Studies on the shelf-life enhancement of potato stuffed paratha using thermal processing

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Abstract Convenient, ready-to consume thermally processed potato stuffed parothas retaining their natural sensory attributes have been developed. Response Surface Methodology was used to optimize the Stuffing: dough ratio along with other ingredients. Optimized Stuffed parothas were packed in indigenously developed retortable pouches and processed in a steam–air retort. The time-temperature history was recorded during heat processing using an Ellab data cum Fo recorder. The total processing time was 25 min with a Fo value of 3.5. The quality of the developed product was evaluated chemically, sensorily and microbiologically to assess the shelf-life. After 12 months of storage, peroxide value (PV), thiobarbituric acid value (TBA) and free fatty acid value (FFA) increases significantly ($p \leq 0.05$) from 9.98 to 29.16 meqO₂/Kg fat, 0.101 to 0.171 mg MA/Kg sample and 1.01 to 2.66 % oleic acid respectively. The chemical changes and overall acceptability scores were found to be negatively correlated during storage. Textural and colour values also had an impact on the sensory scores of stuffed parothas during storage. After 12 months of storage, sensory scores decreases significantly ($p \leq 0.05$) from 8.6 to 7.1 on a nine point hedonic scale. Microbiologically stuffed parothas remained stable during entire period of storage.

Keywords Stuffing · Retort · Shelf life · Paratha · Texture · Sensory

Introduction

Paratha is flat Indian non leavened bread which is an amalgamation of the words parat and atta which literally means layers of cooked dough. Generally paratha are prepared from kneaded dough by mixing wheat flour, fat and water. Dough is converted into small round balls, flattened and baked on a hot plate by applying fat on either side. Most preferred shape of parothas are round or triangular one and can be eaten along with chutney, pickle or curries. To avoid necessity of side dishes, stuffed parothas have gained importance wherein stuffing made of potato, cauliflower or paneer are kept inside a wheat dough ball, flattened and baked on hot plate by applying fat.

Freshly baked stuffed parothas are highly perishable and they contain more than 40 % moisture, and become unfit for consumption after 12–24 h due to development of mold growth and ropiness. Earlier workers (Kannur et al. 1972; Ghosh et al. 1974) attempted to study the effect of heat processing on the stability of stuffed parothas and cutlet in indigenously flexible packaging material (paper/foil/polythene laminate) and reported that appreciable portion of the pouches showed leakage either at the sealed area or across the body of the pouches and this could be attributed to thermo softening of the polythene layer at the processing temperature (121 °C). Mathur et al. (1973) tried to preserve stuffed parothas in cans by thermal processing. But the product was resulted in extensive browning and texture hardening and also the original shape of the parothas was not retained during canning. Various workers were also attempted to preserve chapatias by using propionic acid, sorbic acid and other ingredients with a shelf-life of 6 months (Nath et al. 1957; Kameshwara Rao et al. 1964, 1966). Though the shelf-life of these chapatias was enhanced to 6 months, but could not be successful due to pungent taste and bitter after taste of propionic acid and sorbic acid as well as brittleness observed

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during storage. Arya et al. (1977) preserved parothas by more than 6 months by reducing the concentration of sorbic acid from 0.48 to 0.25 % along with citric acid and giving an inpack heat treatment. The effect of low-dose gamma irradiation on prepacked whole wheat flour was assessed in terms of physico-chemical properties, nutritional quality, chapati making quality and sensory attributes by Marathe et al. (2002). They reported that chapaties prepared using irradiated atta (0.25KGy) were preferred by the taste panelists even after 6 months of storage compared with control chapaties. Sridhar and Manohar (2001) optimized the conditions for continuous extrusion of unleavened bread (chapati) using specially designed extruder. They reported that these chapaties under optimized extruder conditions were compared well with traditional made chapaties in quality. Haridas Rao et al. (1989) studied the effect of damaged starch on the chapati making quality of whole wheat flour and reported that flours with optimized proportions of (14.1–16.5 %) of damaged starch yielded chapaties with better texture, taste and acceptability. Recently Khan et al. (2011) has developed long shelf-life ambient stable chapaties without the use of chemical preservatives by using thermal processing. They reported that these chapaties were stable and acceptable for more than 12 months at ambient conditions. Though many reports are available on the preservation of chapaties/parothas, information is scanty on the development and preservation of stuffed parothas having longer shelf life. Therefore, attempts were made to develop shelf stable potato stuffed parothas by thermal processing without the use of any chemical preservatives.

Materials and methods

Wheat, potato, salt, chilli powder; cumin seed powder; turmeric powder; ginger powder; garlic powder; amchur powder and hydrogenated fat were procured from local market.

