

Original Research Article

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## Retention and Evaluation of Antioxidant Activity of Polyphenol Extract from Mango Peel Powder as a Source of Natural Phyto-Nutrients in Biscuits and Its Shelf Life Study

Baddi Jayalaxmi\* and D. Vijayalakshmi

Department of Food Science and Nutrition, UAS, GKVK, Bengaluru, Karnataka, India

\*Corresponding author

### ABSTRACT

Mango peel is not currently being utilized, it is discarded as waste and becoming a source of pollution. It contains total polyphenols (TPP) which needs to exploit as natural phyto-nutrients. Production and consumption of mango is gradually increasing. As mango peel is not currently being utilized, it is discarded as waste and becoming a source of pollution. It contains total polyphenols (TPP) which needs to exploit as natural phyto-nutrient. The objective of present study was extraction of total polyphenols from mango peel powder, development of value added biscuits its shelf life study, to analyze the retention of extracts in the developed biscuits. The extracts were used in formulation of biscuits at different per cent levels. Biscuits with TPP at 0.5 per cent were best accepted for sensory attributes. The per cent retention of polyphenols (660 to 520  $\mu\text{g}$  GAE/g),  $\beta$ -carotene (22.50 to 13.56  $\mu\text{g}/\text{g}$ ) and antioxidant activity (775 to 194  $\mu\text{g}$  of  $\mu\text{g}$  of Vit-C Eq/100g) was more in TPP 0.5% biscuits than control for six weeks storage period. When analyzed statistically the peroxide and free fatty acid values were non-significant at the initial stage and were found to be significant during second, fourth and sixth week of storage period, indicating that the potency of antioxidant inhibiting formation of free fatty acids. Stored products showed good shelf life in 350-gauge polythene pouches due to TPP extracts of mango peel powder than control.

#### Keywords

Mango peel powder,  
Total polyphenols,  
Biscuits and retention of  
polyphenols extract, Shelf  
life study

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### Introduction

Mango (*Mangifera indica* L., Anacardiaceae) is truly a “King” of fruits has been cultivated for about 4,000 years and its production and consumption has gradually increased as its popularity has grown. During processing of mango, by-products such as peel and kernel constitutes about 17-22 per cent of the fruit (Pitchaon, 2011). In India the area under cultivation occupies 2312.3 hectares with production of 15,026.7 MT of mangoes, which

ranks second among the major fruits and in Karnataka the area is 153.8 hectares with production of 1694 MT, as reported by National Horticulture Board (2010). Besides the fresh fruit, processed mango products such as juices, nectars, concentrates, jams, jelly, powders, fruit bars, flakes and dried fruits have become increasingly popular. Since these by-products represent a serious disposal problem, ways for a sustainable agricultural production has been searched (Kimberly and Krenk, 2009). The characteristic feature of

mango peel is that it has relatively high content of polyphenols and dietary fibre, which is reported to have more health benefits compared to apple peel, orange peel, wheat bran and oat bran. The bioactive components namely, carotenoids, flavanols, and polyphenols, which exert higher health promoting effects than the dietary fibre alone. As peel is not currently being utilized for any commercial purpose, it is discarded and becoming a source of pollution. Recently Ajila *et al.*, (2007) reported that mango peel contains polyphenols and dietary fibers which need to be exploited as natural phyto-nutrients. The objective of present study was extraction of total polyphenols from mango peel powder, development of value added biscuits its shelf life study, to analyze the retention of extracts in the developed biscuits.

### **Materials and Methods**

The Mango peel for research was procured from a local mango processing Safal, industry, Bangalore, Karnataka, India. The sample was cleaned, blanched and dried in hot air oven at 50<sup>o</sup> C. The material was ground to fine powder passed through a 60 mesh sieve and stored in an air tight container in refrigerator conditions for further use. The mango peel samples were finely powdered and were subjected for chemical analysis.

### **Extraction of total polyphenols (TPP)**

Extraction of bulk quantities of total polyphenols from stabilized mango peel powder. 100 gm of mango peel powder was extracted with 1000ml of 80% acetone for 4-5 hr by stirring with magnetic stirrer. The slurry was then strained through muslin cloth to separate the extract. The total polyphenols extracts were then subjected to vacuum evaporation (Rotary evaporator) at 45<sup>o</sup>C to remove acetone completely and concentrated to get total polyphenols extract in liquid form. Stored in air tight container and kept in cool

place. The extraction was repeated to obtain crude total polyphenols extract and was used for product development Sadasivam and Manickam (1991).

### **Estimation of total polyphenols**

Exactly 0.5 to 1.0 gm of the sample was weighed and ground with a pestle and mortar in 10 times volume of 80 percent ethanol. Centrifuged at 10000 RPM for 10 min supernatant was collected. Re-extracted the residue with 5 times volume of 80 percent ethanol centrifuged and the supernatants were poured. The supernatants were evaporated to dryness over water bath. Dissolve the residue in a known volume of distilled water (3ml). 0.5 and 1.0 ml was pipetted out into test tube. Distilled water was added to make up the volume to 3 ml. 0.5 ml FCR was added to each test tube. After 30 min, add 2 ml of 20 percent NaCO<sub>3</sub> solution to each test tube. Mixed thoroughly and the tube was placed in boiling water bath for exactly 1 min, cooled and the OD at 650 nm was measured (Sadasivam and Manickam, 1991).

