden) apparatus as per method [8].

Method of preparation of dough and flattening

The method of processing chapatias has been shown in Figure 1. Atta was sieved through 400µm mesh sieve and weighed quantity of atta was transferred into the dough kneader and mixed for 2-3min.

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Weighed quantity of salt was dissolved in measured quantity of water in a stainless steel vessel and added to the dough kneader and mixed for 1-2min. Required quantity of the vanaspati was heated at 90°C and added to the dough and all the ingredients thoroughly mixed in dough kneader for about 10min to obtain desired consistency. Dough was set aside for about 10min for conditioning and mixed again for about 5min. The dough was removed from the mixer and divided into round balls of 45g each. Each ball was flattened using a semi automatic flattening machine under 75-100kg cm⁻³ for 20-30s to get chapati with a diameter of 150-170mm.

Baking of chapatias

Chapatias were baked on a hot plate (electric/gas). When one side was partially baked, the chapatias were reversed with the help of flat ladle and molten 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 at around 220-230°C.

Packing and retort processing

Four number of chapatias having butter paper lining in between each pair were packed in retortable pouches and sealed immediately using an impulse heat sealing machine. An adequate number of pouches were fixed with thermo couples, carefully introduced into the chapati to study the process control parameters. The come-up-time of the product to attain 100°C was 5-6min. After attaining 100°C, the temperature of the product was raised to 120°C and maintained for 14min. Pressure was maintained at 20lbs with air (5lb) and steam (15lb) throughout the process, using steam-air during heating and air- water while cooling.

After processing the pouches to required F₀ value of 3.0, they were cooled rapidly till the core temperature reached 75°C by pumping water into the retort and circulating it. The pouches were wiped dry and stored at ambient temperature (15-35°C) conditions in a stainless steel racks for further studies.

Chemical analysis

Moisture, protein, fat and total ash were determined using standard methods [9]. Storage changes in retort processed chapatias were evaluated through peroxide value (PV) and free fatty acids (FFA) as per methods [10], while thiobarbituric acid (TBA) value was determined as per the method [11] initially and at an interval of three months. The browning intensity was measured by shaking 5g sample with 100ml 70% ethanol for 2h, filtering and measuring optical density at 420nm. Microbial profiles of the retort processed chapatias were determined using the petri plate 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 [12]. Pathogens viz *E.coli*, *Salmonella* and *Staphylococcus aureus* were also determined by the method [12]. Samples were also analysed for their commercial sterility by incubating at 37°C and 55°C for 14 and 5 days respectively. Sterility test was carried out using dextrose tryptone broth under aerobic and anaerobic conditions [13].

Retort pouch test

The physico-mechanical properties of retort pouch such as variation in thickness, tensile strength, tear strength and seal strength were determined as per methods [14].

Texture profile analysis

Texture profile analysis of retort pouch processed chapatias was performed using a Texture Analyser Plus (Model No.01/TALS/LXE/UK; LLOYD Instruments, Hampshire.UK). The bite test on chapati was carried out using the volvodke bite set designed to imitate incisor teeth shearing through a food sample. The set comprises of upper and lower teeth which during the test penetrate into the sample twice to obtain the peak force and the texture profile at the pre-set speed and position. The chapati strips (2x15mm) were axially compressed to 90% of their original height, avoiding fracture, force-time deformation curve was derived with a 50.0kg load cell applied at a crosshead speed of 10.0mm/min. Attributes were calculated as follows; hardness value as the peak force (N) of the first compression of the sample; cohesiveness as the area of work during the second compression divided by the area of work during the first compression (dimensionless); springiness, the distance (mm) that the sample recovers after the first compression; chewiness (N mm) as the product of the attributes, gumminess and springiness which in sensory terms corresponds to the energy required to chew the food product. Ten measurements per replication were taken for all the textural analysis.

Colour values

The colour values in terms of L, a and b for retort processed chapatias were measured using a Hunter Colour Meter (Data Lab; Silvassa, Gujarat, India) with illuminant D₆₅ and 10° 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.

