JOURNAL OF THE FACULTY OF SCIENCE AND TECHNOLOGY

(JFST) No (5) - (ISSN 1858-6007)

مجلة كلية العلوم والتقانة - جامعة أم درمان الاسلامية – وزارة التعليم العالى والبحث العلمى ، السودان

Research Article

Physicochemical properties of Four New Genotypes of Guar Seeds (*Cyamopsis tetragonoloba* L.).

Amir A. Eldirany; Azhari A. Mohamed Nour; Khadir E. Khadir; Khalid A. Gadeen and Amir M. Mohamed*.

Department of Nutrition and Food Technology, Faculty of Science and Technology, Omdurman Islamic University, Omdurman, Sudan

Abstract

The objectives of this work was to study the physicochemical properties of four new guar genotypes (GM5, GM6, GM9 and GM34) collected from the experimental farm of University of Khartoum- Shambat. Proximate composition, Tannin content. One thousand Kernel weight, Hectoliter weight, seed components and hard seeds percentage were carried out for the guar seeds. Result obtained showed that genotypes GM5 and GM34 had significantly (P≤0.05) higher values of 1000-kernel weight compared to the genotypes GM6 and GM9. Genotype GM5 gave the significant (P≤0.05) lowest percentage for hard seeds (11.67%) fallowed by GM34 (17.67%) and GM6 (20.67%) while GM9 gave the highest value (24.33%). Proximate analysis of guar seeds showed that the GM6 had significant (P≤0.05) highest protein content (42.8%) while GM34 gave the lowest value, Genotype GM34 gave significant (P≤0.05) highest value for ash content (5.54%), for carbohydrate (gum content) GM5 gave significant (P≤0.05) highest value (38.58%) fallowed by GM9 and GM34 but the genotype GM6 gave significant (P≤0.05) lowest value of gum content (30.26%). Tannin content was significantly(P≤0.05) lower in GM5 (0.030%).

Key words: Genotype; hectoliter; guar seeds; kernel; tannin; hard seeds; physicochemical.

1. Background

The guar plant also known as cluster bean (*Cyamopsis tetragonoloba (L)Taub)*, is a drought hardy leguminous crops. Guar is being grown for seed, green fodder, vegetable and green manuring. It is annual plant, about 4 feet high, vertically stacked The guar plant also known as cluster bean cyamopsi with large leaves and clusters of pods. Each pod is about 5-8 cm long and has on 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). 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). A growing season of guar is 15 to 16 weeks and requires reasonably warm weather and moderate flashing rainfall with plenty of sunshine (Sharma, et, al 2007). The Guar seed matured in 120-145 days depending on variety, irrigation practices and location. The crop is sown after the first rain in June and July (Whistler and Hymowitz, 1979). Harvesting occurs 50-80 days after planting in October-November (Premsaker and Venkataraman, 1962). The Guar is a naturally rain fed crop. Depending on the monsoon rainfall the total size of Guar Crop varies from year to year. After harvesting, when the pods become dry through sunlight, they are beaten off and during this process, the seeds come out of the pod (Whistler and Hymowitz, 1979). It is mainly grown in areas of India, Pakistan, Sudan and USA. India produce 6.0 to 7.5 million tons of guar annually. It contributes to around 80% share in the World total production (Sharma et, al 2007). Various exporters and manufacturers export guar splits, Guar gum powder and its derivatives. All over the World the major importing countries of guar gum and its derivatives are USA, Germany, Italy, China, Denmark, France and UK, (Sharma et, al 2007). In Sudan, the guar plant was tried at Gezira Research Station as early as 1930, (Flower man, 1987). When the guar crop was found as a wild plant in the Red Sea Mountains and Arashekol mountains at White Nile State. (Anon,1990). The Sudanese Guar Gum Company was established at Singa in 1996. The guar seeds are contained in pods each pod is about 5-8 cm long and has an average 6-9 small, grayish –white pea shaped seeds. The color of seed varied from green to brown color, and the size of seeds ranged from small to large but the small seeds are not desirable (Whistler and Hymowitz ,1979). According to Eldaw, (1998), the thousand seed weight of guar ranged from 21.5g to 32.65g. Sabah Elkier, (1999), found that the thousand seed weight of guar ranged from 35.6g to 35.7g. The hectoliter weight It is the bulk density measurement that indicates the weight of seeds per unit volume (gram\liter). Eldaw, (1998), reported that the Hectoliter weight of guar seed ranged from 830.30 (g\l) to 857.85(g\l). The hard seeds can affect the granulation of the powder and purification of gum fractions. Eldaw, (1998), reported the hard seeds percentage of three cultivars of guar ranged from 5.98% to 13.60%, Sabah Elkier, (1999), found that the hard seeds percentage of guar varied from 21.7 % to 22.15%. Guar seeds contain three parts: hulls (seed coat), germ and endosperm. The endosperm is the commercially available guar flour entering into ever-expanding industrial markets. The Guar Germ or guar protein is potentially available for human consumption and could add significantly to the world's protein supply, providing increased vegetable protein for human dietary need. Regrettable guar protein as germ is presently mixed with the hulls for sale as Cattle feed. (Whistler and Hymowitz, 1979). Surprisingly, although guar primary is grown for its gum content, very little is known about the variable in the seed of *Cyamopsis tetragonoloba*, (Whistler and Hymowitz, 1979). According to Goldstein and Alter, (1959) the three major components of guar seed are the seed coat (14-17%), endosperm (35-42%), and germ (43-47%). Whistler and Hymowitz, (1979) found that the endosperm components comprise 35-42% of the seed, (13.48-14.05%), endosperm (35.0-39.9%), and germ (43.3-44.2%). Sabah Elkhier, (1999) found that the seed consists of seed coat (30-33%), endosperm (27-30%) and germ (43-47%). The Germ contains most of the protein in the seed while the endosperm contains the galactomannan gum (Whistler and Hymowitz, 1979). The objective of the study to evaluate the four New guar genotypes and to study the

