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Physico-chemical properties of four different varieties of guar seeds (*Cyamopsis Tetragonoloba* L.)

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Abstract
The objective of the study is to evaluate the four new guar varieties (GAUG13, HG563, RGC986 and HG884) to study their chemical composition and physical properties. Samples were collected from the experimental farm, University of agricultural sciences Raichur. Proximate composition, Thousand seed weight, length, width, thickness, geometrical mean diameter, sphericity, bulk density, true density, co-efficient of external friction, co-efficient of internal friction, angle of repose and terminal velocity were carried out for the guar seeds. Result obtained showed that verity HG-365 had a highest content of Ash (7.26 %), Fat (10.16%), Fiber (16.40) and Protein (51.95). Significantly highest value of moisture content (12.55%) and carbohydrates (20.53%) found in the varieties HG-884 and RGC-986. The verity GAUG13 found highest value of length (3.81 mm), thickness (3.74 mm) and geometrical mean diameter (3.62 mm). HG563 found highest value of width (3.47 mm), sphericity (0.98%) and Terminal velocity (4.81 m/s). RGC986 found highest value of co-efficient of external friction (0.77). HG884 found highest value of thousand seed weight (35.21 g), bulk density (1.24 g/cm^3), true density (2.42 g/cm^3), co-efficient of internal friction (0.77) and angle of repose (30.37 ^{o}).

Keywords: Physico-chemical properties, guar seeds, varieties and moisture content

Introduction

The guar plant also known as Cluster Bean (*Cyamopsis tetragonoloba.* L.), is a drought hardy leguminous crops. Guar is being grown for seed, green fodder and vegetable. It is annual plant, about 4 feet high, vertically stacked, with large leaves and clusters of pods. Each pod is about 5-8 cm long with an average 6-9 small grayish white pea shaped seeds. The pods are used as green vegetable or as cattle feed besides the industrial extraction of guar gum (Sharma, *et al.*, 2007) [1]. The plant flower buds start out white and change to a light pink as the flower opens. The flowers turn deep purple and are followed by fleshy seed pods which ripen and harvested in summer (Whistler and Hymouitz, 1979) [2]. A growing season of guar is 15 to 16 weeks and requires reasonably warm weather and moderate flashing rainfall with plenty of sunshine (Premsaker and Venkataraman, 1962) [3].

Physical and chemical properties are important in many problems associated with the design of machines and the analysis of the behavior of the product during agricultural process operations such as handling, planting, harvesting, threshing, cleaning, sorting and drying. Solutions to problems in these processes involve knowledge of their physical and chemical properties. Bulk density and true density can be useful in sizing grain hoppers and storage facilities; they can affect the rate of heat and mass transfer of moisture during aeration and drying processes. Flow ability of agricultural grains is usually measured using the angle of repose. This is a measure of the internal friction between grains and can be useful in hopper design, since the hopper wall's inclination angle should be greater than the angle of repose to ensure the continuous flow of the materials by gravity. The static coefficient of friction is used to determine the angle at which chutes must be positioned in order to achieve consistent flow of materials through the chute. Such information is useful in sizing motor requirements for grain transportation and handling (Shivabasappa *et al.*, 2012) [4].

In India in particular, this important guar gum seed is subjected to local processing method which includes roasting, boiling, dehulling/shelling, soaking, and size reduction, which is labour intensive, with a low output. The aspect which is of interest to the engineer (food processor) is the physicochemical properties, mechanical properties, electrical properties, and thermal properties. This gives the engineer guidelines for the designing of agricultural machine that will be suitable for the processing of the deferent varieties of guar gum seeds. Most important among them is the physicochemical properties which are the first consideration in the design of the handling and sorting equipment; therefore, the objective of this research is justified (Chen, 1996) [5]. The objective of the study is to evaluate the four new guar varieties (GAUG13, HG563, RGC986 and HG884) and to study their chemical composition and physical properties.