### **Development of value added biscuits with the incorporation of extracted total polyphenols (TPP)**

Biscuits were developed with different levels of incorporation of total polyphenols and the best accepted product was taken for shelf life study and retention of extracts during storage period. Biscuits were prepared from doughs containing 0.25, 0.5, 0.75, 1.0 and 1.5 per cent mango peel total polyphenol (TPP) levels for wheat flour and control biscuits without (TPP). The formula used was as follows: 100 g wheat flour, 25 g sugar, 30 g shortening, baking powder 0.5 per cent. The powdered sugar and fat were creamed was added to the cream. The contents were mixed to obtain a homogenized and pluffy texture. Sieved flour was added to the cream and mixed. The dough pieces were sheeted, cut using a circular

mould and baked at 160°C for 9-10 min. After baking, biscuits were cooled at room temperature, were wrapped tightly and kept at room temperature in storage materials *viz.*, high density polythene food grade pouches of 350 gauge for further analysis.

### **Sensory evaluation of developed products**

Criteria for selection of the panel members was their familiarity with the developed products selected for value addition. The panel members were exposed to all the products as preliminary evaluation before the final evaluation. Organoleptic evaluation of value added products: The value added biscuits were standardized in laboratory and organoleptic evaluation was carried out. A nine-point Hedonic Scale was adopted for the evaluation by semi trained panellists. Biscuits incorporated with total polyphenols (TPP) extract from mango peel powder were coded and submitted to sensory evaluation by fifteen semi-trained panel member of Department of Food Science and Nutrition. The panellists were asked to rate each sensory attribute using the control biscuits as the basic for evaluation. Biscuits were evaluated for appearance, texture, colour, aroma, taste and overall acceptability on a 9-point hedonic scale.

### **Retention of added total polyphenols (TPP) extracts**

Retention of the mango peel powder extracts like dietary fiber, total polyphenols, and  $\beta$ -carotenes and antioxidant activity in developed biscuits was analysed for every fifteen days intervals.

### **Estimation of insoluble dietary fiber, soluble dietary fiber and total dietary fiber (AOAC, 1995)**

Defatted foods are gelatinized and proteins and starch are removed by enzymatic

digestion. The residue is quantitated gravimetrically. The soluble fiber is estimated in the filtrate obtained after enzymatic digestion of protein and carbohydrates of defatted sample. The insoluble fiber is precipitated and estimated gravimetrically. The total dietary fiber is the sum of the insoluble and soluble dietary fiber, estimated as follows;

Total Dietary Fiber = IDF+SDF values

### **Estimation of total polyphenols**

Weigh exactly 0.5 to 1.0 gm of the sample and grind with a pestle and mortar in 10 times volume of 80 percent ethanol. Centrifuge at 10000 RPM for 10 min collect supernatant. Re-extract the residue with 5 times volume of 80 percent ethanol centrifuge and pour the supernatants.

Evaporate the supernatants to dryness over water bath. Dissolve the residue in a known volume of distilled water (3ml). Pipette out 0.5 and 1.0 ml into test tube. Add distilled water to make up the volume to 3 ml. Add 0.5 ml FCR to each test tube. After 30 min, add 2 ml of 20 percent NaCO<sub>3</sub> solution to each test tube. Mix thoroughly, place the tube in boiling water bath for exactly 1 min, cool and measure OD at 650 nm (Sadasivam and Manickam, 1991).

### **Estimation of $\beta$ - carotene**

The  $\beta$ - carotene content contents of the mango peel powder was estimated. The carotenes present in the sample were first extracted using acetone and then the carotene was brought to the petroleum ether phase. The concentration of  $\beta$ -carotene in the solution was determined by measuring the optical density of the solution using a spectrophotometer/colorimeter at 452nm (Ranganna, 1995).

### **Estimation of antioxidant activity by DPPH method**

The 2, 2- diphenyl (DPPH) radical was the oxidizing radical to be reduced by the antioxidant (AH) present in the given sample. The disappearance of the DPPH radical absorption at 517nm by the action antioxidants is measured spectrophotometrically in a methanol solution until the absorbance remains constant. The antioxidant activity was expressed in terms of ascorbic acid equivalents; so ascorbic acid is taken as standard. Various concentrations of ascorbic acid were prepared and added to DPPH solution. The decrease in O.D is plotted against concentration of ascorbic acid. The concentration of sample was calculated using the standard curve (Sadasivam and Manickam, 1991).

### **Estimation of total lipids (Bligh and dyer method)**

In this method, a mixture of chloroform and methanol (2:1V/V) was used. The tissue (about 1 g wet weight) was first ground in a pestle and mortar with about 10 ml of distilled water. The pulp was transferred to a conical flask (250ml capacity) and 30ml of chloroform – methanol mixture was added and mixed well.

