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Chemical Composition of Twenty Guar (*Cyamopsis tetragonoloba* L. Taub) Genotypes[1]

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Abstract: This study aimed at evaluating nutritive value and assessing the diversity in chemical composition among twenty newly developed guar (*Cyamopsis tetragonoloba* L. Taub) genotypes. The estimated parameters of proximate analysis of seed included moisture, ash, fiber, oil, carbohydrate, crude protein, mineral, polyphenol, tannin and phytic acid contents which were determined in each sample. The results revealed different patterns of variation among the evaluated genotypes. Significant differences ($p \leq 0.05$) were detected among the tested genotypes in all studied parameters. Genotype Gm23 showed the highest level of crude protein (38.68 %) while L53 showed the lowest value (25.34 %). The mineral content ranged from 8710 to 19100 mg/kg for potassium, 2090 to 4910 mg/kg for calcium and 152 to 370 mg/kg for iron. With regard to the anti-nutritional factors, the highest level of total polyphenols (8.391 mg/g) was obtained from genotype L14, a tannin content of 0.343 mg/g was recorded in Gm18 and Phytic acid of 373.67 mg/100g was detected in Gm34. It was concluded that a wide range of variability exists among the evaluated genotypes in all of the studied parameters. Hence, some of these genotypes can be utilized in breeding programs for the development of improved guar genotypes.

Key words: guar**;** chemical composition; mineral contents; anti-nutritional factors.

[1] Part of a Ph.D. thesis by the first author, submitted to University of Khartoum Sudan

INTRODUCTION

Guar or cluster bean (*Cyamopsis tetragonoloba* L. Taub), belongs to the family (Leguminosae) Fabaceae. It is a drought-tolerant hardy annual crop of the arid and semi-arid zones and is cultivated under rain fed conditions. Guar is a coarse, upright, bushy, drought-resistant summer annual plant ranging from 2-4 feet in height (Warrier *et al.* 1994). Guar is mainly cultivated for food, feed and fodder. Its young pods are used as vegetables, which are also known as a cheap source of energy (16 kcal), protein (3.2g), fat (1.4g), carbohydrates (10.8 g), Vitamin A (65.3 IU), Vitamin C (49 mg), calcium (57 mg) and iron (4.5 mg) for every 100 g of edible portion (Kumar and Singh 2002). Being a leguminous crop, it improves fertility of soil by fixing considerable amount of atmospheric nitrogen and adding organic matter. Guar meal and seeds are the source of high protein and nutritious feed to the cattle (Sabahelkhier 1999).

Guar gum is a guar seed extract, containing about 80% galactomannan, 10 % moisture, 10% protein and trace amounts of heavy metals and ash. Guar seed is composed of 30 – 33 % hull, 27 – 30 % endosperm and 43 – 47 % germ. The germ and hull of the guar seeds are known as guar meal, which is rich in protein, hence used for the cattle feed. It offers relatively inexpensive high protein meal, produced as a by-product of guar gum manufacturing. The protein content of guar meal ranges between 33 and 45 % depending on the fraction types (Conner 2002). The germ has toxic effect but recently advanced research has been made on the germ to reduce its toxic effect and to make it suitable for animal consumption as a rich source of protein. Guar seed endosperm is a source of water soluble gum which is used as stabilizer, emulsifier and thickener in various food products and contributes to soluble dietary fiber (SDF) portion of seed total dietary fiber (TDF). TDF and SDF, respectively, make up 52–58 % and 26–32 % of seed dry weight (Kays *et al*. 2006). As a food additive, it emulsifies, binds water, prevents ice crystals in frozen products, moisturizes, thickens, stabilizes and suspends many liquid–solid systems. It is used in ice cream, sauces, cake mixes, cheese spreads, fruit drinks and dressings usually in amount of <1 % of the food weight (Whistler and Hymowitz 1979; Parija *et al*. 2001). Guar contains

many important nutrients and phytochemicals such as saponin and flavonoids and is well known in traditional folklore medicine (Mukhtar *et al*. 2006). Moreover, Guar beans are potentially high sources of additional phytochemicals (Morris and Wang 2007). In Sudan, guar plant was unknown till recently, though its wild relative *C. senegalensis* was found as a wild plant in the Red Sea mountains and Arashekol mountains of White Nile State. The Blue Nile, White Nile and Kordofan States are considered as the main producing areas of the guar crop under mechanized rain-fed conditions in Sudan (Ibrahim *et al*. 2012).