Chemical composition and physical properties of the four guar genotypes seeds.

2. Materials and Methods:

2.1. Guar seeds:

Four guar genotypes (new genotypes) GM5, GM6, GM9 and GM34 obtained from Department of Agronomy Faculty of Agriculture, U of K were used in this study. These genotypes were planted in (2007-2008) season at Shambat area, Experimental farm of the Faculty of Agriculture, U of K. After harvesting guar seeds were sieved to remove broken seeds, soil particles and foreign material.

2.2. Preparation of guar seed 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.

2.3. General properties of guar seeds:

1. Thousand kernel weight (g):

It was determined according to AOAC (1984).

2. Hectoliter weight (g/liter):

Using a test weight measuring device, the weight was measured and recorded in (g / liter) (ICRIST,1986).

3. Hard seeds (Percentage):

It was determined according to Hulse et al, (1977). Hundred seeds of guar were randomly taken, soaked in distilled water for about 12 hours, the hard seeds (un soaked) were selected, counted and then the hard seed percentage was calculated as follows :-

$$\text{Hard seed}(\%) = \frac{\text{No.of Hard seeds}}{\text{Total No.of socked seeds}}$$

2.4. Determination of guar seed component:

It was determined according to (Bureng 1996). Five gram seeds were weighed, and then soaked in 100 ml distilled water for about 10 hours and manually separated into hull, endosperm and germ. Then these were oven dried. Each part (Hull, germ and Endosperm) was weighed separately until constant weight was reached, the percentage of each was calculated as follows:

$$Part\ \% = \frac{X}{5} \times 100$$

Where: X = weight of sample.

2.5. Chemical composition of guar seeds

1. Proximate analysis

Lipid, ash, total carbohydrate and total nitrogen (micro-Kjeldahl) of guar seeds were determined according to AOAC (1995). Protein was calculated as N% × 6.25. Moisture content was determined by drying a sample at 105 C^0 overnight. Crude fiber content was determined according to the acid/alkali digestion method of AOAC (1984).

2. Tannin content

Vanillin - Hcl in methanol reagent method was used to assay tannin (Price & Butlet, 1977). Catechin was used as reference standard.

2.6. 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 test), was used to separate the means (Peterson, 1985).

3. Results and Discussion

3.1. Physical Properties of Guar Seeds

The physical properties of the four guar genoyypes; GM5, GM6, GM9 and GM34, results are shown in Table (1) and (2).

3.2. Seeds Color and Size:

Table (1) shows the color and size of guar seeds. The color is glassy to greenish for all the samples. All genotypes have large seeds except GM6 which has large –medium size seeds, (plate 1,2,3 and 4).

3.3. Thousand kernel weight (gram)

As can be seen from Table (2) the values of thousand kernel weight for different genotypes of guar were 31.57g (for GM5), 30.7g (for GM6), 30.8g (for GM9) and 31.3g (for GM34).

