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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(3): 18-22

www.thepharmajournal.com
Received: 13-01-2022
Accepted: 16-02-2022

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Comparison of functional properties of tamarind kernel powder with whole wheat flour, lentil powder and evaluation of sensory and nutritional quality of tamarind kernel powder incorporated cookies

Priyanka Tangariya and Sarita Srivastava

Abstract
Tamarind seed (*Tamarindus indica* L., family Fabaceae) a by-product of tamarind pulp industry is the most underutilized and undervalued nutritious legume. Tamarind kernel, obtained after the removal of seed coat, is a good source of nutrients especially protein with good amount of essential amino acids. Therefore, the aims of present study were to study the functional properties of tamarind kernel powder (TKP) with whole wheat flour (WWF) and lentil powder (LP) and to evaluate the sensory properties and proximate composition of TKP and LP incorporated cookies with control WWF cookies. Water absorption capacity (WAC), bulk density (BD) and foaming capacity of LP was higher than WWF and TKP, while oil absorption capacity and gluten content was higher for WWF. TKP incorporated cookies were prepared using eight different flour blends of WWF: TKP : LP ::100:0:0, 90:5:5, 80:10:10, 70:20:10, 60:30:10, 50:30:20, 40:40:20, 30:50:20 with other ingredients viz. sugar, butter, amla candy chips, vanilla essence and water. Results of sensory evaluation revealed that cookies prepared with WWF scored highest for all the sensory parameters namely; color, appearance, taste, crispness, after taste and overall acceptability. A non – significant difference (p<0.05) was observed in the color, appearance and overall acceptability values for cookies with flour blend up to WF:TKP:LP::60:30:10. However, for taste and crispness parameters, all the cookies prepared with eight different blends were found to have non - significant difference (p<0.05) with WWF cookies. Further, control WWF cookies and cookies prepared with WWF: TKP:LP:30:50:20 blend were evaluated for proximate composition and results revealed that TKP and LP incorporated cookies have considerably higher crude protein, total ash, crude fibre and energy content when compared with WWF cookies.

Keywords: tamarind kernel powder, functional properties, flour blends, cookies, sensory evaluation, proximate composition

Introduction
Protein energy malnutrition is a widespread problem throughout the world and has both health and economic consequences. Malnutrition, including protein-energy malnutrition and micronutrient deficiency, is the largest contributor to infant and child mortality worldwide, with 151 million children under the age of 5 being stunted (Black *et al.* 2013; FAO, 2018) [1, 2]. Globally, more than 800 million people have been reported as chronically undernourished each year during the past decade, with approximately 821 million cases recorded in 2017 (FAO, 2018) [2].
Protein, one of the essential macronutrients required for optimal human growth and development, is responsible for almost every function of cellular life (Lonnie *et al.*, 2018) [3]. An effective means of overcoming the global protein crisis is by revealing healthy, accessible, underutilized and sustainable sources of plant-based proteins to feed a soaring population that is expected to reach 9 billion people by mid-century (Godfray *et al.*, 2010; Henchion *et al.*, 2017) [4, 5].
One such nutritious and underutilized plant based protein source is *Tamarindus indica L.* which grows naturally in the tropical and subtropical regions. *Tamarindus indica* is one of the principal leguminous plant species which belongs to family Fabaceae and subfamily Caesalpinioideae. Tamarind is a multipurpose plant species, every part of it (bark, root, leaves, fruit and wood) is used for various purposes (Bin Mohamad *et al.*, 2012) [6]. It is mainly cultivated for its fruit. The fruit has a fleshy, juicy, acidic pulp which can be best described as sweet and sour in taste and is high in tartaric acid, sugar, B vitamins and calcium.

Pulp is used to prepare beverages, *chutney*, curies, sauces and accepted as herbal medicine in many parts of world (Siddhuraju, 2007) [7]. In India the seeds are roasted, seed coats are removed mechanically and dehulled tamarind seeds are soaked overnight and eaten with the addition of sugar/salt by the rural people/certain ethnic groups such as Kurumba, Irulas, Malyali and Dravidian tribes (Siddhuraju *et al.*, 1995) [8].

