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Alane ST
Department of Food Chemistry and Nutrition College of Food Technology, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani, Maharashtra, India

Gadhe KS
Department of Food Chemistry and Nutrition College of Food Technology, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani, Maharashtra, India

Pandit MG
Department of Food Chemistry and Nutrition College of Food Technology, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
Alane ST
Department of Food Chemistry and Nutrition College of Food Technology, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani, Maharashtra, India

Studies on physico-chemical properties of sorghum, soybean, Bengal gram and fenugreek leaves

Alane ST, Gadhe KS and Pandit MG

Abstract
The present investigation was carried out to study the physical and chemical properties of sorghum, soybean, Bengal gram and fenugreek leaves. The properties such as thousand kernel weight, thousand kernel volume, bulk density, true density, porosity and angle of repose were determined. The chemical properties such as moisture, protein, fat, carbohydrate, ash and crude fibre were also evaluated. The results pertaining values for chemical composition of sorghum 7.9% moisture, 10.62% protein, 1.73% fat, 73.85% carbohydrates, 1.31% ash and 2.77% crude fibre. Soybean contained 8.8% moisture, 40.33% protein, 20.4% fat, 23.5% carbohydrates, 2.44% ash and 3.90% crude fibre. The result of chemical composition showed that bengal gram contain 8.51% moisture, 22.4% protein, 5.97% fat, 57.53% carbohydrates, 2.72% ash and 2.60% crude fibre and fenugreek leaves contain 84.51% moisture, 3.75% protein, 0.71% fat, 8.23% carbohydrate, 1.22% ash and 1.64% crude fibre. From the result it can be concluded that physical properties are important for the designing of machine or equipment. It had significant role in examining and defining efficacy of the machine and operation also play role in determining quality or studying the behaviour of the product during agricultural processing unit operations.

Keywords: Sorghum, soybean, Bengal gram, Fenugreek leaves, physical properties, chemical properties

Introduction
Sorghum (*Sorghum bicolor*) is the world's fifth most important crop belonging to family poaceae after the maize (corn-*Zea mays*), rice (*Oryza sativa*) and barley (*Hordeum vulgare*). India rank second in production of sorghum in year 2000 after the United State (Kleih *et al.*, 2007). In present world celiac disease is on rise which appeared due an immunological response to gluten intolerance. Sorghum consists of phenolic compound like flavonoids, which inhibit the growth of tumour and also beneficial to diabetes patient because of slow releasing nature of starch and sugar available in grain (Kulamarva *et al.*, 2008) [8] therefore there is demand of gluten-free food product. Sorghum is gluten free cereal and has a potential to develop gluten free product due to presence of proteins such as kafirin, globulin, glutelin and albumin (Yun *et al.*, 2019) [20].

Soybean (*Glycine max.*) belongs to family leguminosae and native to China. Soybean is inexpensive, cheap source of protein (40%) and fat (20%) therefore use widely all over the world. From ancient time soybean called as meat of field because of its protein quality equals to beef protein and milk protein with amazing amino acid balance (Jooyandeh, 2011) [4]. *Glycine max* is a legume rich in protein and oil content due to which cultivated all over the world. Now it is become a most popular because of its health promoting benefits. Soybean is good source of protein content and also rich in carbohydrates, fats (omega 3 fatty acids), minerals and vitamins. It contains 43.2 g protein, 20.9 g carbohydrates, 19.5 g fat, 240 mg calcium, 11.5 iron, 432 calorie and reasonable amount of minerals and vitamins. Soybean confer health benefits including lower blood cholesterol, check constipation, good for diabetics, prevents cardio-vascular diseases, prevent cancer, osteoporosis and helpful in menopause (Tiwari *et al.*, 2017) [17].

Bengal gram (*Cicer arietinum*) also called garbanzo bean or chickpea. India is one of the Bengal gram producing country with an average production of 6·38 million metric tonnes during 2006–09, accounting for 66% of global Bengal gram production. Bengal gram is one of the cheap source of dietary fibre and bioactive compounds e.g. phytosterols, saponins and oligosaccharides; coupled with its low glycaemic index (GI), Bengal gram may be useful for lowering the risk of CVD. Saponin present in bengal gram make them bitter and decrease its choice for intake by human and animal (Jukanti *et al.*, 2012) [5].

Trigonella foenum-graecum known as fenugreek is one of the ancient medicinal plants belonging to family leguminosae. Fenugreek has been used either as herb (the leaves) or as a spice (the seed) and also used to enhance the flavour, colour and texture of the food materials, because of high fibre, protein and gum content of fenugreek, now-a-days it is used as food stabilizer, adhesive and emulsifying agent (Meghwal and Goswami, 2012) [11].