Preparation of whole wheat flour

The cleaned wheat was ground to 400 µm 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). The ground flour (atta) was packed in PFP and stored at low temperature (4–6 °C) till further use.

Method of preparation of dough

Whole wheat atta was sieved through 400 µm mesh sieve and weighed quantity of atta was transferred into the dough kneader and mixed for 2–3 min. 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 1–2 min.

Required quantities of the hydrogenated fat was melted and added to the dough kneader and the ingredients thoroughly mixed for about 5 min. Mixing was continued for about 10–15 min to get desired consistency. Dough was set aside for about 10 min for conditioning and mixed again for about 5 min.

Preparation of potato stuffing

Potatoes were cleaned with running water and peeled in an abrasive peeler to remove the skin. They were cooked in an autoclave at 15 psi for 15 min. The cooked potatoes were mashed. The cooked and mashed potato was seasoned with known quantity of spices like chilli powder; cumin seed powder; turmeric powder; ginger powder; garlic powder; amchur powder; salt and fried in a hydrogenated fat at 120–130 °C for 10 min till the desired moisture attains and used for the preparation of potato stuffed parothas.

Experimental design

Response surface methodology was used to optimize the level of dough and stuffing for the preparation of potato stuffed parothas. After preliminary trials, upper and lower levels for these variables were established. A central composite rotatable design (CCRD) was prepared to select variable levels in each experiment. The OAA includes attributes like colour, aroma and taste. Thirteen different experiments were carried out with four axial points, four factorial points and five centre points using the statistical software package Design Expert 6.0.9, Statease Inc., Minneapolis, USA. The independent variables with their coded and actual values with the range of levels are given in Table 1. Experimental runs were randomized in order to minimize the effect of unexpected variability in the observed responses. Full second order equation was fitted in each response to describe it mathematically and to study the effect of variables. The equation was as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_1 X_2 + \beta_{11} X_1^2 + \beta_{22} X_2^2 + \beta_{12} X_1 X_2$$

Where Y = Independent variable; X_1 : Dough; X_2 : Stuffing and β represents the co-efficients indicating the relative importance of their X value.

Table 1 Experimental ranges and levels of independent variables used in RSM in terms of actual and coded factors for potato stuffed parothas

Independent variables	Coded levels				
	+1.41	+1	0	−1	−1.41
Dough (X_1)	77.07	75	85	65	62.92
Stuffing (X_2)	37.07	35	30	25	22.92

Preparation of stuffed parothas

The different formulations obtained (Table 2) were weighed separately and were used for the preparation of potato stuffed parothas. Seasoned potato stuffing was stuffed in dough (according to Table 2 formulation), rolled into a circular disc of 7" diameter and either side was baked for 2–3 min at 210–220 °C with the application of hydrogenated fat till golden brown colour is obtained.

Sensory evaluation

The sensory characteristics of potato stuffed parothas were evaluated by a panel of 15 semi trained judges by grading for taste and overall acceptability on a nine point hedonic scale with nine as excellent in all respects and one as unacceptable samples (Larmond 1977).

Thermal processing and storage studies

Potato stuffed parothas (2 Nos each) prepared by using optimized levels of ingredients were packed in retort pouch having butter paper lining in between them and sealed immediately using an impulse heat sealing machine, an adequate number of pouches were fixed with thermo couples which were carefully introduced into the potato stuffed parothas to study the process control parameters. The come up time of the product to attain 121 °C was 5–6 min. The product was hold at 121±1 °C to get required F_0 value. Pressure was maintained at 9.07 Kg with air (2.27 Kg) and steam (6.80 Kg) throughout the process, using steam–air during heating and air–water

while cooling. After processing the pouches to required F_0 value of 3.5, they were cooled rapidly till the core temperature of the product reaches 45 °C by pumping water into the retort and recirculation it. The pouches were wiped dry and used for further studies.