### **Determination of Acid value**

The acid value is the number of milligram of KOH required to neutralise the free acid in 1 g of the substance.

### **Determination of peroxide value**

In the oxidative rancidity, oxidation of fat due to the combination of oxygen with unsaturated fatty acids takes place and results in the formation of compounds with a peroxide structure. These are detected by the liberation

of iodine from an acid solution of potassium iodide. There is another type of rancidity caused by the action of lipase of fat. This rancidity is called hydrolytic rancidity, which is caused by the formation of low molecular weight fatty acids like butyric acid, caproic acid and caprylic acids. This can be estimated by alkali titration method mentioned under acid value of ghee and is expressed in terms of butyric acid.

### **Statistical analysis**

Complete Randomized Design (CRD) analysis of variance was applied and the data obtained for each nutrient and functional property was subjected to statistical analysis to determine the level of significance. One-way analysis of variance was applied to sensory scores. The statistical analysis was done by using Minitab software (Minitab v1511). Significant difference was defined as  $p \leq 0.05$  and  $p \leq 0.01$ .

### **Results and Discussion**

Biscuits were developed by incorporating of total polyphenol at 0.25, 0.5, 0.75, 1.0 and 1.5 per cent level. Sensory evaluations of biscuits revealed that control biscuits showed highest scores of 8.8, 8.6, 8.7, 8.5, 8.6 and 8.7 for appearance, texture, colour, aroma, taste and overall acceptability respectively.

The biscuits with TPP at 0.5 per cent were best accepted for sensory attributes among the variations and scored 8.6, 8.5, 8.6, 8.4, 8.6 and 8.5 for appearance, texture, colour, aroma, taste and overall acceptability respectively. Biscuits were prepared as control and from the incorporation of total polyphenols in different levels ranging from 0.25, 0.5, 0.75, 1.0 and 1.5 per cent. The control and best sensory accepted biscuits (TPP 0.5 per cent) were kept at room temperature in storage material of high density polythene food grade pouches of

350 gauge for retention total polyphenol and storage study for a period of six weeks.

### **Retention of phyto-nutrients of biscuits on storage**

The retention of dietary fiber, total polyphenol,  $\beta$ -carotene content and antioxidant activity of biscuits enriched with total polyphenol (TPP) extract was studied for a period of six weeks (Table 1 and Figure 1 A and B). The per cent retention of TDF (5.8 and 5.7), IDF (3.5 and 3.2) and SDF (2.3 and 2.5) content in the control and TPP biscuit remained almost the same up to sixth week of storage. But in case of polyphenols,  $\beta$ -carotene and antioxidant activity there was a decreasing trend from the initial to sixth week of storage period. The retention of polyphenols (660 to 520  $\mu\text{g GAE/g}$ ),  $\beta$ -carotene (22.50 to 13.56  $\mu\text{g/g}$ ), antioxidant activity (775 to 194  $\mu\text{g Vit-C Eq/100g}$ ) was higher in TPP 0.5 biscuits than control biscuits the polyphenols (200 to 64  $\mu\text{g GAE/g}$ ),  $\beta$ -carotene (3.75 to 2.43  $\mu\text{g/g}$ ), antioxidant activity (250 to 121  $\mu\text{g Vit-C Eq/100g}$ ) during storage. Statistical analysis revealed a non-significant difference in case of TDF, IDS and SDF and there existed a significant difference in the retention of polyphenols,  $\beta$ -carotene and antioxidant activity from initial to six weeks of storage. Table 1 and Figure 1 (A and B) depict the retention of total dietary fiber, insoluble dietary fiber, soluble dietary fiber, total polyphenol,  $\beta$ -carotene and antioxidant activity of control and TPP biscuits. There was no significant change in dietary fiber content. But observed a significant reduction in the total polyphenol (200 to 64  $\mu\text{g GAE/g}$ ),  $\beta$ -carotene (3.75 to 2.43  $\mu\text{g/g}$ ) and antioxidant activity (250 to 121  $\mu\text{g of Vit-C Eq/g}$ ) of control and TPP biscuits with the total polyphenol (660 to 520  $\mu\text{g GAE/g}$ ),  $\beta$ -carotene (22.5 to 13.56  $\mu\text{g/g}$ ) and antioxidant activity (775 to 194  $\mu\text{g of Vit-C Eq/g}$ ). Compared to control biscuits TPP biscuits had

higher retention of total polyphenol,  $\beta$ -carotene and antioxidant activity. Similar results were found in the study conducted by Rupasinghe *et al.*, (2008) that the recovery of polyphenol of apple skin powder after incorporation in muffin the per cent recovery ranged from 16-64 per cent.