Sensory analysis

Organoleptic characteristics were determined through evaluation of different attributes like colour, aroma, taste, texture and overall acceptability by a semi trained panel consisting of ten scientific staff

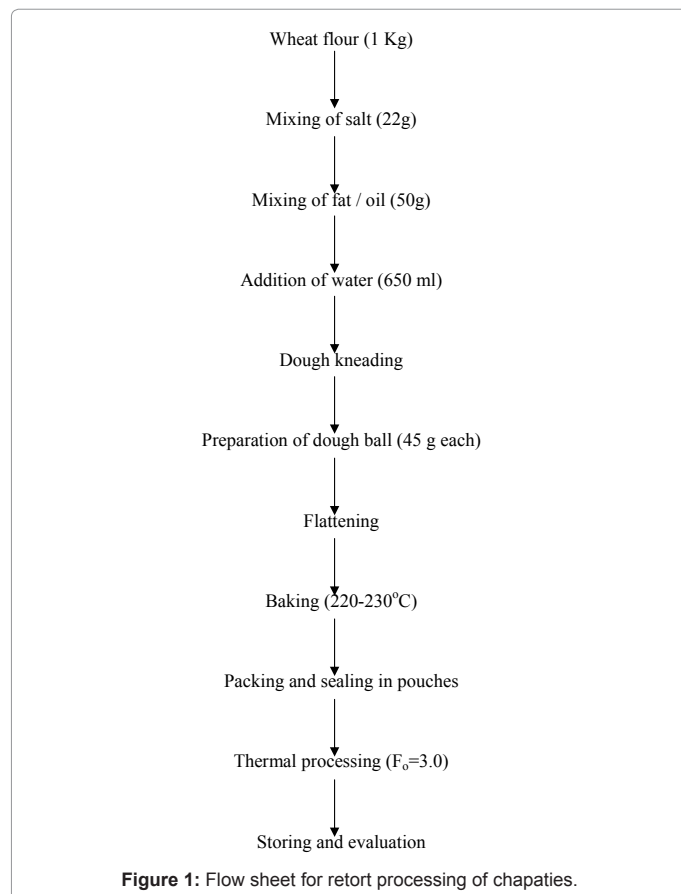


Figure 1: Flow sheet for retort processing of chapatias.

members of the laboratory on a 9 point hedonic scale having a score of 9 for extreme liking and 1 for extreme disliking [15].

Statistical analysis

Experiments were performed using a 2-way factorial design consisting of storage time and packaging materials. 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 [16].

Results and Discussion

Wheat purchased from the local market had a test weight, thousand kernel weight, average kernel length, average grain width of $77.0 \pm 0.7 \text{ Kg hL}^{-1}$, $40.2 \pm 0.3 \text{ g}$, $6.5 \pm 0.02 \text{ mm}$, $3.2 \pm 0.01 \text{ mm}$ respectively. The values of P, L, P/L and W were 121mm, 20mm, 5.96 and 140 joules respectively. The mixing time and peak value of wheat sample was found to be 2.77min and 50.09% torque respectively. The pasting properties like final viscosity which reflects sample's quality was 153.83 RVU, set back which indicated the retrogradation properties of the sample was 67.8 RVU and pasting temperature, an indication of the minimum temperature required to cook a given sample was found to be $67.15 \text{ }^\circ\text{C}$. Falling number which is a measure of alpha amylase activity was found to be 437s.

The shelf-stable (no preservative) chapatias processed by retort pouch processing technology had 31.8 ± 1.2 moisture; 10.1 ± 0.4 protein; 11.20 ± 0.3 fat; 2.1 ± 0.01 ash and 44.8 ± 2.0 carbohydrate by difference. The physical properties of the retort pouch used are given in Table 1. The pouches had high tensile strength in both machine and cross direction, which is satisfactory for withstanding the rigors of heat processing in the autoclave.

The recommended F_0 value for vegetarian products ranges from 3.0 to 6.0 [17]. Chapatias processed at 3.0 and 3.5 F_0 values had highest overall sensory acceptance while the samples processed above these values though microbiologically stable, detrimentally affected their texture and colour quality which in turn lowered sensory acceptance. It is clear from the figures (Figure 2a, Figure 2b and Figure 2c) that as the F_0 value increased L-values (brightness) and b-values (yellowness) decreased with concomitant increase in a-values (redness) indicating the darkening of the product. Similar trend was observed in case of hardness of chapatias which increased with the rise in F_0 values lowering the overall acceptability score of the products (Figure 3). Therefore $F_0 = 3.0$ was taken as optimum for processing of the chapatias.

