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Development and shelf-life evaluation of fiber enriched traditional Indian Parotta

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ABSTRACT: Parotta, a popular, traditional and low fiber delicious dish of southern part of India and Sri Lanka was made from refined wheat flour, water, vegetable fat and salt. Addition of psyllium husk, oats and barley bran in parotta increased dietary fiber content from 0.34 to 15.14 per cent. The fiber addition were optimized at level of 2.0 per cent psyllium husk, 10.0 per cent oat bran, 5.0 per cent barley bran by sensory analysis. Stabilization studies were carried out in fiber-enriched parotta by in-pack pasteurization with and without sorbic acid in polypropylene pouches (75µ) under ambient storage condition. Total dietary fiber content was found to be higher in oat bran added parotta (15.14 %) followed by psyllium husk (14.8 %) and barley bran parottas (9.86 %) compared to refined wheat flour parotta (0.34 %). Calcium, iron, sodium and potassium mineral content were increased significantly ($P<0.05$) on addition of psyllium husk followed by barley and oat bran. The protein content found to be higher in barley bran added parotta (6.21 %) followed by oat (6.01 %) and psyllium husk (5.62 %) parottas. Both control and fiber enriched parottas were found to be stable microbiologically at ambient conditions packed in polypropylene pouches up to 90 days with sorbic acid and up to 14 days without sorbic acid.

Key words: Barley bran, fiber enriched, oat bran, parotta, psyllium husk, refined wheat flour, shelf life, sorbic acid

Roti, chapatti, phulka, nan, poori, parathas and parotta are widely consumed traditional flat bread products in the Indian subcontinent. Parathas/parotta is an amalgamated word of *parat* and *atta*, which literally means layers of roasted dough. Parotta or porotta or Malabar parotta or Kerala parotta, is layered flat bread made out of refined wheat flour (Maida/all-purpose flour). More than 50 % of the wheat flour produced by the roller flour milling industry in South India is utilized for the preparation of parotta (Indrani *et al*., 2000).

Parotta is prepared by kneading refined wheat flour (RWF), milk powder, salt and oil or ghee, egg (in some recipes), and water (Indrani and Venkateshwara, 2001). The dough is beaten into thin layers and later round spiraled into a ball. The ball is rolled flat and baked in hot plates. After roasting, the parotta were made fluffy by clapping action of the hand on stacked parotta. The baked parotta is creamish white in color and possess several distinct layers. The layered and flakey flat breads can be consumed with vegetarian or non-vegetarian curries.

When compared to other bread products fiber content of the parotta is very negligible as it contains refined wheat flour (RWF) as major ingredient. The main ingredient RWF is prepared by removing bran and germ from wheat, which resulted in negligible amount of fiber. Parotta made from RWF congests the gut system, slows down digestion creating a sluggish metabolism, and can often be cause of weight gain, stress, headaches and migraines.

Besides low fiber, RWF is also rich in glycemic index (GI) which releases sugar into blood stream quickly. To counteract, pancreas responds with a sharp insulin spike, which over a period of time with prolonged consumption causes inflammation, insulin resistance and eventually type-2 diabetes (Livesey *et al*., 2013). Therefore, regular consumption of foods with high GI leads to obesity and high triglyceride count in blood leading to cardiovascular morbidity and mortality, including stroke (Dong *et al*., 2012).

Soluble fibers, which include pectin, gums and mucilage are found in many plant cells, fruits and vegetables. Insoluble fibers include cellulose, hemicelluloses and lignin, which are structural parts of plant cell walls. Their major role is prevention of constipation and associated problems such as hemorrhoids and provides numerous benefits to

human health (Oghbaei and Prakash, 2018). Good sources of fiber include wheat bran, corn bran, rice bran, oat bran, barley bran, psyllium husk, skin of fruits and vegetables, nuts, seeds, dried beans and wholegrain foods. Fortification of staple foods with essential nutrients in supplemental form is a best option to mitigate nutrient deficiencies (WHO, 2009; Pachon *et al*., 2015).

Therefore, a study was undertaken to develop fiber rich parotta by incorporation of fibers such as psyllium husk, barley and oat bran along with refined wheat flour at different proportions.

Parotta is mostly prepared and served fresh in households and restaurants, as well as in roadside shops. Ready to toast/half toasted parotta are available commercially with shelf life of 4-5 days under ambient condition and 3-6 months in frozen condition. Effort was also made to enhance the shelf stability of fiber-enriched parotta using permitted preservative and in-pack pasteurization with and without preservatives.

MATERIALS AND METHODS

Ingredients such as refined wheat flour (Double Nandi, Mysore), salt, milk powder, sunflower oil, refined sugar, psyllium husk, barley and oat bran for preparation of the parotta were procured from the local market, Mysuru, Karnataka, India. All chemicals used in this study were analytical grade and procured from M/s S.D Fine Chem.Ltd, Mumbai. Packaging material polypropylene (75µ size) was procured from M/s. Taj Industries, Mysuru.

Preparation of fiber enriched flours

Psyllium husk, barley and oat bran were grinded with Ultra Centrifuge mill ZM 200 – RETSC H, sieved to 300-micron size using sieve ASTM 50 mesh and used for preparation of fiber enriched flours. Fiber enriched flours were prepared by replacing the RWF by (0%) RWF, RWF by Psyllium husk (1-5%), RWF by Barley bran (1-10 %) and RWF by Oat Bran (10-15%). The fiber enriched flours were mixed in mixer (Hobart mixer, N-50 M) for uniform blending.

Method of preparation of parotta

Parotta was prepared by mixing refined wheat flour (500.0 g), skimmed milk powder (2.0 g), water (250-300 g), vegetable oil (30.0 g), sugar (5.0 g) and salt (10 g). In a dough making process salt, milk powder and sugar were dissolved in water. The dough was kneaded in Hobart mixer (N-50 M) at 61 RPM by mixing all the ingredients. Refined rice bran oil was added at the end of dough kneading process. After kneading, dough was smeared with oil and covered with wet muslin cloth and rested for 2 h. After resting period, the dough was kneaded again for 5-6 min and made equal sized balls (80±5 g). The balls were smeared with 2 ml of oil and rested for another 10 minutes. After 10 minutes the balls were rolled on working surface by spreading oil on it to very thin oval shaped sheets. Sheets were carefully folded and coiled to round shaped balls and flattened by hand to obtain layer. Parotta was shallow fried in a hot plate with temperature of 230-250ºC by smearing oil and turning them every 20 sec to ensure proper frying on both the sides (Fig.1). Parotta were cooled and packed in polypropylene (PP) pouches of 75-micron size and hermetically sealed. The sealed pouches in-pack pasteurized at 90°C for 2hr in cabinet dryer and stored at ambient conditions (15-35 ºC) for carrying out analytical as well as shelf-life studies. Sorbic acid at 1500ppm was added during dough preparation based on total dough weight. Similarly, psyllium husk, barley bran and oat bran were added at 1-15 % level on flour weight basis during dough preparation. Rest of the preparation of parotta was followed as per procedure listed above.

