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Effect of tamarind kernel powder incorporation in property and quality aspects of biscuit, bread and cake making

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ABSTRACT

The work investigates utilization of Tamarind kernel powder for preparation of baked food products like biscuit, bread and cake. Research has shown that tamarind seed is an under-utilized seed in food industry; despite having immense nutritional properties its use has been found mainly in textile and paper industries and as adhesives due to its high gelling/ gum like property. In rural areas it has been consumed by roasting after de-hulling, which resembles ground nut in terms of flavor as well as appearance. Based on this information TKP has been used as an alternative source of flour and blended with wheat flour to prepare baked food products. Physicochemical properties of these newly formed food products have been assessed. Biscuits were analyzed for width, thickness and spread factor which revealed notable change with incorporation of TKP. Bread samples were also subjected to physical analysis like weight, volume, specific volume index and width to height ratio. Cake batters were analyzed for pH and specific gravity. Protein content of biscuits ranged between 13-14gm/100gm, of bread was in the range of 15-16gm/100 gm and that of cake was about 9.2 to 9.8 %. Shelf life studies in terms of acid values and peroxide values of the extracted oil of biscuit samples were determined for two months. Both the acid value and peroxide values were within acceptable range after a month, however, peroxide value increased slightly in the second month. Staleness of bread was also reported during storage of 24 h, 48 h and 72 h. A control has been made and compared with each set of these newly developed products. Antioxidant studies of the products showed improved results. The analysis and sensory evaluation showed acceptable results.

Key words: Tamarind kernel powder, bread, biscuit, cake,
Abbreviation*: TKP- Tamarind Kernel Powder, WSI- Water Soluble Index, WAI- Water Absorption Index*

INTRODUCTION

Baked confectioneries particularly the baking of bread is one of the oldest known commodity in the world. Biscuits are the versatile baked food consumed nearly by all sections of the society all over the world. Biscuits are eaten as such or are taken as accompaniment with hot beverages like tea and coffee by many people. Reasons for its popularity include low cost in comparison with other processed foods, nutritional quality and availability, taste and longer shelf life. Baked products are sort of vehicles used for incorporation of different nutritionally rich ingredients **[1, 2, 3].** Biscuits are generally high in carbohydrates, fat and calorie but low in fiber, vitamin, and mineral which make it unhealthy for daily consumption for all age groups.

Conventionally the main ingredient of any bakery products is refined wheat flour which is having deficiency of essential amino acid lysine **[4, 5, 6, 7]**.Whereas tamarind kernel powder is richer in lysine, even more than that is present in soya bean (as reported by , Gunasena and Hughes, 2000) and can be complement to wheat in bakery products. **[8, 9].** Use of non-wheat flour in bakery products is creating immense interest because these grains have important health benefits. Tamarind seed flour is one of such non-wheat flour whose use in food sector is very limited. Bakery products are becoming more and more popular as these are ready-to-eat, economically viable, and are available in various forms with different feel and textural profiles, nutritious and generally have a longer shelf life. **[10].** Bread is a product that is consumed worldwide with variety of types, flavors and characteristics and plays an important part of our day to day diet. Properties of bread can be improved by using a number of methods such as adding essential gluten, emulsifier, oxidant, reductant, hydrocolloid and enzyme. These are done for the purpose of improving bread quality and extending the shelf-life of stored bread which is nowadays getting important for the bread industry **[11, 12, 13, 14, 15].** Tamarind seed is a typical underutilized material. There are industries which use decorticated tamarind seeds as a low cost sizing material particularly in textile industries , there have been hardly any other uses including using it as an additive in food formulations. The excellent gelling and adhesive characteristics of decorticated seed powder of tamarind possess several applications in food & pharmaceutical industries which are evident by a number of past researches. It is desirable that more research works are conducted on the processing aspects of this seed and incorporation of this flour in food preparation, to make it more useful for the food processors. **[9].** Therefore, attempt has been taken to utilize this less known seed flour in baked food preparation.

MATERIALS AND METHODS

Raw materials:
Tamarind kernel powder (gifted in bulk amount by M/S Progressive Exim Ltd., Raipur, India), Wheat flour (refined), Sugar, Baker's yeast, milk powder, Egg, Rice bran oil, were all obtained from the local market.

All of the other chemicals, reagents and solvents used in the study were of analytical grade and obtained from Merck Pvt Ltd. Distilled water was used in all of the experiments throughout the study.