The objective of this study was to determine the chemical composition of 20 newly developed guar genotypes.

MATERIALS AND METHODS

Material

Seeds of twenty newly developed genotypes of *Cyamopsis tetragonoloba* L. Taub (Gm2, Gm4, Gm5, Gm6, Gm7, Gm8, Gm9, Gm16, Gm17, Gm18, Gm19, Gm21, Gm22, Gm23, Gm24, Gm29, Gm31, Gm34, L14 and L53) were kindly provided by Dr. Abdel wahab H. Abdalla, Department of Agronomy, Faculty of Agriculture, University of Khartoum. The studied genotypes were developed by the classical method of breeding for improvement of guar gum quality.

Seed preparation

For the proximate analysis**,** healthy dry seeds were ground into fine powder using an electric grinder and the powdered samples were kept in a container in a refrigerator at 4°C.

Proximate analysis:
Moisture, ash, fiber and protein content were determined according to the procedure of A.O.A.C (2000). Total carbohydrate content was calculated by subtraction (Merrill and Watt 1973).

Oil extraction and determination
For oil extraction, Soxhlet method was used. Thrity g of guar seed flour were placed into a cellulose paper cone and extracted using n-hexane in a 5-1 Soxhlet extractor for 8 h (Pena *et al*. 1992).

Mineral composition
Mineral elements were determined using an x-rays (XRF) apparatus (MCA Canberra series 35 plus).

Determination of anti- nutritiontal factors:
Total polyphenol content: Polyphenolics present in each seed sample were estimated using the Prussian blue assay, as described by Price and Butler (1977).

Tannin content: Quantitative estimation of tannin in each sample was carried out using modified vanillin/ HCl in methanol method as described by Price *et al*. (1978). A standard curve was prepared expressing the results as catechin equivalents, i.e. amount of catechin (mg/ml) which gives a color intensity equivalent to that given by tannins.

Phytic acid content: Phytate was determined according to the method described by Wheeler and Ferrel (1971). A standard curve of different Fe $(NO_3)_3$ concentrations was plotted to calculate the ferric ion concentration. The Phytate phosphorus from the ferric ion concentration was calculated assuming 4:6 iron: phosphorous molar ratio.
All tests were carried out using triplicate samples.

Statistical analysis
The recorded data were subjected to analysis of variance described for a completely randomized design (Gomez and Gomez 2010). Then means were

compared following the method of the least significant difference using Excel version 2007 computer package.

RESULTS AND DISCUSSION

Proximate analysis: The results revealed that there were highly significant differences ($p \leq 0.01$) among the tested genotypes, in moisture, protein content and total carbohydrates. There were significant differences ($p \leq 0.05$) in ash content, crude fiber and oil content. Moisture content of guar seed (Table 1) ranged from 5.6 – 8.7 %, these results are in agreement with the findings of Elmustafa and Ibrahim (1999) and Sabahelkheir (1999). However, the obtained results were lower than 9.7 %, reported by Rodge et *al*. (2012) and Whistler and Hymowitz (1979). Ash content ranged from 1.8 – 4.34 %, which is in agreement with that obtained by Al-Hafed and Siddiqui (1998) and Khatta *et al.* (1988). Crude fiber content ranged from 6.47 – 11.38%, which is in agreement with the findings of Khatta *et al*. (1988) , However it was higher than the values reported by Elmustafa and Ibrahim (1999). Crude protein content ranged between 25.34 – 38.68 %, which is in line with the findings of Kobeasy *et al* (2011) and higher than those reported by Kays *et al*. (2006). The amount of total carbohydrates varied from 38.36 – 51.50 %; these results are in accordance with Kays *et al*. (2006). However, they were higher than the values reported by Yadava and Manju. (1985). The oil content ranged from 2.02 – 3.72 %, which is in agreement with that of Kays *et al.* (2006). On the other hand, it was higher than that reported by Elmustafa and Ibrahim (1999) and lower than that reported by Al-Hafedh and Siddiqui (1998).