Physicochemical analysis

Moisture, total ash and nitrogen content were estimated as per the standard methods of (AOAC, 2000). The nitrogen content was determined by Kjeldahl distillation methods and converted to total protein by multiplying with a factor 5.71 for cereals (AOAC, 2000). Petroleum ether extractable fat was determined using soxhlet fat extraction apparatus (AOAC, 2000). Total dietary fiber was analyzed as per (Asp *et al*., 1983) with slight modifications. Quantity of wet gluten is estimated using hand gluten washing (AOAC, 1984). Peroxide value, free fatty acids and thiobarbituric acid were estimated by

method of (AOCS, 1990).The mineral content in samples was determined by using atomic absorption spectrophotometer as per the method of (AOAC, 1990). Sorbic acid was estimated using the method of (Arya *et al*., 1977). Microbiological analysis was carried out as per the method of (APHA, 1992).

Rheological characteristics

Rheological characteristics of control and fiber enriched flours were evaluated by Rapid viscoanalyser 4D (Newport Scientific Private Limited, WarieWood, Australia). RVA 4D was used for measuring pasting properties of flours as described by (AACC, 2000) method. α-amylase activity and gluten content of the mixes were determined using Falling number (M/s Perten Instruments Pvt Ltd) and Gluten analyser (M/s LCGC Instruments) according the approved method (AACC, 2000).

Sensory Analysis

The sensory characteristics of parotta with different fiber combinations were evaluated for attributes like colour, aroma, taste, texture and over all acceptability on a 9- point Hedonic scale keeping 9 for excellent and 1 for very poor. A semi- trained taste panelists consisting of 10 persons were presented with parotta samples and asked to evaluate them in a random order to obtain sensory scores based on the above scale (Larmond, 1977).

Statistical Analysis

All the reported values are mean of three replications and were subjected to one-way and two-way analysis of variance (ANOVA) and analysis (MANOVA) using statistical software (IBM-SPSS Statistic 20 software). Significant differences between the means were tested by Tukey's test at Pd"0.05 significance levels.

RESULTS AND DISCUSSION

Proximate analysis of raw material

Raw materials used for preparation of parotta i.e., refined wheat flour (RWF), oat bran (OB), barley bran (BB) and psyllium husk (PH) were analyzed for moisture, crude protein, fat, minerals, ash, crude fiber, gluten content according to described methods as above. The results are shown in Table 1.

The proximate analysis of raw materials revealed that psyllium husk contains high amount of moisture (12.24 %) followed by RWF and barley bran. The moisture content was found to be lowest in oat bran. The ash content was lowest for RWF than other ingredients. The fat and protein content were found to be nil in psyllium husk. Psyllium husk showed highest mineral content when compared to refined wheat flour and barley fiber. The dietary fiber content in RWF is very less i.e., 0.3% whereas psyllium husk, oat bran and barley bran showed 76.36, 22.61 and 16.28 % respectively. Conclusions are in agreement with those of (Talukdar and Sharma, 2010) and (Yadav *et al*., 2010). The analysis of fiber content clearly revealed that addition of fiber rich components resulted in fiber rich parotta as RWF lack both soluble and insoluble dietary fiber.

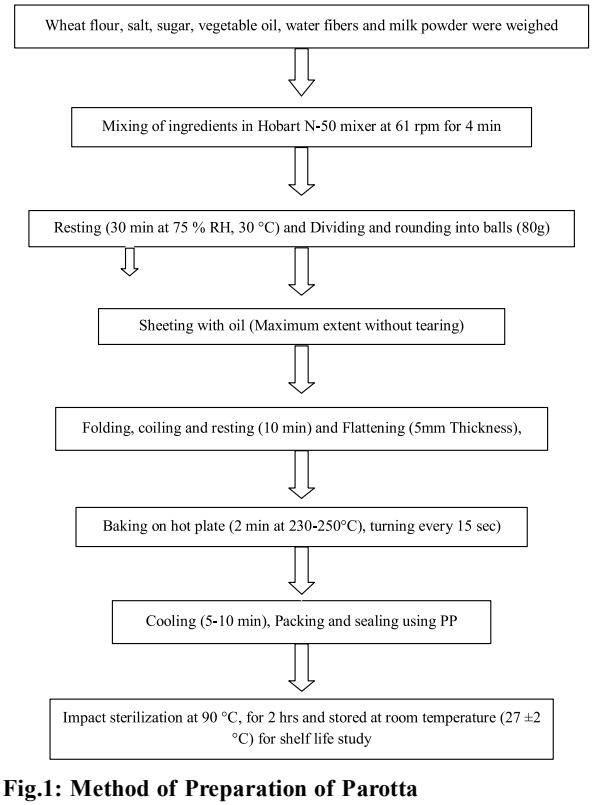

Fig.1: Method of Preparation of Parotta

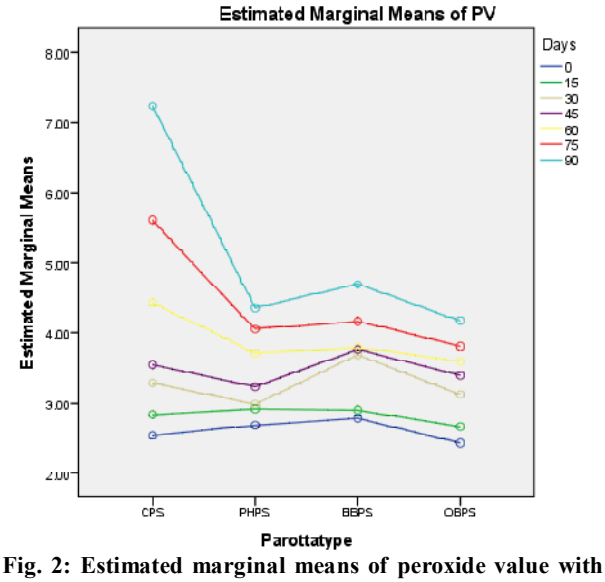

Fig. 2: Estimated marginal means of peroxide value with respect to parotta type.

