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Physical Properties of Green Gram and Tamarind Kernel and Analysis of Functional Properties of Composite Flours Incorporating Tamarind Kernel Powder

Swati Shukla[1], Pratima Awasthi[2]

[1]Research Scholar, Department of Food and Nutrition, College of Home Science, G.B. Pant University of Agriculture and Technology, Uttarakhand, India- 263145

[2]Professor, Department of Food and Nutrition, College of Home Science, G.B. Pant University of Agriculture and Technology, Uttarakhand, India- 263145

Abstract: ***Shift in dietary pattern and load on agriculture as a result of industrialization, demands incorporation of underutilized and otherwise considered waste agriculture crops into conventional crops that are nutritionally rich and health beneficial. The physical properties of grain and the functional properties of the flour plays an important role in determining the quality, physico-chemical characteristics as well as the further processing of the formulated product. In the present study, whole wheat flour, barley flour, malted green gram flour and tamarind kernel powder was taken to formulate composite flours. The whole green gram was found to have thousand kernel weight and thousand kernel volume of 40.57g and 26.33ml respectively with bulk density of 0.86g/cc. Tamarind kernel had average weight per seed and average volume per seed of 0.7g and 0.58cm^3 respectively. The water absorption capacity (285.3ml/g) and solubility index(21.9per cent) of tamarind kernel powder was highest whereas malted green gram flour had highest bulk density (0.86g/cm^3) and barley flour had highest swelling power (9.71g/g). In composite flours, the bulk density showed decrement whereas other parameters showed increasing trend. The present study emphasizes the flour combination that can be used for further product formulation ensuring reduced pressure on commercial crops with nutrient enhancement.***

Keywords: composite, malted green gram, tamarind, functional, physical

1. Introduction

Since past few decades, an increased urbanization and rapid industrialization has been witnessed that resulted in an increased consumption of snacks which are easy to access and convenient to consume. The most of such snacks including biscuits, crackers and breads have wheat as the vital ingredient leading to an increased pressure on its cultivation and commercialization. Also, various factors like market liberalization, food diversification have an impact on the food system and change in dietary pattern that has caused the emergence of array of diseases ranging from obesity and non communicable diseases (NCDs) to under nutrition that are prevalent and rising globally especially in developing nations. Encouragement to healthy food culture is necessary to alleviate such health related problems [20]. Therefore, fortification of whole wheat flour with other, non-wheat flours is now gaining importance due to its nutritious and a therapeutic benefit that simultaneously is also advantageous for agriculture sector as reduce dependency and pressure on wheat crop as well as encourages diversified farming of local crops [26].

Various researches have been done on the composite flour technology using various ingredients that are easily available, culturally acceptable and nutritionally adequate as well as impart acceptable functional and rheological properties for product formulation [5]. Composite flour technology is the mixing of variety of flours that may be cereal, legume or tuber with or without wheat flour- to economize the local crops with nutritional adequacy and acceptable product. Legumes are rich sources of essential amino acids and bioactive compounds and also possess the functional properties like oil absorption, water absorption, gelation and foaming capacity [10]. This makes legume a potential ingredient of composite flour as enhances the nutritional and functional quality of the basic wheat flour when mixed with starch sources like wheat, maize, barley and oats [11]. Green gram is a widely consumed pulse having high protein content, dietary fiber. Its malting even increases the bio availability of bio active compounds, minerals and reduces the anti nutritional factors like tannins and phytic acid [24]. Also, other member of Leguminaceae family is tamarind (*Tamarindus indica* L.) which is an evergreen tree that grows abundantly in the tropical regions of Asia. The tamarind kernel powder is mostly used in the textile and paper industry. Its utility in food industry is limited as an additive but it is a rich source of antioxidants and proteins comprising of some essential amino acids and also have proven to possess therapeutic benefits as well.