### **Peroxide and free fatty acid value of biscuit**

Table 2 and Figure 2 (A and B), represents the peroxide and free fatty acid value of biscuits and are compared with standard normal values. Peroxide value of both control and TPP 0.5 per cent biscuits showed significant difference. Initially control biscuits had 2.7 milliequiv. of peroxide/Kg of sample compared to that of TPP 0.5 per cent biscuits (0.7 milliequiv. of peroxide/Kg of sample). The peroxide content of control biscuits increased to 23.9 milliequiv. of peroxide/Kg of sample for sixth week, more rapidly than TPP biscuits (9.5 milliequiv. of peroxide/Kg of sample) during six weeks of storage period. The results are compared with standard peroxide value. Control biscuits was above the normal range during fourth and sixth week (18.1 and 23.9 milliequiv. of peroxide/Kg of sample), but in case of TPP at 0.5 per cent of incorporation, it was within the normal range of 6.4 and 9.5 milliequiv. of peroxide/Kg of sample on storage period. The free fatty acid values were above the standard values for the period of two weeks in the control biscuit (2.7 % of oleic acid per 100g) whereas the TPP biscuits were below the standard values up to fourth week (0.9 % of oleic acid per 100g). When analyzed statistically the peroxide and free fatty acid values were non-significant at the initial stage and were found to be significant during second, fourth and sixth week of storage period.

Peroxide values measures the content of hydro peroxides and are often used as an indicator of primary products of lipid oxidation.

**Table.1** Retention of phyto-nutrients in biscuits on storage

Biscuits	Duration	Total	Insoluble	Soluble	Polyphenols	β-carotene	Antioxidant activity
		Dietary	Dietary	Dietary			
(%)	(Days)	Fibre (g/100g)	Fibre (g/100g)	Fibre (g/100g)	(µg GAE/g)	(µg/g)	(µg of Vit-C Eq/g)
	Initial	5.8	3.5	2.3	200	3.75	250
Control	2 <sup>nd</sup> week	5.8	3.5	2.3	184	3.10	231
	4 <sup>th</sup> week	5.7	3.4	2.3	167	2.64	142
	6 <sup>th</sup> week	5.8	3.5	2.3	64	2.43	121
	Initial	5.9	3.3	2.6	660	22.50	775
TPP 0.5%	at 2 <sup>nd</sup> week	5.8	3.3	2.5	645	19.07	549
	4 <sup>th</sup> week	5.7	3.2	2.5	580	17.25	287
	6 <sup>th</sup> week	5.7	3.2	2.5	520	13.56	194
F-value		NS	NS	NS	*	*	*
SEm±		51.0	16.74	9.54	19.92	93.18	57.0
CD at 5%		0.34	0.12	0.22	0.42	0.35	0.43

\*Significant at 5% level  
NS: Non Significant

**Table.2** Peroxide and free fatty acid value of biscuits

Sample	Initial	2nd week	4th week	6th week
<b>Peroxide value (milliequiv. of peroxide/Kg of sample)</b>				
Control	2.7	8.5	18.1	23.9
TPP 0.5%	0.7	3.1	6.4	9.5
F-value	NS	*	**	**
SEm±	53.06	32.06	23.60	19.06
CD at 5%	0.42	0.23	0.52	0.12
<b>Free fatty acid value (% of oleic acid/100g of sample)</b>				
Control	0.7	2.7	3.5	5.9
TPP 0.5 %	0.5	0.7	0.9	2.6
F-value	NS	*	**	**
SEm±	3.02	3.16	5.70	3.90
CD at 5%	0.09	0.19	0.03	0.13

\*Significant at 5 % level, \*\* Significant at 1% level, NS: Non Significant  
Standard values: Peroxide value less than 10 milliequiv. of peroxide/Kg of sample. Free fatty acids less than 1.0 of oleic acid/100g of sample. (Food Regulation Act)

**Table.3** Microbial load of biscuits on storage (per gram)

Biscuits	Duration (Days)	Group of microorganisms		
		Total Bacterial count (x 10 <sup>5</sup> CFU)	Molds (x 10 <sup>2</sup> CFU)	Yeast (x 10 <sup>2</sup> CFU)
Control	Initial	Nil	Nil	Nil
	2weeks	Nil	Nil	Nil
	4weeks	3	1	2
	6weeks	6	2	5
TPP 0.5%	Initial	Nil	Nil	Nil
	2weeks	Nil	Nil	Nil
	4weeks	Nil	Nil	Nil
	6weeks	Nil	Nil	Nil
F-value		*	*	*
SEm±		3.75	5.03	1.92
CD at 5%		0.73	0.43	0.21

