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Physico-chemical and Functional Characteristics of Selected Millets and Pulses

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Abstract

The physico-chemical and functional properties of selected millets (viz., kodo millet, little millet, proso millet and pearl millet) and pulses (viz., horse gram and soybean) were studied. Millets are good sources of energy, protein, fatty acids, vitamins, minerals, dietary fibre and polyphenols. Thousand grain weights of the selected millets was found to be high in pearl millet (11.39 g/100g) compared to kodo millet, proso millet and little millet (2.45, 2.43 and 2.23 g/100g, respectively) and in pulses the highest and lowest values were observed in soybean (146.03 g/100g) and horse gram (34.25 g/100g) respectively. Bulk density of millets and pulses was recorded to be high in pearl millet (1.75) and soybean (1.96) when compared to the other grains. Water absorption index was high in wheat flour (9.10%) while the water solubility index was high in pearl millet flour (9.62%) respectively. The protein content was maximum in proso millet (12.86 g/100g) and soybean (42.72 g/100g) followed by pearl millet, kodo millet, little millet and horse gram. Fat content was low in all the millets and it was maximum in soybean (18.80 g/100g). Among the four millets the fiber and ash contents were high in kodo millet followed by little, pearl and proso millet. Also higher levels of calcium, iron and phosphorus were observed in millets and pulses.

Keywords: Auditing, Data Dynamics, Data Storage Correctness, Mobile Cloud, Provable Data Possession, Trusted Third Party

1. Introduction

Millets are important foods in many underdeveloped countries because of their ability to grow under adverse weather conditions like limited rainfall. India has the largest millet producing country in the world with a total area of 23 million ha and small millets alone account for about 3.5 million hectare[1]. The major millets are pearl millet, foxtail millet, proso millet and finger millet. The most important minor millets cultivated in India are barnyard millet, kodo millet, little millet, guinea millet and browntop millet[2]. Millets are more nutritious and they are non-glutinous and non-acid forming and easy to digest.

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Millets are more nutritious and they are non-glutinous and non-acid forming and easy to digest. Millets are good sources of energy, protein, fatty acids, vitamins, minerals, dietary fibre and polyphenols. Millet proteins contain good sources of essential amino acids except lysine and threonine but have relatively high quantity of sulphur containing amino acids (methionine and cysteine). Millets are rich sources of phytochemicals, micronutrients and antioxidants, such as phenolic acids and glycated flavonoids[3]. Minor millets, with their low carbohydrate content, low digestibility and water soluble gum content (b-glucan) have been attributed to improve glucose metabolism. These grains release sugar slowly

in the blood and also diminish the glucose absorption[4]. The dietary fibre and resistant starch of minor millets have been attributed to exhibit hypoglycemic and hypolipidemic effects[5]. Further the antioxidative properties of minor millets against hyperglycemia and oxidative stress have also been studied, which is mainly determined by their higher reserves of phytochemicals like phenolics, tannins, phytates, and micro minerals etc6. Kodo millet (Paspalum scrobiculatum) is rich B vitamins especially niacin, pyridoxine and folic acid as well as the minerals such as calcium, iron, potassium, magnesium and zinc. It is also rich in fiber and low in fat content. It contains a high amount of lecithin and is an excellent for strengthening the nervous system. The fibre content of the whole grain is very high, low in fat content and has around 11 per cent protein. Little millet (Panicum sumatrense) is rich in fibre, iron and carotene content. Little millet has a significant role in providing nutraceutical components such as phenols, tannins and phytates along with macro and micro-nutrients[7]. Nutritionally, pearl millet (Pennisetum glaucum) is superior to major cereals with reference to energy value, high quality proteins (13.6%), fat (7.8%), crude fiber (2.8%), starch (63.2%), ash (2.1%) and minerals such as calcium, phosphorus, iron, zinc and certain vitamins. Besides, it is also a rich source of dietary fiber and micro nutrients[8]. Pearl millet was found to be significantly rich in resistant starch, soluble and insoluble dietary fibers and antioxidants[9]. Proso millet is rich in protein (11.6%), B vitamins especially vitamin B6 and folic acid and it was significantly richer in essential amino acids (leucine, isoleucine and methionine) than wheat protein[10]. Horse gram (Macrotyloma uniflorum) is an important source of protein (20%) and also rich in minerals such as calcium, phosphorus, iron, molybdenum and vitamins like thiamine, riboflavin, niacin and L-ascorbic acid[11]. Whole horse gram grains exhibit excellent prophylactic and curative effects of dietary fibre (soluble and insoluble fibre) and are extremely useful in the management of diabetes mellitus, atherosclerosis, colon cancer, ischaemic heart disease, gallstone, diverticulosis, hypertension and constipation[12]. Soybean (Glycine max) is an excellent source of good quality protein (43%) and is also rich in lysine and isoflavone which have the potential to reduce the levels of Low Density Lipoprotein (LDL) and total cholesterol levels in the blood[13]. Soybean protein has been found to reduce the risk of coronary heart disease and cancer[14]. Hence, the present study aims to assess the physicochemical and functional characteristics of the selected millets and pulses and its utilization for product formulation.