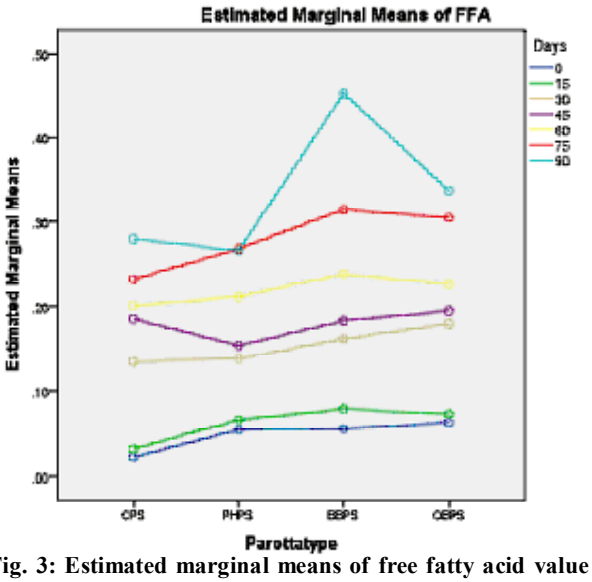

Fig. 3: Estimated marginal means of free fatty acid value with respect to parotta type.

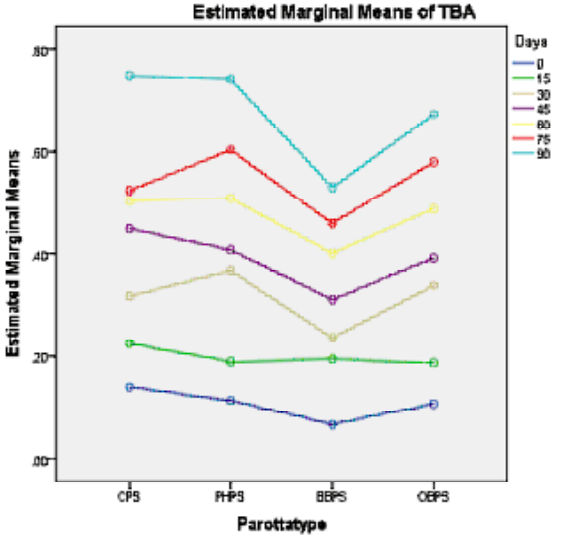

Fig. 4: Estimated marginal means of Thiobarbituric acid value with respect to parotta type.

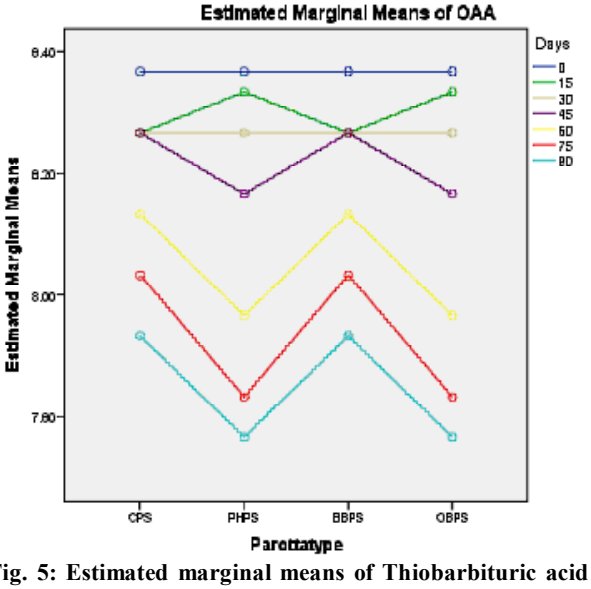

Fig. 5: Estimated marginal means of Thiobarbituric acid value with respect to parotta type.

Optimization of fiber fortification in parotta using sensory evaluation

The amount of dietary fibers to be incorporated in parotta was evaluated by mixing fibers at different levels ranging from 1.0 per cent to 15.0 per cent. All other parameters like amount of water, oil, dough kneading time, baking time, baking duration and resting time, were kept as constant. After baking, parotta prepared using psyllium husk, oat bran and barley bran were kept for sensory evaluation. The sensory analysis was carried out with 10 numbers of panelists for optimization of fiber content in parotta. The results are shown in Table 2.

The main aim of the study was to prepare parotta with maximum per centage of fiber and overall acceptability above 7-point in Hedonic scale. The maximum concentration of fiber incorporation varied according to type of fibers and increase in

Table 1: Proximate analysis of raw materials

Raw materials	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Total Dietary Fiber (%)	Insoluble Dietary fiber (%)	Soluble Dietary fiber (%)
Refined Wheat Flour	$11.63\pm0.15_{c}$	$0.67\pm0.11_{a}$	$0.96\pm0.01_{b}$	$11.28\pm0.10_{b}$	$75.87\pm0.32_{b}$	$0.32\pm0.3_{a}$	0.21±0.2	0.11±0.4
Psyllium husk	$12.24\pm0.14_{d}$	$2.73\pm0.12_{c}$	0.0_{a}	0.0_{a}	$84.46\pm0.43_{c}$	$76.36\pm.24_{d}$	$11.46\pm2.32_{b}$	64.9±1.2
Barley bran	$6.66\pm0.12_{b}$	$3.19\pm0.05_{d}$	$4.29\pm0.06_{c}$	$12.24\pm0.10_{c}$	$74.34\pm1.57_{b}$	$22.61\pm0.22_{c}$	$15.54\pm0.36_{c}$	$7.07\pm0.36_{c}$
Oats bran	$6.24\pm0.16_{a}$	$2.14\pm0.06_{b}$	$8.53\pm0.07_{d}$	$16.33\pm0.11_{d}$	$67.07\pm0.99_{a}$.	$16.28\pm0.46_{b}$	$7.2\pm0.30_{b}$	9.0±0.20