Preparation of baked food and their respective analysis
Biscuits
Sample preparation: Six different sample formulation were prepared using Tamarind kernel powder and wheat flour in proportion of 0+100 (control sample), 10+90, 30+70, 50+50, 70+30 and 90+00 gm.

Formulation of biscuit: Biscuits were prepared as per standard method **[16]** with some modifications. The ingredients were weighed accurately. The dry ingredients (various proportions of tamarind kernel flour, wheat flour, baking powder and salt) were thoroughly mixed in a bowl by hand for 3 minutes. Then creaming of rice bran oil (50 ml) and sugar powder (23.3 g) was done in a mixer till foaming occurred. The flour mixture was added to the creamy mass and mixed for 3 minutes at medium speed in a laboratory mixer (LUMIX). The dough was then rested for 30 minutes followed by rolling them into sheets and cutting the sheets to a desired shape of uniform thickness. The dough pieces was placed on baking trays leaving 25 mm space in between and baked at 175° C for 25 minutes in the baking oven. Following baking, the biscuits were cooled to ambient temperature packed in polythene bags and kept in airtight containers prior to subsequent analysis- physical analysis, proximate composition analysis, antioxidant properties, stability studies and sensory evaluation.

Physical attributes: Biscuits were analyzed for width, thickness and spread factor by following the procedure of AOAC **[4, 16]**. Width (W) was measured by placing the biscuit samples horizontally in a row and their average diameter was measured using a vernier caliper with 0.01 mm accuracy. Thickness of the samples was measured by taking their average thickness using vernier caliper with 0.01 mm accuracy. The spread factor (SF) were calculated using relationship between W, T and correlation factor CF as shown in the formula given below $SF= (W/T \times CF) \times 10$**.** Wettability of biscuits was analyzed following the method of B.Srilakshmi **[17]**. Color reading for L, a, b value was taken using a Konica Minolta color reader CR-10.

Proximate composition: Proximate composition (carbohydrate, protein and fat content) were determined by using standard methods **[18].**

Determination of antioxidant properties: Antioxidant properties of the products in terms of Oryzanol content, total phenolic content and radical scavenging activity were carried out **[19, 20, 21]**

Shelf-life study: Shelf-life studies of biscuits were also carried out by packing them in polyethylene pouches, stored in air tight containers at ambient temperature and analyzed at an interval of 1 month for stability studies by determination of peroxide value and acid value up to 2 months. Peroxide value and acid value was determined by following standard method **[22]**

Sensory evaluation: Consumer acceptance test of the biscuits were evaluated in terms of taste, appearance, odor, texture, and overall acceptability by 10 semi-trained panelists using 9 point hedonic scale.

Bread

Sample preparation: The tamarind kernel flour was incorporated into wheat flour at different levels and bread was made from composite flours for evaluation of quality characteristics.

Bread making: Breads were prepared according to the procedure of Irvine and McMullan **[23]**.

The basic recipe consisted of tamarind kernel powder + wheat flour 100 g (0+100, 10+ 90, 30 + 70, 50 + 50, 70 + 30 and 90 + 10)g; sugar 2 g; salt 1 g; fat 2 g; yeast 2 g; milk powder 2 g and water. Dough was prepared using the straight dough method. Specifications of bread baking conditions were: proofing time 45 min, at 37º C baking temperature 180-200ºC and baking time 25 min.

Physical attributes: Bread quality analysis was measured including weight, volume (rapeseed displacement), specific volume index, width/ height ratio of the central slice and moisture content were assessed. **[24][25][26]** Firmness of crumb texture of bread samples was determined by a penetrometer (Stanhope- Seta Surrey, England). It has a conical penetration body with an apical angle of 45°C and a weight of 72.5 g. The depth of penetration was measured for 5 sec at a product temp of 20° C just after baking. Wettability of bread was analyzed following the method of B.Srilakshmi **[17].**

Proximate analysis: Proximate composition of the wheat flour based bread and the composite flour based bread samples were determined using AOAC methods **[18]**

Determination of antioxidant properties: Antioxidant properties of the products in terms of total phenolic content and radical scavenging activity were carried out **[20, 21]**

Evaluation of Staling rate of bread: After baking, breads were cooled, packed in polypropylene bags and evaluated for freshness and staleness after 24, 48 and 72h, by 10 semi trained panel members, following the approved method 74–30 (AACCI 2000), using a 6-point ranking test (completely soft-06, soft-05, slightly soft-04, slightly firm-03, firm-02 and completely firm-01) **[24,27]**

Sensory evaluation: Consumer acceptance test of the bread samples were evaluated in terms of taste, appearance, odor, texture, and overall acceptability by 10 semi-trained panelists using 9 point hedonic scale.