Mineral content

Mineral content data are shown in (Table 2). On the average, all genotypes were very rich in potassium (8710 – 19100 mg/kg) followed by calcium (2090 – 4910 mg/kg) and iron (152 – 370 mg/kg). The amount of copper was in the range of 9.31 – 11.1 mg/kg and zinc in the range of 8.93 – 17.1 mg/kg. The amount of potassium in seeds of genotype Gm7 was extremely high as compared with the other genotypes. However, genotype Gm34 had the highest iron and Zinc content 370 mg/kg and 17.1 mg/kg, respectively. These

results were higher than those reported by Ahmed *et al.* (2009); but were lower than those reported by Badr *et al.* (2014). With respect to the heavy metals, only traces of Pb (average of 1.05mg\kg) and Cr (average of 1.31mg\kg) were detected in the evaluated guar genotypes.

Table 1. Means of the different chemical components (%) in seed of guar genotypes

Genotype	Moisture Content	Ash content	Crude Fiber	Crude Protein	Oil Content	Carbohydrates
Gm2	8.36 b	2.05 k	9.95 bc	29.50 l	2.86 cd	47.28 de
Gm4	7.56 fgh	2.40 i	7.58 gh	30.89 jk	3.72 a	47.84 d
Gm5	8.70 a	1.80 k	8.42 ef	35.51 d	2.80 cd	42.76 i
Gm6	7.74 de	3.83 b	9.84 bc	32.78 f	2.96 cd	42.85 i
Gm7	8.47 b	2.07 jk	9.71 bc	31.19 ij	2.83 cd	45.73 f
Gm8	7.57 fg	2.50 hi	9.34 cd	33.75 e	2.24 gh	44.60 g
Gm9	7.39 i	2.82 fg	9.97 bc	31.32 i	2.55 ef	45.96 f
Gm16	7.42 hi	2.73 fgh	8.23 f	37.81 b	3.06 bc	40.74 j
Gm17	7.77 d	3.25 d	6.52 i	28.51 m	2.72 de	51.23 b
Gm18	6.87 j	3.20 d	9.96 bc	32.36 g	3.24 b	44.37 gh
Gm19	6.71 k	2.58 ghi	7.42 h	37.11 c	2.38 fg	43.80 h
Gm21	7.60 efg	3.12 de	8.04 fg	26.73 o	3.21 b	51.31 b
Gm22	7.67 def	3.54 c	8.99 de	30.76 k	2.91 cd	46.13 f
Gm23	7.64 def	4.34 a	8.95 de	38.68 a	2.02 h	38.36 k
Gm24	7.48 ghi	3.79 bc	8.40 ef	29.43 l	3.51 a	47.37 de
Gm29	6.52 l	2.33 ij	6.47 i	28.42 m	2.39 fg	53.87 a
Gm31	5.60 m	2.88 ef	9.63 bc	29.15 l	2.74 de	50.01 c
Gm34	7.37 i	3.61 bc	9.59 c	31.92 h	2.87 cd	44.65 g
L14	8.17 c	2.82 fg	11.38 a	27.87 n	2.83 cd	46.93 e
L53	6.50 l	2.89 ef	10.23 b	25.33 p	3.55 a	51.50 b
Mean	7.456	2.928	8.931	31.452	2.869	46.364
Sd ±	0.1385	0.2714	0.5745	0.3517	0.2387	0.7723

Means with the same letter within a column are not significantly different at $p \leq 0.05$

Table 2. Mean mineral content (mg/kg) of twenty guar genotypes.