Table 2: Sensory evaluation of different fiber enriched parotta

Level of fiber (%)	Parameters					
	Colour	Aroma	Texture	Taste	Layers	OAA
Control Parotta						
0	8.3±0.20	8.4±0.11	8.4±0.23	8.5±0.05	8.5±0.5	8.5±0.20
Psyllium Husk Parotta[b]						
1	$8.3\pm0.10_{c}$	$8.3\pm0.10_{b}$	$8.3\pm0.05_{b}$	$8.1\pm0.05_{b}$	$8.4\pm0.05_{b}$	$8.3\pm0.05_{b}$
2	$7.9\pm0.10_{b}$	$8.1\pm0.05_{b}$	$8.1\pm0.10_{b}$	$8.2\pm0.10_{b}$	$8.2\pm0.05_{b}$	$8.2\pm0.05_{b}$
5	$6.8\pm0.05_{a}$	$6.9\pm0.11_{a}$	$6.8\pm0.10_{a}$	$6.7\pm0.11_{a}$	$6.8\pm0.05_{a}$	$6.9\pm0.26_{a}$
Barley Bran Parotta[a]						
1	$8.4\pm0.05_{d}$	$8.3\pm0.05_{c}$	$8.3\pm0.05_{c}$	$8.2\pm0.11_{c}$	$8.3\pm0.05_{d}$	$8.3\pm0.15_{c}$
2	$8.2\pm0.0_{c}$	$8.2\pm0.05_{c}$	$8.2\pm0.15_{c}$	$8.1\pm0.05_{c}$	$8.1\pm0.05_{d}$	$8.3\pm0.10_{c}$
5	$7.8\pm0.11_{b}$	$7.9\pm0.15_{b}$	$7.8\pm0.17_{b}$	$7.7\pm0.11_{c}$	$7.5\pm0.11_{c}$	$8.1\pm0.00_{c}$
8	$6.9\pm0.10_{a}$	$6.7\pm0.11_{a}$	$6.9\pm0.05_{a}$	$7.0\pm0.10_{b}$	$6.9\pm0.11_{b}$	$6.9\pm0.11_{b}$
10	$6.8\pm0.11_{a}$	$6.8\pm0.05_{a}$	$6.6\pm0.20_{a}$	$6.3\pm0.41_{a}$	$6.3\pm0.20_{a}$	$6.5\pm0.23_{a}$
Oat Bran Parotta[b]						
1	$8.4\pm0.05_{d}$	$8.3\pm0.05_{d}$	$8.2\pm0.11_{e}$	$8.3\pm0.11_{d}$	$8.3\pm0.10_{d}$	$8.5\pm0.05_{d}$
2	$8.4\pm0.00_{d}$	$8.3\pm0.05_{d}$	$8.2\pm0.00_{de}$	$8.1\pm0.05_{bc}$	$8.1\pm0.05_{d}$	$8.4\pm0.05_{d}$
5	$8.3\pm0.05_{d}$	$8.2\pm0.10_{d}$	$8.3\pm0.20_{e}$	$8.3\pm0.20_{d}$	$8.4\pm0.05_{de}$	$8.3\pm0.11_{cd}$
8	$8.0\pm0.00_{c}$	$7.9\pm0.05_{c}$	$7.8\pm0.11_{cd}$	$7.8\pm0.11_{b}$	$7.8\pm0.05_{c}$	$8.1\pm0.15_{bc}$
10	$7.7\pm0.05_{c}$	$7.7\pm0.05_{c}$	$7.7\pm0.57_{c}$	$7.7\pm0.05_{b}$	$7.7\pm0.05_{c}$	$8.1\pm0.50_{b}$
12	$6.9\pm0.05_{b}$	$7.1\pm0.10_{b}$	$7.0\pm0.11_{b}$	$6.9\pm0.05_{a}$	$7.1\pm0.05_{b}$	$6.9\pm0.50_{a}$
15	$6.4\pm0.25_{a}$	$6.7\pm0.20_{a}$	$6.6\pm0.17_{a}$	$6.7\pm0.23_{a}$	$6.8\pm0.05_{a}$	$6.8\pm0.10_{a}$

Values with different subscripts in column differs significantly ($P \leq 0.05$)

concentration of fibers decreased the overall acceptability score. The acceptable range of fibers incorporated was 2 per cent psyllium husk, 5 per cent barley bran and 10 per cent oats bran. Below this level acceptability was always higher.

In case of psyllium husk, above 2.0 per cent incorporation resulted in decreased OAA score and cracked surface parotta. Parotta prepared using 2.0 per cent psyllium received OAA of 8.2 on a 9-point Hedonic scale and parotta with 10 per cent oat bran and 5 per cent barley received 8.1 and 7.7 of OAA respectively.

The incorporation more than 10.0 per cent of oat bran and 5 per cent of barley fiber resulted in the hard structured parotta with improper layers. Similar finding was reported by (Yadav *et al*., 2010) on the formulation of fiber rich chapattis by using oat bran. The color of the parotta also turned from creamish white to brownish white with change in aroma and taste. Based on the sensory analysis the parotta with psyllium husk (2.0%), barley (5.0 %) and oats bran (10.0%) were selected for shelf-life extension and physico-chemical parameter studies.

Influence of fibers on rheological parameter flour for dough mixing

The fiber enriched flour developed by mixing RWF and psyllium husk, oat bran and barley bran with addition of water possesses viscoelastic characteristics, which is vital for dough handling and final product quality. The viscoelastic nature of dough is attributed to gluten proteins namely gliadins and glutenins. The gliadins impart extensibility to

dough, whereas glutenin is held responsible for strength and elastic character of gluten and dough. The changes in gluten content of both wet and dried form of RWF incorporated with psyllium, fiber, oat bran and barley bran (0-10%) were carried out by using gluten analyzer and the results obtained are shown in Table 3. It was observed that with the increase in fiber, there was a decrease in both wet and dried gluten content. Wet gluten was found to decrease from 22.63% to 15.63% and dry gluten decreased from 9.16% to 6.86%. Falling number, which measures the presence of amylase activity in the wheat flour found to decrease from 443 to 419 sec with the increase in fiber addition. Addition of fiber significantly ($P<0.05$) increased water absorption capacity of fiber enriched flour compared to RWF with highest moisture absorption in oat bran enriched flour (70.3 ml) followed by barley bran enriched flour (63.3 ml) and psyllium husk flour (61.2 ml). Similar finding was reported by (Mohebbi *et al*., 2018) on development of prebiotic bread using beta-glucan and resistant starch. Increased water absorption in fiber enriched flour may be attributed to more number of hydroxyl groups present in fiber structure, which permit more water interactions through hydrogen bonding (Rosell *et al*., 2001; Lazaridou and Biliaderis, 2007 and Perez-Quirce *et al*., 2017).

