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Physical properties and nutritional composition of tamarind kernel powder and quality evaluation of instant chutney mix prepared incorporating tamarind kernel powder

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Abstract
The industrial processing of fruits and vegetables generates considerable amount of peels, stones and seeds which are generally discarded as waste. Presently, new aspects concerned with the efficient utilization of the powder made from these agro by-products as novel ingredients or additives to supplement food have gained increasing interest because of their nutrient dense composition. Tamarind kernel powder (TKP) has been identified as an alternative and cheap source of proteins and other essential nutrients. In order to determine its potential use, the study was conducted to evaluate the physical properties and nutritional composition of tamarind kernel powder. Optimum water uptake and water absorption capacity was recorded as 133 ml and 193 per cent respectively and particle size index was calculated as 11.22. The moisture content, crude protein, crude fat, crude fiber and total ash in TKP was found to be 4.67 %, 24.61 %, 2.46 %, 3.70 % and 2.50 % respectively. TKP had 62.06 % carbohydrates and the physiological energy value was recorded as 369 kcal/100g. The calcium and iron content in TKP was 145 mg and 15.46 mg per 100 g, whereas; tannic acid and phytate content were found to be 0.006 mg and 0.49 mg per 100 g respectively. Instant chutney mixes were prepared using TKP as a base. Three blends of instant chutney mix were made following standard recipes which were incorporated to prepare coconut, groundnut and coriander chutneys. All the chutneys were found to be acceptable and no significant difference was observed in the sensory characteristics of chutney using different blends. Incorporation of instant chutney mixes improved the nutritional composition of all the chutneys. A substantial increase could be seen with respect to the protein and calcium content after the addition of instant chutney mix powder.

Keywords: Instant chutney mix, nutritional composition, sensory quality, tamarind kernel powder

Introduction
Tamarind (*Tamarindus indica* L.) is a member of the dicotyledonous family fabaceae. It is known as *tamarindo* in Spanish, *tamarin* in French, *dakar* in Senegalian and *imli* in Indian language. The major areas of production of tamarind are Asian countries like India, Bangladesh, Sri Lanka, Thailand, Indonesia and some other African and American countries. The potential of exporting tamarind from India in past five years shows a good market for tamarind, especially in gulf countries and Europe (De Caluwe *et al*., 2010) [12].

The tamarind fruit contains about 55 per cent pulp, 34 per cent seeds and 11 per cent shell and fiber in a pod. The seeds are very hard, shiny, reddish or purplish brown in colour (El-Siddig *et al*., 2006) [13]. Tamarind is cultivated mainly for the pulp in the fruit, which is used to prepare beverages and to flavor confectionaries, curries and sauces. Apart from pulp, tamarind seeds are also used to some extent.

The by-products of agricultural activities are usually referred to as "agricultural waste" because they are not being utilized up to their potential. Tamarind seed is such a by-product of tamarind pulp industry which has a potential to be used as a food source. The presence of tannins and antinutrients in the seed coat make the whole seed unsuitable for consumption. By removal of seed coat tamarind kernel is obtained which is ground to fine particle size to obtain tamarind kernel powder (TKP). Presently, TKP is primarily being utilized as an important sizing material in textile and jute industries for merchandizing purposes. In food industries TKP is used for thickening, stabilizing and gelling agent. It is commercially available as a food additive for improving the texture and viscosity of processed foods (El-Siddig *et al.*, 2006) [13]. In various research studies TKP has been identified as a rich source of protein and various other nutrients. Therefore, keeping in view the advantages of tamarind kernel like low cost, better nutritional quality and better sustainability, the utilization of TKP can be enhanced by incorporating it into various food products for attaining maximum benefits.

Materials and methods

Procurement of materials Tamarind along with the seeds and other ingredients such as spices, refined oil, coconut, groundnut and coriander were procured from the local market of Pantnagar, Uttarakhand.