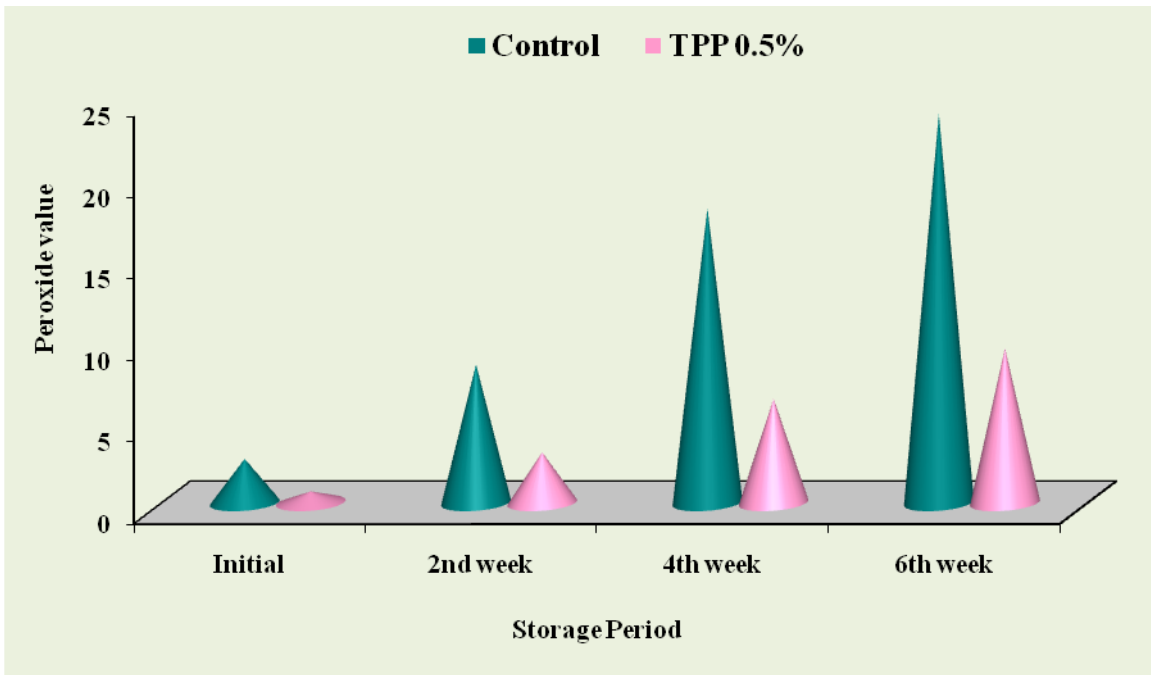
\*Significant at 5 per cent level  
Note: Nil value is taken as zero