2. Materials and Methods

Whole wheat, kodo millet (CO3), little millet (CO6), pearl millet (COC9) and proso millet (COPV5) were collected from Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. Horse gram and soybean was collected from local departmental store.

3. Materials

3.1 Preparation of Flour

Millets and pulses were ground and sieved through BS No. 60 mesh sieve (British Sieve Standards) to obtain uniform particle size of the flour. The flour samples were defatted by solvent extraction process using petroleum ether (60 - 80°C) and dried at a temperature of 50°C for 5 hr in a hot air oven and after cooling packed in air-tight container.

3.2 Physical Characteristics of Millet and Pulse Flour

3.2.1 Thousand-Kernel Weight, Volume and Bulk Density

Millet and pulse samples were assessed for physical characteristics. Thousand grains were randomly selected from a well-mixed sample and weighed. The volume of 1000 grains was determined by oil displacement method. In brief, the grains were added to a known volume of oil in a graduated flask. The difference between the initial and final volume indicates the volume of the seeds. The ratio between the weights of 1000 grains to its volume was calculated as bulk density[15].

3.3 Functional Properties of Millet and Pulse Flour

3.3.1 Water Absorption Index and Water Solubility Index

Water Absorption Index (WAI) and Water Solubility Index (WSI) were studied by the method described by Anderson et al.[16].

WAI and WSI of the flours were determined in triplicate. The flour sample (2.5 g) was dispersed in 30 mL of distilled water, using a glass rod, and cooked at 90^{0}C for 15 min in a water bath. The cooked paste was cooled to room temperature and transferred to centrifuge tubes, and then centrifuged at 3000 rpm for 10 min. The supernatant was decanted into a tarred evaporating dish and the sediment was weighed. The weight of dry solids in supernatant was determined by evaporating the supernatant at 110^{0}C. WSI (g /100g) and WAI (g /100g) were calculated as per the equation 1 and 2 respectively.

$$WAI = \frac{\text{Weight of the sediment}}{\text{Weight of the flour sample}} \quad \text{Equation----1}$$

$$WSI = \frac{\text{Weight of dissolved solids in the supernatant}}{\text{Weight of the flour}} \times 100 \quad \text{Equation 2}$$

3.3.2 Water Absorption Capacity

Water Absorption Capacity (WAC) of flours was measured by the centrifugation method described by Sosulski and Garratt[17]. The sample (3.0 g) was dispersed in 25 mL of distilled water and placed in preweighed centrifuge tubes. The dispersions were stirred, held for 30 min, followed by centrifugation for 25 min at 3000 rpm. The supernatant was decanted, excess moisture was dried at 50^{0}C for 25 min and the sample was reweighed after cooling. The average values of three replicates were reported.