Preparation of the sample Tamarind seeds were separated from pulp and cleaned properly. The seeds were then dried at 140°C for 30 minutes followed by cooling to room temperature. A part of the seeds was kept for the estimation of physical properties and the other part was used for the production of tamarind kernel powder (TKP). For this, tamarind seeds were roasted and dehusked manually using pestle and mortar and then ground to fine powder in electric grinder. The powder was sieved and stored in clean air tight container for further study.

Determination of physical properties of tamarind seeds The physical properties namely seed size, average weight per seed and average volume per seed were measured in triplicates (Bhattacharya *et al.,* 1993) [9]. Per cent powder recovery was calculated by measuring the yield of tamarind kernel powder obtained from the known amount of seeds using formula:

$$\text{Per cent powder recovery} = (\text{Tamarind kernel powder}/\text{Amount of seeds}) \times 100$$

Physical properties of tamarind kernel powder (TKP) Colour of TKP was assessed by comparison with Munsell soil colour chart and matching the hue, value and chroma (Colour 1975) [11]. Optimum water uptake of the sample was determined according to the method given by Anderson (1969) [4]. Water absorption capacity was estimated by procedure suggested by Smith and Circle (1972) [25] and particle size index of TKP was determined using method of Bedolla and Rooney (1984) [8].

Nutritional composition of TKP Moisture, total ash, crude fat, crude fiber and calcium were estimated as per the standard procedures of AOAC (1995) [7]. Crude protein was determined by method given in AOAC (1984) [6]; carbohydrate by difference and physiological energy was calculated using the method of Mudambi *et al.,* (2006) [19]. Iron content in TKP was analysed colourimetrically by Wong's method as quoted in Ranganna (1986) [21]. Phytates were estimated according to the method described by Wheeler and Ferrel (1971) [26] and tannins by colorimetric method given in AOAC (1970) [5] quoted in Sadasivam and Manickam (2005) [22].

Preparation of instant chutney mix powder Tamarind kernel powder was used as a base for the chutney mix which also acts as a thickener, providing the desired consistency to the chutney. Three blends of instant chutney mix powder were prepared in which the spices used and the amount in which they were added were in accordance with the various recipes for chutney given by Phillip (1965) [20]. The composition of blends used for the preparation of instant chutney mix has been given in Table 1 and the process has been depicted in Figure1.

Table 1: Composition of the blends for making instant chutney mix

Ingredients	Blend 1	Blend 2	Blend 3
TKP	50 g	50 g	50 g
Red chilli	3 g	3 g	3 g
Mustard seeds	5 g	5 g	5 g
Asafoetida	a pinch	a pinch	a pinch
Salt	½ tsp	½ tsp	½ tsp
Refined oil	1 tsp	1 tsp	1 tsp
Cumin seeds	-	10 g	10 g
Coriander seeds	-	5 g	5 g
Pepper corn	-	-	3 g
Sugar	-	-	5g
Mango powder	-	-	5 g