**Table.4** Mean sensory scores of biscuits on storage

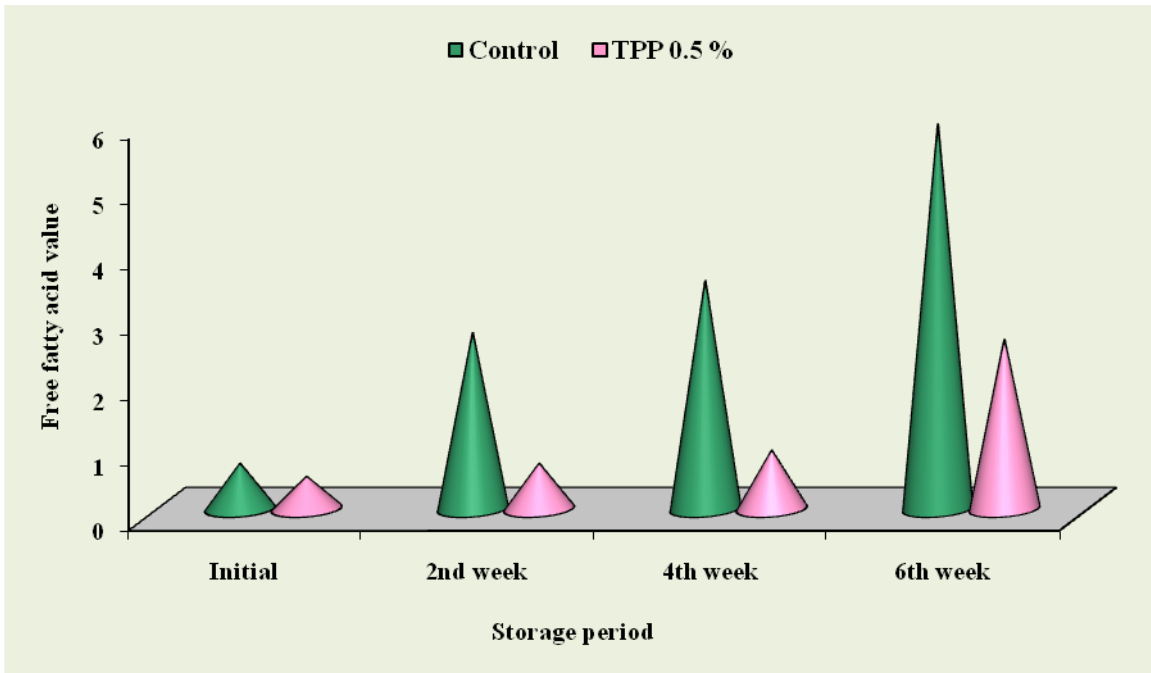
N=15

Biscuits	Duration Weeks	Sensory attributes					
		Appearance	Texture	Colour	Flavour/ Aroma	Taste	Overall Acceptability
Control	Initial	8.8	8.6	8.7	8.5	8.5	8.7
	2 <sup>nd</sup> week	7.5	7.0	7.8	7.1	7.0	7.1
	4 <sup>th</sup> week	-	-	-	-	-	-
TPP 0.5%	Initial	8.6	8.5	8.6	8.4	8.6	8.5
	2 <sup>nd</sup> week	7.2	7.8	7.7	7.9	7.8	7.6
	4 <sup>th</sup> week	5.7	5.0	5.8	6.0	6.3	5.8
	6 <sup>th</sup> week	5.5	4.3	5.1	5.4	4.5	5.4
F-value		**	**	**	**	**	**
SEm±		13.84	19.0	12.19	10.29	8.63	12.57
CD at 1%		0.63	0.46	0.36	0.32	0.38	0.27

