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Studies on physicochemical properties of cereals (Rice, sorghum, finger millet, amaranth) and Pulses (Green gram, black gram and chickpea)

SS Bhosale, BS Agarkar, RB Kshirsagar and BM Patil

Abstract
This study has investigated the comparative relation between physical properties (bulk density, true density, porosity, 1000-kernel weight and angle of repose) and chemical constituents (moisture, protein, fat, carbohydrate and ash content) of selected cereals (rice, sorghum, finger millet, amaranth) and pulses (green gram, black gram and chickpea). Each grain has their own nutritional profile, hence combining two or more grains and pulses may add additional nutrients in the final product. In view of nutritional and health benefits of different cereals and pulses are used because sorghum, millet grains and pulses contain substantial levels of a wide range of phenolic compounds, health-promoting properties [reduces the risk of cardiovascular disease, some cancers (colon, breast and prostate) and also helps to manage body weight due to its satiety value], antioxidant activities, and their use as nutraceuticals and functional foods. Physical properties, Nutritional composition and health benefits of selected cereals and pulses are summarised in the current research.

Keywords: Rice, sorghum, finger millet, amaranth, green gram, black gram, chick pea, physical properties, chemical composition, minerals

Introduction

Rice (*Oryza sativa* L.) is a major staple food, especially in Asia. However, starch, as the main component of rice (72% to 82% dry weight), has shown to impart high glycemic index (GI) associated with health issues including obesity and cardiovascular disease. Rice is one of the leading food crops and sustains two-third of the world's population providing 20% of the world's dietary energy supply.

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the important staple food crops in the semi-arid regions of sub- Saharan Africa and India. Sorghum is commonly called as jowar or great millet and it is primarily produced in Maharashtra and southern states. It is a potential source of energy and provides about 349 Kcal/100g and gives 72.6% of carbohydrates (Gopalan *et al*., 1996) [8]. Sorghum does not contain gluten hence it becomes an ideal gluten free energy source.

Finger millet, [*Eleusine coracana* (L.)], is a cereal grown for food in Africa and southern Asia. Finger millet grain is usually converted into flour and made into cakes, bread and other bakery products, or malted and used as a nourishing food for infants. The sprouted seeds are also nutritious and easily digestible. Compared to other cereals, finger millet grains also have a relatively higher content of minerals such as calcium, phosphorus, iron and manganese.

Green gram *(Vigna radiata* (L.) Wilczek) is a legume widely grown and consumed in South East Asia. The mung bean is commonly known in Asia as the green gram. It is an excellent source of digestible protein, with a higher lysine content than any other legume, and is free from factors that cause flatulence. Mung bean contains 26.4g protein, 0.72g non-protein nitrogen, 4.5g ash, 1.75g fat, 6.15 crude fiber, and 61.2g carbohydrates in 1005 on dry weight basis. The green gram is a source of protein, carbohydrates, amino acids and minerals. Green gram-based products are used for diabetic patients, children, aged people because it is easy for digestion.

The chickpea (*Cicer arietinum* L.) is an annual legume of the family Fabaceae, subfamily Faboideae. It is one of the world's most important legume crops as it contains approximately 50% available carbohydrate it is in the form of starch, and is considered to be a good source of (Paul & Southgate, (1978) [17].

Black gram (*Vigna mungo* L.) originated in India. It is an annual pulse grown mostly as a

follow crop in rotation with cereals. It is mostly cultivated in Maharashtra, UP, AP, Orissa, Tamil Nadu, Rajasthan, Chhattisgarh and Madhya Pradesh. Black gram is perfect combination of all nutrients, which includes proteins (23%), carbohydrates (51%), fat (1.7%), ash (3.17%), zinc (3.00mg), iron(5.97mg) and calcium (55.64mg). It stands next to soybean in its dietary protein content (Anjali and Varsha Rani, 2018) [2]. Amaranth is good source of protein, soluble fibre, calcium, iron, magnesium, zinc, vitamin A, C and several B vitamins. Flavonoids (such as rutin and some phenolic acids as gallic acid, p-Hydroxybenzoic acid and vanillic acid) with anti-oxidant effects also occur in amaranth seeds and sprouts. Amaranth is gluten-free and easy to digest. The health benefits attributed to amaranth include decreasing plasma cholesterol levels protecting the heart, stimulating the immune system, exerting an anti-cancer activity, reducing blood glucose levels and improving conditions of hypertension and anemia.