Fenugreek contains 23–26% protein, 6–7% fat and 58% carbohydrates of which about 25% is dietary fibre (US Department of Agriculture, 2012) [18]. Fenugreek is also a rich source of iron, containing 33 mg/100 g dry weight (US Department of Agriculture, 2001) [18]. Engineering properties of grains are important in designing of machines, processes and structure. Also, these properties are used in examining and defining efficacy of the machine and operation or process even that it play role in determining quality or studying the behaviour of the product during agricultural processing unit operations.

The physical properties like size, shape, volume, density, porosity, colour and appearance are important in designing particular equipment or determining the behaviour of the product for its handling. It is quite important to have an in depth knowledge of the physical and mechanical properties of oil bean seed which is considered an essential engineering data needed in the design of machine, storage structures, processing and quality control (Supram *et al.*, 2019) [16].

Materials and Methods

Materials

The raw material such as sorghum (*Sorghum bicolor*), soybean (*Glycine max*), Bengal gram *(Cicer arietinum)*, fenugreek (*Trigonella foenum-graecum*) leaves were purchased from local market of Parbhani.

Methods

Physical properties

To measure physical properties of sorghum, soybean and bengal gram were cleaned and sorted and analysed for various properties according to their respective methods as described by (Sunil *et al*., 2016) [15].

Thousand seed weight

Thousand seed weight was measured by counting 100 randomly selected grains and weighing them using an electronic balance having an accuracy of 0.001 g and then multiplied by 10 to give mass of 1000 seeds.

Thousand kernel volume

Volume of thousand grams of dry seed was measured by water displacement in millilitres**.**

Bulk density

Bulk density was calculated by using a container of known volume. The sample was taken into the container for the known volume and weighed. The bulk density was calculated with the help of following formula (Sunil *et al*., 2016) [15].

$$\text{Bulk density (g/ml)} = \frac{\text{weight of grain (g)}}{\text{Volume of grains including pore space (ml)}}$$

True density

50 ml of toluene was taken in a measuring cylinder. A known weight of grain sample was poured to the measuring cylinder and rise in the toluene level was recorded. The true density of the grain was calculated by using the following formula (Sunil *et al*., 2016) [15].

$$\text{True density (g/ml)} = \frac{\text{Weight of grains (kg)}}{\text{volume of grains excluding void space (ml)}}$$

Porosity

Porosity of grains was calculated from the bulk density and true density values (that were found earlier) by using the following formula (Sunil *et al*., 2016) [15].

$$\text{Porosity (per cent)} = 1 - \frac{\text{Bulk density}}{\text{True density}} \text{ X } 100$$

Angle of repose

Angle of repose (Ø) is the frictional property. Angle of repose is the angle between base and slope of the cone formed on a free vertical fall of grains on to a horizontal plane. It was determined by the procedure described by Sunil *et al***.,** (2016) [15]. It was found by measuring the height (h, mm) and radius (r, mm) of the grains heaped in natural piles by using the expression;

Angle of repose (◦) = tan-1{h/r}

Where, h = Height of heap

r = Radius of base of heap

Proximate analysis

All samples were analyzed for moisture, crude protein, crude fat, total ash, mineral and total carbohydrate contents according to their respective standard methods as described in (A.O.A.C., 2018) [1].

Result and Discussion

Physical properties of sorghum, soybean and Bengal gram

Different physical properties such as thousand kernel weight, thousand kernel volume, bulk density, true density, angle of repose and porosity of sorghum, soybean and bengal gram were evaluated and results obtained are tabulated in Table 1.

Table 1: Physical properties sorghum, soybean and Bengal gram

Physical Parameters	Mean Value		
	Sorghum	Soybean	Bengal gram
Thousand kernel weight (g)	33.7	112.33	54.86
Thousand kernel volume (ml)	25.7	54.1	34.7
Bulk Density (g/ml)	0.66	0.63	0.84
True Density (g/ml)	1.5	1.36	1.53
Angle of Repose (Degree)	31.208	41.063	31.42
Porosity (%)	61	47.33	42.2

*Each value represents the average of three determinations

The data depicted in Table 1 revealed that thousand kernel weight and thousand kernel volume was found highest in soybean 112.33 g and 54.1 ml followed by bengal gram 54.86 g and sorghum 33.7 g and 25.7 ml respectively. Due to its size difference large deviation was recorded in 1000 kernel weight. 1000 kernel weight was important factor to determine grain yield. Bengal gram showed highest bulk density and true density which was 0.84 and 1.53 g/ml respectively. The true density and bulk density plays a significant role in drying, design of silos and storage bins, separation of undesirable materials, seed purity determination and grading (Mohsenin, 1986) [13].