Analysis

Moisture, protein, fat and total ash were determined by standard AOAC (1990) methods. Initially and at regular interval of 3 months, the changes in quality of potato stuffed parothas were monitored through 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). Browning intensity in stored samples was determined by measuring the optical density of the alcoholic extract (5 g sample+50 ml, 70 % ethanol, shake for 2 h) at 420 nm. Mineral content were determined using atomic absorption spectrophotometer (Vario 6, Analytika Jena., Germany) after wet digestion as per the method of Semwal et al. (1995). Fatty acid composition of extracted fat from thermally processed potato stuffed parothas was determined by standard AOCS (1990) methods using gas liquid chromatograph (Chemito, HR 1000, Chennai, India) on a 10 % diethylene glycol-succinate column (DEGS, 8 × 1/8") with nitrogen as carrier gas and flame ionization detector. During analysis, the column temperature was maintained at 190 °C while injector and detector temperatures were maintained at 210 °C and 230 °C respectively. Microbial profiles of the thermally processed potato stuffed parothas were determined using the petri plates method as describes by APHA (1992) for standard plate count on plate count agar, coliform count on violet red bile agar, faecal coliform on Escherichia coli broth and yeast and mold counts on potato dextrose agar. Presence of pathogens viz coliform, salmonella and staphylococcus aureus were also determined by APHA (1992). Samples were also analysed for their commercial sterility using Dextrose tryptone broth under aerobic and anaerobic conditions. After incubation the samples were found to be commercially sterilized. The physico-mechanical properties such as variation in thickness, tensile strength, seal strength and bursting strength were determined as per ASTM methods (1984).

Texture analysis

Potato stuffed parothas prepared by using different formulation of dough and stuffing were evaluated for their texture using Texture profile analysis of thermally processed potato stuffed parotha was performed using a Texture Analyser Plus (Model No.01/TALS/LXE/UK; LLOYD Instruments, Hampshire, UK) as described by Yadav et al. (2008).

Table 2 Experimental design matrix for the development of potato stuffed parotha

Exp. no.	Variables		Responses	
	Dough	Stuffing	Hardness	OAA
1.	−1	−1	7.1	7.0
2.	1	−1	7.05	6.9
3.	−1	1	4.5	7.7
4.	1	1	5.2	7.8
5.	−1.41	0	6.2	7.4
6.	1.41	0	6.6	7.6
7.	0	−1.41	6.95	6.5
8.	0	1.41	4.21	7.3
9.	0	0	4.6	8.55
10.	0	0	4.84	8.6
11.	0	0	4.71	8.4
12.	0	0	4.76	8.45
13.	0	0	4.91	8.5

Colour values

The colour values in terms of L, a and b for thermally processed potato stuffed parothas were measured using a Hunter Colour Meter (Data Lab; Silvasa, Gujarat, India) with illuminant D₆₅ and 10° observer. A higher L value indicated a brighter or whiter sample, while values of a and b indicated the red-green and yellow-blue chromaticity respectively.

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 given by Snedecor and Cochran (1968).

Results and discussion

Potato stuffed paratha was developed using RSM. The 13 experimental combinations of central composite rotatable design with two independent variables and responses studied have been given in Table 2. Since texture plays an important attribute in judging the overall acceptance of potato stuffed paratha, it is taken as response along with overall acceptability score (OAA). F-ratio and co-efficient of determination (R^2) were used to evaluate the adequacy of the model. The co-efficient of determination was found to be more than 80 % and lack of fit was insignificant indicating the fitness of polynomial models used for describing the effect of independent variables (Henika 1982). The effect of dough and stuffing on the hardness and overall acceptability of potato stuffed parothas could be predicted by following regression equations.

$$\begin{aligned} \text{Hardness} &: +4.76 + 0.15 * X_1 - 1.04 * X_2 + 0.19 * X_1 X_2 + 0.81 * X_1 + 0.40 * X_2 \\ \text{OAA} &: 8.50 + 0.035 * X_1 + 0.034 * X_2 + 0.050 * X_1 X_2 \end{aligned}$$

Table 3 revealed that variables dough and stuffing had a mixed effect on the final quality of potato stuffed paratha. At the intercept level both the variables had a positive effect on both the responses. At the linear level stuffing had negative effect ($p \leq 0.05$) on the hardness and positive effect on the overall acceptability, whereas dough had a positive effect ($p \leq 0.05$) on hardness, whereas there was no significant effect of dough on the overall acceptability of the potato stuffed paratha. At interactive level though both the variables had a significant effect on the hardness, but no significant effect was found on the overall acceptability of the potato stuffed parothas.

Table 3 Co-efficients of second order polynomial regression models for the various parameters

Co-efficient constant	Hardness	Overall acceptability
Intercept		
β_0	4.76*	8.50*
Linear		
β_1	0.15*	0.035
β_2	-1.04*	0.34*
Quadratic		
β_{11}	0.81*	-0.46*
β_{22}	0.40*	-0.76*
Interactive		
β_{12}	0.19*	0.050
R^2	0.99	0.98

*Significant ($p \leq 0.05$)

Optimisation of level of variables was achieved by desirable maximization of the necessary responses along the fitted polynomial models by numerical optimization procedures of design expert software. The optimized recipe for the potato stuffed paratha was stuffing 70 g and dough 32 g. The predictions for hardness and OAA were 8.46 and 4.32 respectively with a desirability of 0.949 (Fig. 1).