Experimental

Guar seeds

Four guar varieties GAUG13, HG563, RGC986 and HG884 were obtained from the experimental farm, University of Agricultural Sciences, Raichur were used in this study. After harvesting, guar seeds were subjected to remove broken seeds, soil particles and foreign materials.

Preparation of guar seeds for analysis

Guar seeds were ground to fine particle size using milling machine and sieved by (0.4 mm mesh sieve) and stored in polyethylene bags and keep in refrigerator at 7 °C for further analysis.

Physical properties of gum seeds

Physical properties such as thousand seed mass, length, width and thickness, geometric mean diameter, sphericity, true density, bulk density, angle of repose, terminal velocity, co-efficient of internal and external friction were determined according to the methods described by Gharibzahedi *et al*. (2013) [6], Adejumo and Abayomi, (2012) [7], Mohsenin. (1992) [8], (Mohsenin, 1980) [9], Koocheki *et al.* (2007) [10], Killckan and Guner (2006) [11].

Proximate composition of guar seeds

The proximate composition *viz*., moisture content, total ash content, crude fat, crude fiber, protein and carbohydrates of guar seeds were estimated by following the standard procedure. Moisture, lipid, ash, total nitrogen (micro-Kjeldahl) of guar seeds were determined according to AOAC (1995) [12]. Crude protein was calculated as N% × 6.25. Carbohydrate was calculated by difference Crude fiber content was determined according to the acid/alkali digestion method of AOAC (2005) [13].

Statistical analyses

Replicate of each sample was analyzed using statistical system, the analysis of variance was performed to examine the significant effect in all parameters, Least Significant Difference test (LSD), was used to separate the means (Dinesha *et al*., 2016) [14].

Results and Discussion

Physical properties of guar seeds

The physical properties of the four guar varieties; GAUG-13, HG-365, RGC-986 and HG-884 are shown in Table.1.

Thousand seed mass

The values of thousand kernel weight of different varieties of guar were 32.59 g (for GAUG13), 31.07 g (for HG563), 33.13 g (for RGC986) and 35.21 g (for HG884). It is noticed that there is insignificant difference ($P \geq 0.05$) in thousand seed mass among varieties GAUG13 and HG563 but significant difference ($P \leq 0.05$) between varieties HG563 and RGC986 were observed at one side and varieties RGC986 and HG884 on the other side was observed. These results agree with the results reported by Eldaw, (1998) [15] which read as the thousand seed mass of guar seeds to range from 21.5 g to 32.65 g, but were lower than those reported by Sabah which read a range of 35.6 g to 35.7 g. The variation in thousand seed mass among genotypes might be attributed to genetic variation and environmental conditions.

Table 1: The physical properties of the four guar varieties

Varieties	Thousand seed weight (g)	Length (mm)	Width (mm)	Thickness (mm)	GMD (mm)	Sphericity (%)	Bulk density (g/cm^3)	True density (g/cm^3)	Co-efficient of external friction	Co-efficient of internal friction	Angle of repose (º)	Terminal velocity, m/s
GAUG13	32.59 ^{a}	3.81^{a}	3.34 ^{a}	3.74 ^{a}	3.62 ^{a}	0.94 ^{a}	1.22 ^{a}	1.83 ^{a}	0.73 ^{a}	0.46 ^{a}	26.84 ^{a}	4.51 ^{a}
HG563	31.07 ^{a}	3.36 ^{a}	3.47 ^{a}	3.43 ^{a}	3.52 ^{a}	0.98 ^{a}	1.20 ^{a}	1.84 ^{a}	0.61 ^{b}	0.53 ^{b}	26.79 ^{a}	4.81 ^{a}
RGC986	33.13 ^{b}	3.50 ^{a}	3.33 ^{a}	3.21 ^{a}	3.33 ^{a}	0.95 ^{a}	1.23 ^{a}	1.72 ^{a}	0.77 ^{a}	0.46 ^{a}	28.63 ^{b}	5.51 ^{b}
HG884	35.21 ^{c}	3.40 ^{a}	3.45 ^{a}	3.25 ^{a}	3.42 ^{a}	0.96 ^{a}	1.24 ^{a}	2.42 ^{b}	0.72 ^{a}	0.77 ^{c}	30.37 ^{c}	4.31 ^{c}
S.Em	0.103	0.115	0.013	0.019	0.013	0.03	0.013	0.014	0.009	0.013	0.023	0.032
Cv.	0.543	5.72	0.679	0.972	0.669	0.59	1.796	1.247	2.197	3.921	0.143	1.144
CD (5%)	4.066	0.375	0.043	0.062	0.044	0.011	0.041	0.046	4.066	0.041	0.076	0.103
CD (1%)	7.591	0.546	0.063	0.091	0.064	0.016	0.06	0.67	7.591	0.06	0.11	0.15