Effect of addition of fiber on the pasting properties of RWF is shown in Table 3. It is evident from the table that increase in fiber concentration resulted in reduction of peak viscosity, which could be attributed to ability of starch molecules to swell freely before their physical break down decrease from 312 to 258 Rapid-Visco Analyser units (RVU). It can be

Table 3: Gluten Content & Pasting properties of dough

Sample	Wet Gluten content (%)	Dry gluten content (%)	Falling number	Peak Viscosity (RVU)	Break Down Viscosity RVU)	Setback RVU)	Water absorption (ml)
Refined Wheat Flour	$22.63\pm0.25_{d}$	$9.16\pm0.30_{d}$	$443\pm3.0_{c}$	312±2.0d	$122.0\pm2.0_{a}$	$153.3\pm3.0_{a}$	$56.3\pm0.5_{a}$
Psyllium Fiber enriched flour	$19.60\pm0.20_{c}$	$8.74\pm0.12_{c}$	$431\pm2.0_{b}$	$293.3\pm3.0_{c}$	$132\pm2.0_{b}$	$160.0\pm2.0_{ab}$	$61.2\pm1.0_{b}$
Barley Bran enriched flour	$16.83\pm0.05_{b}$	$7.63\pm0.15_{b}$	$428\pm2.0_{b}$	$280\pm2_{b}$	$144.3\pm.0_{c}$	$172.6\pm3.0_{b}$	$63.3\pm1.5_{c}$
Oats barn enriched flour	$15.63\pm0.15_{a}$	$6.86\pm0.17_{a}$	$419\pm1.5_{a}$	$258.0\pm2.0_{a}$	$170\pm3.05_{d}$	$194.66\pm9.8_{c}$	$70.3\pm1.5_{d}$

Values with different subscripts in column differs significantly ($P\leq0.05$)

Table 4: Proximate analysis parotta samples

Parotta samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbo-hydrate (%)	Total Dietary Fiber (%)	Insoluble Dietary fiber (%)	Soluble Dietary fiber (%)	Energy Kcal/ 100g
Control parotta	$24.79\pm0.43_{a}$	$1.38\pm0.14_{a}$	$11.00\pm0.20_{a}$	$5.97\pm0.28_{a}$	$59.14\pm2.74_{b}$	$0.34\pm0.3_{a}$	$0.24\pm0.2_{a}$	$0.10\pm0.4_{a}$	$358.24\pm11.6_{b}$
Psyllium husk Parotta	$28.28\pm0.61_{b}$	$1.46\pm0.04_{ab}$	$11.76\pm0.50_{a}$	$5.62\pm0.27_{a}$	$51.01\pm0.88_{a}$	$14.8\pm0.14_{c}$	$2.96\pm1.24_{b}$	$11.84\pm2.1_{d}$	$340.16\pm2.05_{a}$
Barley Bran Parotta	$25.91\pm0.54_{a}$	$1.40\pm0.08_{a}$	$13.90\pm0.20_{c}$	$6.21\pm0.32_{a}$	$50.31\pm0.26_{a}$	$9.86\pm0.32_{b}$	$6.40\pm0.28_{c}$	$3.46\pm0.18_{b}$	$360.26.\pm4.22_{b}$
Oat Bran Parotta	$27.55\pm0.48_{b}$	$1.60\pm0.11_{b}$	$14.93\pm0.41_{d}$	$6.01\pm0.16_{a}$	$47.45\pm0.81_{a}$	$15.14\pm0.38_{c}$	$6.84\pm0.30_{c}$	$8.3\pm0.30_{c}$	$358.05\pm1.08_{b}$

Values with different subscripts in column differs significantly ($P\leq0.05$)

Table 5: Mineral content of parotta

Parotta samples	Calcium mg/100g	Iron mg/100g	Zinc mg/100g	Sodium mg/100g	Potassium mg/100g
Control parotta	$16.30\pm0.55_{a}$	$6.18\pm0.42_{a}$	$2.92\pm0.10_{c}$	$2017.3\pm21.93_{a}$	$120.0\pm7.9_{a}$
Psyllium husk Parotta	$22.94\pm0.48_{c}$	$18.19\pm0.51_{b}$	$0.49\pm0.06_{a}$	$2150.0\pm50.0_{a}$	$486.6\pm30.51_{d}$
Barley Bran Parotta	$16.08\pm0.30_{a}$	$33.88\pm1.32_{c}$	$1.18\pm0.19_{b}$	$2340.0\pm40.0_{b}$	$415.3\pm11.0_{c}$
Oat Bran Parotta	$19.37\pm0.84_{b}$	$51.38\pm1.03_{d}$	$0.74\pm0.08_{a}$	$2576.6\pm116_{c}$	$351.3\pm12.0_{b}$

Values with different subscripts in column differs significantly ($P\leq0.05$)

Table 6: Changes in peroxide values (PV, meq O_2/kg fat), free fatty acids (FFA, % Oleic acid) thiobarbituric acid (TBA, mg malonaldehyde/kg sample) and overall acceptability (OAA) parotta without sorbic acid

Days	PV	FFA	TBA	OAA
Control parotta without sorbic acid				
0	$2.02\pm0.05_{a}$	$0.045\pm0.003_{a}$	$0.144\pm0.02_{a}$	$8.46\pm0.05_{a}$
15	$2.56\pm0.08_{b}$	$0.052\pm0.004_{a}$	$0.172\pm0.04_{a}$	$8.23\pm0.05_{a}$
30	$3.33\pm0.09_{c}$	$0.151\pm0.034_{b}$	$0.350\pm0.01_{b}$	Nil
Psyllium husk parotta without sorbic acid				
0	$2.70\pm0.15_{a}$	$0.019\pm0.003_{a}$	$0.124\pm0.004_{a}$	$8.33\pm0.04_{a}$
15	$2.94\pm0.41_{bc}$	$0.024\pm0.004_{a}$	$0.154\pm0.005_{a}$	$8.26\pm0.04_{a}$
30	$3.25\pm0.14_{c}$	$0.2187\pm0.050_{b}$	$0.397\pm0.040_{b}$	Nil
Barley Bran parotta without sorbic acid				
0	$2.69\pm0.16_{a}$	$0.023\pm0.002_{a}$	$0.074\pm0.054_{a}$	$8.46\pm0.05_{a}$
15	$3.62\pm0.25_{b}$	$0.033\pm0.003_{a}$	$0.206\pm0.172_{b}$	$8.23\pm0.05_{a}$
30	$3.86\pm0.01_{b}$	$0.326\pm0.080_{b}$	$0.663\pm0.026_{c}$	
Oat Bran Parotta without sorbic acid				
0	$2.45\pm0.15_{a}$	$0.022\pm0.003_{a}$	$0.119\pm0.054_{a}$	$8.33\pm0.05_{a}$
15	$3.11\pm0.41_{b}$	$0.031\pm0.008_{a}$	$0.139\pm0.007_{a}$	$8.26\pm0.05_{a}$
30	$3.56\pm0.34_{b}$	$0.232\pm0.043_{b}$	$0.250\pm0.053_{b}$	Nil

Values with different subscripts in column differs significantly ($P\leq0.05$)

Table 7: Multivariate tests analysis of parottas without sorbic acid during storage

Effect		Multivariate Tests (Design: Intercept + Parotta type + Days + Parotta type * Days)						
		Value	F	Hypothesis df	Error df	Sig. Parameter	Non cent. Power	Observed
Parottatype	Wilks' Lambda	.026	13.869	12.000	55.852	.000	132.977	1.000
Days	Wilks' Lambda	.000	1244.387^{b}	8.000	42.000	.000	9955.099	1.000
Parotta type * Days	Wilks' Lambda	.008	9.273	24.000	74.470	.000	174.394	1.000

concluded from the above results that swelling capacity of starch granules decreased on addition of fiber. (Symons and Brennan, 2004) also reported that substitution of wheat starch with 5.0 per cent barley b-glucan ûber fractions reduced peak viscosity due to reduction in starch for gelatinization and less water available for initial swelling of starch granule. Gomez *et al.* (2013) also reported a decrease in peak viscosity with increase in concentration of rice bran and moringa leaves in the preparation of bread.