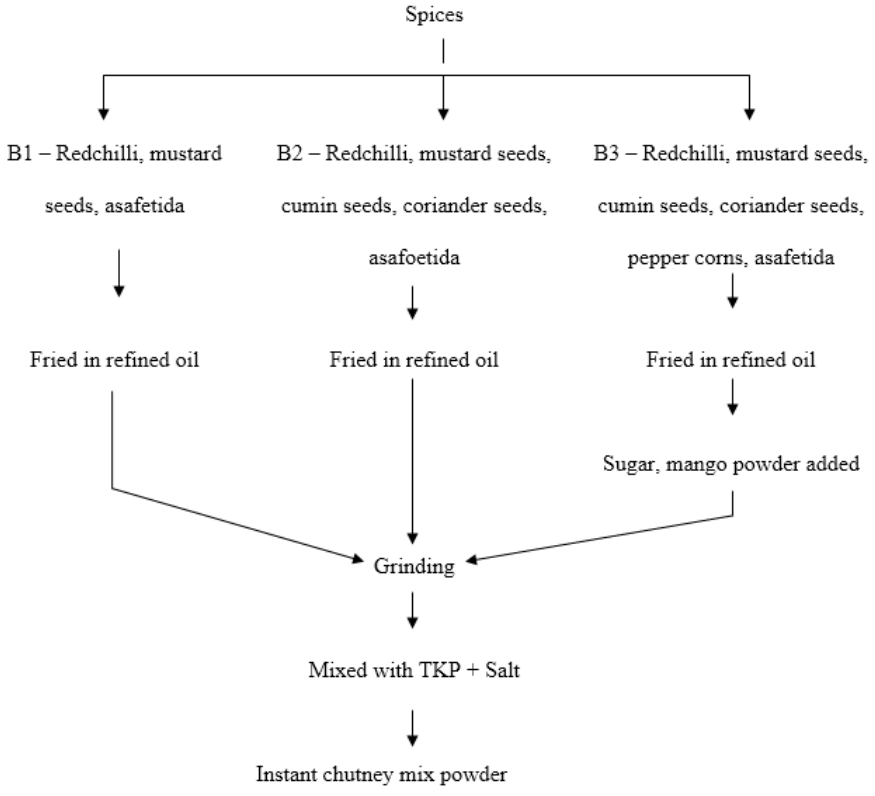

Fig 1: Flow chart for the preparation of instant chutney mix

Preparation of chutneys Three types of chutneys viz. coconut, groundnut and coriander chutney were prepared using blends (B1, B2 and B3) of instant chutney mix powder. Coconut chutney was made by grinding fresh coconut (1 cup) to fine paste. Water was added to make it to a desired consistency followed by addition of two teaspoons of instant chutney mix. All the ingredients were mixed thoroughly. One tea spoon of oil was heated and a pinch of mustard seeds were made to sputter which was then added to chutney. For groundnut chutney 50 g of groundnut was roasted, skin/outer covering was removed and then ground to paste. Water was added to get a desired consistency. Two teaspoons of instant chutney mix powder was added to it and all the ingredients were mixed thoroughly. Coriander chutney was prepared by washing one medium size bunch of coriander leaves and grinding it to a fine paste with green chilies (2 in number), 2 g of ginger and two cloves of garlic. Two teaspoons of instant chutney mix powder and 10 g of tamarind pulp were added to it. All the ingredients were mixed thoroughly.

Sensory evaluation of chutneys The sensory evaluation of three types of chutneys was conducted by a panel of 10 semi-trained members using sensory score card method (Amerine *et al*., 1965) [3]. Each sample was evaluated for organoleptic attributes i.e. colour, flavor, texture, appearance, taste and overall acceptability.

Nutritional composition of chutneys The nutritional compositions of chutneys were determined on calculative basis with the help of values reported by Gopalan *et al.*, (2010) [14] and from the values analysed for TKP.

Statistical analysis Data pertaining to the physical properties and nutritional composition was analysed to compute mean and standard deviation. ANOVA was applied for the sensory evaluation of chutneys to find out the significant differences among the blends used for preparation of instant chutney mix.

Results and Discussion

Physical properties of tamarind seeds Tamarind seeds do not have any standard size or shape; and length, breadth and thickness of seeds differ from one another. The mean length, breadth and thickness of seeds were found to be 15.92 mm, 12.55 mm and 6.53 mm respectively. Average seed weight was recorded as 0.80 g whereas the average seed volume was 0.61 cm^3. The values for size, average weight and average volume obtained in the study were slightly higher than those reported by Bhattacharya *et al*., (1993) [9]. Shukla and Awasthi (2017) [23] reported the length, breadth and thickness of seeds to be 13.67 mm, 11.55 mm, 5.43 mm respectively; average seed weight as 0.72 g and average seed volume as 0.58 cm^3. Percent powder recovery of tamarind seeds was found to be 48.46 per cent. The data related to the physical properties of the tamarind seeds have been presented in Table 2.