Barley is a cereal grain which is resistant to severe climatic conditions and can grow in temperate and tropical climate. Various studies have emphasized its nutritional, functional and therapeutic importance that ensures its blending with other flours. Its fortification with legume flours and wheat flour was found to have superior organoleptic properties for the resultant product been formulated [15]. The present study was conducted with the objective of determining the physical properties of whole green gram and tamarind kernel as well as to study the functional properties of whole wheat flour, barley flour, malted green gram flour and tamarind kernel powder along with the different combinations of composite flours.

2. Materials and Methods

Procurement of raw material

The whole wheat flour, barley flour, whole green gram grains and whole tamarind was procured from the local market of G.B. Pant University of Agriculture and Technology, Pantnagar, India. The tamarind kernel powder of food grade quality was supplied by Magic trade links, Ahmadabad, Gujarat, India. The malted green gram flour was prepared by soaking it in water for 10 hours followed its germination for another 10 hours. The germinated grains were dried in oven at 60˚C for 4 hours, followed by its dehulling and treatment in flour mill for obtaining the malted green gram flour.

Physical Properties of green gram

Various properties were estimated by standard methods. Thousand kernel weight of whole green gram was determined by weighing hundred sound grains, multiplied by a factor of 10 and expressed in grams [38]. Thousand kernel volume was measured by displacement method where thousand grains of green gram were put in a calibrated measuring cylinder and then, 25ml of water was poured. After firm shaking, seed volume was measured with subtraction of 25ml volume of water [38]. Hydration capacity was measured by keeping the pre weighed hundred green gram grains in a beaker and pouring 100ml of water. The beaker was kept for overnight. Afterwards, the remaining water was drained out and soaked grains were weighed and recorded.

$$\text{Hydration capacity} = \frac{\text{weight after soaking- before soaking}}{100}$$

Bulk density was calculated by method given by [25], where a calibrated graduated cylinder of 1000 ml was filled with kernels with the help of tapping, after that the contents of the cylinder were weighed. The bulk density of sample was expressed as g/cc. Pericarp color was analyzed with the help of Munsell Soil Color chart.

Physical properties of tamarind kernel

Physical parameters of tamarind seeds were analyzed as per the method prescribed by [7]. The size of the seed was measured by measuring length, breadth and thickness of 50 seeds using vernier calliper and expressed in millimeters. Average weight per seed was measured by weighing one hundred tamarind seeds and average weight per seed was expressed in grams. Average seed volume was evaluated by taking one hundred seeds in a calibrated measuring cylinder and filling with hexane up till no empty spaces are left. The average volume of seed is expressed in cm^3 as

$$\text{Volume per seed} = \frac{(V\text{-}V_1)}{100}$$

Where, V is the average volume of the tamarind seed (cm^3) and V_1 is the volume of hexane to fill the empty spaces (cm^3).

Formulation of composite flour blends

The experimental variations of the composite flour were prepared by using whole wheat flour, barley flour, malted green gram flour and tamarind kernel powder. The control flour consisted of whole wheat flour. The composite flour with variations in the proportion of individual ingredient were: CPI (WWF: BF: MGGF: TKP:: 30:20:15:35), CPII (WWF: BF: MGGF: TKP:: 30:20:20:30) and CPIII (WWF: BF: MGGF: TKP:: 30:20:25:25) as shown in Table 1.

Table 1: Proportion of ingredients in control flour and composite flours

Flours	*Ingredients*	*WWF*	*BF*	*MGGF*	*TKP*
Control		100	-	-	-
CPI		30	20	15	35
CPII		30	20	20	30
CPIII		30	20	25	25

*WWF: Whole wheat flour, BF: barley flour, MGGF: malted green gram flour, TKP: tamarind kernel powder