3.3.3 Oil Absorption Capacity

Oil Absorption Capacity (OAC) of flour was measured by the centrifugation method described by Lin and Humbert[18]. One gram of sample was mixed with 6ml of oil in pre-weighed centrifuge tubes. The contents were stirred for 1 min with a thin brass wire to disperse the sample in the oil. After a holding period of 30 min, the tubes were centrifuged for 25min at 3000 rpm. The separated oil was then removed with a pipette and the tubes were inverted for 25 min to drain the oil prior to reweighing. The average values of three replicates were reported. The WAC and OAC were expressed as grams of water or oil bound per 100g (g 100g^{-1}) of the sample on a dry basis.

4. Colour Value of Millet and Pulse Flour

Colour measurements (L∗ a∗ b∗ values) of the millet and pulse flour was determined using a Lovibond Tintometer (Model # Lovibond RT 100) with the Lovibond RT Colour software (Version 3.0). Before measuring the colour

of the samples, the instrument was standardized by placing black and white standard plates and L, a and b colour values were recorded. The deviation of the colour of the samples to standard were observed and recorded in the computed interface. L ∗values correspond to lightness/ darkness and extend from 0 (black) to 100 (white) with higher values corresponding to more lightness. The a∗ and b∗ values correspond to an object's color dimensions, with a ∗ values describing a sample's red (+a) to greenness (-a), while b∗ values describe a sample's yellow (+b) to blueness (-b). Larger a∗ values indicate more redness and larger b∗ values indicate more yellowness.

5. Proximate Composition of Millets and Pulses

All samples were analyzed for contents of moisture (Hot air oven drying method), protein, fat, ash[19], fiber[20], starch[21] and amylose[22]. Minerals viz., calcium, phosphorus and iron were analyzed by dry ashing method. Calcium, magnesium was determined by the method described, Jackson[23], iron, zinc and copper were determined by the method described by Lindsay and Norvell[24] and phosphorus was determined by the method described by Piper[25].

6. Result and Discussion

6.1 Physical Parameters of Millets and Pulses

The physical parameters like thousand grain weight, seed volume and bulk density were assessed and the results are presented in Table 1. The maximum thousand grain weight was observed in pearl millet (11.39 g/100g) and soybean (146.03 g/100g) followed by kodo millet (2.45 g/100g), proso millet (2.43 g/100g), little millet (2.23 g/100g) and horse gram (34.25 g/100g).

The maximum seed volume was observed in pearl millet (6.46 ml) and soybean (110.80 ml) followed by proso millet (2.65 ml), kodo millet (2.15 ml), little millet (1.48 ml) and horse gram (31.70 ml). Pearl millet and soybean had the highest bulk density followed by other millets and pulses.

6.2 Functional Properties of Millets and Pulses

Water Absorption Index (WAI), Water Solubility Index (WSI), Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC) of selected millet and pulse flours were presented in Table 2.

6.2.1 Water Absorption Index (WAI)

The water absorption index measures the volume occupied by the starch after swelling in excess water, which maintains the integrity of starch in aqueous dispersion. Results showed that highest WAI was observed in wheat flour (9.10 g/100g) when compared with millet and pulse flour and the lowest for horse gram flour (5.47 g/100g).

6.2.2 Water Solubility Index (WSI)

The swelling power and solubility of starch granules showed a great evidence of interaction on the starch chains between the amorphous and crystalline regions. When starch was subjected to heating in excess water, there is a relaxation of the crystalline structure and the groups of amylose and amylopectin associate with water molecules through hydrogen bonding. This causes an increase in the swelling power and the solubility of the granules26. Water solubility index as related to the presence of soluble molecule, for the millet flours ranged from 6.16 to 9.62 g/100g and 7.28 to 7.72 g/100g in pulse flour. Results showed that the WSI was highest for pearl millet flour (9.62 g/100g) and horse gram flour (7.72 g/100g) followed by other millet and pulse flours.