Susceptibility of cooked starch granules to disintegration is measured by break down viscosity and is highly influenced by the amylose content, which increased from 122 to 170 RVU. The setback viscosity, which is a measure of the recrystallization of gelatinized starch during cooking and also represents the effect of cooking and tendency to retrograde increases significantly from 153 to 194 RVU. The changes in viscosities due to the incorporation of fiber may be attributed to the partial gelatinization of starch and denaturation of proteins and less water available for initial swelling of starch granules. The aggregation of amylose fractions also resulted in the changes in pasting properties of refined wheat flour used for preparation of parotta.

Proximate analysis of parotta samples

The proximate analysis of parotta samples prepared with 2 per cent psyllium husk, 5 per cent barley and 10 per cent oat bran were analyzed for moisture, ash, protein, fat, crude fiber and gluten content according to methods described in (AOAC, 2000) and was illustrated in Table 4. The results revealed that addition of fiber increased moisture content of parotta samples. Significant difference ($P<0.05$) in moisture content was noticed in parotta samples enriched with psyllium husk and oat bran than control & barley bran enriched parotta. Highest level of moisture (28.28%) was observed in parotta on addition 2 % psyllium husk followed by parotta

Table 8: Changes in peroxide values (PV, meq O_2 /kg fat), free fatty acids (FFA, % Oleic acid) thiobarbituric acid (TBA, mg malonaldehyde/kg sample) and overall acceptability (OAA) parotta with sorbic acid

Parotta	Days	PV	FFA	TBA	OAA
Control parotta with sorbic acid	0	$2.54\pm0.04_{a}$	$0.220\pm0.002_{a}$	$0.140\pm0.001_{a}$	$8.46\pm0.02_{de}$
	15	$2.83\pm0.04_{ab}$	$0.313\pm0.015_{a}$	$0.224\pm0.019_{b}$	$8.26\pm0.04_{cd}$
	30	$3.29\pm0.10_{bc}$	$0.135\pm0.010_{b}$	$0.318\pm0.025_{c}$	$8.26\pm0.05_{cd}$
	45	$3.55\pm0.05_{c}$	$0.186\pm0.004_{cd}$	$0.449\pm0.304_{d}$	$8.21\pm0.07_{cd}$
	60	$4.43\pm0.35_{d}$	$0.201\pm0.007_{de}$	$0.504\pm0.012_{e}$	$8.13\pm0.04_{bc}$
	75	$5.60\pm0.20_{e}$	$0.233\pm0.011_{e}$	$0.524\pm0.006_{e}$	$8.03\pm0.02_{ab}$
	90	$7.23\pm0.15_{f}$	$0.280\pm0.020_{f}$	$0.747\pm0.004_{f}$	$7.93\pm0.05_{a}$
Psyllium husk parotta with sorbic acid	0	$2.68\pm0.04_{a}$	$0.054\pm0.004_{a}$	$0.113\pm0.004_{a}$	$8.41\pm0.01_{de}$
	15	$2.91\pm0.04_{b}$	$0.066\pm0.004_{a}$	$0.118\pm0.006_{b}$	$8.33\pm0.02_{de}$
	30	$2.98\pm0.03_{b}$	$0.138\pm0.001_{b}$	$0.367\pm0.024_{c}$	$8.26\pm0.04_{cd}$
	45	$3.24\pm0.04_{c}$	$0.154\pm0.002_{b}$	$0.408\pm0.010_{d}$	$8.16\pm0.02_{c}$
	60	$3.71\pm0.05_{d}$	$0.212\pm0.015_{c}$	$0.509\pm0.001_{e}$	$7.96\pm0.02_{bc}$
	75	$4.05\pm0.11_{e}$	$0.268\pm0.024_{d}$	$0.603\pm0.015_{f}$	$7.83\pm0.05_{ab}$
	90	$4.36\pm0.06_{f}$	$0.266\pm0.011_{d}$	$0.741\pm0.011_{g}$	$7.76\pm0.05_{a}$
Barley bran parotta with sorbic acid	0	$2.78\pm0.04_{a}$	$0.055\pm0.032_{a}$	$0.670\pm0.007_{a}$	$8.4\pm0.05_{de}$
	15	$2.89\pm0.03_{a}$	$0.079\pm0.008_{a}$	$0.194\pm0.005_{b}$	$8.27\pm0.01_{cd}$
	30	$3.69\pm0.16_{b}$	$0.162\pm0.017_{b}$	$0.236\pm0.028_{b}$	$8.24\pm0.02_{cd}$
	45	$3.76\pm0.15_{b}$	$0.184\pm0.012_{bc}$	$0.311\pm0.013_{c}$	$8.20\pm0.04_{cd}$
	60	$3.80\pm0.20_{cd}$	$0.239\pm0.003_{cd}$	$0.401\pm0.007_{d}$	$8.13\pm0.04_{bc}$
	75	$4.16\pm0.11_{de}$	$0.314\pm0.016_{e}$	$0.460\pm0.008_{e}$	$8.03\pm0.01_{ab}$
	90	$4.70\pm0.17_{f}$	$0.452\pm0.038_{f}$	$0.530\pm0.020_{f}$	$7.93\pm0.02_{a}$
Oat bran parotta with sorbic acid	0	$2.43\pm0.12_{a}$	$0.063\pm0.004_{a}$	$0.107\pm0.004_{a}$	$8.8.4\pm0.01_{e}$
	15	$2.66\pm0.10_{b}$	$0.742\pm.0.002_{a}$	$0.186\pm0.034_{b}$	$8.33\pm0.02_{e}$
	30	$3.12\pm0.11_{c}$	$0.180\pm0.005_{b}$	$0.338\pm0.022_{c}$	$8.26\pm0.24_{de}$
	45	$3.40\pm0.02_{d}$	$0.195\pm0.003_{b}$	$0.392\pm0.021_{c}$	$8.14\pm0.27_{d}$
	60	$3.60\pm0.05_{de}$	$0.227\pm0.004_{c}$	$0.489\pm0.027_{d}$	$7.98\pm0.02_{bc}$
	75	$3.81\pm0.03_{e}$	$0.305\pm0.013_{d}$	$0.580\pm0.019_{e}$	$7.83\pm0.05_{b}$
	90	$4.17\pm0.06_{f}$	$0.337\pm0.010_{e}$	$0.673\pm0.027_{f}$	$7.76\pm0.05_{a}$