Genotype Mineral	Gm2	Gm4	Gm5	Gm6	Gm7	Gm8	Gm9	L14	Gm16	Gm17	Gm18
K	15100	16900	8710	17500	19100	11600	12200	17900	15800	16400	17900
Ca	4910	3080	2090	4090	3950	3600	3390	3720	2960	3860	3540
Cr	1.36	1.50	1.16	1.25	1.19	1.10	1.36	1.28	1.33	1.36	1.29
Mn	27.4	24.5	14.8	16.9	26.7	14.9	19.1	16	21.3	22.7	23.8
Fe	327	289	152	320	291	289	276	256	258	265	341
Cu	9.66	9.35	9.50	10.5	9.36	9.69	9.49	9.62	10.3	9.52	10.6
Zn	14.1	14.3	10.4	13.3	12.3	11.6	13.6	11.3	11.2	13.1	13.3
Pb	1.11	1.03	0.925	0.875	0.997	1.03	0.984	1.21	1.21	1.05	1.16
Br	6.72	11.1	4.63	7.91	15.1	5.60	11.7	7.67	8.23	8.80	10.8
Rb	9.50	7.40	6.48	7.07	2.26	9.32	7.05	6.03	6.46	6.23	3.93
Sr	19.0	21.0	14.5	18.2	21.1	16.0	24.7	22.8	24.1	26.7	26.6

Chemical composition of twenty guar genotypes

Table 2 (continued)

Genotype Mineral	Gm19	Gm21	Gm22	Gm23	Gm24	Gm29	Gm31	Gm34	L53	Mean	Sd±
K	15200	14200	18600	18100	15200	13300	16600	17200	17100	1573.5	2639.6
Ca	3600	2920	4280	4130	3210	3800	3840	4260	4070	3665	615.4
Cr	1.30	1.51	1.26	1.58	1.48	1.12	1.23	1.24	1.36	1.313	0.53
Mn	16.6	16.8	23.0	17.1	16.4	18.1	15.8	18.0	18.1	19.4	49.17
Fe	244	219	288	290	257	228	370	294	214	237.1	3.95
Cu	9.98	9.92	11.1	9.94	10.8	9.31	10.3	10.2	9.52	9.93	0.13
Zn	11.0	10.2	14.2	13.1	12.4	8.93	17.1	16.2	13.3	12.75	3.29
Pb	1.07	1.10	1.08	1.17	1.08	0.917	0.988	1.05	1.07	1.05	0.10
Br	7.64	9.59	8.36	8.81	13.2	8.51	6.06	4.11	6.94	8.57	2.18
Rb	4.76	2.96	4.15	7.24	3.62	3.83	11.8	8.90	16.1	6.75	1.98
Sr	23.5	25.8	27.9	27.8	26.9	24.3	17.7	19.4	17.4	22.27	4.18

Anti – nutritional factors (ANFs)

Total polyphenols:

Statistical analysis revealed the presence of highly significant differences ($p \leq 0.01$) among the evaluated genotypes in total polyphenols. (Table 3) The total polyphenols ranged from 8.203 – 8.391 mg/g, which is higher than 3.76 and 2.47 mg/g reported by Kobeasy *et al*. (2011) and Badr *et al.* (2014), respectively.

Tannin content:

Tannin content indicated that there were significant differences ($p \leq 0.05$) among the twenty guar genotypes (Table 3). Tannin content ranged from .0247–0.343 mg/g. These results are in agreement with the findings of Kobeasy *et al.* (2011). All the studied genotypes contained very low amount of tannin as compared with those reported by Badr *et al.* (2014) .

Phytic acid:

Analysis indicated that there were highly significant differences ($p \leq 0.01$) among guar genotypes in phytic acid content (Table 3). It ranged from 189.16 to 373.67 mg/100g. Phytate is a cyclic compound that chelates with mineral ions (Ca,Fe, Zn) and forms compounds not readly absorbed in the intestine (Liener 1989). Therefore, future breeding should aim at reducing phytate content in order to improve the nutritive value of guar meal.