Table 2: Physical properties of tamarind seeds

Physical properties	Values	Maximum value	Minimum value
Length (mm)**	15.92±1.13	17.98	10.10
Breadth (mm)**	12.55±1.14	15.39	9.58
Thickness (mm)**	6.53±0.51	7.81	5.66
Average seed weight (g)**	0.80±0.04	0.85	0.76
Average seed volume (cm^3)**	0.61±0.03	0.65	0.58
Per cent powder recovery	48.46	-	-

**Values are mean of triplicate observations ± SD

Physical properties of tamarind kernel powder (TKP) Colour of TKP was found to be pale yellow (2.5 Y 8/4) having hue of 2.5 Y, value 8 and chroma 4. Optimum water uptake for TKP was recorded to be 133 ml. TKP had water absorption capacity of 193.33 per cent which was similar to the value (196.60 per cent) reported by Kumar and Bhattacharya (2008) [17]. The water absorption capacity of TKP was found to be much higher than that of the wheat flour recorded as 145 to 150 per cent by Adejumo (2013) [1]. Shukla and Awasthi (2017) [23] reported the water absorption capacity of TKP as 285.3 ml/g. Particle size index of tamarind kernel powder was found to be 11.22. The physical properties of TKP are given in Table 3.

Table 3: Physical properties of tamarind kernel powder

Physical properties	Values
Colour	Pale yellow (2.5Y 8/40
Optimum water uptake (ml)**	133.33±3.06
Water absorption capacity (per cent)**	193.33±11.54
Particle size index	11.22

**Values are mean of triplicate observations ± SD

Nutritional composition of tamarind kernel powder The nutritional composition of tamarind kernel powder is depicted in Table 4. The moisture content in TKP was recorded as 4.67 per cent. Siddhuraja *et al*., (1995) [24] and Ajayi *et al.,* (2006) [2] reported the moisture content in tamarind seeds as 8 and 10.75 per cent respectively; whereas, Gunasena and Huges (2000) [15] found the moisture content in tamarind kernel in the range 11.40 to 22.70 per cent. The lower moisture content obtained in the present study may be due to the evaporation of moisture from the kernel as a result of heat treatment given to process them to tamarind kernel powder.

Total ash which represents the total mineral content of the food stuff was found to be 2.50 per cent in TKP. Similar results were obtained for tamarind seeds by Ishola *et al*., (1990) [16] and Lockett *et al*., (2000) [18]. However, Gunasena and Huges (2000) [15] reported that the ash content ranged from 3.90 to 16.20 per cent in tamarind kernel.

Crude protein content of TKP was estimated to be 24.61 per cent. It is in accordance with the previous studies in which the crude protein content was found to be 26.93 g and 24.28 g respectively (Ishola *et al*., 1990 [16]; Ajayi *et al.,* 2006 [2]). Gunasena and Huges (2000) [15] found the crude protein content ranging between 15 to 20.90 percent which was slightly lower than the values obtained in present study. The protein content in TKP was quite higher in comparison to the common cereals like rice and wheat and fall in the range of protein content of most pulses. Therefore, it is considered to be a cheap source of protein.

The fat content of TKP was 2.46 percent. Lockett *et al*., (2000) [18] found 3.03 per cent fat in tamarind seeds whereas a higher value of crude fat ranging from 3.90 to 16.20 per cent was reported by Gunasena and Huges (2000) [15].

Tamarind kernel powder had a crude fiber content of 3.70 per cent. Gunasena and Huges (2000) [15] recorded 2.50 to 8.20 per cent crude fiber for tamarind kernel. However, Siddhuraja *et al*., (1995) [24] and Lockett *et al*., (2000) [18] found crude fiber in whole tamarind seeds to be 14 and 16.73 per cent respectively. Crude fiber content of TKP was much higher than that of major cereals like raw milled rice and wheat flour which contain 0.20 per cent and 1.90 per cent fiber respectively (Gopalan *et al.,* 2010) [14].