Chemical characteristics like moisture (%), peroxide value (PV, $\text{meqO}_2/\text{Kg fat}$), free fatty acid (FFA, % oleic acid), thiobarbituric acid (TBA, mg MA/Kg sample) values and browning index (OD at 420nm) analyzed periodically have been given in Table 2. The moisture content

Parameters	Result
Total thickness	110 μm
Tensile strength (machine direction)	438.49 kg/cm^2
Tensile strength (cross direction)	342 kg/cm^2
Elongation at break (machine direction)	147%
Elongation at break (cross direction)	108%
Tearing strength (machine direction)	106 g
Tearing strength (cross section)	94 g
Seal strength (Top)	3.64 $\text{kg}/10\text{mm}$
Seal strength (Side)	4.17 $\text{kg}/10\text{mm}$
Seal strength (bottom)	3.82 $\text{kg}/10\text{mm}$

Table 1: Physical properties of retort pouch.

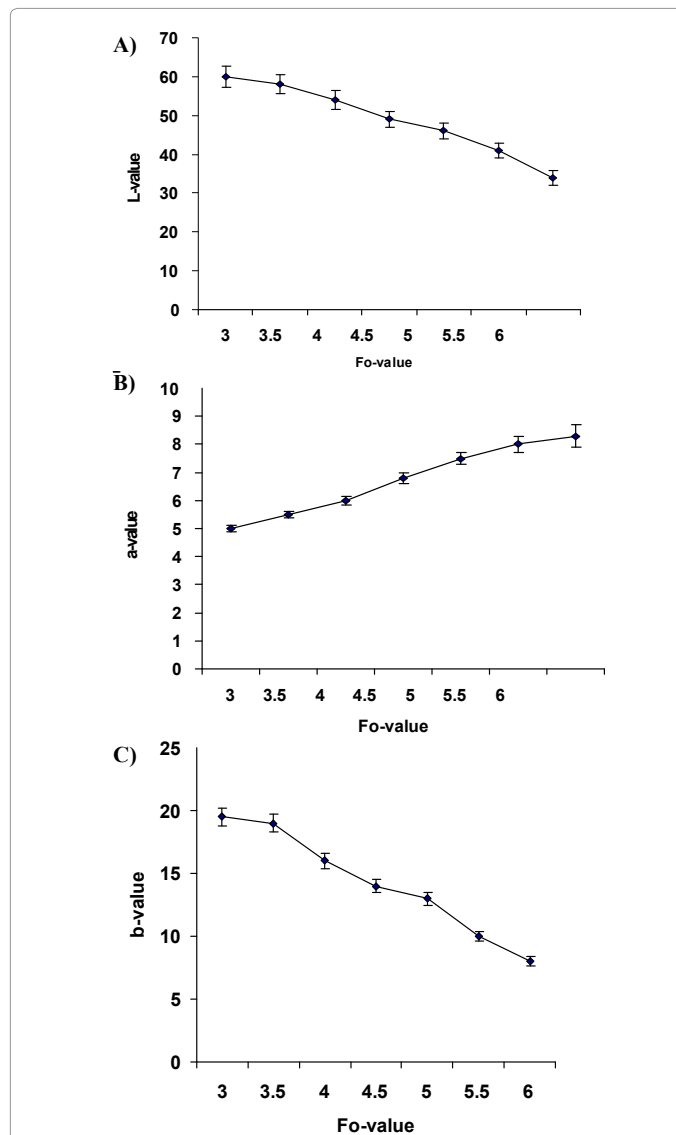


Figure 2: A) Effect of F_0 values on colour (L-value) of retort processed chapatias. B) Effect of F_0 values on colour (a-value) of retort processed chapatias. C) Effect of F_0 values on colour (b-value) of retort processed chapatias.