6.2.3 Water Absorption Capacity (WAC)

The water absorption capacity of millet flours ranged from 74.08 to 76.83 ml/100g and the data projected for water absorption revealed that the water absorption capacity were maximum in wheat flour (78.80 ml/100g) when compared to millet flour and minimum in soybean flour (58.17 ml/100g).

6.2.4 Oil Absorption Capacity (OAC)

The oil absorption capacity of millet flours ranged from 73.58 to 85.57 ml/100g and 80.95 to 82.36 ml/100g in pulse flour. Wheat flour showed the highest oil absorption capacity (87.27 ml/100g) while proso millet flour had minimum oil absorption capacity (73.58 ml/100g).

6.3 Colour Index of Millet and Pulse Flour

Measurement of colour (L, a, b) of different millet and pulse flour are shown in Table 3. The varietal differences were observed for various Hunter colour parameters. Millet and pulse flour showed the highest L value indicating its lighter colour, negative a value, which indicated a slight green tint in them and highest b value indicating its comparatively darker and yellow colour. Colour changes gives information about the extent of browning reactions such as caramalization, maillard reaction and degree of cooking and pigment degradation that take place during the starch extraction process[27].

6.4 Chemical Composition of Millets and Pulses

The chemical composition of selected millets and pulses are given in Table 4 and 5. The maximum moisture content of selected millets ranged from 11.46 to 11.83 g/100g and lowest in soybean 9.28 g/100g followed by horse gram (10.82g/100g). Kulkarni and Naik[28] reported that proso millet recorded a high moisture content ranging from 10.60 to 15.00 per cent, followed by little, foxtail and kodo millet with values of 10.7, 11.5 and 10.2 per cent, respectively. Among the millets the protein content was recorded to be high in proso millet 12.86 g/100g followed by pearl millet (11.84 g/100g), wheat (12.71 g/100g), kodo millet (8.94 g/100g) and little millet (8.66 g/100g). Among the pulses the soybean and horse gram recorded 42.72 and 21.25 g/100g respectively. The average protein content in proso, little, kodo and foxtail millet were reported to be about 8.5, 9.5, 8.8 and 11.07 per cent respectively, with varietal differences within species as reported by several investigators[29]. Among the millets and pulses the lowest fat content was observed to be 1.34 g/100g in kodo millet and horse gram contained 0.82 g/100g followed by other millets and pulses. Kumar and Parameshwaran[30] found that foxtail millet recorded a fat content ranging from 2.3 to 5.9 per cent, followed by proso (2.1 to 5.2%), little (3.10 to 4.1 %) and kodo millet (1.1 to 3.3%).

Table 1. Physical characteristics of selected millets and pulses

Millets & Pulses	Seed weight (g/1000 grain)	Seed Volume (ml/1000 grain)	Bulk density (w/v)
Kodo millet	2.45 ± 0.03	2.15 ± 0.01	1.56 ± 0.02
Little millet	2.23 ± 0.02	1.48 ± 0.06	1.65 ± 0.05
Pearl millet	11.39 ± 0.19	6.46 ± 0.06	1.75 ± 0.01
Proso millet	2.43 ± 0.09	2.65 ± 0.04	1.65 ± 0.06
Horse gram	34.25 ± 1.17	31.70 ± 0.31	1.53 ± 0.01
Soybean	146.03 ± 6.18	110.80 ± 4.59	1.96 ± 0.03

Results are Mean ± SD of three determinations

Table 2. Functional properties of selected millets and pulses.