Materials and Methods

Materials

Raw material like rice, chickpea, finger millet, etc. was procured from the local market of Parbhani. Chemical and reagent were obtained from laboratory, Department of Food Engineering, College of Food Technology, VNMKV, Parbhani.

Physical properties

Thousand Kernel weight

One thousand kernels will be counted and weighed by a digital weighing balance in three replication and mean value will be recorded.

Thousand Kernel volume

Volume will be calculated by measuring cylinder and the amount of kerosene displayed by 1000 kernels (Dutta *et al.*, 1988) [7].

Bulk Density

25 g of sound selected raw materials will be weighed on the digital weighing balance and filled into the measuring cylinder earlier filled with reference solution of kerosene or toluene. The increase in the level of liquid will be measured after adding the grains. It is bulk density represented in g/L (Dutta *et al.*, 1988) [7].

$$\text{Bulk Density} = \frac{\text{wt. of grains}}{\text{Volume display}}$$

True Density

25 g of will be filled into the measuring cylinder and volume occupied by them will be measured. It will be then calculated by following formula and represented in g/ml (Rooney *et al.*, 1982) [20].

$$\text{True Density} = \frac{\text{Weight of grains}}{\text{Volume occupied}}$$

Angle of Repose

Angle of repose will be determined using a method described by (Mohsenin 1986) [13].

Color

The color of cereal and pulses will be determined visually and will be evaluated by matching the samples with a Munsell colour chart (1957). The values are reported in Munsell notations for hue, value, and chroma (Rooney *et al*. 1980) [20].

Proximate analysis

Proximate analysis will be carried out for raw materials as well as for anti-stress extruded product by following methods. Proximate composition *viz.*, moisture, crude protein, ash, fat and crude fibre contents will be determined according to standard procedure of AOAC (1990) [3], AACC (1995).

Moisture

The moisture content of oats, millets, porridge mix will be determined by oven drying at 135ºC for 4 h until the moisture content comes to constant point (AOAC Method 44-19, 1990) [3].

$$\text{Moisture \%} = \frac{\text{Initial weight} - \text{final weight}}{\text{Total weight of the}} \text{ X } 100$$

Ash content

Ash will be estimated by direct incineration of sample; igniting it in a Muffle Furnace at 550°C till greyish white residue (AACC, (2000); Method No. 08-01).

Protein content

Protein content will be determined by using Micro Kjeldhal Apparatus as described in AACC (2000).

Fat content

Total fat content will be determined using hexane as a solvent in soxhlet apparatus as per the procedure given in AACC (2000) Method No. 30-25.

Crude fiber content

Crude fiber was determined by following the method No. 32-10 as described in (AACC.2000).

Total Carbohydrates

difference method: Carbohydrates =100 – % (Moisture + Fat + Protein + Ash + Crude fiber).

Mineral contents

The sample will be analyzed for its mineral profile following AOAC (2000).

Results and Discussion

Physical properties of selected cereals

The physio-chemical characteristics of raw material significantly affect the quality of finished product. Importance of studying physical properties is considered as the basic data in designing the machinery and equipment used during the harvesting and in the post harvesting operations. Importance of these properties in determining the size of the machines particularly that of the separation, transfer, and sorting equipment. The understanding of physical quality attributes is critical in determining the consumer acceptability of product.

Different physical properties such as colour, true density, bulk density, porosity, 1000 kernel weight, angle of repose were evaluated, and results obtained are presented in Table No. 1.