of the product slightly decreased during storage upto 12 months. The packaging system based on aluminium 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 [18]. During storage, FFA content increased from 0.46 to 1.79% as oleic acid and which may be due to the breakage of long fatty acid chains into individual fatty acid moieties and also increased lipid hydrolysis at elevated temperatures. Earlier also some workers [19,20] have observed retort process to increase the FFA fraction in lipids of fish meat. Peroxide and TBA values gradually increased during storage of chapatias (Table 2). After 12 months of storage, PV increased from 4.94 to $15.10 \text{ meqO}_2/\text{Kg fat}$. The TBA value which is an index of secondary lipid oxidation also followed a similar pattern and ranged from 0.053 to $0.082 \text{ mgMA/Kg sample}$ throughout the storage. However, decreasing trends in TBA value in canned fish were also reported [21,22]. The decrease in TBA value of canned fish meat to be due to the dilution of secondary oxidation product by fill oils or loss to the aqueous extrudates from the meat [23]. However,

in case of chapatias TBA content gradually increased during storage, which may be due to the fact that processed chapatias used in our study contained only solids and there was no liquid medium. Hence there had been no dilution of TBA reacting substances.

Analysis of the colour data like L, a and b of the chapatias (Table 3) revealed a decrease in L values indicating the darkening of samples during storage. There was no significant change in the 'a' values of

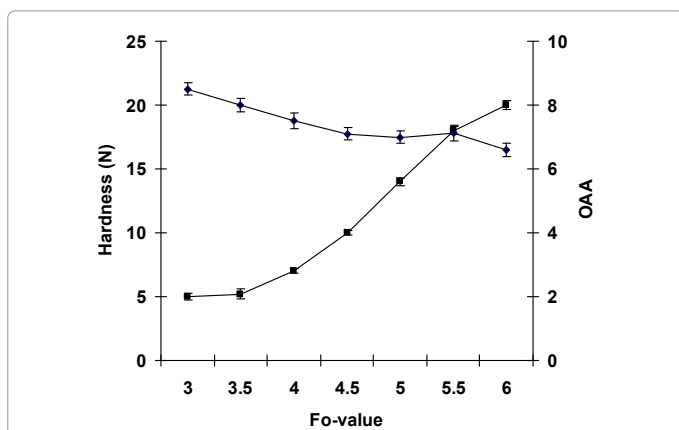


Figure 3: Relationship between hardness and overall acceptability scores of retort processed chapatias processed at different F_0 Values.

Storage period (Months)	Moisture	PV	FFA	TBA	Browning
0	31.81 ^a	4.94 ^a	0.46 ^a	0.053 ^a	0.049 ^a
3	31.69 ^a	6.20 ^b	0.80 ^b	0.058 ^b	0.061 ^b
6	31.45 ^a	9.82 ^c	1.06 ^c	0.065 ^c	0.072 ^c
9	30.85 ^b	12.92 ^d	1.58 ^d	0.074 ^d	0.084 ^d
12	30.68 ^b	15.10 ^e	1.79 ^e	0.082 ^e	0.092 ^e

^{a-e} Values within the same column with different superscripts differ significantly ($p \leq 0.05$).

Table 2: Changes in moisture content (%), peroxide value (PV, meqO₂/kg fat), free fatty acid value (FFA, (% oleic acid), thiobarbituric acid value (TBA, mg MA/kg sample) and browning index (OD at 420 nm) of retort processed chapatias ($F_0 = 3.0$) and stored under ambient temperatures (14-35°C).

Storage period (Months)	L (Lightness)	A (Redness)	b (Yellowness)
0	60.14 ^a	5.22 ^a	20.15 ^a
3	58.21 ^b	5.38 ^b	18.25 ^b
6	55.94 ^c	5.56 ^c	16.88 ^c
9	50.22 ^d	6.72 ^d	14.53 ^d
12	44.12 ^e	7.40 ^e	11.43 ^e

^{a-e} Values within the same column with different superscripts differ significantly ($p \leq 0.05$).

Table 3: Tristimulus colour values of retort processed chapatias ($F_0 = 3.0$) and stored under ambient temperature (14-35°C) conditions.

Storage period (Months)	Hardness (N)	Chewiness (N,mm)	Stiffness (N,mm)	Springiness (mm)
0	5.12 ^a	3.81 ^a	15.22 ^a	1.85 ^a
3	6.18 ^b	4.22 ^b	20.34 ^b	1.20 ^b
6	8.22 ^c	4.86 ^c	28.40 ^c	0.90 ^c
9	11.54 ^d	5.14 ^d	34.21 ^d	0.80 ^d
12	14.40 ^e	6.25 ^e	39.12 ^e	0.64 ^e

^{a-e} Values within the same column with different superscripts differ significantly ($p \leq 0.05$).