Tamarind seeds are an important source of protein and essential amino acids. Tamarind seeds are reported to have comparatively higher content of isoleucine, leucine, lysine, methionine and valine than some of the most commonly consumed pulses like cowpea, chickpea and soy bean. It is also found to have higher level of *in vitro* protein digestibility (71.3%). However, antinutritional factors like tannin and other coloring compounds present in the seed coat make the whole tamarind seed unsuitable for human consumption (Kumar and Bhattacharya, 2008) [9]. Tamarind kernel, obtained after the removal of seed coat, is a good source of nutrients specially protein with good amount of essential amino acids, minerals like: potassium, iron and significant bioactive compounds. The crude protein content of the tamarind kernel varies from 15.76 to 52.4 g/100g observed by (Kaur *et al*., 2013; Oluseyi and Temitayo, 2015) [10, 11]. Even after being a good and cheap source of protein content, tamarind kernels have not been utilized up to its potential for food purposes. Difficult processing of whole tamarind seeds and lack of awareness among people regarding its nutritional and therapeutic properties are some of the reasons for its underutilization. Therefore, the present study was planned to: 1) analyze the functional properties of tamarind kernel powder (TKP) against wheat flour and lentil powder, 2) evaluate the potential of TKP to be used as a food source by its incorporation into cookies based on sensory evaluation and 3) assess the proximate composition of TKP incorporated cookies and control whole wheat flour (WWF) cookies.

Materials and Methods

Locale of study and procurement of raw materials

The present study was conducted in the department of Foods and Nutrition, G. B. Pant University of Agriculture & Technology, Pantnagar. For the study, whole tamarind seeds were procured from New Delhi *mandi* with the help of local supplier. Other ingredients required for making cookies viz; lentil dal, whole wheat flour, butter, sugar, amla candy and vanilla essence were purchased from the local market of Pantnagar.

Preparation of tamarind kernel powder (TKP) and lentil powder (LP)

All the tamarind seeds were screened out for broken seeds, foreign materials and impurities. Thereafter, seeds were dried at 160°C for 35 minutes in hot air oven and were allowed to cool completely. Further, seed coat was removed manually with the help of mortar and pestle. Decorticated seeds/kernels were then passed through willy grinder to break down the hard kernels into coarse grits. Thereafter, coarse grits were ground into powder using electric grinder. For the preparation of lentil powder, lentil *dal* was washed properly and dried at 60°C temperature for 6 hours in hot air oven. Further, dried *dal* was processed into powder with the help of electric grinder. TKP and LP were then sieved through 60 mesh sieve for further study.

Evaluation of functional properties of wheat flour (WWF), lentil powder (LP) and tamarind kernel powder (TKP)

Water absorption capacity (WAC)

Water absorption capacity was determined by modifying the method of Adele and Odedeji (2010) [12]. In a centrifuge tube 1 g of flour was taken and 15 ml water was added. It was then centrifuged at 3250 rpm for 25 min and the supernatant decanted. The volume of free water was measured and the water retained by the flour was computed as water absorbed and expressed as ml of water absorbed per gram of sample.

Fat absorption capacity (FAC)

Fat absorption capacity was determined by the method given by Lin *et al.* (1974) [13]. One g of flour was transferred to graduated cylinder and mixed properly with 6 ml of soybean oil with the help of a glass rod. The tubes were centrifuged for 20 minutes at 3700 rpm. Then the volume of free oil was measured and FAC was expressed in terms of ml/g.

Bulk density (BD)

Bulk density of the flours was determined by the method of Wang and Kinsella (1976) [14]. One hundred gram of flour was placed in a graduated cylinder of 100ml capacity and then tapped gently on a rubber sheet or surface until a constant volume was obtained. The sample present in the cylinder was then weighed. The bulk density was expressed as g/ml of sample.

$$\text{Bulk density (g/ml)} = \frac{\text{Weight of sample (g)}}{\text{Volume of sample(ml)}}$$

Foam capacity

A 100 ml of distilled water was added to 3g flour and initial volume was measured. The mixture was homogenized for 5 min in a blender at high speed and then transferred to a 250 ml measuring cylinder. The volume of foam was then was measured and the increase in volume was expressed as % foam capacity.

$$\text{Foaming capacity \%} = \frac{\text{Volume after blending(ml)} - \text{volume before blending (ml)}}{\text{Volume before blending (ml)}} \times 100$$

Foam stability

Foam stability was determined by measuring the decrease in volume of foam as a function of time up to a period of 30 minutes. Volume of foam was measured after 30 minutes of standing and the remaining foam was described as foam stability.

$$\text{Foam stability \%} = \frac{\text{Foam volume after standing for 30 min (ml)}}{\text{Volume before blending (ml)}} \times 100$$

Gluten estimation

Gluten content was determined following the AOAC (2000) procedure [15]. A 25 g flour was kneaded in a bowl adding sufficient water. The dough ball was placed in water at room temperature for 1 hour. The dough was then kneaded with fingers gently in a thin stream of tap water until all the starch and soluble matter were removed. The gluten thus obtained by washing was pressed as dry as possible between hands, made into a ball and weighed. The gluten was then dried in the dish at 100 ºC for 4 hours to a constant weight and per cent dry gluten was calculated.