Table 1: Physical properties of selected cereals

Ingredients	Mean values (physical parameters					
	Colour	1000 kernel weight (g)	Bulk density (g/cm^3)	True density (g/cm^3)	Porosity (%)	Angle of Repose (degree)
Rice	White	16.23	0.8	1.52	47.4	34.63
Sorghum	Yellow	29.98	0.79	1.44	45.2	26.73
Finger millet	Brown	3.7	0.86	1.37	37.3	29.15
Amaranth	Pale cream	0.57	0.68	1.12	39.3	27.53

The data given in Table No.1 revealed various physical characteristics of cereals such as colour is an important characteristic for determining the visual acceptance. The colour of raw rice, sorghum, finger millet and amaranth were found to white, yellow, brown, and pale cream respectively. The 1000 kernel weight of rice, sorghum, finger millet and amaranth were found 16.23g, 29.98g, 3.7g, and 0.57g, respectively.

Bulk density, true density, porosity, and angle of repose of rice were found to be 0.8 g/cm^3, 1.52 g/cm^3, 47.4% and 34.63º, respectively. Results reported on physical properties of rice are in close agreement with Prashant N. Ghadge and K. Prasad (2012) [9].

Bulk density, true density, porosity, and angle of repose of sorghum were found to be 0.79g/cm^3, 1.44 g/cm^3, 45.2% and 26.73º, respectively. Results reported on physical properties of sorghum are in close agreement with Shashikumar, G. S. Kumaran *et al*. (2018) [22].

Bulk density, true density, porosity, and angle of repose of finger millet were found to be 0.86g/cm^3, 1.37 g/cm^3, 37.3% and 29.15º, respectively. Results reported on physical properties of finger millet are in close agreement with Shonisani R., *et al*. (2017) [23].

Bulk density, true density, porosity, and angle of repose of amaranth were found to be 0.68g/cm^3, 1.12 g/cm^3, 39.3% and 27.53º, respectively. Results reported on physical properties of amaranth are in close agreement with Sangeeta and R. B. Grewal (2018) [21].

Physical properties of selected pulses

Physical properties of selected pulses are carried out and presented in Table No. 2.

Table 2: Physical properties of selected pulses

Ingredients	Mean values (physical parameters					
	Colour	1000 kernel weight (g)	Bulk density (g/cm3)	True density (g/cm3)	Porosity (%)	Angle of repose (degree)
Green gram	Green	37.35	0.71	1.16	38.8	33.25
Chickpea	Brown	117.96	0.82	1.4	41.5	21.66
Black gram	Black	42.18	0.69	1.1	37.3	27.93

As shown in the above table the colour of the green gram, chickpea, black gram was green, brown, and black respectively. The 1000 kernel weight recorded as 37.35g, 117.96g and 42.18g, respectively.

Bulk density, true density, porosity, and angle of repose of green gram were found to be 0.71 g/cm^3, 1.16 g/cm^3, 38.8% and 33.25º, respectively. Results reported on physical properties of green gram are in close agreement with Ravi P., Tirupathi V. *et al*. (2017).

Bulk density, true density, porosity, and angle of repose of chickpea were found to be 0.82g/cm^3, 1.4 g/cm^3, 41.5% and 21.66º, respectively. Results reported on physical properties of chickpea are in close agreement with Laxmikanth, Sushilendra, *et al*. (2020).

Bulk density, true density, porosity, and angle of repose of black gram were found to be 0.69g/cm^3, 1.1 g/cm^3, 37.3% and 27.93º, respectively. Results reported on physical properties of black gram are in close agreement with Rajni Modgil, *et al*. (2019) [19].

Chemical composition of selected cereals

In the present investigation it was important to analyse the chemical properties of all the selected cereals and pulses used to prepare the multigrain chakli to study the nutritional and chemical changes in the final product. Chemical analysis of cereals including moisture, protein, crude fibre, fat was determined by standard AOAC 2000 method. The chemical composition of raw material (cereals) was carried out and the obtained results are tabulated in Table No. 3.

