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Physico-chemical and nutritional characteristics of coarse cereal grains, *Tulsi* and their composite flours

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Abstract
The present investigation aims to evaluate the physico-chemical and nutritional characteristics of pearl millet, sorghum, oat, chickpea grains and *Tulsi* and their composite flours. Six types of composite flours were prepared. Three composite flours were prepared from blanched pearl millet: sorghum: dehusked oat: germinated chickpea in ratios of 80:5:5:10 (Type-I), 60:10:10:20 (Type-II) and 40:15:15:30 (Type-III) (W/W), three composite flours consisted of blanched pearl millet: sorghum: dehusked oat: germinated chickpea: *Tulsi* leaves in ratios of 80:5:5:5:5 (Type-IV), 60:10:10:15:5 (Type-V) and 40:15:15:25:5 (Type-VI) (W/W). The results revealed that chickpea grains had significantly (P<0.05) higher seed weight, seed volume and seed density as compared to other grains. Sedimentation value and water absorption capacity were significantly higher in sorghum and lower in chickpea flour. The protein content was significantly higher in chickpea and crude fat content was significantly higher in pearl millet than other grains. *Tulsi* leaves had significantly higher crude fibre and ash content. As the level of sorghum, oat and chickpea flour increased in composite flours, the crude protein, crude fibre and ash content increased, while, crude fat decreased. Supplementation of *Tulsi* leaves powder significantly (P<0.05) increased the ash and crude fibre content of composite flours.

Keywords: Coarse cereals, physico-chemical, nutritional, *Tulsi*, composite flour

Introduction
India is the largest producer of many kinds of coarse cereals which includes pearl millets, sorghum, oats, barley, finger millets, foxtail millet etc. These are largely grown in the semi-arid tropical regions of Asia and Africa, under rain-fed farming systems with little external inputs with grain yield levels being low (often less than 1 tonne/ha) (Rai *et al*., 2008) [13]. They form staple foods for a large segment of the population in the semi-arid tropics of Asia and Africa. Among these, pearl millet (*Pennisetum glucum*) and sorghum (*Sorghum bicolor moench* L.) are unique millets rich in dietary fibre, micronutrients and phytochemicals (Bouis, 2000) [4]. The coarse cereals and millets require more cooking time and have relatively poor digestibility and low availability of minerals due to presence of inherent anti nutritional factor which limit their uses in various food preparations. The food uses of these crops are very much restricted to traditional consumers. The nutritional and sensory qualities of millet products are limited by the deficiency of certain essential amino- acids, lower digestibility, presence of phenolic compounds, and coarse nature of grain and rapid development of rancidity of bitterness in the flour after milling. Efforts are needed to improve and optimize methods which could improve their acceptability and availability of nutrients. Soaking, germination, cooking and fermentation may be good choice in order to enhance the nutritional quality and utility of these grains. Oats (*Avena sativa* L.) products are well accepted in human nutrition compared with other grains. In terms of nutrition, oat contains high concentration of protein with beneficial amino acid composition, advantageous profile of fatty acids, with high amount of PUFA, excellent source of different dietary fibre, starch, phenolic compound, minerals, vitamins, and antioxidants. Moreover, β- glucans which also exhibit an antioxidant capacity, including the soluble dietary fibre fraction of oats that participate in glucoregulation and causes a decrease in serum cholesterol levels in humans (Butt *et al.*, 2008) [5]. Chickpea (*Cicer arietinum*) is a major pulse crop in India and accounts for more than 66% of total word production.

Chickpea is a good source of carbohydrate, mineral, protein and its protein quality is similar to or better than other legumes such as black gram and green gram. It is a cholesterol free pulse and is a good source of dietary fiber, vitamin and minerals (Jukanti *et al*., 2012) [9]. *Tulsi* (*Ocimum sanctum L.*) is highly complex, containing many nutrients and other biologically active compounds. It contains vitamin C and A, minerals like calcium, zinc and iron as well as chlorophyll and many other phytonutrients (Anbarasu and vijayyalakshmi, 2007) [3]. *Tulsi* enhances efficient digestion, absorption of nutrients from foods and it has been used from ancient times in *Ayurveda* due to its anti oxidant, anti inflammatory, anti bacterial and immune enhancing properties (Sah *et al*., 2018) [15]. Composite flour technology refers to the process of mixing various different coarse cereals with pulse flour and medicinal plant leaves to make economic use of local cultivated crops to produce quality food products. To improve the nutritive value and consumption of coarse cereals, supplementation with chickpea and *Tulsi* leaves is of paramount importance due to nutritional as well as health benefits. Therefore, the present study was done to assess the physico-chemical properties and nutritional composition of coarse grains, *Tulsi* and their composite flours.