*Means not sharing a common letter in the same column are significantly different ($p \leq 0.05$).

*Each value in the table is a mean of three replicates ±S.D.

Length, width and thickness

The values of length of guar seed varieties GAUG13, HG563, RGC986 and HG884 were found 3.81, 3.36, 3.50 and 3.40 mm. Width of seeds were noticed that 3.34, 3.47, 3.33 and 3.45 mm. Thickness of the seeds were observed that 3.74, 3.43, 3.21 and 3.25 mm. From the table, it can be noticed that, the variation in length, width and thickness were significantly ($P \leq 0.05$) different among varieties. These results were comparable with the literature values of Nimkar and Chattopadhyay, (2001) [16], who reported that the length, width and thickness values of *French bean* seeds for different genotypes had 1.8 to 1.2cm, 06 to08 cm and 05 to 07 cm respectively.

Geometric mean diameter and sphericity

Geometric mean diameter and sphericity of guar seed varieties GAUG13, HG563, RGC986 and HG884 were found to be 3.62, 3.52, 3.33, 3.42mm and 0.94, 0.98, 0.95, 0.96. These results were in good agreement with the literature values of Bashar *et al.* (2014) [17], who reported the geometric mean diameter values of Malaysian rice MR219 seeds of 3.448 to 3.687 mm and sphericity was ranging from 0.352 to 0.362% respectively.

Bulk density and true density

The variation of bulk density and true of different varieties of guar seeds were depicted in Table. 1. It can be seen that the values of bulk density for different varieties varied insignificantly ($p \geq 0.05$) from 1.20 to 1.24 g/cm^3. True density varied significantly ($P \leq 0.05$) from 1.72 to 2.42 g/cm^3 among the varieties RGC986 and HG884, but an insignificant difference ($P \geq 0.05$) between varieties GAUG13 and HG563 was noticed, and also insignificant difference ($P \geq 0.05$) between varieties HG563 and RGC986 was observed. The same range of values have also been reported by Paksoy and Aydin (2004) [18], Aydin and Ozcan (2002) [19], Aviara *et al*. (1999) [20] and Sreenarayanan *et al*. (1988) [21] for squash, terebinth fruits, guna seeds and soybean, respectively.

Coefficient of external friction and internal friction

Coefficient of external friction of different varieties of guar seeds ranged from 0.61 to 0.77 and coefficient of internal friction from 0.46 to 0.77. The result showed that coefficient of external friction was higher than that of internal friction which in turn is higher than the static friction. This variation may be due to increase adhesion between the seeds and the surface at higher moisture levels (Altuntas and Dermirtola, 2007) [22]. Several researchers had found the same trend, Nimkar and Chattopadhyay, (2001) [16]; Gezer *et al.*, (2002) [23].

Angle of repose and terminal velocity

From the Table.1. It can be noticed that, angle of repose of different varieties of guar seeds ranged from 26.79 to 30.37 (°). Similar results were obtained by Sirisomboon *et al.* (2007) [24] and Garnayak *et al.* (2008) [25]. This is because seeds are viscous at higher moisture levels and the cohesion forces between seeds and the wall are stronger than cohesion between seeds.