Table 3: Chemical composition of selected cereals

Ingredients	Mean values (Chemical parameters)					
	Moisture (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Fiber (%)	Ash (%)
Rice	11.27±0.25	7.88±0.26	0.81±0.20	78.63±0.03	0.7±0.1	0.69±0.31
Sorghum	10.12±0.13	10.24±0.07	1.66±0.14	72.87±0.22	2.91±0.04	2.04±0.41
Finger millet	9.88±0.28	8.36±0.07	1.03±0.02	73.41±0.94	4.7±0.44	2.5±0.05
Amaranth	9.17±0.06	14.14±0.03	3.16±0.05	69.52±0.18	2.1±0.02	1.9±0.12

From the above table we revealed that moisture content, protein, fat, carbohydrate, fiber, ash of rice was 11.27%, 7.88%, 0.81%, 78.63%, 0.7% and 0.69%, respectively. These values recorded as proximate composition of rice was found to be matched with Deepak K. V. and Prem P. S. (2017).

Moisture content, protein, fat, carbohydrate, fiber and ash content of sorghum was 10.12%, 10.24%, 1.66%, 72.87%, 2.91% and 2.04%, respectively. These revealed that sorghum is good source of fiber. These values recorded as proximate composition of sorghum was found to be matched with Patekar S. D. (2017).

The grains of finger millet were analysed for its nutritional

composition and revealed values as Moisture content, protein, fat, carbohydrate, fiber and ash content of finger millet was 9.88%, 8.36%, 1.03%, 73.41%, 4.7% and 2.5%, respectively. These revealed that finger millet is good source of fiber, so it is easily digested, and it is the most nutritious cereal. These values recorded as proximate composition of finger millet was found to be matched with Ekta Singh Chauhan, Sarita (2018) [5].

The grains of amaranth were analysed for its nutritional composition and revealed values as Moisture content, protein, fat, carbohydrate, fiber and ash content of amaranth was 9.17%, 14.14%, 3.16%, 69.52%, 2.1% and 1.9%, respectively. These revealed that amaranth is good source of protein. These values recorded as proximate composition of amaranth was found to be matched with Sangeeta and Grewal R. B. (2018) [21].

Chemical composition of selected pulses

Chemical analysis of pulses was determined by standard AOAC 2005 [4] method. The chemical composition of pulses was carried out and the obtained results are tabulated in Table No. 4.

Table 4: Chemical composition of selected pulses

Ingredients	Mean values (Chemical parameters)					
	Moisture (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Fiber (%)	Ash (%)
Green gram	10.1±0.04	24.4±0.07	1.2±0.13	59.8±0.07	1.1±0.37	3.4±0.32
Chickpea	9.8±0.36	20.6±0.10	5.1±0.45	60.1±0.27	1.3±0.17	2.5±0.23
Black gram	10.7±0.18	24.1±0.21	1.6±0.03	59.3±0.26	0.8±0.11	2.8±0.46

Table no.4 revealed the proximate composition of the different pulses used for preparation of multigrain chakli, these grains were examined for different constituents like moisture, crude fat, protein, carbohydrate, crude fibre. As data showed that green gram having moisture content 10.1% protein content 24.4% and green gram have fat percent that is 1.2 % the green gram has carbohydrate content 59.8% and crude fibre contain 1.1% the ash content of green gram was observed 3.4% according to the data the protein content of the green gram is very high so that it gives the nutritional quality to the final product. The proximate composition value of green gram was found similar with the values recorded by Chavan U. D., Pansare S.S. *et al*. (2015) [6].

Moisture content, protein, fat, carbohydrate, fiber and ash content of chickpea was 9.8%, 20.6%, 5.1%, 60.1%, 1.3% and 2.5%, respectively. These revealed that chickpea is also good source of protein. These values recorded as proximate composition of chickpea was found to be matched with Husnain R. *et al*. (2019).