\*\* Significant at 1 per cent level

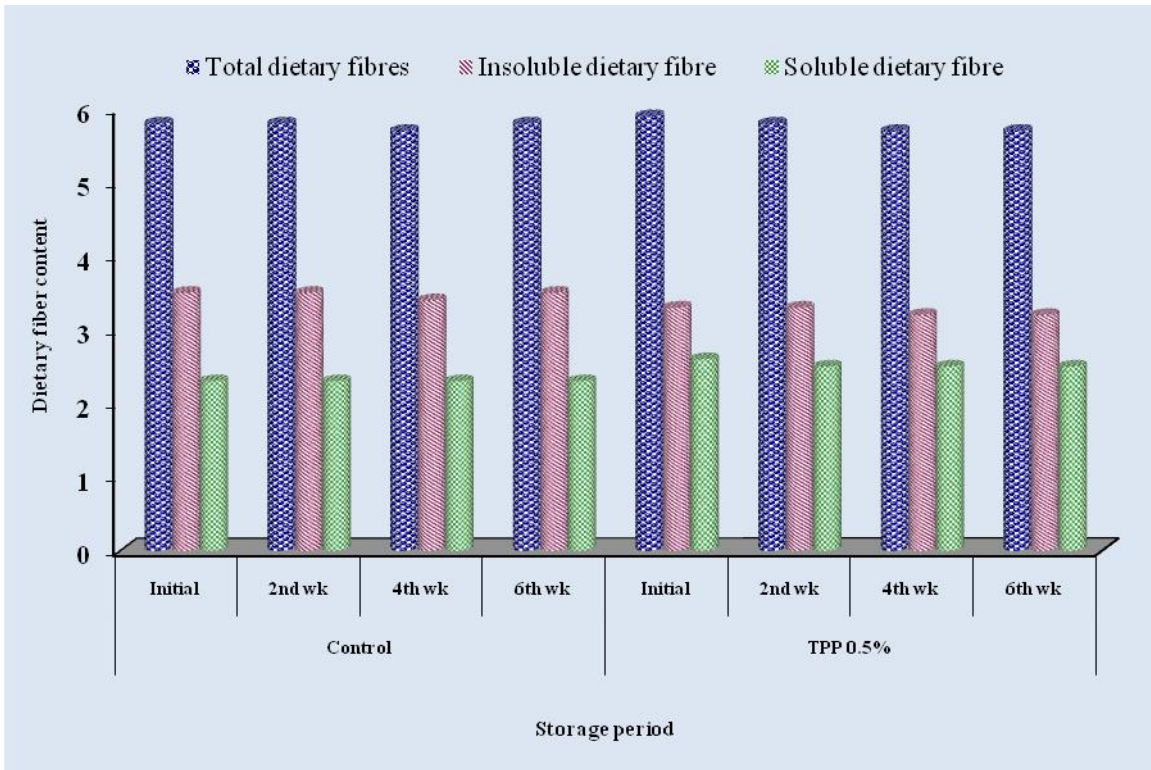


**Fig.1 (A)** Peroxide value of biscuits (milliequiv. of peroxide /Kg of sample)

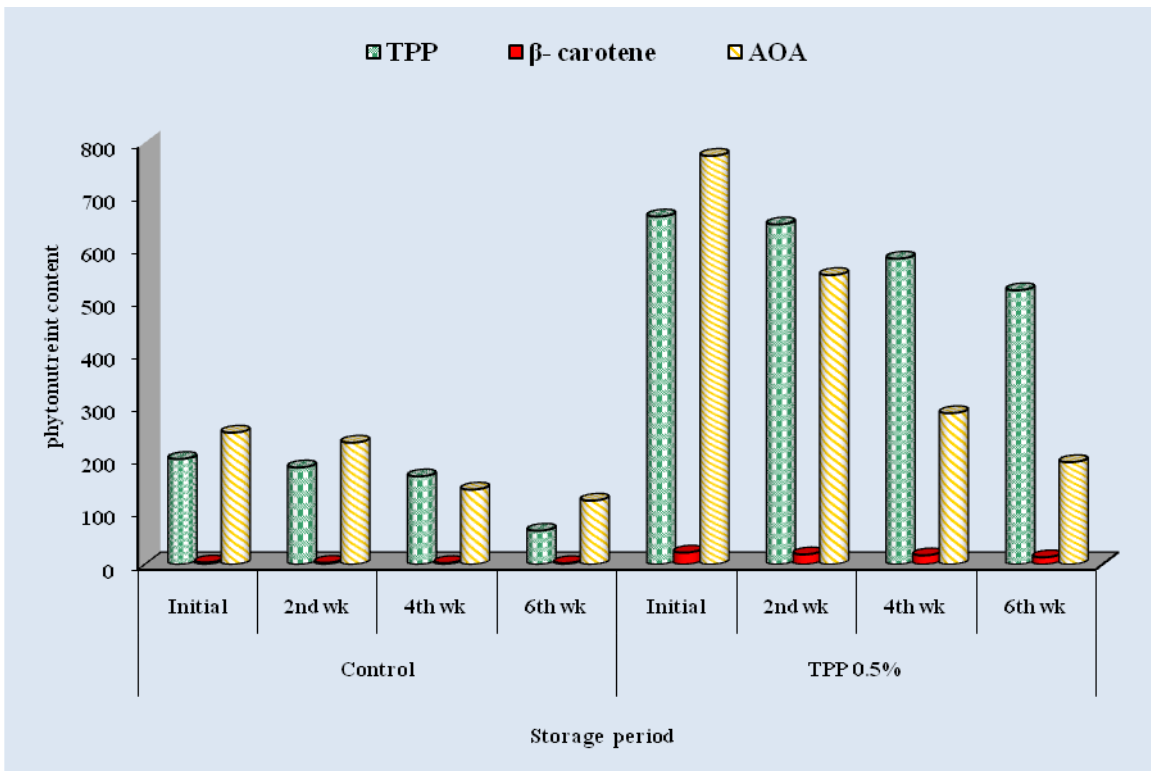


**Fig.1 (B)** Free fatty acid value of biscuits (% of oleic acid/100g of sample)





**Fig.2 (A)** Retention of phyto-nutrients in biscuits on storage



**Fig.2 (B)** Retention of phyto-nutrients in biscuits on storage

Changes occurring in the peroxide and free fatty acids values of biscuits variations during storage are presented in Table 2 and Figure 2 (A and B). The increase in peroxide value was observed in both biscuit samples; however, control biscuit had highest value of 2.7 to 23.9 milli equiv. of peroxide per kg of sample, after 6 weeks and the peroxide value of TPP 0.5 per cent level biscuits range from 0.7 to 9.5 milli equiv. of peroxide per kg of sample from initial to sixth week. TPP biscuit ranged from 0.7 to 9.5 the value obtained are within the acceptable range and significantly lower in TPP 0.5 per cent level after six weeks of storage. The increase in free fatty acid was observed in control and TPP biscuits on storage. The increase was considerably higher in control biscuits (0.7 to 5.9 per cent of oleic acid/ 100g of sample) compared to TPP biscuits (0.52 to 2.6 per cent of oleic acid/ 100g of sample) indicating the potency of antioxidant inhibiting the formation of free fatty acids. The values were comparable to study conducted by Reddy *et al.*, (2005), reported that the higher efficiency of plant extract could be due to stability of natural antioxidants during baking. Addition of natural antioxidant can increase shelf-life of food products containing fats and oils.

Similar values were reported by Magda *et al.*, (2008) mandarin and navel orange peel extracts have antioxidant activity. Addition of peels inhibited lipid oxidation as indicated by the peroxide value of navel orange and mandarin biscuits. The peroxide value after six months of storage at 25<sup>0</sup> C and 40<sup>0</sup> C were (8.9 and 10.3meq. /Kg fat) and (8.2 and 12.5 meq. /Kg fat) which can be used instead of synthetic antioxidants. Betsy, (2011) reported the ORAC values of the mango puree 1770 units on Day 1 and 1210 units after Day 28, respectively; gluten-free mango cookie was 645 units on Day 1 and 623 units after Day 28, respectively; and gluten-free plain cookie was 480 ORAC units on Day 1

and 270 units after Day 28, respectively. Gluten free mango cookie which exhibited the least decrease of antioxidant activity was highlighted as the potential of nutraceutical food product. The results showed that antioxidant level was present in the products after 28 days of storage, thus enhancing health benefits to consumers.

Microbial load of biscuits on storage period (per gram): Microbial count (total bacteria, molds and yeast) was estimated by using the dilutions and results are depicted in the Table 3. Biscuits were prepared as control and from the incorporation of total polyphenols in different levels ranging from 0.25, 0.5, 0.75, 1.0 and 1.5 per cent.