Millets & Pulses	Water absorption index (g/100 g)	Water solubility index (g/100 g)	Water absorption capacity (ml/100g)	Oil absorption capacity (ml/100g)
Kodo millet flour	8.27 ± 0.31	9.08 ± 0.28	74.93 ± 2.86	74.74 ± 3.00
Little millet flour	8.72 ± 0.15	6.68 ± 0.21	76.83 ± 3.38	84.36 ± 3.27
Pearl millet flour	8.25 ± 0.30	9.62 ± 0.35	74.08 ± 1.78	85.57 ± 3.00
Proso millet flour	7.40 ± 0.32	6.16 ± 0.13	75.30 ± 3.25	73.58 ± 2.18
Horse gram flour	5.47 ± 0.14	7.72 ± 0.52	64.83 ± 1.81	80.95 ± 1.93
Soybean flour	6.34 ± 0.21	7.28 ± 0.59	58.17 ± 2.46	82.36 ± 2.50
Wheat flour	9.10 ± 0.42	3.40 ± 0.07	78.80 ± 3.26	87.27 ± 3.87

All data are the Mean ± S.D of three replicates

Table 3. Colour value of selected millets and pulses

Millets and pulse flour	Colour		
	L*	a*	b*
Kodo millet flour	117.75 ± 3.03	-6.25 ± 0.05	12.40 ± 0.47
Little millet flour	121.23 ± 2.79	-6.29 ± 0.04	11.13 ± 0.48
Pearl millet flour	103.94 ± 4.40	-3.26 ± 0.04	37.97 ± 1.54
Proso millet flour	126.62 ± 1.70	-6.67 ±0.07	31.10 ± 1.33
Horse gram flour	118.00 ± 4.67	-6.53 ± 0.06	39.01 ± 1.74
Soybean flour	106.51 ± 1.92	-6.21 ± 0.03	12.17 ± 0.39
Wheat flour	129.53 ± 5.49	-5.52 ± 0.01	29.48 ± 0.89

Among the millet and pulses the highest fibre content was recorded in kodo millet (9.95 g/100g) and horse gram (5.64 g/100g) followed by other millet and pulses. Crude fibre content reported in kodo millet was 6.3 per cent, little millet was 5.73 per cent and proso millet was 5.51 per cent[31]. The highest starch content of millet and pulses was recorded in kodo millet (58.45 g/100g) and horse gram (28.62 g/100g) and lowest starch content was observed in little millet (55.84 g/100g) and soybean (16.27 g/100g). Kim et al.32 evaluated the amylose content of proso millet to be between 1.2 and 21.5 per cent. Starch content ranged from 84.4 to 85.67 per cent respectively. Higher levels of calcium iron and phosphorus was observed in all millets and pulses. It was inferred that

Table 4. Chemical characteristics of selected millets and pulses (g/100g)

Millets & Pulses	Moisture (%)	Protein (g)	Fat (g)	Crude fiber (g)	CHO (g)	Starch (g)	Amylose (g)	Amylopectin (g)	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)	Ash (g)
Kodo millet	11.72 ± 0.23	8.94 ± 0.41	1.34 ± 0.04	9.95 ± 0.36	63.62 ± 2.61	58.45 ± 1.13	25.75 ± 0.90	32.74 ± 0.63	0.76 ± 0.02	1.03 ± 0.02	1.89 ± 0.04	3.3 ± 0.04
Little millet	11.83 ± 0.43	8.66 ± 0.38	4.92 ± 0.01	7.73 ± 0.25	64.51 ± 2.79	55.84 ± 1.14	20.47 ± 0.11	35.46 ± 1.06	0.82 ± 0.02	1.65 ± 0.05	2.67± 0.07	2.9 ± 0.04
Pearl millet	11.46 ± 0.40	11.84 ± 0.30	4.30 ± 0.04	2.25 ± 0.19	65.56 ± 2.36	56.82 ± 1.18	22.18 ± 0.39	34.74 ± 0.68	0.73 ± 0.02	1.96 ± 0.01	2.79 ± 0.02	2.9 ± 0.07
Proso millet	11.75 ± 0.12	12.86 ± 0.47	3.78 ± 0.01	4.87 ± 0.29	64.84 ± 2.45	56.48 ± 1.21	28.53 ± 0.10	27.92 ± 0.59	0.87 ± 0.01	0.92 ± 0.01	1.83 ± 0.05	2.4 ± 0.03
Horse gram	10.82 ± 0.33	21.25 ± 0.67	0.82 ± 0.01	5.64 ± 0.33	52.27 ± 2.16	28.62 ± 1.11	12.46 ± 0.20	16.25 ± 0.25	0.82 ± 0.02	4.00 ± 0.09	4.89 ± 0.21	3.1 ± 0.01
Soybean	9.28 ± 0.25	42.72 ± 1.78	18.80 ± 0.35	4.90 ± 0.23	22.86 ± 1.01	16.27 ± 0.12	11.87 ± 0.13	4.47 ± 0.12	2.38 ± 0.01	2.00 ± 0.07	4.58 ± 0.15	4.8 ± 0.06
Wheat	11.74 ± 0.29	12.71 ± 0.24	1.45 ± 0.06	1.72 ± 0.03	68.56 ± 3.31	67.65 ± 1.53	31.11 ± 0.56	36.57 ± 0.85	0.93 ± 0.03	2.23 ± 0.07	3.16 ± 0.08	1.6 ± 0.02