It is noticed that there is no significant difference(P≤0.05) in 1000-kernel weight among genotypes GM5 and GM34 and among genotypes GM6 and GM9, but significant difference (P≤ 0.05) between genotypes GM5 and GM34 (from one side, which gave highest values) and genotypes GM6 and GM9 on the other side (which gave lowest values) was observed. These results agree with the results reported by Eldaw, (1998) which read as the 1000-kernel weight of guar seeds to range from 21.5g to 32.65g, but is lower than those reported by Sabah Elkhier, (1999) which read a range of 35.6g to 35.7g. The variation in 1000-kernel weight among genotypes might be attributed to genetically variation.

Table 1. Color and Size of Guar Seeds.

Genotype	Color	Size
GM5	Glassy-greenish	Large
GM6	Glassy-greenish	Large-medium
GM9	Glassy-greenish	Large
GM34	Glassy-greenish	Large

3.4. Hectoliter Weight:

Table (2) showed the values of Hectoliter weight (gram/liter) of guar seeds genotypes: GM5, GM6, GM9 and GM34. It is observed that the variation in Hectoliter weight is not significantly different (P≤ 0.05) among genotypes. The values of Hectoliter weight of guar seeds genotypes GM5, GM6, GM9 and GM34 ranged from 841.0(g/L) (GM9) to 852.7 (g/L) (GM6) which was in conformity with the values 830.30 to 857.85 (g/L) obtained by Eldaw, (1998).

Table 2. physical properties of guar seeds.

Genotype	1000-Kernel weight (g)	Hectoliter weight (g\L)	Hard Seeds (%)
GM5	31.57 (±0.34) [a]	848.7(±8.6) [a]	11.67 (±2.8) [c]
GM6	30.7 (±0.14) [b]	852.7 (±2.8) [a]	20.67 (±1.7) [b]
GM9	30.8 (±0.47) [b]	841.0(±2.1) [a]	24.33 (±3.4) [a]
GM34	31.3 (±0.08) [a]	848.8 (±6.4) [a]	17.67 (±0.47) [b]
L.S.D	0.36	10.50	4.45
C.V%	0.76	0.82	15.76
S.E±	0.07	1.2	0.85

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

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

3.5. Hard Seeds Percentage

Table (2) gives the degree of hard seeds percentage from guar seed genotypes. It is found that the variation in hard seed percentage did not show significant difference (P≤0.05) between genotypes GM6 and GM34, but significant difference (P≤0.05) was noticed between them and genotypes GM9 and GM5, and a significant difference (P≤0.05) between genotypes GM9 and GM5. The values of Hard Seeds (%) for guar seed genotypes were 11.67 for (GM5), 20.67 (for GM6), 24.33 (for GM9) and 17.67 (for GM34). These results are higher than the values reported by Eldaw, (1998) which ranged from 5.78%-13.6%. These values of hard Seeds (%) for genotypes GM5, GM34 and GM6 are lower than the values ranging from 21.75% to 22.15% reported by Sabah Elkhier, (1999) but the value of genotype GM9 is higher than the values reported by the same author. The variation in hard seeds percentage might be due to genetically factors.

3.6. Guar Seed Components

1. Hull

The average Hull percentage was found to be 13.77%, 13.8%, 14.08% and 14.14% for GM6, GM5, GM34 and GM9 guar seeds genotypes respectively, (Table 3). These results obtained from genotypes GM34 and GM9 were comparable to the values ranging from 14-17% reported by Goldstein and Alter, (1959) and Whistler and Hyniwitiz, (1979) but the values of genotypes GM5 and GM6 are higher than

the values reported by the same authors. Results indicated here were comparable to the values ranging from 13.48 to 14 .05% reported by Eldaw (1998), but is lower than the values (30-33%) reported by Sabah Elkhier (1999). It is observed that there were no significant differences (P≤ 0.05) in the hull percentage between the genotypes studied.

2. Endosperm

The values of endosperm content (gum content) was found to be 37.04%, 37.08), 37.3% and 37.82% for GM5, GM34, GM6 and GM9 guar genotypes respectively (Table 3). It is noticed that the variation in endosperm content was not significantly different (P≤ 0.05) among genotypes.

Table 3. Guar Seeds Components.