The control and best sensory accepted biscuits (TPP 0.5 per cent) were kept at room temperature in storage material of high density polythene food grade pouches of 350 gauge for storage study period for a period of six weeks. The microbial count was taken from initial day of storage to 2, 3, 4, 5 and 6 week intervals. Bacterial population of control biscuits in the initial day and second weeks was found to be nil in case of all group of microorganisms like total bacterial, molds and yeast, but in fourth week the bacteria was recorded 3 x 10<sup>5</sup> CFU, molds was found to be recorded 1 x 10<sup>2</sup> CFU and yeast recorded 2x 10<sup>2</sup> CFU. In sixth week all the three microorganisms were found (total bacterial 6 x 10<sup>5</sup>, CFU molds 2x 10<sup>2</sup> CFU and yeast 5 x 10<sup>2</sup> CFU) In case of TPP 0.5 per cent level all the three group of microorganisms were found to be nil from the initial day and up to sixth weeks of storage periods. These results clearly indicate that the biscuit with total polyphenols at 0.5 per cent level found to have antimicrobial effect and has increased the shelf life of the biscuits. Statistical analysis revealed that there is a significant difference during storage intervals for control and TPP 0.5 percent biscuits at 5 per cent

level. Hence, the shelf life of TPP extract biscuits were up to 6 weeks compared to control biscuits which had lower scores. Microbial load becomes an important issue from safety point of view as mango peel extracts will be incorporated in to food products hence in the present study microbial was carried out for samples.

Biscuits stored in 350 gauge polythene pouch at ambient temperature and the microbial load of TPP biscuits on storage are presented in Table 3. The result showed that the biscuits were contaminated with bacteria, mold and yeast after fourth week of storage in case of control biscuits where as in TPP biscuit microbial count was not found till sixth week of storage period and showed statically significant at 5 per cent level. Masibo and He (2009) stated that leaf extracts of mango leaf possess antimicrobial activity; this may be due to abundant polyphenol in mango leaf extract. Qin (2007) reported that the mango peel ethanol extract reported strong antimicrobial activity which helps in shelf life of the product.

#### **Mean scores for shelf life studies of biscuits**

Biscuits (control and TPP 0.5 per cent level) were kept for storage study. The samples were observed daily for visual changes and were subjected to sensory evaluation on weekly basis. The results of the mean sensory evaluation of biscuits from initial day to end of storage study period are presented in the Table 4 depicts that the control biscuits showed highest scores of 8.8, 8.6, 8.7, 8.5, 8.5 and 8.7 for all the sensory parameters for the initial day, However at the end of second weeks the control biscuits had lower scores of (7.5, 7.0, 7.8, 7.1, 7.0 and 7.1) for appearance, texture, colour, aroma, taste and overall acceptability and by fourth week they were unfit for the sensory evaluation due to microbial growth. The TPP biscuits with 0.5

percent incorporation showed scores of 8.6, 8.5, 8.6, 8.4, 8.6 and 8.5 for appearance, texture, colour, aroma, taste and overall acceptability respectively at initial day which are on par with control values and had shelf life up to 4 weeks. However, at end of sixth week scores showed decreasing trend (5.5, 4.3, 5.1, 5.4, 4.5 and 5.4) for all the sensory parameters. Statistical analysis revealed a significant difference for all the sensory characteristics between control and TPP biscuit from initial to the end of storage period. Shelf life is a major consideration in developing, producing and marketing food product it refers to the time during which a product remains 'acceptable' to a consumer in terms of sensory characteristics. Many factors influence the shelf life of a product viz., moisture loss, and spoilage due to microorganism, enzymatic changes and oxidation (Adegoke *et al.*, 1998).

Mean sensory scores for shelf life study of TPP depicted in Table 4. The biscuits exhibited highest mean scores in the initial period for both control and TPP biscuits. The mean scores for appearance, texture, colour, flavor, taste and overall acceptability showed decreasing trend during second week of storage in both control and TPP biscuits. But the mean scores for TPP biscuits were higher than control which confirms that natural extraction has antioxidant property which in turn increased the shelf life of biscuits. Similar results were found by Reddy *et al.*, (2005) who reported that biscuits treated with natural antioxidant extracted from raisins and drumstick leaves received higher sensory scores during storage period of 6 weeks, than control and butylated hydroxyl anisole biscuits.

Consumers are currently demanding less use of chemicals, so more attention had been paid to search for naturally occurring substances from plant sources. This is particularly true

for plant materials that act as alternative antioxidant sources. Natural antioxidants have gained considerable interest in recent years for their role in preventing the auto oxidation of fats, oils and fat containing food products. The addition of extracts of the mango peel Total Polyphenols (TPP), gave an excellent retention of phytonutrients such as total polyphenols,  $\beta$ - caratene and antioxidant effect on the biscuits compared with the effect of control. The higher efficiency of the plant extracts could be due to the stability of these natural antioxidant during baking. Results of sensory evaluation reveal that the mango peel extract at concentrations of 0.5 per cent may be used in place of synthetic antioxidants, since these extracts had no effect on the organoleptic properties of the biscuit. Addition of natural antioxidants can increase shelf-life of food products containing fats and oils. In addition, natural antioxidants are safe and impart health benefits to the consumer.

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