Results are Mean ± SD of three determinations

Table 5. Mineral content of selected millets and pulses (mg/100g)

Millets & Pulses	Calcium (mg)	Iron (mg)	Phosphorus (mg)	Magnesium (mg)	Manganese (mg)	Sodium (mg)	Potassium (mg)	Copper (mg)	Zinc (mg)
Kodo millet	31.83 ± 0.83	3.85 ± 0.13	164.43 ± 3.73	132.47 ± 2.72	1.42 ± 0.06	4.37 ± 0.04	136.43 ± 5.26	2.15 ± 0.01	1.37 ± 0.05
Little millet	16.75 ± 0.18	7.63 ± 0.12	208.21 ± 3.37	123.52 ± 3.67	1.05 ± 0.04	9.68 ± 0.22	115.27 ± 4.41	1.75 ± 0.05	2.83 ± 0.01
Pearl millet	39.63 ± 1.06	9.60 ± 0.17	256.42 ± 6.23	128.46 ± 2.77	3.36 ± 0.02	12.24 ± 0.39	287.51 ± 12.70	1.47 ± 0.06	2.49 ± 0.07
Proso millet	14.76 ± 0.64	1.54 ± 0.04	208.63 ± 5.28	146.51 ± 3.30	1.27 ± 0.02	8.97 ± 0.19	98.68 ± 3.02	2.26 ± 0.08	2.63 ± 0.08
Horse gram	295.32 ± 3.19	6.94 ± 0.16	298.72 ± 8.88	165.34 ± 2.16	3.92 ± 0.12	16.65 ±0.69	367.73 ± 13.91	2.47 ± 0.02	3.47 ± 0.14
Soybean	197.50 ± 2.66	9.42 ± 0.23	672.81 ± 15.16	163.57 ± 2.52	4.76 ± 0.12	2.28 ± 0.04	43.68 ± 1.95	2.18 ± 0.09	4.76 ± 0.02
Wheat	30.32 ± 0.98	3.50 ± 0.06	105.75 ± 3.91	137.63 ± 2.37	3.35 ± 0.02	15.72 ± 0.54	293.25 ± 12.42	1.19 ± 0.04	1.86 ± 0.08

All data are the Mean ± S.D of three replicates

that among the different millets, kodo millet had the highest proportion of total minerals (4.9%) and lowest was recorded in foxtail millet (1.4%). The ionisable iron content was 1.47, 1.50, 0.55, 10.76 and 1.38 mg in proso, kodo, Italian, little and barnyard millet respectively. Similar range of values for iron and calcium in barnyard millet viz., 1.27 to 1.50 mg, and 20.31 to 32.78 mg/100 g respectively was reported by Veena et al.[29].

7. Conclusion

This investigation concluded that all millets and pulses contained good sources of protein, fibre and minerals and had low fat content. Hence various innovative products may be developed to suit the consumer needs and also to achieve nutrition security.

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