Material and Methods

Procurement of material

Seeds of pearl millet (HHB-272) were procured from bajra section, sorghum (HJ-513) and oat (HJ-8) from forage section, chickpea (HC-5) from pulses section and *Tulsi* leaves at optimum maturity level were procured in a single lot from Medicinal, Aromatic and Underutilized Plant Section, Department of Genetics and Plant Breeding, College of Agriculture, CCSHAU. All the seeds were cleaned and made free of dust, dirt and foreign material prior to primary processing. Raw materials were stored in clean and hygienic condition for further use.

Processing of grains

Blanching of pearl millet was done by the process of Chavan and Kachare (1994) [6]. The grains were subjected to boiling water (1:5 ratio of seeds to boiling water) for 30 seconds and dried at 50°C for 60 minutes.

Grains of oats were dehusked. Chickpea grains were soaked in tap water for 12 h at 37 °C. Seed to water ratio of 1:5 (W/V) was used. The unimbibed seeds were discarded. The soaked seeds were germinated in sterile petri dishes lined with wet filter paper for 48 h at 37 °C with frequent watering. The sprouts were rinsed in distilled water and dried at 50-55°C. The *Tulsi* leaves (*Ocimum sanctum* L.) were trimmed in order to remove any dead or spoiled part. Then washed and dried at -50°C temperature using freeze dryer. The dried unprocessed samples of sorghum, dehusked oat, germinated chickpea and blanched pearl millet were ground to fine powder in an electric grinder and then stored in plastic containers at room temperature (32 °C).

Preparation of composite flours

Ground and blanched pearl millet, unprocessed sorghum, dehusked oat, germinated chickpea and dried *Tulsi* leaves were used to prepare composite flours. Six types of composite flours were prepared.

Three composite flours were prepared from blanched pearl millet: sorghum: dehusked oat: germinated chickpea in ratios of 80:5:5:10 (Type-I), 60:10:10:20 (Type-II) and 40:15:15:30 (Type-III) (W/W), Three composite flours consisted of blanched pearl millet: sorghum: dehusked oat: germinated chickpea: *Tulsi* leaves in ratios of 80:5:5:5:5 (Type-IV), 60:10:10:15:5 (Type-V) and 40:15:15:25:5 (Type-VI) (W/W). The resultant blends were passed through 60 mesh size sieve to obtain uniform mixing.

Determination of physico chemical and proximate composition

All the samples of unprocessed grains (pearl millet, sorghum, oat and chickpea) were assessed for physico-chemical properties i.e. seed weight, seed volume, seed density, sedimentation value and water absorption capacity. Seed weight was determined according to AACC (2000) [1] procedure. Seed volume was determined by using the water displacement method described by Phirke *et al.* (1982) [12]. Sedimentation value in was determined according to procedure given by Mishra *et al.* (1998) [10]. Water absorption capacity was determined by Sathe *et al.* (1981) [16].

All the samples of above grains and composite flours were also analyzed for proximate composition by employing the standard methods of analysis (AOAC 2012) [2]. Crude protein was estimated using micro-kjeldhal method using KEL PLUS Automatic Nitrogen Estimation System and a conversion factor of 6.25 was used to convert nitrogen into protein. Crude fat was determined by the soxhlet extraction method using Automatic SOCS plus Solvent Extraction System. Crude fibre was estimated by acid and alkaline digestion method using Automatic Fibra plus system. Statistical analysis of the obtained data was carried out using completely randomized design according to the standard method (Panse and Sukhatme, 1961) [11].