Functional Properties of flours and flour blends

Water absorption capacity was measured by the modification in the method given by [2] where one gram of flour sample was taken and 15ml of water was added. It was then centrifuged at 3250rpm for 25 minutes. The supernatant was removed followed by weighing the residue. The water absorption capacity was expressed in ml/gm. Bulk density was measured by pouring hundred gram of flour sample in a calibrated 100ml measuring cylinder and tapping gently on a surface until a constant volume was obtained. The bulk density was expressed in gm/ml [37]. Swelling capacity and solubility index was estimated by the method given by [34].One gram of flour sample was taken in centrifuge tube and 50ml of water was added. The slurry thus obtained after shaking was heated in water bath at 80˚C for 15 minutes with constant shaking. After this, it was rapidly cooled and centrifuged at 3000rpm for 10 minutes. The supernatant was decanted after centrifuging and the weight of the sediment was recorded. Dry matter of the gel was obtained by determining the moisture content of the sediments gel.

$$\text{Swelling Power} = \frac{\text{Weight of wet mass}}{\text{Weight of dry mass in gel}}$$

$$\text{Solubility index (\%)} = \text{Weight of dried solid} \times 100$$

3. Results and Discussion

Physical properties of whole green gram and tamarind kernel

The physical property of a grain is a determining factor of its quality categorization and utilization in further products accordingly. The physical properties also determine the milling procedure and characteristics of flour. Table 2 depicts the physical properties of green gram.

Table 2: Physical properties of green gram

Physical properties	*Whole Green Gram*
Thousand kernel weight(g)	40.57± 0.03
Thousand kernel volume (ml)	26.33±1.15
Bulk density (g/cc)	0.86±0.02
Hydration capacity (g)	0.069±0.003
Pericarp color	Dull Green (5Y 6/5)

The thousand kernel weight is an important attribute for analyzing the quality of the grain, its yield and its further milling procedure. In the present study, the thousand kernel weight of green gram was found to be 40.57g whereas thousand kernel volume was found to be 26.33ml. The thousand kernel weight of 52.3gm for green gram was reported by [19] which is higher than the present value and may vary according to variety, region and seasons as well. Also, various studies have reported the value of thousand kernel volume. The thousand kernel volume of 27.88 mm^3 as reported by [36] whereas the value of 30 mm^3 per seed for green gram grain by [6]. The bulk density of a grain is defined as the weight of a sample per unit volume which is dependent on the particle size as well as the moisture content of the sample. In the present study, the bulk density of green gram was observed to be 0.86g/cc which lies in the range of 0.67-1.2 gm/ml as observed by [9] as per the variation in the seed variety. The hydration capacity of the grain is its potential to hold the water and depends on the pore size, permeability and hygroscopic properties of the grain. The hydration capacity of the green gram was found to be 0.069g which was higher than the hydration capacity of value 0.049gm/seed among three varieties of green gram as obtained by [6]. The color of green gram grain was observed to be dull green according to standard Munsell soil color chart system that may vary as the characteristic of genetics and morphology of plant.

Physical properties of the tamarind Seeds

The physical property of tamarind kernels were estimated and depicted as in Table 3.

Table 3: Physical property of tamarind Seeds

Physical Parameters		*Values*
Average size	Length (mm)	13.67±1.09
	Breadth (mm)	11.55±1.17
	Thickness (mm)	5.43±2.02
Average weight per seed (gm)		0.72±0.35
Average seed volume (cm^3)		0.58±0.78

The analysis of physical parameters of tamarind kernel revealed that average length of tamarind seeds was found to have 13.67mm, average breadth was found to be 11.55mm and average thickness of 5.43mm.The average weight per seed was found to be 0.72g. The average seed volume of tamarind seed was found to be 0.58 cm^3 It was in accordance with the observations reported by [7] who reported the average length, breadth and thickness of 1.44cm, 1.05cm and 0.63cm respectively. Also, he reported the average weight per seed of 0.69gm and the seed volume of 0.48 cm^3 of tamarind seed.