Genotypes	Hull (%)	Endosperm (%)	Germ (%)
GM5	13.8 (±0.29) [a]	37.03 (±0.5) [a]	48.6 (±0.00) [a]
GM6	13.77 (±0.12) [a]	37.3 (±0.08) [a]	48.86 (±0.08) [a]
GM9	14.14 (±0.28) [a]	37.82 (±0.33) [a]	47.9 (±0.54) [a]
GM34	14.08 (±0.08) [a]	37.08 (±0.6) [a]	48.03 (±0.54) [a]
L.S.D	0.40	0.79	0.70
C.V%	1.9	1.39	0,96
S.E±	0.08	0.15	0.13

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

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

These results are comparable to the values varying from 35% to 42% previously reported by Goldstein and Alter (1959), Whistler and Hymwitz (1979) and Eldaw, (1998), but is higher than the results obtained by Sabah Elkhier, (1999), which read as (27% to 30%).

3. Germ

The values of germ content of guar seeds were found to be 47.9%, 48.03%, 48.6% and 48.86% for GM9, GM34, GM5 and GM6 guar genotypes respectively, show (Table 3). It is observed that the variation in germ content of guar genotypes seeds is not significantly different (P≤0.05) among the four guar seeds genotypes. These results are higher than the results ranging from 43% to 47% obtained by Whistler and Hymowitz, (1979) and Sabah Elkhier (1999), and Eldaw, (1998) who reported a range of 43.37% to 44.24%. The variation of germ content of guar seed might be due to genetically factors.

3.7. Chemical Composition of Guar Seeds

1. Moisture Content (%).

Data in Table (4) shows that moisture content of four guar seeds genotypes was found to be 7.25%, 9.5%, 9.75% and 10.66% for GM5, GM34, GM6 and GM9 genotypes respectively. It is clear that there were no significant differences (P≤ 0.05) among genotypes GM6 and GM34, but significant difference (P≤ 0.05) between them and genotypes GM9 and GM5 was noticed, and also significant difference (P≤ 0.05) between genotypes GM9 andGM5. These results are lower than the values ranging from 10% to 15% reported by Whistler and Hymowitz (1979) but is higher than the mean value 6% obtained by Thomas, et, al (1980), and values 5.5% to 5.9% Reported by Elsiddig and Khalid, (1999). Moisture content of genotypes GM6, GM34 and GM9 were comparable to the values ranging from 9.05% to 12.4% reported for moisture content of guar seeds by Eldaw, (1998), but genotype GM5 value agrees with the result reported by Sabah Elkhier (1999) which was 7.10 to 8.19%. The variation in the moisture content of guar seeds of different genotypes might be due to genetically variation and relative humidity of the surrounding atmosphere at harvest and during storage time.

2. Protein Content:

From Table (4) it is seen that the average of protein content of four guar seeds genotypes

was found to be 42.80%, 38.73%, 38. 52% and 37.61% for GM6, GM9, GM5 and GM34 samples respectively. It is observed that the variation in protein content of guar seeds is not significantly different (P≤ 0.05) between genotypes GM5 and GM9 but significant difference (P≤ 0.05) between them and genotypes GM6 and GM34, and significant different (P≤ 0.05) between genotypes GM6 and GM34, was observed. These results are higher than the values ranging from 28.17% to 29.6 reported by Eldaw, (1998) and the values of 16.7% to 20.5% reported by Elsiddig and Khalid, (1999). This value is relatively similar to the result 25.3%-42% for proteins content of guar seed obtained by Thomas et, al (1980). Also matching with the range of 32.87% to 43.48% reported by Sabah Elkhier, (1999). The variation in protein content of the genotypes in this study might be attributed to genetically factors.

3. Oil Content

Table (4) shows the analytical data of oil content of guar seeds for genotypes GM5 (2.21%), GM6 (2.77%), GM9 (2.43%) and GM34 (2.29%). It is observed that the variation in oil content of the different guar seeds is not significantly different (P≤ 0.05) among all genotypes. These results are higher than the values ranging from 1.42% to 1.78% reported by Eldaw, (1998), but are in agreement with the results reported by Thomas *et, al* (1980) which read as ranging from 0.87% to 5%, and relatively similar to the results 1.47% to 2.2% obtained by Elsiddig and Khalid, (1999), but lower than those obtained by Sabah Elkhier, (1999) which read 3.04% to 3.27%. The variation in the oil content may be controlled by genetically factors and environmental conditions