Cake

Sample preparation: The cakes were prepared following a standard formulation as adapted by Érica Aguiar Moraes et al. with slight modification. **[28]**. The ingredients egg (26.5 g), sugar (29.5 g), and rice bran oil (18 g) were homogenized with an electric mixer at medium speed for 5 minutes; next, tamarind kernel powder and refined wheat flour was taken in the ratio of 0:45, 9:36, 18:27, 22.5:22.5, 27:18 and 36:9, and water (22.5 gm) were added to the mixture. The mixture was homogenized until it was uniform in consistency, and baking powder (1.38 gm) was added. The batter was placed into aluminum cups, previously oiled and sprinkled with wheat flour, and baked in a conventional oven pre-heated to 180 °C for 25 minutes. After cooling, the cakes were weighed. The samples were taken, wrapped in plastic bags, and kept in a freezer at –20 °C for further chemical analysis.

Physical characteristics: The specific gravity of the sample of different cake batter was determined by standard method, 2.5 ml of batter was put into the 25ml measuring cylinder and weighed properly. Then the same amount of water was put into a 25ml measuring cylinder and weighed carefully. **[29]**. pH of the cake batter was determined using a pH meter. **[30]**. Weight of the cake was determined by weighing it in an analytical balance. **[31]**. Volume of the cakes was determined by measuring the length, breadth and height of the cake. **[31].** WAI and WSI were determined by the method of Anderson (1969) [**32**]. Firmness of cake samples of crust and crumb was determined by a penetrometer (Stanhope- Seta Surrey, England). The depth of penetration was measured for 5 sec at a product temp of 20° C just after baking. Wettability of cake samples was analyzed following the method of B.Srilakshmi **[17].** Color values in terms of L, a, b was measured using a Konica Minolta color reader CR-10.

Determination of proximate values of different cakes: Proximate composition of wheat flour based control cake and the composite cake samples were determined using AOAC methods. **[18]**

Determination of antioxidant properties: Antioxidant properties of the products in terms of Oryzanol content, total phenolic content and radical scavenging activity were carried out. **[19, 20, 21]**
Sensory evaluation: Consumer acceptance test of cake samples were evaluated in terms of taste, appearance, odor, texture, and overall acceptability by 10 semi-trained panelists using 9 point hedonic scale.

Statistical Analysis: Statistical Analysis was performed by using analysis of variance (ANOVA) and the means are compared using (Tukey's HSD multiple comparison test). All experiments were conducted in triplicates repeated at least twice using Origin Pro 8 statistical software and significant differences were determined at $p \leq 0.05$.

RESULTS AND DISCUSSION

Biscuits

The baked food products made from TKP were tested for their physicochemical and functional properties. Physical measurements like width, thickness, spread factor, and color values of biscuit determined are listed in table 1. The moisture content of biscuit samples varied between 7-9%. Wettability percentage of the product is shown in Fig 2. The width of the biscuits decreases from 53.46 to 37.66 mm with increasing level of addition of TKP. However biscuit thickness increases from 10.63 to 11.66 mm, the lowest value was recorded in control whereas the highest was recorded in product 5. The spread factor of biscuits decreases from 50.28 to 32.34 with increase in amount of TKP incorporation. The results as documented in table 1 shows that control biscuit has maximum spread factor and product 5 with highest amount of TKP incorporation has the lowest spread factor. Color reading as seen from table shows decrease in L value with increase in TKP in biscuit samples, effect of baking might have resulted in Millard reaction imparting dark color to the biscuits.

Table 1. Physical parameters of biscuits

Sample	Width (mm)	Thickness (mm)	Spread Factor	Color values		
				L	$^{+}$a	$^{+}$b
Control	53.46±0.41	10.63±0.05	50.28±0.40	58.36±0.05	10.16±0.05	12.20±0.01
Sample 1	52.66±0.57	10.70±0.00	49.21±0.54	55.20±0.01^{c}	10.63±0.05^{b}	19.69±0.01^{a}
Sample 2	44.00±1.00^{c}	10.73±0.05	40.99±1.12^{c}	50.01±0.01^{b}	8.80±0.00^{a}	12.90±0.00^{b}
Sample 3	43.33±0.57^{b}	10.86±0.05^{b}	39.87±0.46^{a}	47.76±0.05^{a}	11.53±0.46^{c}	13.69±0.08^{d}
Sample 4	40.66±0.57^{a}	10.93±0.05^{b}	37.19±0.46^{a}	46.63±0.05^{a}	9.73±0.05^{b}	9.26±0.05^{c}
Sample 5	37.66±0.57^{a}	11.66±0.57^{a}	32.34±1.94^{b}	44.83±0.05^{a}	8.83±0.05^{a}	10.86±0.05^{d}