Terminal velocity of seeds found to be 4.51, 4.81, 5.51 and 4.31 m/s for different varieties. The results reveal that air velocity needed for separating a specific fraction of seeds by fluidization. For separating seeds heavier it was necessary to apply a velocity of 4.81 m/s (Karaj and Muller, 2010) [26].

Chemical composition of guar seeds

Moisture content

Data in Table. 2. shows that the moisture content of four guar genotypes were found to be 9.02%, 7.78%, 7.46% and 12.55% for GAUG13, HG563, RGC986 and HG884, respectively. It is clear that there were significant differences ($P \leq 0.05$) among genotypes GAUG13 and HG5634, but an insignificant difference ($P \geq 0.05$) between them and genotypes HG563 and RGC986 was noticed, and also significant difference ($P \leq 0.05$) between genotypes RGC986 and HG884 was observed. These results are lower than the values ranged from 10% to 15% vreported by Whistler and Hymowitz (1979) [2], but higher than the means value 6% obtained by Thomas *et al*., (1980) [31], and values 5.50% to 5.90%, reported by El-Siddig and Khalid, (1999) [27]. The variation in the moisture contents of guar seeds of different varieties may be due to genetic variation and relative humidity of the surrounding atmosphere at harvest and during the storage time.

Table 2: The chemical compositions of the four guar varieties

	MC (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrates (%)
GAUG-13	9.02^a	5.66^a	6.37^a	13.79^a	49.15^a	17.60^b
HG-365	7.78^b	7.26^b	10.16^c	16.40^b	51.95^b	20.27^a
RGC-986	7.46^b	5.36^a	6.16^a	6.74^c	48.35^c	23.40^c
HG-884	12.55^a	6.05^c	5.18^c	14.00^a	49.97^a	20.53^a
S.Em	0.219	0.173	0.456	0.407	0.606	2.55
Cv.	4.116	4.938	11.166	5.386	2.106	23.129
CD (5%)	0.713	0.566	1.488	1.327	1.977	8.315
CD (1%)	1.038	0.823	2.166	1.931	2.877	12.099

*Means not sharing a common letter in the same column are significantly different ($p \leq 0.05$).

*Each value in the table is a mean of three replicates ±S.D

Ash content

Data in Table. 2. shows that the ash content of four guar seeds varieties were found to be 5.66%, 7.26%, 5.36 % and 6.05 % for GAUG13, HG563, RGC986 and HG884, respectively. It is clear that there were significant differences ($P \leq 0.05$) among genotypes GAUG13 and HG365, but insignificant difference ($P \geq 0.05$) between them and genotypes GAUG-13 and RGC-986 was noticed, and also significant difference ($P \leq 0.05$) between genotypes RGC986 and HG-884 was observed. Higher value noticed in the verity HG365. These results are higher than the values ranged from 0.5 to 1% reported by El-Siddig and Khalid (1999) [27] and values 3.25 to 3.75% obtained by Eldaw (1998) [15], but are agree with the results reported by Amir *et al*. (2015) [28] which read as 4.5 to 5.5%. The variation in ash content may be due to genetic factors and environmental factors under which plant materials were tested.

Fat content

Table. 2. Shows the analytical data of fat content of deferent guar varieties. The varieties GAUG-13 (6.37%) and HG-365 (10.16%) were significant different ($P \leq 0.05$), whereas GAUG-13 (6.37%) and HG-884 (5.18 %) were insignificant different ($P \geq 0.05$) and RGC-986 (6.16%) and HG-884 (5.18%) were significant different ($P \leq 0.05$). The verity HG-365 found significantly higher value fat content (10.16%). These results are higher than the values ranged from 1.42 to 1.78% reported by Eldaw, (1998) [15], but agree with the results reported by Amir, (2015) [28], which findings ranged from 2.30 to 6.5%, but lower than findings obtained by Sabah-Elkhier, (1999) [29] which ranged from 3.04 to 3.27%. The variation in the oil content may be controlled by genetic factors and environmental conditions (Dinesha *et al*., 2018) [33].