Functional properties of the flours and flour blends

The functional properties are the fundamental physico-chemical properties that define the relationship between physical structure, composition, molecular structure as well as in interaction with other food groups. It can be defined in terms of physical, chemical or organoleptic properties of the food sample [13]. In the present study, the functional properties of individual flours and flour blends were analyzed. Table 4 shows various functional attributes of whole wheat flour, barley flour, malted green gram powder and tamarind kernel powder. The water absorption capacity (WAC) is defined as the amount of water absorbed per gram of the protein content of the sample so as to achieve the dough of desirable consistency. Optimum water absorption is necessary as high amount causes brittleness in the formulated product and low absorption capacity hinders the binding of the ingredients together. In the present study, the WAC of whole wheat flour was found to be 158.6ml/g which was higher than the findings reported by [14], who found the WAC of wheat flour to be 150ml/g. The WAC of barley flour was found to be 168ml/g which was non significantly higher than the WAC of wheat flour owing to high fiber content. The WAC ranging between 162-176ml/g among two varieties of barley flour was reported by [8].

The WAC of malted green gram flour was found to be 233.3ml/g which is significantly higher than the WAC of wheat and barley flour owing to high protein content as well as higher than the value of 213.2ml/g reported for sprouted green gram flour by [31]. Also, the WAC of tamarind kernel was found to be 285.3ml/g owing to higher protein content.

Bulk density of flour is an important factor for product designing where flours with high bulk density are preferred for food formulation whereas flours with low bulk density are required for powdered food items like soups [3]. In the present study, the bulk density of whole wheat flour was found to be 0.75 g/cm^3 and the bulk density of barley flour

be 6.34g/g, lower than range of 7.14-7.22 per cent reported by [18] due to increased solubility with increasing time period. The swelling power of tamarind kernel powder was found to be 9.69g/g and is in agreement with the value of swelling power ranging from 7.64-12.30 per cent [30]. The Solubility index is an indicator describing the amount of hydrophilic groups present in the food sample as well as the extent to which a molecule can be degraded upon addition of water [22]. The solubility index of whole wheat flour was found to be 5.76 per cent which is lower than the solubility index of 9.84 per cent as reported by [1] and the value of 6.02 per cent for wheat flour by [39]. The solubility index of barley flour was found to be 13.73 per cent which is higher than the solubility index range of 6.02-7.98 per cent as reported by [39]. The solubility index of malted

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Table 4: Functional properties of flours

Functional properties	*WWF*	*BF*	*MGGF*	*TKP*	*S.Em.*	*CD at 5%*
Water absorption Capacity (ml/g)	158.6± 0.57[ab]	168± 5.6[a]	233.3± 6.02[bc]	285.3± 5.0[c]	16.44	53.59
Bulk Density (g/cm^3)	0.75± 0.00[a]	0.53± 0.00[b]	0.86± 0.00[c]	0.57± 0.00[d]	0.329E-02	.107E-01
Swelling Power (g/g)	7.57± 0.09[a]	9.71± 0.36[b]	6.34± 0.46[c]	9.69± 0.01[b]	0.17	0.56
Solubility Index (%)	5.76± 0.30[a]	13.73± 0.47[b]	1.4± 0.25[c]	21.9± 0.26[d]	0.19	0.63

*All results are mean ± standard error for three replicates
*Different alphabets in superscript in each row show significant difference between values
* **W**hole wheat flour (WWF), barley flour BF), malted green gram flour (MGGF) and Tamarind kernel Powder (TKP)

was found to be 0.53g/cm^3. These values are lower than the value of 0.81g/ml for wheat flour and 0.79g/ml for barley flour as reported [29]. The bulk density of malted green gram flour was observed to be 0.86g/cm^3 which is higher than the bulk density value of 00.62g/ml [16]. This may be attributed to the difference in particle size as high bulk density indicates smaller particle size [28]. Also, the bulk density of tamarind kernel powder was found to be 0.57g/cm^3 which is significantly lower than other flours and may be attributed to larger particle size.