Results and Discussion

The data presented in table 1 indicated that chickpea grains had significantly (P<0.05) higher seed weight (16.17 g/100 seeds), seed volume (12.67 ml/100 seeds) and seed density (1.28 g/ml) as compared to other grains. The seed weight was 1.01, 2.19 and 3.59 g/100 seeds in pearl millet, sorghum and oat, respectively.

The results for 1000-grain weight in present study are consistent to those reported by Cheik *et al.* (2006) [7] and Jambamma *et al.* (2011) [8]. The seed volume of oat (5.00 ml/100 seeds) was significantly higher than that of sorghum (2.00 ml/100 seeds) and pearl millet (1.00 ml/100 seeds). Seed density ranged from 0.72 to 1.09 g/ml among oat, sorghum and pearl millet. Similar results were also reported by Sehgal and Kawatra (2002) [17].

The data presented in table 2 revealed that sedimentation value of different flours ranged from 7.33 to 15.33 ml and water absorption capacity ranged from 0.93 to 2.17 ml/g. Sedimentation value and water absorption capacity were significantly higher in sorghum and lower in chickpea flour. The values obtained are comparable to the results obtained earlier by Sikandra and Boora (2007) [19] and Sibian *et al.* (2013) [18].

The data pertaining to proximate composition of different grains and *Tulsi* leaves has been presented in table 3. The moisture content of *Tulsi* leaves was 86.35 per cent which was significantly higher than other grains. Sarfraj *et al*. (2011) [14] and Tewari *et al*. (2012) [20] also reported similar moisture content for *Tulsi* leaves. Sorghum grains (8.71%) had significantly higher moisture content than other grains, whereas moisture content did not differ significantly among pearl millet, oat and chickpea. The protein content was significantly higher in chickpea (20.27%) followed by oat

(12.40%), pearl millet (11.67%) and sorghum (10.21%). The protein content (1.02%) of *Tulsi* leaves was significantly lower. Crude fat content of pearl millet (5.97%) was significantly higher than other grains and *Tulsi* leaves (1.27%) had significantly lowest amount. Crude fibre content was observed to be significantly higher in *Tulsi* leaves (6.83%) followed by chickpea (4.23%), oat (3.53%), sorghum (1.87%) and pearl millet (1.53%).

The ash content was significantly higher in *Tulsi* leaves (9.65%), whereas, it ranged from 1.73 to 3.49 per cent among other grains. The data regarding proximate composition of composite flours has been presented in table 4. The moisture content of different combinations of composite flours ranged from 6.92 to 7.15 per cent, whereas, in *Tulsi* leaves powder supplemented composite flours it ranged from 7.82 to 8.10 per cent. The crude protein content of composite flours differs significantly and it increases as the level of chickpea flour increases. Maximum crude protein content was found in Type-III (14.15%) followed by Type-II (13.27%) and Type-I (12.54%). The values for crude protein content of the composite flours supplemented with *Tulsi* leaves powder showed significant (P<0.05) difference and it ranged from 11.43 to 13.13 per cent. A significant difference was observed in the fat content of different types of composite flours. The fat content of Type-I, Type-II and Type-III composite flour was 5.37, 4.75 and 4.10 per cent, respectively.

Fat content of Type-I composite flour was significantly (P<0.05) higher as compared to Type-II and Type-III composite flour. Crude fat content of *Tulsi* leaves powder supplemented composite flours varied significantly (P<0.05) from 4.00 per cent to 5.27 per cent. Highest amount of crude fat was found in Type IV composite flour and lowest in Type-VI composite flour. Different combinations of composite flours had significant (P<0.05) difference in crude fibre content. As pearl millet replaced with sorghum, oat and chickpea crude fibre content increased significantly (P<0.05) and being maximum (2.73%) at Type-III composite flour followed by Type-II (2.30%) and Type-I (1.93%) composite flour. Similarly, the same trend was observed in composite flours enriched with *Tulsi* leaves powder. Composite flour with combination of Type-VI showed significantly (P<0.05) higher crude fiber content. The crude fiber content of Type-IV, Type-V and Type-VI composite flours was 2.07 per cent, 2.47 per cent and 2.83 per cent, respectively. Ash content of Type-I, Type-II and Type-III, Type-IV, Type-V and Type-VI composite flours was observed as 2.07, 2.39, 2.46, 2.39, 2.68 and 2.87 per cent, respectively. Composite flours prepared from Type-III and Type-VI composition had significantly (P<0.05) higher amount of ash in their respective group. The ash content was found to be significantly (P<0.05) higher in *Tulsi* leaves powder based composite flours than unsupplemented composite flours.