Table 9: Multivariate Tests analysis of parotta with Sorbic acid during storage

Effect		Multivariate Tests (Design: Intercept + Parotta type + Days + Parotta)						
		Value	F	Hypothesis df	Error df	Sig.	Non cent. Parameter	Observed Power[d]
Parotta type	Wilks' Lambda	.004	87.339	12.000	140.516	.000	783.183	1.000
Days	Wilks' Lambda	.000	63.139	24.000	186.105	.000	1096.047	1.000
Parotta type * Days	Wilks' Lambda	.001	13.828	72.000	210.766	.000	960.524	1.000

incorporated with 10 per cent oats bran (27.55%) and 5 per cent barley bran (25.91%). Presence of soluble fibers in psyllium husk and oat bran may be attributed to enhanced moisture absorption in psyllium and oat parotta. (Raymundo *et al*., 2014) reported similar finding on biscuits, prepared with psyllium fiber.

Small but statistically significant difference (P<0.05) was obtained in the ash content in psyllium & oat bran enriched parotta compared to control and barley bran parotta. The ash content was found to be higher in oat bran parotta (1.60%) followed by psyllium (1.46%) and barley bran parotta (1.40%). (Fradinho *et al*., 2015) reported similar finding on biscuits development by using psyllium husk. Addition of barley and oat bran showed significant (P<0.05) increase in the fat content of parotta compared to psyllium and control parotta. There were no significant differences (P<0.05) among protein value of parotta prepared by different fiber formulation. Protein content was found to be low in psyllium parotta and the same may be attributed to absence of protein in the psyllium fiber.

A significant increase in total dietary fiber content

Table 10: Microbiological profile of control and fiber enriched parotta

PAROTTA	DAYS	Total aerobic plate count (CFU/g)	Coliforms (CFU/g)	Yeast and Moulds (CFU/g)	*E. coli (*CFU/g)
CP	0	4.0×10^{2}	Absent	Absent	-Ve
	15	2.0×10^{4}	Absent	Absent	-Ve
	30	2.0×10^{6}	Absent	2.0×10^{2}	-Ve
CPS	0	1.0×10^{1}	Absent	Absent	-Ve
	15	2.0×10^{1}	Absent	Absent	-Ve
	30	2.0×10^{1}	Absent	Absent	-Ve
	45	2.0×10^{2}	Absent	Absent	-Ve
	60	2.0×10^{2}	Absent	Absent	-Ve
	75	4.0×10^{3}	Absent	Absent	-Ve
	90	4.0×10^{3}	Absent	Absent	-Ve
PHP	0	1.0×10^{2}	Absent	Absent	-Ve
	15	2.0×10^{4}	Absent	Absent	-Ve
	30	3.0×10^{6}	Absent	Absent	-Ve
PHPS	0	1.0×10^{1}	Absent	Absent	-Ve
	15	2.0×10^{1}	Absent	Absent	-Ve
	30	$2.0\times10^{2.}$	Absent	Absent	-Ve
	45	2.0×10^{2}	Absent	Absent	-Ve
	60	2.0×10^{2}	Absent	Absent	-Ve
	75	3.0×10^{3}	Absent	Absent	-Ve
	90	3.0×10^{3}	Absent	Absent	-Ve
BBP	0	3.0×10^{2}	Absent	Absent	-Ve
	15	4.0×10^{3}	Absent	Absent	-Ve
	30	$>30\times10^{5}$	Absent	2.0×10^{1}	-Ve
BBPS	0	0.3×10^{1}	Absent	Absent	-Ve
	15	2.0×10^{1}	Absent	Absent	-Ve
	30	2.0×10^{3}	Absent	Absent	-Ve
	45	2.0×10^{2}	Absent	Absent	-Ve
	60	2.0×10^{2}	Absent	Absent	-Ve
	75	3.0×10^{3}	Absent	Absent	-Ve
	90	3.0×10^{3}	Absent	Absent	-Ve
OBP	0	2.0×10^{3}	Absent	Absent	-Ve
	15	1.0×10^{4}	Absent	Absent	-Ve
	30	$>40\times10^{5}$	Absent	2.0×10^{2}	-Ve
OBPS	0	2.0×10^{1}	Absent	Absent	-Ve
	15	2.0×10^{1}	Absent	Absent	-Ve
	30	2.0×10^{3}	Absent	Absent	-Ve
	45	2.0×10^{2}	Absent	Absent	-Ve
	60	2.0×10^{2}	Absent	Absent	-Ve
	75	3.0×10^{3}	Absent	Absent	-Ve
	90	3.0×10^{3}	Absent	Absent	-Ve

CP - Control Parotta; CPS – Control Parotta with sorbic acid; PHP – Psyllium husk parotta;
PHPS – Psyllium husk parotta with sorbic acid; BBP – Barley bran parotta; BBPS – Barley bran parotta with sorbic acid; OBP – Oat bran parotta; OBPS – Oat bran parotta with sorbic acid.

was noticed in parotta enriched with oat bran, psyllium fiber, and barley bran compared to control. Parotta with highest dietary fiber content was showed by parotta prepared by oat bran (15.54 %) followed psyllium incorporated parotta (14.8 %). Nearly 30-40 fold increase in dietary fiber content was achieved by the incorporation of fiber component in formulation. Soluble dietary fiber per centage also increased from 0.10 – 11.84 per cent in fiber enriched parottas. Similar findings were reported by (Fradinho *et al.,* 2015; Yadav *et al.,* 2010; Sakhare and Prabhashankar, 2021) on development of fiber rich baked products.

Results also showed significant decrease in

carbohydrate content by the addition of fibers to refined wheat flour. This could be due to lower carbohydrate in oat and barley bran compared to RWF. Significant difference (P<0.05) in calorific value was observed in fiber enriched parotta compared to control parotta.