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

Proximate analysis showed protein value ranged between 13.4 to 14.8g/100g and increased with incorporation of TKP, carbohydrate ranged between 67 to 75g/100g. Fat content was in the range of 0.86-0.93 g/100g and values are listed in table 2.

Table 2. Proximate values of Biscuit

Sample	Proximate constituents g.100 g-1		
	Protein	Carbohydrate	Fat
Control	13.43±0.13	75.51±0.29	0.88±0.01
Sample 1	13.65±0.21	75.64±0.50	0.88±0.00
Sample 2	14.07±0.09^{c}	73.18±0.67^{c}	0.88±0.00
Sample 3	14.32±0.04^{b}	72.03±0.71^{c}	0.87±0.00
Sample 4	14.48±0.05^{b}	70.48±0.34^{b}	0.93±0.0^{a}
Sample 5	14.88±0.02^{a}	67.99±0.34^{a}	0.86±0.00

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

Shelf life studies of the products were studied in terms of acid value and peroxide value for two months, shown in table 3. Acid values of all the products were in the range of 0.37 - 0.42, whereas peroxide values ranged between

1.91-1.96 meq/kg after one month. After two months the acid value slightly increased but were within the considerable range, peroxide values were in the range of 2.1 - 2.3 meq/kg.

Table: 3 Shelf Life Studies (1 Month / 2 Months)

Sample	After 1 month		After 2 months	
	Acid value	Peroxide value meq/kg of oil	Acid value	Peroxide value meq/kg of oil
Control	0.40±0.00	1.94±0.00	0.44±0.00	2.14±0.00
Sample 1	0.42±0.00[b]	1.95±0.00[b]	0.45±0.00	2.31±0.00[a]
Sample 2	0.40±0.00	1.96±0.00[b]	0.46±0.00[b]	2.16±0.00[c]
Sample 3	0.41±0.00[b]	1.95±0.00[b]	0.42±0.00[b]	2.17±0.00[d]
Sample 4	0.38±0.00[a]	1.92±0.00[a]	0.43±0.00	2.11±0.00[b]
Sample 5	0.37±0.00[a]	1.91±0.00[a]	0.40±0.00[a]	2.10±0.00[d]

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

Antioxidant properties in terms of total phenolic content of the biscuits showed that TKP incorporation has remarkably increased the polyphenolic content in the products as can be seen from Fig 1; radical scavenging activity of the TKP incorporated biscuits ranged between 23.21 to 48.87% showing that TKP incorporation in samples increases their radical scavenging power and the γ-Oryzanol content of the products also seen from Fig 1 ranged between 0.58 to 0.61, indicating good antioxidant property due to rice bran oil incorporation in cake and biscuit .

Sensory evaluation of the products, as recorded in table 4 showed that taste of biscuit fetched slightly better rating up to 30 % of TKP incorporation as compared to control sample and texture has no remarkable change with up to 50 % of TKP addition. TKP incorporation also improved the odor of baked samples. Sample 2 recorded the highest overall acceptability of 7.33 score.

Table 4: Sensory evaluation of biscuits

Sample	Taste	Appearance	Odor	Texture	Overall Acceptability
Control	7.16±0.28	8.16±0.28	7.16±0.28	7.16±0.28	7.00±0.00
Sample 1	7.33±0.28[a]	8.00±0.00[a]	8.00±0.00[a]	7.16±0.28	6.66±0.28[c]
Sample 2	7.40±0.00[a]	8.00±0.00[a]	8.00±0.00[a]	7.16±0.28	7.33±0.28[a]
Sample 3	6.00±0.00	8.00±0.00[a]	8.00±0.00[a]	7.16±0.28	7.00±0.00
Sample 4	5.33±0.28[b]	7.66±0.28[c]	8.73±0.28[b]	7.00±0.00[b]	6.33±0.28[b]
Sample 5	4.16±0.28[b]	7.16±0.28[b]	8.83±0.28[c]	7.33±0.28[a]	6.16±0.28[b]

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

Bread

Physical analysis of the bread samples as seen from table 5 shows that weight, volume and specific volume of bread increases with TKP incorporation, the improvement in the volume of the breads, with different levels of TKP, was around 200–580 cc. However, the improvement in the bread volume reduced as the TKP content increased above 50%. The penetration study shows that more than 50% TKP incorporation hardens the bread; this hardening could be due to presence of gel- like material (gellose) in TKP.