4. Ash Content

As can be seen from Table (4) the ash content for four guar seeds genotypes was found to be 4.76%, 4.86%, 4.82% and 5.54% for GM5, GM6, GM9 and GM34 genotypes respectively. It is noticed that there were no significant differences (P≤ 0.05) among genotypes GM5, GM6, and GM9 (with lower values), but significant difference(P≤0.05) between them and genotype GM34 (higher value) was noticed. These results are higher than the values ranging from 0.5% to 1% reported by Elsiddig and Khalid (1999) and values 3.25% to 3.75% obtained by Eldaw (1998), but are in agreement with the results reported by Sabah Elkhier,

significantly different (P≤ 0.05) among all genotypes. These results are higher than the values ranging from 1.42% to 1.78% reported by Eldaw, (1998), but are in agreement with the results reported by Thomas *et, al* (1980) which read as ranging from 0.87% to 5%, and relatively similar to the results 1.47% to 2.2% obtained by Elsiddig and Khalid, (1999), but lower than those obtained by Sabah Elkhier, (1999) which read 3.04% to 3.27%. The variation in the oil content may be controlled by genetically factors and environmental conditions**.**

Table (4): Chemical Composition and Tannin content (%) of Gaur Seeds.

Geno type	Moisture (%)	Crude protein (%)	Crude oil (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)	Tannin (%)
GM5	7.253 [c] (±0.2)	38.524 [b] (±0.4)	2.214 [a] (±0.04)	4.757 [b] (±0.1)	8.675 [b] (±0.027)	38.578 [a] (±0.41)	0.0303 (±0.001) [b]
GM6	9.746 [b] (±0.05)	42.801 [a] (±0.2)	2.765 [a] (±0.04)	4.858 [b] (±0.11)	9.569 [a] (±0.13)	30.259 [c] (±0.26)	0.0638 (±0.002) [a]

GM9	10.658 [a] (±.006)	38.733 [b] (±0.39)	2.428 [a] (±0.25)	4.821 [b] (±0.08)	7.788 [c] (±0.04)	35.671 [b] (±0.45)	0.0611 (±0.0026) [a]
GM34	9.506 [b] (±0.38)	37.610 [c] (±0.043)	2.292 [a] (±0.01)	5.543 [a] (±0.05)	9.547 [a] (±0.20)	35.50 [b] (±0.82)	0.0594 (±0.00) [a]
L.S.D	0.16	0.72	0.34	0.32	0.585	0.977	0.00339
C.V %	1.86	1.20	9.49	4.33	4.32	1.84	0.35
S.E±	0.05	0.14	0.06	0.06	0.11	0.2	0.00068

*****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.
*Carbohydrate by difference.

5. Ash Content:

As can be seen from Table (4) the ash content for four guar seeds genotypes was found to be 4.76%, 4.86%, 4.82% and 5.54% for GM5, GM6, GM9 and GM34 genotypes respectively. It is noticed that there were no significant differences ($P \leq 0.05$) among genotypes GM5, GM6, and GM9 (with lower values), but significant difference($P \leq 0.05$) between them and genotype GM34 (higher value) was noticed. These results are higher than the values ranging from 0.5% to 1% reported by Elsiddig and Khalid (1999) and values 3.25% to 3.75% obtained by Eldaw (1998), but are in agreement with the results reported by Sabah Elkhier, (1999) which read as 4.25% to 9.99%. The variation in ash content may be due to genetically factors and environmental factors under which plant materials were tested.

6. Crude Fibre Content

Table (4) shows the crude fibre content of the seeds of four guar genotypes GM5 (8.68%), GM6 (9.57%), GM9 (7.79%) and GM34 (9.55%). It is observed that the variation in crude fiber content is not significantly different ($P \leq 0.05$) between genotypes GM6, and GM34, but significantly different ($P \leq 0.05$) between them and genotypes GM5, and GM9 and significantly different ($P \leq 0.05$) between genotypes GM5, and GM9. These results are lower than the values (12%to 13.8%) reported by Thomas et, al, (1980) but are relatively similar to the results 7.47% to8.95% reported by Elsiddig and Khalid, (1999). But are in agreement with the results reported by Eldaw, (1998) which read as ranging from 8.48% to 9.37%, crude fibre content of GM6 and GM34 are comparable to values ranging from 9.03% to 10.1% obtained by Sabah Elkeir, (1999). The variation in the crude fibre content among genotypes might be attributed to genetically variation.