Crude fibre content

Table. 2. Shows the crude fibre content of the seeds of four guar varieties GAUG13 (13.79), HG563 (16.40), RGC986 (6.74) and HG884 (14.00). It is observed that the variation in crude fiber content was insignificantly ($P \geq 0.05$) differences between varieties GAUG-13, and HG884, but significantly different ($P \leq 0.05$) between varieties GAUG-13 and HG365; RGC-986 and HG-884. These results are comparatively similar values (12% to 13.8%) reported by Thomas *et al*, (1980) [31] but are relatively higher values 7.47 to8.95% reported by El-Siddig and Khalid (1999) [27]. But are in agreement with the results reported by Eldaw, (1998) [15] which read as ranging from 8.48 to 9.37%. The variation in the crude fibre content among genotypes might be attributed to genetic variation and environmental conditions.

Protein content

Table 2 shows that the average of protein content of four guar seeds varieties was found to be 49.15%, 51.95%, 48.35% and 49.97% for GAUG13, HG563, RGC986 and HG884, respectively. It is observed that the variation in protein content of guar seeds was insignificantly different ($P \geq 0.05$) between genotypes GAUG-13 and HG-884 but significant difference ($P \leq 0.05$) between them and varieties GAUG-13 and HG-365, and also significant different ($P \leq 0.05$) between genotypes RGC-986 and HG-884, was observed. These results are higher than the values ranged from 28.17% to 29.6 reported by Eldaw, (1998) [15] and the range values of 37.61 - 42.80% reported by Majed *et al*. (2006) [30]. This value is relatively similar to the result ranged from 25.3% to 42% of proteins content for guar seed obtained by Thomas *et al.*, (1980) [31]. The variation in protein content of the genotypes in this study may be attributed to genetic factors and environmental conditions.

Carbohydrate content

Data in Table. 1. Shows that the carbohydrate content of guar seeds was found to be 17.60, 20.27, 23.40 and 20.53% for GAUG13, HG563, RGC986 and HG884, respectively. It is noticed that there were significant ($P \leq 0.05$) difference between genotypes RGC-986 and HG-884, but insignificant difference ($P \geq 0.05$) between varieties HG-365 and HG-884, and a significant ($P \leq 0.05$) difference between genotypes RGC-986 and HG-884 was observed. These results are lower than the value 37.61 to 42.80% reported by Irtwange and Igbeka, (2002) [32], but lower than those ranged reported by Eldaw, (1998) [15], but is still lower than the value obtained by El-Siddig and Khalid (1999) [27]. Also matching with the range of 26.47% to 20.48% reported by Sabah-Elkhier (1999) [29]. Variation in carbohydrate (as glactomanan) content among the different genotypes might be attributed to genetic variation and environmental conditions.

Conclusion

The genetic variation and environmental conditions have affected on the chemical composition and physical properties of guar seeds. The verity HG-365 has a highest content of Ash (7.26 %), Fat (10.16%), Fiber (16.40) and Protein (51.95). Highest value of moisture content and carbohydrates found in the varieties HG-884 and RGC-986. The verity GAUG13 found highest value of length (3.81 mm), thickness (3.74 mm) and geometrical mean diameter (3.62 mm). HG563 found highest value of width (3.47 mm), sphericity (0.98%) and Terminal velocity (4.81 m/s). RGC986 found highest value of co-efficient of external friction (0.77). HG884 found highest value of thousand seed weight (35.21 g), bulk density (1.24 g/cm^3), true density (2.42 g/cm^3), co-efficient of internal friction (0.77) and angle of repose (30.37°).

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