Table 5: Physical characterization of bread samples

Sample	Weight (g)	Volume (cc)	Specific Volume index (cc/g)	Width/ Height ratio	Penetration (1/10th mm)	
					Crust	Crumb
Control	205.90±1.15	836.07±3.14	4.05±0.03	1.42±0.00	54.00±0.00	72.01±0.00
Sample 1	214.33±3.05[d]	1040.62±11.39[c]	4.85±0.10	1.50±0.00[d]	58.00±1.00[c]	71.00±0.10
Sample 2	222.33±2.51[c]	1263.10±9.96[d]	5.68±0.06[b]	1.55±0.00[c]	59.66±1.15[a]	68.21±0.28[a]
Sample 3	234.33±1.15[a]	1415.94±6.65[b]	6.03±0.04[a]	1.67±0.00[a]	59.80±0.00[a]	65.02±0.15[c]
Sample 4	232.00±2.64[b]	1272.34±5.65[d]	5.47±0.04[c]	1.59±0.00[c]	47.00±0.00[b]	52.01±0.10[b]
Sample 5	229.66±2.51[c]	1255.52±1.62[a]	5.45±0.03[c]	1.64±0.00[b]	43.33±0.57[d]	52.00±0.00[b]

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

Moisture content was around 13-20%, wettability in case of bread sample 2 was 99.8% as seen in Fig 2 which depicts sufficient moistness or softness. The color reading of bread as indicated in table 6 shows that control sample has the highest L value (both in crust and crumb) that is it's the lightest in color among all the breads. The highest +a value were found in the crust of sample 1 of bread which indicates its more redness. The + b value was found to be highest in sample 5 i.e. more is its yellowness.

Table 6: Color values of TKP incorporated Bread and Cake samples

Sample	Side	Bread			Cake		
		L	+a	+b	L	+a	+b
Control	Crust	62.05±0.00	11.86±0.05	23.70±0.57	50.75±0.05	12.33±0.11	22.53±0.11
	Crumb	61.80±0.42	6.30±0.00	21.00±0.28	52.33±0.05	13.30±0.00	19.33±0.11
	Crust	54.33±0.05^{a}	14.76±0.05^{a}	19.53±0.05^{b}	58.83±0.05^{a}	10.30±0.1^{b}	28.56±0.15^{b}
Sample 1	Crumb	58.10±0.07	6.20±0.14	11.90±0.14	57.48±0.10^{b}	10.10±0.01^{a}	20.09±0.01^{c}
	Crust	53.63±0.11^{b}	13.56±0.05^{b}	18.36±0.05^{a}	56.79±0.02^{a}	8.63±0.25^{b}	22.04±0.21^{c}
Sample 2	Crumb	57.20±0.07	14.40±0.35	16.40±0.35	51.19±0.07^{d}	14.23±0.15^{e}	19.60±0.3
	Crust	53.33±0.05^{a}	13.80±0^{a}	19.16±0.05^{b}	53.48±0.08^{c}	11.12±0.02^{b}	21.66±0.15^{c}
Sample 3	Crumb	55.75±0.35	5.25±0.21	11.75±0.35	49.79±0.02^{b}	14.23±0.05^{d}	17.00±0.00^{b}
	Crust	52.20±0.00^{c}	10.60±0.00^{b}	15.13±0.05^{a}	54.53±0.15^{c}	10.20±0.01^{a}	22.33±0.05
Sample 4	Crumb	49.10±0.21	10.90±0.07	13.90±0.14	63.63±0.11^{a}	9.46±0.11^{c}	22.43±0.11^{b}
Sample 5	Crust	53.83±0.05^{a}	13.46±0.05^{b}	19.33±0.05^{b}	69.36±11.46^{d}	11.02±0.02^{b}	29.20±0.00^{a}
	Crumb	54.80±0.07	8.05±0.07	14.10±0.35	54.16±0.05^{c}	16.53±0.05^{b}	24.26±0.05^{a}

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

The proximate compositions of bread samples like protein, carbohydrate, and fats are being evaluated and found to be no less than control product. The new formed food products are enough nutritious to be consumed, Table 7 shows the values in detail.