Table 4: Nutritional composition and anti-nutrients in tamarind kernel powder

Proximate composition	Values
Moisture (%)	4.67±0.20
Total ash (%)	2.50±0.08
Crude protein (%)	24.61±0.63
Crude fat (%)	2.46±0.08
Crude fiber (%)	3.70±0.48
Carbohydrate (%)	62.06±0.40
Physiological energy (Kcal/100g)	368.82±1.89
Minerals	
Calcium (mg/100g)	145.20±8.80
Iron (mg/100g)	15.46±0.32
Ant nutrients	
Tannins (mg/100g)	0.006±0.001
Phytates (mg/100g)	0.49±0.09

Values are mean of triplicate observations ± SD

Carbohydrate content of TKP was found to be 62.06 g per 100 g powder. Siddhuraja *et al*., (1995) [24] recorded 61.70 g carbohydrate in tamarind seeds. The carbohydrate content was higher and ranged between 65.10 to 72.20 g in tamarind kernel as reported by Gunasena and Huges (2000) [15].

Physiological energy of tamarind kernel powder was calculated as 369 Kcal per 100 g. (El-Siddig *et al*., 2006) [13] reported a slightly lower value (340 Kcal per 100 g) of physiological energy for tamarind kernel. TKP has physiological energy value higher than rice and wheat. Rice and wheat contained 345 Kcal and 341 Kcal per 100 g respectively (Gopalan *et al*., 2010) [14].

The calcium content of TKP was 145 mg per 100 g, which falls within the range of 9.30 to 786.0 mg per 100 g recorded by Gunasena and Huges (2000) [15]. However, the value for the calcium content in TKP obtained in the present investigation was lower than the values of 172 mg and 185 mg per 100 g reported for the tamarind seeds by Siddhuraja *et al*., (1995) [24] and Lockett *et al*., (2000) [18] respectively. Calcium content of TKP was higher than the wheat flour which contains 48 mg per 100 g of calcium (Gopalan *et al*., 2010) [14].

Iron content in TKP was estimated to be 15.46 mg per 100 g which was higher than the value (6.50 mg per 100 g) obtained by Gunasena and Huges (2000) [15]. Ajayi *et al.,* 2006 [2] reported much higher iron content (45.50 mg per 100 g) in the tamarind seeds. Iron in TKP was quite high in comparison to the major cereal grains. Raw milled rice and wheat flour contained 0.70 and 4.90 mg per 100 g iron respectively (Gopalan *et al.,* 2010) [14].

Antinutritional factors The tannin content of TKP was estimated as tannic acid which was found to be 0.006 mg per 100 g. Gunasena and Huges (2000) [15] reported that tamarind kernel did not contain any tannin. Whole seeds of tamarind have good amount of tannins as represented in previous studies (Bhatta *et al*., 2001 [10]; El-Siddig *et al*., 2006 [13]). The decrease in the amount of tannins may be attributed to the removal of the seed coat. Phytates in TKP was found in the form of phytate phosphorus. Phytate content in TKP was estimated to be 0.49 mg per 100 g.

Sensory evaluation of chutneys The sensory scores for the chutneys namely coconut chutney, groundnut chutney and coriander chutney prepared with the blends of instant chutney mix have been presented in Table 5, 6 and 7 respectively. The statistical analysis of the sensory scores showed no significant Difference among the quality parameters viz. colour, flavor, texture, appearance, taste and overall acceptability for the chutneys with regard to the blends. However, for the coconut and groundnut chutney, the scores for all the sensory parameters were highest for B3; whereas, for coriander chutney the scores were found to be highest for blend B1.