The swelling power of a flour is its ability to absorb water and expand in a given time and temperature. It signifies the intermolecular forces among the flour sample, amylase content [32] as well as depends on the particle size and variety. As depicted in Table 4, the swelling power of the whole wheat flour was found to be 7.57g/g which is in agreement with the swelling power of 7.50 per cent as reported by [14. The higher swelling power of 10.21 per cent was observed in wheat flour by [1]. The swelling power of barley flour was found to be 9.71g/g which was significantly higher than that of whole wheat flour and can be attributed to high content of dietary fiber and lies in the range of 2.91-21.03 per cent in barley flour [17]. Also, the swelling power of malted green gram flour was found to green gram flour was found to be 1.4 per cent as depicted in Table 4. The solubility index of 0.3-1.1 per cent in green gram that varied with the increase in temperature was reported by [33]. Also, the solubility index of tamarind kernel powder was found to be 21.9 per cent which is in accordance with the solubility index range of 8.02-21.82 per cent as observed by [30].

Functional properties of composite flours

The functional properties of composite flours CPI, CPII and CPIII are depicted in Table 5.

Water absorption capacity (WAC) in the present study, increased from CPI to CPIII with lowest WAC of 176.66ml/g for CPI and highest of 212.33ml/g if CPIII. Similar trend was observed in various studies [12] and [27] who reported that WAC increased with increase in protein content of the flour. This can be attributed to increased availability of hydrophilic regions in the flour as compared to whole wheat flour that attracts more water [40]. The bulk density showed a decrement with the increase in the proportion of other flours from 0.71g/cm^3 from CPI and 0.67g/cm^3 for CPIII composite flour.

Table 5: Functional properties of flour blends

Functional properties	*CPI*	*CPII*	*CPIII*	*S.Em.*	*CD at 5%*
Water absorption Capacity (ml/g)	176.66± 4.04[a]	200± 17.32[ab]	212.33± 11.54b	7.06	24.42
Bulk Density (g/cm^3)	0.71± 0.00[a]	0.70± 0.00[b]	0.67± 0.01[c]	0.005	.02
Swelling Power (g/g)	5.77± 0.2[a]	6.06± 0.07[ab]	6.25± 0.28[b]	0.128	0.44
Solubility Index (%)	13.16± 0.63[a]	13.63± 0.15[a]	14± 0.4[a]	0.25	0.882

*All results are mean ± standard error for three replicates
*Different alphabets in superscript in each row show significant difference between values
*Flour blends: CPI (WWF: BF: MGGF: TKP:: 30:20:15:35),
CPII (WWF: BF: MGGF: TKP:: 30:20:20:30) and CPIII (WWF:BF:MGGF:TKP:: 30:20:25:25**)**

This can be attributed to the increase in the proportion of flours with coarser particle size as well as the structure of starch polymer that may have cause reduction in the bulk density overall [21].

As shown in Table 5, the swelling power of the composite flour increased non significantly from CPI to CPIII with lowest value of 5.77g/g in CPI to 6.25g/g in CPIII composite flour. The similar trend was observed by [35], who observed decrease in swelling power with increase in proportion of soy flour due to the fact that high protein in flour reduces the process of starch gelatinization due to interaction of protein matrix with starch molecules [4]. Also, the solubility index was found to have an increment from CPI to CPIII with lowest of 13.16 per cent in CPI and highest value of 14 per cent in CPIII composite flour. Similar trend of increment in the solubility index from 17.52 per cent to 20.23 per cent was observed by [21].

4. Conclusion

The present study determined the physical properties of whole green gram grains, tamarind seed and functional characteristics of flours and composite flour blends. These properties define the processing and formulation of products and their respective characteristics. The combination of whole wheat flour with barley flour, malted green gram flour and tamarind kernel powder has been found to have the functional characteristics similar to those found by other studies been rich in various legume flours and can be helpful in product designing further that would be enriched with many nutrients as compared to the whole wheat flour as fortified with protein and fiber rich non-wheat flours. Also, this study ensures the better utilization of tamarind kernel powder which is otherwise considered a by-product and is discarded or used in non-food industries. Further studies on the nutritional composition and products formulation should be performed for elaborative research.

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