Table 7: Proximate values of bread

Sample	Proximate constituents g.100 g-1		
	Protein	Carbohydrate	Fat
Control	15.54±0.07	76.53±0.03	1.34±0.04
Sample 1	15.71±0.05^{c}	75.32±0.06^{d}	1.42±0.06
Sample 2	15.84±0.10^{c}	71.48±0.04^{a}	1.21±0.10
Sample 3	16.07±0.03^{b}	71.06±0.05^{b}	1.07±0.06^{c}
Sample 4	16.14±0.02^{b}	69.81±0.08^{b}	0.88±0.04^{b}
Sample 5	16.36±0.04^{a}	67.87±0.19^{c}	0.54±0.04^{a}

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

The freshness of bread as presented in Table 8 shows that TKP incorporation reduces the staling property of bread samples.

Table 8: Staleness /Freshness of bread

Sample	Score after 24 h	Score after 48 h	Score after 72 h
Control	4.33±0.57	3.00±0.00	2.00±0.00
Sample1	4.66±0.57	4.00 ±0.00^{a}	2.66±0.57
Sample2	5.00±0.00	3.66±0.57	2.33±0.57
Sample3	5.33±0.57	3.66±0.57	2.66±0.57
Sample4	5.33±0.57	4.00 ±0.00^{a}	3.00±0.00^{a}
Sample5	5.33±0.57	3.33±0.57	2.33±0.57

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

According to the Hedonic rating done, Bread sample 1, 2 and 3 are most accepted in terms of taste; values are shown in table 9.Texture improved with addition of TKP up to 30% afterwards it was not much accepted by the consumers due to stickiness of the product. Sample 4 and 5 are least accepted among the products.

Table: 9 Sensory evaluation of bread

Sample	Taste	Appearance	Odor	Texture	Overall Acceptability
Control	7.16±0.28	8.16±0.28	8.16±0.28	7.16±0.28	8.00±0.00
Sample 1	7.00±0 .00	8.00±0.00	8.00±0.00	8.00±0.00^{b}	7.50±0.50^{b}
Sample 2	7.33±0.28^{b}	7.33±0.28^{a}	8.00±0.00	8.16±0.28^{b}	7.33±0.28^{a}
Sample 3	7.00±0 .00	7.33±0.28^{a}	7.33±0.28^{a}	6.00.±0.00^{a}	7.33±0.28^{a}
Sample 4	6.33±0.28^{a}	7.33±0.28^{a}	6.16±0.28^{c}	6.00±0.28^{a}	5.33±0.28^{c}
Sample 5	6.16±0.28^{b}	7.00±0.00^{b}	7.16±0.28^{b}	5.16±0.28^{c}	5.00±0.00^{c}

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

Antioxidant studies of the bread in terms of polyphenolic content shows gradual increase with addition of TKP in bread, fermentation with yeast during bread making might have resulted in further rise in radical scavenging activity of the samples.

Cake

The specific gravity of the cake batter indicates air incorporated into the batter, lower the specific gravity more is the air incorporated in the batter; specific gravity of the cake batter is within 1- 1.08. Specific gravity and pH of the cake batter are listed in table 10.

Table 10: Physical properties of cake batter

Sample	Specific gravity of cake batter(g/cc)	pH of cake batter
Control	1.01±0.00	7.13±0.05
Sample1	1.01±0.01	6.86 ± 0.05^{c}
Sample 2	1.08 ± 0.00^{a}	6.76 ± 0.05^{d}
Sample 3	1.02±0.04	6.70 ± 0.00^{b}
Sample 4	1.04±0.04	6.43 ± 0.05^{b}
Sample 5	1.08 ± 0.04^{b}	6.36 ± 0.05^{a}

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

Moisture content of cake ranged between 11-19%. The highest wettability of cake was 83.6% which was of the control product, shown in Fig 2. Wettability is the ability to absorb moisture during a controlled period of time. The more were the weight of the sample after soaking in water for 5 seconds, the more are their wettability %. High moisture retention means a cake is sufficiently moist. Different values of wettability indicate the baking nature of the cake. The higher values indicate the moistness and softness of cake, indicating better baking than the other.

Among the cakes, sample 5 has the highest L value of crust. Color values of the cake are listed along with bread in Table 6.

Proximate study of cakes gave nearly similar values with that of control sample; protein ranging from 9.4-9.88 g/100g, carbohydrate around 30-38g/100g and fat about 15.5-15.8g/100g with TKP incorporation. Values presented in table 11.