Optimization of cookies using different combinations of WWF, TKP and LP

For optimization of TKP incorporated cookies, eight different flour blends of WWF: TKP : LP 100:0:0, 90:5:5, 80:10:10, 70:20:10, 60:30:10, 50:30:20, 40:40:20, 30:50:20 were taken. Cookie dough was prepared according to the method of Singh *et al.* (2011) [16] with slight modifications.

Butter (50g) and powdered sugar (36g) were mixed thoroughly until a uniform creamy paste was obtained. Thereafter, flour (100g) and baking powder (2g) were sifted on a plate followed by addition of amla candy chips (20g).Creamy paste was then poured onto sifted flour and rubbed into the flour using finger tips till the dough of desired texture was obtained. Water may also be added if required. Prepared dough was then sheeted uniformly using a wooden rolling pin to a thickness of 5 mm. The cookies were cut and placed on a well greased oven tray and baked at 170±2ºC temperature for 25 to 30 minutes in a preheated oven. Baked cookies were cool down and further subjected to sensory evaluation.

Sensory evaluation of WWF cookie and TKP incorporated cookies

All the cookies were evaluated for their sensory quality by a semi-trained panel of 15 members from the department of Foods and Nutrition, G.B.P.U.A.T., Pantnagar. Nine point Hedonic scale was used to determine the most acceptable cookie based on various sensory parameters (Meilgaard *et al*., 2007) [17].

Nutritional quality evaluation of control WWF cookies and TKP incorporated cookies

Based on the results of sensory evaluation control, WWF cookie and the most acceptable TKP incorporated cookie were evaluated for their crude protein, crude fat, ash, crude fibre, carbohydrate and physiological energy content on calculation basis.

Results and Discussion

Functional properties of wheat flour (WWF), lentil powder (LP) and tamarind kernel powder (TKP)

The results pertaining to various functional properties of whole wheat flour (WWF), lentil powder (LP) and tamarind kernel powder (TKP) have been presented in Table 1. Water absorption capacity (WAC) is the ability of any flour to associate with water under a specific condition where water is limiting, which is predominantly dependent on the proteins at room temperature and to a lesser extent on starch and cellulose (Otegbayo *et al*., 2013) [18]. In the present study WAC of LP was observed as 1 ml/g which is significantly higher (p<0.05) than the WAC of WWF and TKP. WAC of the LP observed in the present study is relatively lower than the WAC of 1.17 g/g reported by Ghavidel and Prakash (2006) [19] for lentil flour. The WAC values of WWF and TKP were found to be as 0.91 ml/g and 0.83 ml/g, respectively. Ahmad *et al.* (2015) [20] and Uzodinma *et al.* (2020) [21] in their studies reported similar WAC of 0.87 ml/g and 0.97ml/g for WWF and TKP, respectively.

Oil absorption capacity (OAC) of flour is due to the complex interactions between non-polar amino acid side chains and hydrocarbon chains of lipid molecules that determine mouth-feel and flavor retention of products (Sindhu and Khatkar, 2016) [22]. In case of OAC, WWF was found to have significantly higher (p<0.05) OAC value of 1.58 ml/g followed by TKP (0.98 ml/g) and LP (0.81 ml/g). Ahmad *et al.* (2015) reported moderately lower OAC of 1.22 ml/g for wheat flour. A moderately higher OAC value of 1.3 ml/g for TKP and similar OAC value of 0.869 ml/g for lentil flour was reported by Oluseyi and Temitayo (2015) [23] and Ghavidel and Prakash (2005) [19], respectively.