Table 5: Mean sensory scores for coconut chutney prepared with blends of instant chutney mix

Chutney mix blends	Colour	Flavour	Texture	Appearance	Taste	Overall Acceptability
B1	6.10	5.50	5.70	5.90	5.60	5.70
B2	6.50	6.50	6.30	6.50	6.70	6.80
B3	6.50	6.20	6.20	6.40	6.50	6.70
CD at 5%**	1.087	1.280	1.220	1.195	1.423	1.298
SEM	0.374	0.441	0.420	0.411	0.490	0.447

**Significance at 5 per cent level

Table 6: Mean sensory scores for groundnut chutney prepared with blends of instant chutney mix

Chutney mix blends	Colour	Flavour	Texture	Appearance	Taste	Overall Acceptability
B1	8.00	8.00	7.80	8.10	8.10	8.30
B2	8.20	8.30	8.50	8.40	8.40	8.50
B3	8.70	8.70	8.60	8.50	8.60	8.80
CD at 5%**	0.742	0.832	0.898	0.964	0.895	0.793
SEM	0.256	0.287	0.309	0.322	0.308	0.273

**Significance at 5 per cent level

Table 7: Mean sensory scores for coriander chutney prepared with blends of instant chutney mix

Chutney mix blends	Colour	Flavour	Texture	Appearance	Taste	Overall Acceptability
B1	9.00	9.10	8.80	9.10	9.50	9.50
B2	8.70	8.90	8.90	8.90	9.10	9.10
B3	8.80	8.40	8.40	8.50	8.80	8.70
CD at 5%**	0.822	0.832	1.129	1.003	0.728	0.779
SEM	0.283	0.286	0.389	0.345	0.250	0.268

**Significance at 5 per cent level

Nutritional composition of chutney The results pertaining to the nutritional composition of the chutneys revealed that the carbohydrate and protein content of coconut, groundnut and coriander chutney increased to a great extent after the incorporation of the instant chutney mix. A slight increase in the fiber and fat content of chutneys were observed and the mineral content also improved with the addition of chutney mix powder. Data related to the nutritional composition of the chutneys is given in Table 8. In coconut chutney, substantial increase in protein, calcium and iron content has been observed after the incorporation of instant chutney mix. The protein content which was 2.70 mg in plain coconut chutney later increased to 5.16 mg. The calcium and iron content also increased from 6 mg to 20.50 mg and 1.02 to 2.56 per 100g respectively after the instant chutney mix powder was added. For the groundnut chutney, incorporation of TKP based chutney mix increased the protein content from 12.65 g to 15.11 g per 100 g. Calcium increased from 45 mg to 59.50 mg whereas iron content increased from 1.25 to 2.79 mg per 100g. Similar results were found in coriander chutney, where protein content in increased from 1.71 mg to 5.42 mg per 100 g in TKP incorporated coriander chutney. The calcium content increased from 92 mg to 107 mg per 100g whereas iron content increased from 0.70 to 4.41 mg per 100g after the addition of instant chutney mix.

Table 8: Nutritional composition of chutneys (per 100 g)

Chutneys	Carbohydrates (g)	Energy (Kcal)	Protein (g)	Fat (g)	Fiber (g)	Calcium (mg)	Iron (mg)
Coconut chutney							
Plain coconut chutney	7.80	266	2.70	24.96	2.16	6	1.02
TKP incorporated coconut chutney	14.0	303	5.16	25.20	2.53	20.50	2.56
Groundnut chutney							
Plain groundnut chutney	13.05	284	12.65	20.05	1.55	45	1.25
TKP incorporated groundnut chutney	19.25	320	15.11	20.29	1.92	59.50	2.79
Coriander chutney							
Plain coriander chutney	3.15	22	1.71	0.34	0.61	92	0.70
TKP incorporated coriander chutney	18.08	100	5.42	0.69	1.90	107	4.41

Conclusion

It is apparent from the study that the tamarind kernel which is an agricultural by-product has a potential to be exploited optimally in the food processing industries. Tamarind kernel powder has properties and nutritional qualities at par with the major cereal crops. It can therefore be utilized for the development of novel food products like instant mixes and can also be blended with other cereals and pulses for the preparation of traditional savories. In the present study, TKP used as a base with variety of spices to formulate instant chutney mix successfully improved the consistency of the chutneys together with enriching them with a variety of nutrients.

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Disclosure of potential conflict of interest

Conflict of Interest: The authors declare that they have no conflict of interest.

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