Table 3. Means of the different Anti nutritional factors in seeds of guar genotypes

Genotype	Total polyphenols (mg\g)	Tannin content (mg\g)	Phytic acid (mg\100g)
Gm2	1.493 [1]	0.025 d	275.04 j
Gm4	2.428 f	0.297 ab	326.94 c
Gm5	4.165 c	0.212 [bcd]	217.45 n
Gm6	1.63 h i	0.120 bcd	334.95 b
Gm7	7.905 b	0.111 cd	288.21 h
Gm8	2.154 g	0.085 cd	241.21 l
Gm9	1.468 i	0.086 cd	190.07 q
L14	8.391 a	0.116 bcd	313.77 f
Gm16	1.648 hi	0.074 cd	280.20 i
Gm17	2.872 e	0.070 cd	197.56 p
Gm18	1.691 hi	0.343 a	290.79 g
Gm19	8.203 a	0.110 cd	321.26 e
Gm21	1.87 h	0.070 cd	275.04 j
Gm22	2.875 e	0.132 bcd	221.32 m
Gm23	1.68 hi	0.046 d	272.71 j
Gm24	1.429 i	0.102 cd	248.95 k
Gm29	1.809 h	0.250 abc	203.50 o
Gm31	2.158 g	0.075 cd	323.85 d
Gm34	3.486 d	0.080 cd	373.67 a
L53	1.504 i	0.092 cd	189.16 q
Mean	3.01	0.114	264.70
Sd ±	0.494	0.084	60.36

Means with the same letter within a column are not significantly different at $p \leq 0.05$

CONCLUSIONS

- It could be concluded that the evaluated guar genotypes were rich in crude protein (25.34–38.68%),carbohydrates (38.36 -51.50%), potassium(1573.5mg/kg), calcium (3665mg/kg) and iron (273.1mg/kg.
- In addition, all the studied genotypes contained very low amount of tannin content.However, the genotype Gm 34 showed high amount of phytic acid.

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التحليل الكيميائي لعشرين طراز من القوار (*Cyamopsis tetragonoloba* L. Taub)[2]

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المستخلص: هدفت هذه الدراسة إلى تقدير القيم الغذائية وتقييم التنوع في المكونات الكيموحيوية بين عشرين طراز من الأنماط الجينية المطورة حديثاً للقوار. شملت الاختبارات، الرطوبة، الرماد، الالياف، الدهون، الكربوهيدرات، البروتين، العناصر المعدنية، مضادات التغذية كالفينولات المتعددة، التانينات، حمض الفيتيك ..أوضحت النتائج أنماطاً متعددة للإختلاف بين الطرز التي تم اختبارها. تم رصد فروقات معنوية ($p \leq 0.05$) وسط طرز القوار في كل الاختبارات .وقد أظهر الطراز Gm23 أعلى قيمة فيما يتعلق بالبروتين الخام (38%) بينما سجل الطراز L53 أدنى قيمة(25%). بالنسبة للعناصر المعدنية فقد تراوح المدى بين 8710 – 19100 ملجم/كجم للبوتاسيوم، 2090-4910 للكالسيوم، 152-370 ملجم/كجم للحديد. فيما يتعلق بمضادات التغذية أظهر الطراز L14 أعلى قيمة في الفينولات المتعددة (8.39 مجم/جم)، وسجل Gm18 أعلى قيمة في التانينات (0.343 مجم/جم) وسجل Gm34 أعلى قيمة لحمض الفايتيك (373.67 مجم/100جرام).
خلصت الدراسة الى وجود مدى واسع من التباين بين الأنماط الوراثية التي تم تقييمها في جميع الصفات المدروسة؛ وعليه يمكن استخدام بعض هذه الطرز في برامج التربية لتحسين القوار.

[2] مستلة من أطروحة الدكتوراه للمؤلف الاول