The optimized thermally processed potato stuffed paratha had moisture 42.70 %; protein 7.26 %; fat 7.21 %; ash 2.75 %; providing energy of K.cal 255/100 g. The retort pouches had a total thickness of 109 μm , tensile strength 435 Kg/cm², seal strength 4.15 Kg/10 mm and bursting strength of 137.9 KPa which can withstand the heat processing in over pressure autoclave. The optimized potato stuffed parothas were thermally processed at different F_0 values from 2.5 to 6.0 as the recommended F_0 value for vegetarian products ranges from 3.0 to 6.0 as described by Kumar et al. (2007). Potato stuffed parothas processed at different F_0 values were evaluated for microbiological, textural, colour and sensory attributes. It was found that with the increasing in F_0 value, the browning index and hardness increases thereby affecting the sensory attributes

Fig. 1 Graphical representation of optimised levels of independent variables of potato stuffed parothas

Fig. 2 Heat penetration curve during thermal processing of potato stuffed parothas

of the potato stuffed parotha though all were microbiologically stable. Therefore $F_0=3.5$ was selected as standardised one for processing of the potato stuffed parothas. A typical heat penetration curve obtained during the thermal processing of potato stuffed parotha is shown in Fig. 2.

The chemical changes in stored potato stuffed parothas at ambient temperature were monitored on the basis of changes in peroxide value (PV), free fatty acid value (FFA), thiobarbituric acid value (TBA) and browning index and the data has been presented in Table 4. It is observed that the rates of autoxidation as measured by changes in PV and TBA values were significantly ($P \leq 0.05$) increased during storage (12 months) and ranged from 9.98 to 29.16 and 0.101 to 0.171 respectively. The similar trend was reported earlier by Khan et al. (2011). Although Manju et al. (2004) and Tanaka et al. (1985) reported a decreasing trend in TBA value in canned fish. The increase in TBA content during storage of potato stuffed parothas is due to the fact that, processed parothas 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. FFA content in stuffed parothas increases from 1.01 to 2.66 during storage of 12 months. The increase in FFA content may be attributed to the breakage of long fatty acid chain into individual fatty acid moieties and at higher temperature there will be an increase in lipid hydrolysis Fritsch (1981). During storage moisture content decreases from 42.05 to 40.11 % after 12 months. The decrease in the rate of moisture content was not significant upto 3 months, but later the changes in moisture was found to be significant ($p \leq 0.05$).

Colour values like lightness (L), redness (a) and yellowness (b) were analysed using Hunter colorimeter and the data has been shown in Fig. 3. From the figure it is evident that, with the increase in storage period, the lightness and yellowness decreases while the redness gets increased. The decrease in L and b is due to the fact that during storage, the samples become darker and also due to enzymatic and non enzymatic browning since potato is used in the development of stuffed parothas.

Table 4 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), browning index (OD at 420 nm) and overall

acceptability score (OAA) of potato stuffed parothas stored at ambient temperature conditions (14–34 °C)

Storage period (months)	Moisture*	PV*	FFA*	TBA*	Browning*	OAA**
0	42.05 ^a ±0.20	9.98 ^a ±0.11	1.01 ^a ±0.01	0.101 ^a ±0.001	0.071 ^a ±0.001	8.6 ^a ±0.05
3	41.85 ^a ±0.20	12.12 ^b ±0.15	1.22 ^b ±0.01	0.121 ^b ±0.003	0.079 ^b ±0.002	8.4 ^b ±0.04
6	41.05 ^b ±0.19	17.51 ^c ±0.20	1.41 ^c ±0.02	0.139 ^c ±0.002	0.092 ^c ±0.002	8.0 ^b ±0.08
9	40.61 ^b ±0.17	21.54 ^d ±0.32	1.95 ^d ±0.02	0.156 ^d ±0.002	0.113 ^d ±0.004	7.4 ^c ±0.07
12	40.11 ^c ±0.15	29.16 ^e ±0.36	2.66 ^e ±0.03	0.171 ^e ±0.003	0.128 ^e ±0.003	7.1 ^d ±0.09

*mean ± SD (n=3)

**mean ± SD (n=15)

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

Fig. 3 Changes in Lightness (L); Redness (a) and Yellowness (b) of potato stuffed parothas during storage at ambient temperature conditions

Textural attributes like hardness, chewiness and springiness of potato stuffed parothas were carried out at a regular interval using a food texture analyzer and the data has been presented Fig. 4. It is clear from the graph that, with the increase in storage period, the hardness increases from 4.32 to 13.12 N. It may be attributed to the fact that during baking amylase and amylopectin gets random conformation as a result of gelatinization, and on storage and cooling they get reorient themselves into helical structure leading to crystallization of starch molecules resulting in the hardness of stuffed parothas (Arya 1984). Springiness, the elastic property decreased from 0.88 to 0.46 mm whereas chewiness, the force require to chew a sample increased significantly from 0.65 to 2.14 Nmm in chapatias during storage upto 12 months at ambient temperature (15–34 °C).