Minerals analysis

The mineral composition of control parotta and fortified parotta with the addition of fiber was depicted in Table 5. The study clearly revealed that addition of fibers significantly enhanced calcium, iron, sodium and potassium mineral content in parotta. Parotta enriched with 2 per cent psyllium husk showed higher level of calcium (22.94 mg/ 100g) followed by oat bran parotta. There is no significant (P<0.05) difference between control and barley bran parotta with respect to calcium mineral content. Parotta prepared by fiber addition showed significant increase in iron content compared to control parotta. 3-8-fold increase in iron content was noticed with highest iron content of 51.38 mg/100g in parotta prepared with oat bran. Parotta prepared with oat and barley bran at 10 per cent and 5 per cent levels respectively exhibited statistically significant (P<0.05) increase in sodium content compared to psyllium and control parotta. Highest level of potassium (486 mg/100g) was observed in psyllium parotta followed by barley bran parotta. Similar finding was reported by (Padmashree *et al*., 2017) on development of phytonutrient rich south Indian parotta. Significant (P<0.05) decrease in zinc content was observed upon the addition of fibers in preparation of parotta. Psyllium parotta had low zinc (0.49 mg/kg) followed by oat bran parotta.

Chemical changes during storage

Raw ingredients were mixed with 1500 ppm of sorbic acid to enhance shelf life and to avoid microbial contamination. The parotta prepared without sorbic acid were kept as control. After baking, parotta were cooled and packed in polypropylene pouches and sealed properly. The packets were in pack pasteurized at 90 ºC for 2 hours using cabinet dryer. The products were kept at room temperature for further analysis. The changes in peroxide value (PV), free fatty acids (FFA), thiobarbituric acid (TBA), sorbic acid (SA), browning index and over all acceptability (OAA) of control as well as fiber incorporated parotta without sorbic acid are shown in Table 6.

Parotta samples prepared without sorbic acid showed significant (P<0.05) increase in rate of peroxidation during 30 days period of storage. The rate of peroxidation in the range of 2.02 - 3.86 meq O_2/kg of fat with highest level in barley bran parotta followed by oat bran parotta. This could be due to the higher level of fat in oat and barley bran in comparison to psyllium husk.

No significant difference was noticed in FFA and TBA content during 15 days of storage compared to 0 day of storage. However, FFA and TBA content slightly but significantly (P<0.05) increased during 30 days of storage with range of 0.151 – 0.326 % oleic acid and 0.250 - 0.663 mg malonaldehyde/kg respectively. The overall acceptability (OAA) score of all parotta calculated by considering colour, aroma, taste and textural attributes on point a 9 point Hedonic scale found to be almost same without much statistical difference. The multivariate analysis showed statistically significant interaction effect between parotta type and days on the combined dependent variables, $F(12, 24) = 9.273$, $p = 0.000$; Wilks' $\Lambda = 0.008$.

After 15 days of storage, parotta samples without sorbic acid showed mold and fungal growth and were not used for the sensory analysis. It is clearly evident from the study that in pack pasteurization at 90 ºC for 2 hour for control as well as fiber enriched parotta without sorbic acid enhanced shelf-life up to 15 days under ambient storage condition (temperature; 24-32ºC and relative humidity; 30-60 %).

The changes in peroxide value (PV), free fatty acids (FFA), thiobarbituric acid (TBA), sorbic acid (SA), and browning index and over all acceptability (OAA) of control as well as fiber incorporated parotta with sorbic acid are shown in the Table 7. The results clearly showed statistically significant (P<0.05) increase with respect to PV, FFA and TBA and

decrease with respect to overall acceptability of all parotta prepared with addition of fiber. It is observed from the Table 7 and figure 2 that both fiber enriched and control parotta prepared by addition of sorbic acid at 1500 ppm showed significant (P<0.05> increase in rate of peroxidation during storage period of 90 days. The rate of peroxidation was in the range of 4.16-7.23 meq O_2/kg of fat with highest level in control parotta (7.23 meq O_2/kg) followed by barley bran parotta (4.70 meq O_2/kg). This could be due to low level of fat in psyllium husk and oat bran. The increase in rate of peroxidation indicated formation of aldehydes and ketones due to lipid oxidation. The results clearly showed that sorbic acid along with fibers especially psyllium husk and barley bran play a major role in inhibition of lipid per oxidation besides microbial growth. The parotta were found to be stable without developing much rancidity.

Sorbic acid added parotta showed no significant difference in peroxide value free fatty acid and TBA content during 15 days of storage compared to 0-day storage. However, FFA and TBA content significantly increased during 90 days of storage in the range of 0.226 – 0.742 % oleic acid and 0.107-0.747 mg malonaldehyde/kg respectively (Figure 2, 3 and 4). The increase in rate of autoxidation may be attributed to 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. Thakur and Arya (1990) reported an increase in FFA in processed cereal products from decomposition of hydroperoxide rather than lipids. The gradual increase in TBA in parotta during storage is due to the fact that processed parotta 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. (Khan *et al*., 2015) reported similar finding on storage stability of spinach chapaties.

An overall acceptability parotta on a 9 point Hedonic scale calculated using colour, aroma, taste and texture as attributeswere found to be more than 8.4 for control as well as fiber enriched parotta (Figure.5). After three months of storage, there was a steep and significant (Pd"0.05) decrease of overall acceptability scores of parotta prepared with fiber addition and control. The OAA score decreased from 8.4 to 7.76 in parotta. Textural hardness during storage due to retrogradation starch may be main reason for decrease in sensory level. However the OAA remained above 7.5 for all parotta and showed acceptability of products even after 3 months storage. The multivariate analysis showed statistically significant interaction effect between parotta type and days on the combined dependent variables; PV, FFA, TBA & OAA $F(12, 78) = 13.828$, $p = 0.000$; Wilks' $\Lambda = .0001$.

Changes in microbial parameters of parotta during storage period

The microbial analysis of control and fiber enriched parotta with and without sorbic acid were carried out initially and during 90 days of storage is depicted in the Table 8. It is evident from microbiological data that total aerobic mesophilic, coliforms, yeast & mold and E. coli counts remained in acceptable limit for 90 days in parotta prepared using sorbic acid and for 15 days in parotta without sorbic acid addition. The microbial load differed significantly with respect to treatments, storage period and interaction between all these parameters. The microbiological analysis indicated that parotta without sorbic acid had higher microbial load than parotta with sorbic acid. Coliform was found to be absent in all the samples. Therefore, it was concluded that the parotta with sorbic acid had better shelf life than that of parotta without sorbic acid.

CONCLUSION

The production of fiber-enriched parotta with psyllium husks, oat bran and barley bran is a best vehicle to include this health promoting fiber in human nutrition. The optimized formulation indicated that addition of 2 per cent psyllium husk, 10 per cent oat bran and 5 per cent barley bran as ingredients during preparation of parotta enhanced dietary fiber and mineral content without affecting sensory attributes. The fiber enriched parotta with sorbic acid (1500 ppm) addition was found to be

stable upto 3 months both chemically and microbiologically with higher over all acceptability. Further technological intervention for preparation of soft pliable parotta with improved textural integrity using permitted heath promoting substance is necessary to produce consumer acceptable parotta to reduce risk of lifestyle related diseases.

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