Bulk density (BD) is the mass of bulk solid that occupies a unit volume of a bed, including the volume of all inter-particle voids (Fitzpatrick *et al*., 2013) [24]. An understanding of bulk density is useful in determining the packaging requirement, application in wet processing and material handlings of flours (Adebowale *et al*., 2008) [25]. With respect to BD of flours, LP with a value of 0.83 g/ml had significantly higher (p<0.05) bulk density than WWF (0.75 g/ml) and TKP (0.71 g/ml). Aguilera *et al.* (2009) [26] reported slightly higher bulk density of 0.91 g/ml for lentil flour. Shukla and Awasthi (2017) [27] in their study reported similar bulk density of 0.75 g/ml for wheat flour, however relatively lower bulk density of 0.57 g/ml for TKP.

Table 1: Functional properties of whole wheat flour (WWF), lentil powder (LP) and tamarind kernel powder (TKP)

Flour properties	Whole wheat flour (WWF)	Lentil Powder (LP)	Tamarind kernel powder (TKP)	CD value at 5%
Water absorption capacity (ml/g)	0.91 ± 0.02^b	1 ± 0.00^a	0.83 ± 0.02^c	0.047
Oil absorption capacity (ml/g)	1.58 ± 0.02^a	0.81 ± 0.02^c	0.98 ± 0.00^b	0.058
Bulk density (g/ml)	0.75 ± 0.00^b	0.83 ± 0.00^a	0.71 ± 0.00^c	0.006
Foaming Capacity (%)	15.47 ± 0.36^b	32.36 ± 0.32^a	10.74 ± 0.06^c	0.572
Foaming stability (%)	89.13 ± 0.27^c	90.87 ± 0.29^b	94.41 ± 0.24^a	0.542
Gluten (%) on dry basis	8.73 ± 0.04^a	0 ± 0.00^b	0 ± 0.00^c	0.048

All values are mean of triplicate observations ± standard deviation

Means having different superscripts differ significantly in each row (p<0.05)

WF: Wheat flour; TKP: Tamarind kernel powder; LP: Lentil powder

Foam capacity of protein refers to the amount of interfacial area that can be created by the protein. Foam is a colloid of many gas bubbles trapped in a liquid or solid. Small air bubbles are surrounded by thin liquid films (Fennama, 1996) [28]. In the present study LP was found to have significantly higher (p<0.05) foam capacity of 32.36% followed by the foam capacity of WWF (15.47%) and TKP (10.74%). Pertaining to gluten content, only WWF was found to have gluten content of 8.73% (dry basis) while LP and TKP lacked in gluten content. In different wheat cultivars 8.65 to 10.35% of gluten content has been reported by Kaushik *et al.* (2015) [29].

Sensory evaluation of control WWF cookie and TKP incorporated cookies

WWF cookies and different combinations of TKP incorporated cookies were evaluated for various sensory parameters viz; color, appearance, taste, crispness, after taste and overall acceptability using nine- point Hedonic scale (Table 2). The results of sensory evaluation revealed that a non – significant difference (p<0.05) was observed in the color, appearance and overall acceptability values for cookies with flour blend up to WF:TKP:LP::60:30:10. However, for taste and crispness parameters, all the cookies prepared with eight different blends were found to have non - significant difference (p<0.05) with WWF cookies. This may be attributed to the nutty flavor and lack of after taste in TKP which results in its easier blending with wheat flour. Since taste and after taste properties were not affected adversely with incorporation of TKP up to 50%, cookies prepared with flour combination of WF:TKP:LP::30:50:20 were selected for calculation of proximate composition with control WWF cookies. Sindhuja *et al.* (2005) [30] in their study also reported improved values of flavor and mouthfeel for cookies developed by replacing wheat flour with amaranth flour up to 35% only. Similarly, Aziah *et al.* (2012) [31] also reported improved flavor and aftertaste in cookies with addition of 35% of chickpea flour and 15% corn flour. Chandra *et al.* (2015) [32] formulated composite flour biscuits with rice flour (15%), green gram flour (15%) and potato flour (15%) and found higher value for taste when compared with control wheat four biscuits. All these findings are in accordance with the results of present study.