Fig. 4 Changes in hardness, chewiness and springiness of potato stuffed parothas during storage at ambient temperature conditions

Sensory evaluation of thermally processed potato stuffed parothas were carried out using a nine point hedonic scale with nine taken as excellent in all respects while overall acceptability score below seven 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 chapatias decreased from 8.6 to 7.1 after 12 months of storage and the data is presented in Table 4.

Fatty acid and mineral compositions of potato stuffed parotha are given in Table 5. Oleic acid was found to be the major fatty acid followed by palmitic, linoleic and stearic. After 12 months of storage, there was decrease in the concentration of linoleic acid and corresponding increased in the concentration of saturated fatty acids. Sodium was found to present in higher level due to the addition of sodium chloride during the preparation of potato stuffed parothas. Except potassium all other minerals viz iron, zinc, copper, magnesium and manganese were present in much smaller quantities. During storage it was found that there were no significant changes in the concentration of mineral contents.

Microbiological profile of fresh and stored thermally processed potato stuffed parothas were determined using the petri plate method as described by APHA (1992) for standard plate count on agar, coliform count on violet red bile agar, faecal coliform on E.coli agar and yeast and mold counts on the potato dextrose agar. Further the samples were also subjected to commercial sterility by using dextrose tryptone broth and no growth was observed after 12 months of storage.

Table 5 Fatty acids*(%) and mineral composition*(mg/100 g) of potato stuffed parothas

	Initial	12 months
Myristic (C _{14:0})	1.10 ^a ±0.02	1.14 ^b ±0.01
Palmitic (C _{16:0})	40.97 ^a ±0.11	45.03 ^b ±0.16
Stearic (C _{18:0})	3.87 ^a ±0.02	4.94 ^b ±0.08
Oleic (C _{18:1})	45.20 ^a ±0.30	43.96 ^b ±0.57
Linoleic (C _{18:2})	8.70 ^a ±0.12	4.64 ^b ±0.14
Calcium	12.5 ^a ±1.2	12.2 ^a ±1.0
Iron	3.8 ^a ±0.019	3.65 ^b ±0.016
Sodium	982.5 ^a ±10.5	980.1 ^a ±10.0
Potassium	320.0 ^a ±30	317.3 ^a ±29.1
Zinc	2.03 ^a ±0.11	2.01 ^a ±0.10
Copper	0.21 ^a ±0.01	0.19 ^a ±0.02
Manganese	0.67 ^a ±0.05	0.65 ^a ±0.03
Magnesium	18.2 ^a ±1.9	17.6 ^a ±1.8

*mean ± SD (n=3)

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

Correlation analysis

The chemical changes and overall acceptability scores were found to be negatively correlated during storage. The correlation between PV & OAA, FFA & OAA, TBA & OAA and BI & OAA were found to be -0.98 , -0.96 , -0.98 and -0.99 respectively. The negative correlation indicated that with the increase in PV, FFA, TBA and BI, the overall acceptability of stuffed parothas during storage decreased. There was a positive correlation between springiness and OAA ($r=0.92$), whereas hardness and chewiness were negatively correlated with OAA with a correlation of $r=-0.99$ and -0.97 respectively. Correlations between colour values obtained by using hunter colorimeter and their effect on sensory scores of stuffed parothas during storage were analysed. It was found that lightness and yellowness were negative correlated ($r=-0.91$, $p\leq 0.05$) with overall acceptability, while redness was positively correlated ($r=0.93$, $p\leq 0.05$) with overall acceptability of stuffed parothas during storage.

Conclusions

With the ongoing discussion it can be concluded that a traditional food product like potato stuffed paratha which is perishable in nature, could be preserved using thermal processing with a standardized F_0 value of 3.5. RSM can be utilized for the optimization of ingredients like dough and stuffing. Even though, there was an increase in the peroxide value, free fatty acid value and thiobarbituric acid value, still the product remained stable and acceptable for 12 months as the product was found microbiologically stable during the entire storage period. Thus a highly nutritious thermally processed potato stuffed paratha having a shelf-life of 12 months can be developed through thermal processing with wider consumer applications.

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