The grains of black gram were analysed for its nutritional composition and revealed values as Moisture content, protein, fat, carbohydrate, fiber and ash content of black gram was 10.7%, 24.1%, 1.6%, 59.3%, 0.8% and 2.8%, respectively. These revealed that black gram is best source of protein, and it is nutritious pulse. These values recorded as proximate composition of black gram was found to be matched with Modgil R. *et al.* (2019) [19].

Mineral composition of cereals

Mineral composition of cereals is carried out in table No. 5.

Table 5: Mineral composition of selected cereals

Ingredients	Minerals (mg/100g)			
	Calcium	Phosphorus	Magnesium	Iron
Rice	8.78	23.11	15.41	0.8
Sorghum	13.58	511.90	104.62	4.22
Finger millet	327.85	280.18	138.16	3.07
Amaranth	158.62	551.11	247.2	6.16

In the above table it is revealed that calcium content of rice was recorded 8.78mg/100g, phosphorus content, magnesium and iron content of rice was found 23.11mg/100g, 15.41mg/100g and 0.8mg/100g, respectively. This mineral composition of rice recorded are in close agreement with Verma K.D. and Srivastav P.P. (2017) [24].

Calcium content of sorghum was recorded is 13.58mg/100g, phosphorus content, magnesium and iron content of sorghum was found 511.90mg/100g, 104.62mg/100g and 4.22mg/100g, respectively. This mineral composition of sorghum recorded are in close agreement with Abe S. G., Maryke L. *et al.* (2015) [1].

Calcium content of finger millet was found 327.85mg/100g, phosphorus content, magnesium and iron content of finger millet was found 280.18mg/100g, 138.16mg/100g and 3.07mg/100g, respectively. This mineral composition of finger millet recorded are in close agreement with Hiremath N., Geetha K. *et al.* (2020) [10].

Calcium content of amaranth is 158.62mg/100g, phosphorus content, magnesium and iron content of amaranth was found 551.11mg/100g, 247.2mg/100g and 6.16mg/100g, respectively. This mineral composition of amaranth recorded are in close agreement with Nathan A. K. and Weston F. M. (2015) [14].

Mineral composition of pulses

Mineral composition of pulses is carried out in table No. 6.

Table 6: Mineral composition of selected pulses

Ingredients	Minerals (mg/100g)				
	Calcium	Phosphorus	Magnesium	Iron	Sodium
Green gram	75.8	403.1	123.5	4.1	27.96
Chickpea	58.6	312.5	128.6	5.2	72.89
Black gram	152.3	382.8	132.3	3.5	39.64

The calcium content of green gram recorded 75.8mg/100g. the phosphorus, magnesium, iron, and sodium content of green gram recorded 403.1mg/100g, 123.5mg/100g, 4.1mg/100g and 27.96mg/100g, respectively. The calcium content of chickpea recorded 58.6mg/100g. The phosphorus, magnesium, iron, and sodium content of chickpea recorded 312.5mg/100g, 128.6mg/100g, 5.2mg/100g and 72.89mg/100g, respectively. The calcium content of black gram recorded 152.3mg/100g. The phosphorus, magnesium, iron, and sodium content of black gram recorded 382.8mg/100g, 132.3mg/100g, 3.5mg/100g and 39.64mg/100g, respectively. This data shows that all pulses were good source of all minerals. This mineral composition of pulses recorded are in close agreement with Kamboj R. and Nanda V. (2017) [18].

Conclusion

The present study was concluded that the selected ingredients i.e., cereals (sorghum, rice, finger millet, amaranth) and pulses (green gram, chick pea, black gram) contain an appreciable amount of macro and micro nutrients which could be add nutritive value and health benefits in preparation of different products. This will help to minimize risk of nutrients deficiency of consumers. All these ingredients are palatable, less expensive and abundantly available in market.

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