The key function of porosity is resistance to air flow of bulk grain. The highest value of porosity was recorded in sorghum 61per cent than soybean 47.33 and bengal gram 42.2 per cent

respectively. Angle of repose is an indicator of free flowing nature of seeds and is important for designing of processing equipment (Barbosa *et al.*, 2006) [2]. The highest angle of repose was observed for soybean 41.06 º and the lowest was observed for sorghum 31.20 º. The similar results recorded for the physical properties of grains were reported by the (Masane *et al.*, 2016; Hamdani *et al.*, 2014) [10, 3].

Chemical composition of sorghum and soybean

The chemical composition of sorghum, soybean and Bengal gram were carried out and the results obtained are tabulated in Table 2.

Table 2: Chemical composition of sorghum, soybean and Bengal gram

Parameter	Sorghum	Soybean	Bengal gram
Moisture (%)	7.9 ± 0.2	8.8 ± 0.36	8.51 ± 0.36
Total Fat (%)	1.73 ± 0.26	20.4 ± 0.70	5.97 ± 0.14
Total Carbohydrates (%)	73.85 ± 0.34	23.05 ± 0.71	57.53 ± 0.35
Total Protein (%)	10.62 ± 0.44	40.33 ± 0.33	22.4 ± 0.26
Ash (%)	1.31 ± 0.18	2.44 ± 0.29	2.72 ± 0.19
Crude Fibre (%)	2.77 ± 0.11	3.90 ± 0.20	2.60 ± 0.20

*Each value represents the average of three determinations

The data depicted in Table 2 exhibited that sorghum contained carbohydrate 73.85 per cent and moisture 7.9 per cent. The fat 1.73 per cent and protein 10.62 per cent and crude fibre 2.77 per cent was observed. The results were comparable with (Patekar *et al.*, 2017) [14].

From Table 2 clearly observed that soybean had fat 20.4 per cent and protein 40.33 per cent respectively. It was also found that soybean contained 23.05 per cent carbohydrate, 2.44 per cent ash and 3.90 per cent crude fibre. The similar results were observed by (Kokani and Ranganathan, 2018) [6].

It was observed from Table 2 bengal gram contained 5.97 per cent fat, 57.53 per cent carbohydrate, 22.4 per cent protein, 2.72 per cent ash, 2.60 per cent fibre and 8.51 per cent moisture. These results were comparable with (Kokani *et al.*, 2019) [7].

Proximate analysis of fenugreek leaves

The chemical composition of fresh fenugreek leaves and dried fenugreek leaves were carried out and the results obtained are tabulated in Table 3. The high moisture content, perishable nature and seasonal availability limits green leafy vegetable utilization. Therefore it requires adequate and appropriate processing technique like drying, dehydration and freeze drying for elongation of shelf life among these drying at 40 ºC for 5 hrs carried out for best result of proximate analysis and value depicted in Table 3.

Table 3: Proximate analysis of fenugreek leaves

Parameter	Fresh Fenugreek Leaves	Dried fenugreek leaves
Moisture (%)	84.51 ± 0.36	8.21± 0.25
Total Fat (%)	0.71 ± 0.02	4.81 ± 0.09
Total Carbohydrates (%)	8.23 ± 0.29	70.9 ±0.56
Total Protein (%)	3.75 ± 0.11	8.27 ±0.25
Ash (%)	1.22 ± 0.23	2.83 ±0.18
Crude Fibre (%)	1.64 ± 0.22	4.98 ±0.21

*Each value represents the average of three determinations

The fresh fenugreek leaves comprises 84.51 per cent moisture, 0.71 per cent fat, 8.23 per cent carbohydrate, 3.75 per cent protein, 1.22 per cent ash and 1.64 per cent crude fibre. The results were equivalent with (Mohammed *et al.*, 2018) [12]. The dried fenugreek leaves contain 8.21 per cent moisture, 4.81 per cent fat, 70.9 per cent carbohydrate, 8.27 per cent protein, 2.83 per cent ash and 4.98 per cent crude fibre. The similar results on chemical composition of dried fenugreek leaves were reported by (Mahmoud *et al.*, 2012) [9].

Conclusion

Thus in light of scientific data of the present investigation, it may be concluded that the evaluation of different physico-chemical properties of sorghum, soybean, bengal gram and fenugreek leaves carried out. The physico-chemical characteristics are very important for designing and development of process machineries as well as for the development of products of higher nutritional quality.

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