7. Carbohydrate Content

Data in Table (4) shows that the carbohydrate content of guar seeds was found to be 38.58%, 30.26, 35.67 and 35.50% for GM5, GM6, GM9 and GM34 genotypes respectively. It is noticed that there was no significant difference ($P \leq 0.05$) between genotypes GM9, and GM34, but significant difference ($P \leq 0.05$) between them and genotypes GM5 and GM6, and a significant difference ($P \leq 0.05$) between genotypes GM5 and GM6 was observed. These results are higher than the value 30% reported by Thomas et al, (1980), but lower than those values 44.8% to 47.1% reported by Eldaw, (1998), but is still lower than the value 58.5% to 60.7% obtained by Elsiddig and Khalid (1999). Also matching with the range of 26.47% to 40.48% reported by Sabah Elkier (1999). Variation in carbohydrate (as glactomanan) content among the different genotypes might be attributed to genetically variation.

8. Tannin Content

As can be seen from Table (4), the tannin content of guar seeds is found to be 0.030%, 0.064, 0.0611 and 0.059 for GM5, GM6, GM9 and GM34 genotypes respectively. It is observed that the variation in the tannin content of four guard's seeds genotypes is not significantly different (P≤ 0.05) between genotypes GM6, GM9 and GM34, but significantly different (P≤ 0.05) from genotype GM5.This result is in conformity with the value of 0.024% to 0.95% obtained by Sabah Elhkier, (1999). The variation in the Tannin content of guar seeds may be due to genetically variation.

Conclusion:

The genetically variation have affected on the chemical composition and physical properties of guar seeds. The genotype GM6 has higher content of protein. The genotype GM5 has lowest content of tannin. The GM5 and GM6 were ranked as the beter genotypes in physicochemical properties

References

Anon. (1990). Mechanized Agriculture Conference in Khartoum. Unpublished report ministry of Agricultural, Sudan.

AOAC. (1995). Association of Official Analytical Chemists. Official Method Of Analysis, 16^{th} edn. Washington D.C.

AOAC. (1984). "Official Methods of Analysis". 14th edition. Published by AOAC Inc. Virginia 22209. USA.

Bureng, P.L. (1996). Guar gum in composite flour. Internal Report, Food Research Center, Shambat, Khartoum North, Sudan.

Eldaw, G.E. (1998). A study of guar seed and guar gum properties (*Cyamopsis tetragonoloba* (L). M.Sc. Thesis, Faculty of Agriculture, U of K, Sudan.

El-Siddig, A.E. and Khalid, A.I. (1999). In the effect of Bradyrhizobium inoculation on Yield and Seed quality of guar (*Cyamopsis tetragonoloba*). J. Food Chem, 19:8-19.

Flowerman, P.M. (1987). The Potential of guar in Sudan agriculture, process, industry and trade. Unpublished report on a mission to Sudan,19th March-30th June.

Goldstein, A. M. and Alter, E.N. (1959). Guar gum, industrial gums, polysaccharides, and their derivatives, R.L. Whistler, Ed. New York: Academic press.

Hulse, J.H; Rachie, K.O. and Billingstey, L.W. (1977). Nutritional standard and methods of evaluation for food legumes breeders. (Billingstey, L. W; (ed), IDRC.TS7e, Ottowa, Canada.

ICRISAT; (International Crop Research Institute for the semi-Arid Tropis). (1986). Annual Report 1985, P: 175, Patancheru, A. P,502: 324 India.

Peterson, R. G. (1985). Design and analysis of experiments. March Dekker Inc., New York, PP: 429.

Premsaker, S. and Venkataraman, K. (1962). "Pusa Mausmi" guar has no rivals.J. Indian Farming 12:15.

Price, M. L., Scoyo, V. S. and Butler, L.C. (1978). Acritical evaluation of the vanillin reaction as an assay for tannin in Sorghum Grain J. Agric.Food Chem,26: 1214 -1218.

Sabah Elkhier, M. K. (1999). Improvement of yield and quality of Guar (*Cyamopsis tetragonoloba*). PhD. Thesis, Faculty of Agriculture, U of K, Sudan.

Sharma, B. R; Chechani, V., Dhuldhoya, N.C. and Merchant, U. C. (2007). "Guar Gum" J. Science Tech Entrepreneur. Lucid Colloids Limited, Jodhpur-342005, Rajasthan, India.

Thomas, T. A; Dabas, B. S. and Chopra, D.D. (1980). Guar gum has many uses. J. Indian Farming. 32 (4): 7-10.

Whistler, R. L and Hymowitz, T. (1979). Guar Agronomy, Production, Industrial Use, and Nutrition. Purdue University Press. West Lafayette, Indiana, USA