Table 11: Proximate analysis of cake and penetration study

Sample	Proximate constituents ($g.100\ g^{-1}$)			Penetration (1/10th mm)	
	Protein	Carbohydrate	Fat	Crust	Crumb
Control	9.21±0.04	34.57±0.09	15.80±0.02	61.33±1.52	177.00±2.64
Sample 1	9.42 ± 0.02^{b}	34.13±0.68	15.08±0.58	65.66 ± 1.52^{a}	171.00 ± 1.00^{a}
Sample 2	9.80 ± 0.02^{a}	38.38 ± 0.10^{a}	15.50 ± 0.07^{c}	64.33 ± 1.52^{b}	170.00 ± 1.00^{b}
Sample 3	9.85 ± 0.01^{a}	32.69±0.29c	15.6 ± 0.075^{a}	65.00 ± 1.00^{a}	164.33 ± 1.52^{c}
Sample 4	9.88±0.02	31.62 ± 0.34^{c}	15.53±0.20	61.00±1.00	167.33 ± 1.527^{c}
Sample 5	9.85 ± 0.11^{b}	30.87 ± 0.32^{b}	15.46 ± 0.11^{b}	61.33±1.52	164.33 ± 2.08^{c}

Data is expressed in mean±S.D. and values in same columns having different superscript are significantly different at p≤0.05.

Except sample 4 and 5 all other cakes are accepted well. However, it was noted that more than 50 % of TKP addition with the wheat flour is resulting in poor taste and texture of the product. There is no remarkable change in appearance and odor of the product made.

Table 12: Sensory evaluation of cake samples

Sample	Taste	Appearance	Odor	Texture	Overall Acceptability
Control	8.33±0.28	8.33±0.57	8.00±0.00	8.50±0.00	8.66±0.57
Sample 1	8.00 ± 0.00^{b}	7.50 ± 0.50^{c}	8.16 ± 0.28^{a}	8.50±0.50	7.83 ± 0.28^{c}
Sample 2	8.16 ± 0.28^{a}	8.16 ± 0.28^{a}	8.16 ± 0.28^{a}	8.00 ± 0.00^{a}	8.50 ± 0.00^{a}
Sample 3	7.16 ± 0.28^{b}	8.16 ± 0.28^{a}	8.00±0.00	6.66 ± 0.57^{c}	7.83 ± 0.28^{c}
Sample 4	6.16 ± 0.28^{d}	8.20 ± 0.00^{b}	8.00±0.00	5.50 ± 0.50^{b}	5.00 ± 0.00^{b}
Sample 5	5.16 ± 0.16^{c}	8.26 ± 0.28^{b}	8.33 ± 0.57^{b}	5.00 ± 0.00^{b}	5.00 ± 0.00^{b}

Data is expressed in mean±S.D. and values in same c olumns having different superscript are significantly different at p≤0.05.

The antioxidant properties of the TKP incorporated cake sample as represented in Fig 1 reveals that cakes are showing better scavenging activity; values increasing from around 4.2 to 15.4 times more than the control product. The incorporation of rice bran oil in the samples also improved the antioxidant content as can be seen from the Oryzanol content of the product. Polyphenolic content also increased in the products.