Table 2: Sensory evaluation of cookies prepared using different blends of whole wheat flour, tamarind kernel powder (TKP) and lentil powder

Flour blends	Color	Appearance	Taste	Crispness	After taste	Overall acceptability
WF:TKP:LP::100:0:0	8.36 ± 0.61[a]	8.23 ± 0.53[a]	8.3 ± 0.67[a]	8.23 ± 0.64[a]	8.25 ± 0.5[a]	8.3 ± 0.67[a]
WF:TKP:LP::90:5:5	8.3 ± 0.36[ab]	8.21 ± 0.46[a]	8.26 ± 0.39[a]	8.2 ± 0.99[a]	8.13 ± 0.26[ab]	8.23 ± 0.34[ab]
WF:TKP:LP::80:10:10	8.25 ± 0.34[abc]	8.15 ± 0.49[ab]	8.18 ± 0.61[a]	8.15 ± 0.44[a]	8.03 ± 0.29[abc]	8.16 ± 0.40[abc]
WF:TKP:LP::70:20:10	8.20 ± 0.23[abc]	8.08 ± 0.22[abc]	8.13 ± 0.28[a]	8.11 ± 0.26[a]	7.91 ± 0.39[bcd]	8.1 ± 0.29[abcd]
WF:TKP:LP::60:30:10	8.11 ± 0.37[abcd]	8.0 ± 0.26[abc]	8.05 ± 0.38[a]	8.06 ± 0.25[a]	7.83 ± 0.32[bcde]	8.03 ± 0.22[abcd]
WF:TKP:LP::50:30:20	8.08 ± 0.52[bcd]	7.91 ± 0.40[bc]	8.0 ± 0.37[a]	8.01 ± 0.29[a]	7.75 ± 0.40[cde]	7.95 ± 0.34[bcd]
WF:TKP:LP::40:40:20	8.0 ± 0.26[cd]	7.85 ± 0.47[c]	7.9 ± 0.66[a]	7.95 ± 0.31[a]	7.66 ± 0.41[de]	7.88 ± 0.31[cd]
WF:TKP:LP::30:50:20	7.91 ± 0.26[d]	7.81 ± 0.24[c]	7.83 ± 0.69[a]	7.91 ± 0.36[a]	7.53 ± 0.66[e]	7.83 ± 0.44[d]
CD value at 0.05	0.281	0.290	0.45	0.30	0.304	0.289

All values are mean of fifteen observations ± standard deviation
Means having different superscripts differ significantly in each column (p<0.05)
WF: Wheat flour; TKP: Tamarind kernel powder; LP: Lentil powder

Proximate composition of control WWF cookies and TKP incorporated cookies on calculation basis

Table 3 exhibits proximate composition of control WWF cookies and cookies prepared with flour combination of WF:TKP:LP::30:50:20, on calculation basis. The table represents that incorporation of 50% of TKP and 20% of LP in cookies resulted in two-fold increase in crude protein, total ash, crude fibre content, 1% increase in fat and 9% increase in physiological energy content. In a similar study, Rajiv *et al.* (2012) [33] formulated cookies by incorporating 10 to 50% of green gram flour and observed significant increase in protein (from 10.12 to 14.04%) and total ash content (0.91 to 2.3%) with increase in the level of green gram flour. In another study, Kulthe *et al.* (2014) [34] prepared defatted soy flour added cookies and reported increased protein content from 6.1 to 10.5%, increased ash content from 0.9 to 1.9% and increased crude fibre content from 0.5 to 0.85% on addition of 25% soy flour. However, similar to the present study carbohydrate content showed a decreasing trend from 66.4 to 61.4%. Cheng *et al.*(2016) [35] formulated cookies using underutilized jering legume and found significant increase (p<0.05) in the crude protein from 6.82 to 9.34%, ash content from 0.89 to 1.47% and crude fibre from 0.49 to 1.36% on addition of 20% jering legume flour.

Table 3: Nutritional composition of control WWF cookies and TKP incorporated cookies (calculation basis)

Nutrients	WWF cookies WF:TKP:LP::100:0:0	TKP incorporated cookies WWF:TKP:LP::30:50:20
Crude protein (%)	5.32	11.83
Total ash (%)	1.31	2.27
Crude fat (%)	20.16	20.36
Crude fibre (%)	1.13	2.35
Carbohydrate (%)	56.76	56.54
Energy (Kcal)	433	445

Conclusion

The present study revealed that TKP incorporated cookies were highly acceptable as the incorporation of tamarind kernel powder (TKP) up to 50% did not affect the taste and crispness properties of cookies significantly (p<0.05) when compared with control WWF cookies. Moreover, incorporation of TKP remarkably increased crude protein, total ash, crude fibre and energy content of cookies. Therefore, tamarind kernel, an underutilized protein rich legume, may be successfully used for cookie preparation at commercial level without adversely affecting its sensory properties. The added advantage of TKP is that it is gluten free. Hence gluten free cookies may also be explored using TKP.

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