Table 4: Changes in texture profile of retort processed chapatias ($F_0 = 3.0$) and stored under ambient temperature (14-35°C) conditions.

Storage period (Months)	Colour	Aroma	Taste	Texture	Overall Acceptability
0	8.5 ^a	8.5 ^a	8.5 ^a	8.5 ^a	8.5 ^a
3	8.0 ^b	8.0 ^b	8.0 ^b	7.8 ^b	8.0 ^b
6	7.8 ^c	7.9 ^c	7.8 ^c	7.5 ^c	7.9 ^c
9	7.6 ^d	7.8 ^d	7.6 ^d	7.3 ^d	7.6 ^d
12	7.3 ^e	7.5 ^e	7.3 ^e	7.1 ^e	7.2 ^e

^{a-e} Values within the same column with different superscripts differ significantly ($p \leq 0.05$).

Table 5: Changes in overall acceptability of retort processed chapatias ($F_0 = 3.0$) and stored under ambient temperature (14-35°C) conditions.

Storage period (Months)	Standard Plate Count	Coliform	Yeast and Mold	E.coli	S.aureus	Salmonella
0	nil	nil	nil	-ve	-ve	-ve
3	nil	nil	nil	-ve	-ve	-ve
6	nil	nil	nil	-ve	-ve	-ve
9	nil	nil	nil	-ve	-ve	-ve
12	nil	nil	nil	-ve	-ve	-ve

-ve, not detected

Table 6: Microbiological profile of retort processed chapatias ($F_0 = 3.0$) and stored under ambient temperature (14-35°C) conditions (n=3).

Storage period (Months)	Aerobic		Anaerobic	
	37°C	55°C	37°C	55°C
0	No growth	No growth	No growth	No growth
3	No growth	No growth	No growth	No growth
6	No growth	No growth	No growth	No growth
9	No growth	No growth	No growth	No growth
12	No growth	No growth	No growth	No growth

Table 7: Sterility test of retort processed chapatias ($F_0 = 3.0$) stored under ambient temperature (14-35°C) conditions using Dextrose Tryptone Broth at 37°C and 55°C (n=3).

the sample indicating that the redness of the samples did not change. However, there was a considerable decrease in 'b' values which may be due to the maillard reaction between the sugar and amino acids.

Texture of the chapatias after thermal processing was determined using a food texture analyzer. Different parameters like hardness, fracture, chewiness, stiffness and springiness were studied and the data has been presented in Table 4. The data revealed an increased in hardness and stiffness in chapatias during storage ($p \leq 0.05$), which may be because most of the starch molecules in freshly baked chapatias hydrated randomized form and most of the glucose moieties have inter-molecular hydrogen bonding with water resulting in a soft and pliable texture. However the starch molecules on storage 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 [24]. Brittleness of chapatias is not a desired characteristic [25]. Springiness, the elastic property decreased from 1.85mm to 0.64mm whereas chewiness, the energy required to chew a sample increased significantly from 3.81Nmm to 6.25Nmm in chapatias during storage upto 12 months under ambient temperature (15-35°C) conditions.

Sensory evaluations of thermally processed chapatias were carried out using a 9 point hedonic scale and overall acceptability score of 7 was taken as the unacceptable. Based on this criterion the samples remained stable and acceptable throughout the storage period of 12 months. The overall acceptability score of chapatias decreased from 8.5 to 7.2 after 12 months of storage and the details are given in Table 5.

The data on the microbiological profile of the chapatias are shown in Table 6. The microbiological data showed that no SPC, coliform and yeast and mold were found in the stored chapati samples upto 12 months. The pathogens viz. *E.coli*, *S.aureus* and *Salmonella* were also absent in all the samples. Further the chapati samples were also subjected to commercial sterility test by using dextrose tryptone broth and no growth was observed after 12 months stored samples confirming the product quality (Table 7).

Conclusions

It is evident from the study that highly acceptable no preservative chapatias can be prepared through thermal process at a F_0 value of 3.0. The product remained stable and highly acceptable even after a storage period of 12m under ambient temperature (14–35 °C) conditions. Development of retort pouch processed shelf stable chapatias has established that traditional products like chapatias can be preserved for long term storage, increasing their commercial scope and viability.

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