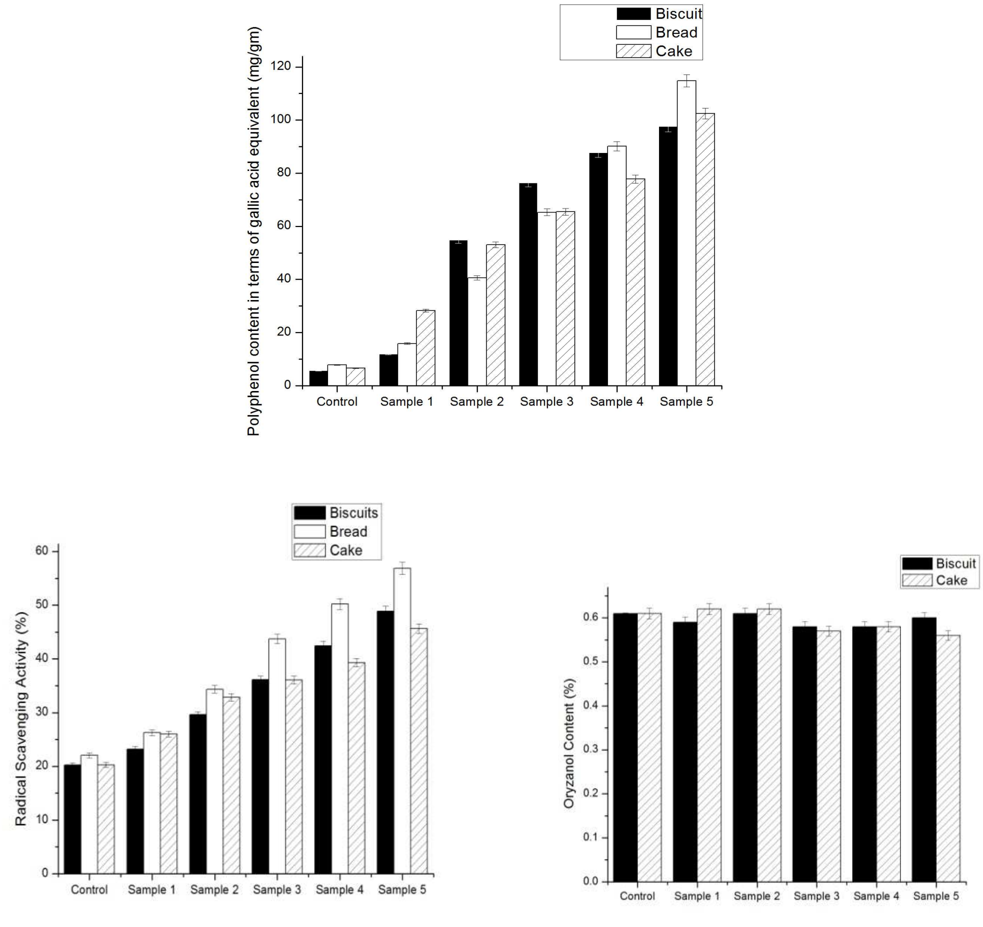

Fig 1: Polyphenolic content of biscuits, bread and cake; Radical scavenging activity of biscuits, bread and cake; Oryzanol content of biscuits and cake

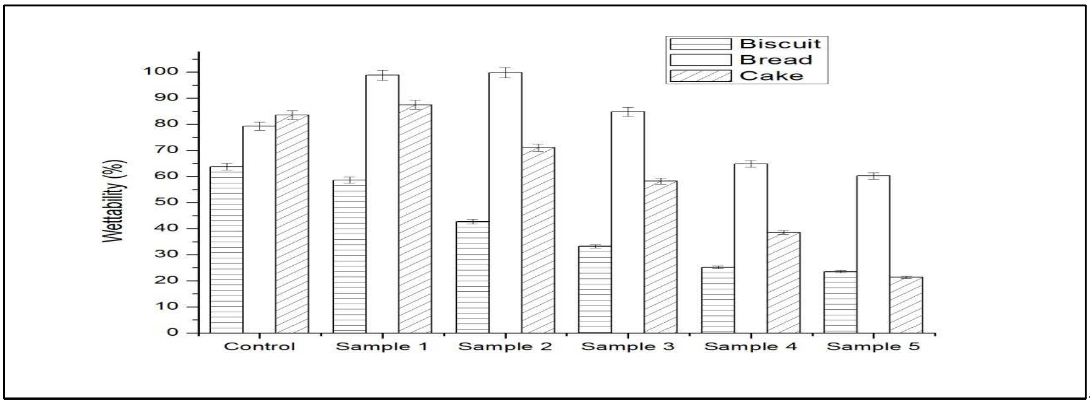

Figure 2: Wettability of biscuit, bread and cake

CONCLUSION

It can be concluded from current study that Tamarind Kernel Powder can have potential use in food processing industries, mainly bakery industries. Due to its high nutritional content, it can have vast role in bakery and confectionary. From the present study it has been found that TKP can be used as blends with other flours and baked food products can be formed with better nutritional composition.TKP incorporated bakery items also showed good antioxidant properties which might have also resulted in increasing storage life of the products. The improved antioxidant properties in the products render these products healthy compared to baked items made from normal bread wheat. The products were also found to be quite acceptable in terms of taste, texture and flavor, however, in most of the baked products made in this study it was noted that more than 30-50% of TKP incorporation results in poor taste and texture which indicates that TKP can be used as value added flour along with wheat in bakery industry but it cannot completely replace wheat flour due to its property. Overall the baked products made from TKP which is easily available under-utilized, low cost seed flour, can fetch good recognition in food and bakery industry.

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