Table 1: Physicochemical properties of grains

Grains	Seed weight (g/100 seeds)	Seed Volume (ml/100seeds)	Seed Density (g/ml)
Pearl Millet	1.01±0.05	1.00±0.00	1.01±0.05
Sorghum	2.19±0.02	2.00±0.00	1.09±0.01
Oat	3.59±0.10	5.00±0.00	0.72±0.02
Chickpea	16.17±0.06	12.67±0.17	1.28±0.02
CD (P≤0.05)	0.21	0.28	0.09

Values are mean ± SE of three independent determinations

Table 2: Physicochemical properties of flours

Flours	Sedimentation Value (ml)	Water absorption capacity (ml/g)
Pearl Millet	14.67±0.33	1.22±0.02
Sorghum	15.33±0.33	2.17±0.17
Oat	12.33±0.33	1.70±0.03
Chickpea	7.33±0.33	0.93±0.03
CD (P≤0.05)	1.10	0.29

Values are mean ± SE of three independent determinations

Table 3: Proximate composition of grains and *Tulsi* leaves (%, dry weight basis)

Grains	Moisture	Crude Protein	Crude Fat	Crude Fibre	Ash
Pearl Millet	6.83±0.26	11.67±0.15	5.97±0.07	1.53±0.03	1.95±0.02
Sorghum	8.71±0.11	10.21±0.15	1.70±0.03	1.87±0.03	1.73±0.06
Oat	6.73±0.05	12.40±0.15	3.92±0.02	3.53±0.07	3.15±0.01
Chickpea	6.85±0.08	20.27±0.14	2.77±0.04	4.23±0.03	3.49±0.06
Tulsi leaves	86.35±0.32	1.02±0.14	1.27±0.02	6.83±0.03	9.65±0.04
CD (P≤0.05)	0.62	0.46	0.13	0.14	0.14

Values are mean ± SE of three independent determinations

Table 4: Proximate composition of composite flours with and without *Tulsi* (%, dry weight basis)

Composite Flours	Moisture	Crude Protein	Crude Fat	Crude Fibre	Ash
Blanched Pearl Millet: Sorghum: Oat: Germinated Chickpea					
Type-I 80:5:5:10	6.93±0.13	12.54±0.15	5.37±0.04	1.93±0.09	2.07±0.06
Type-II 60:10:10:20	7.02±0.12	13.27±0.14	4.75±0.06	2.30±0.06	2.39±0.04
Type-III 40:15:15:30	7.15±0.11	14.15±0.15	4.10±0.09	2.73±0.08	2.46±0.04
Blanched Pearl Millet: Sorghum: Oat: Germinated Chickpea: *Tulsi* leaves Powder					
Type-IV 80:5:5:5:5	7.82±0.12	11.43±0.05	5.27±0.04	2.07±0.07	2.39±0.02
Type-V 60:10:10:15:5	8.00±0.06	12.40±0.15	4.68±0.16	2.47±0.06	2.68±0.04
Type-VI 40:15:15:25:5	8.10±0.04	13.13±0.00	4.00±0.03	2.83±0.03	2.87±0.04
CD (P≤0.05)	0.32	0.38	0.26	0.22	0.13

Values are mean ± SE of three independent determinations

Conclusion

It may be concluded from the present study that the physico-chemical properties are important from commercial point of view because they help to know the nature of developed product and development of composite flour from coarse cereals is nutritionally superior and addition of *Tulsi* leaves powder increased the ash and fibre contents of composite flours. Thus, consumption of *Tulsi* leaves in our daily diet helps in prevention of many diseases.

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