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Assessment of the technological quality characters and chemical composition for some Egyptian Faba bean germplasm

Abeer A. Ahmed[a*], Shaaban K. Mohamed[b,c] and Shaban A. A. Abdel-Raheem[d]

[a]Seed Technology Research Department, Field Crops Res. Inst., Agricultural Research Center, Giza. Egypt
[b]Chemistry and Environmental Division, Manchester Metropolitan University, Manchester, M1 5GD, England
[c]Chemistry Department, Faculty of Science, Minia University, 61519 El-Minia, Egypt
[d]Soils, Water, and Environment Research Institute, Agricultural Research Center, Giza, Egypt

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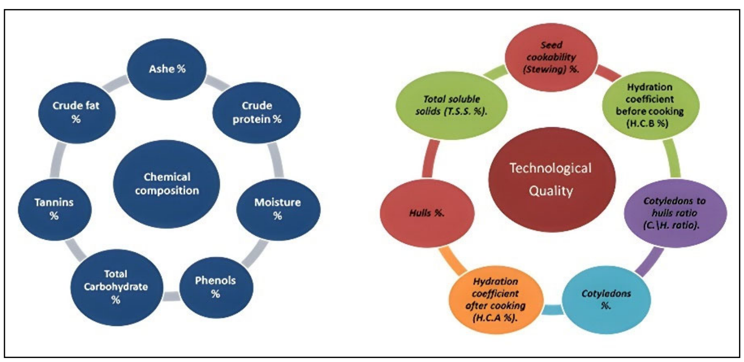
ABSTRACT

Increasing the yield and nutritional value of faba beans is one of the main objectives of the common bean cultivar improvement programs due to its contribution to terminate protein deficiency malnutrition in developing countries and raising the income level of smallholder farmers. In this study, the technological quality of bean seeds from twenty-four genotypes were evaluated (twenty germplasm and four improved cultivars (Misr 1, Giza 429, Giza 716, Giza 843). The results showed a significant diversity in the Egyptian bean germplasm in their quality traits compared to the control cultivars and indicated that the genotypes had a high hydration coefficient that ranged between (98.6-112.4%). While most of the genotypes for cotyledons to hull ratio met the commercial criteria that ranged between (7.41-6.41%). Twenty genotypes had the highest total soluble solids (6.90-11.78%) and were superior to the control cultivars. The seeds chemical composition analysis showed that the genotypes differed in their composition such as protein (26.65 to 30.72 %.), carbohydrate (58.00 to 62.25%), tannin (70.67 to 157.45%), phenols (35.23-51.02 %), and moisture (9.15 to 10.45%).



Graphical Abstract

1. Introduction

Faba bean (*Vicia faba* L.) is one of the most important cultivated and consumed leguminous crops. From a nutritional and economic point of view, it ranks fourth in the world after dry beans, dry peas and chickpeas.[1,2] This crop has gained increasing interest in recent years. It is mainly grown all over the world due to its high content of nutrients, and thus it is used in both food and forage.[3-5] It's importance as a food crop and forage lies in its high content of high-quality proteins

* Corresponding author.
E-mail address abeerabdelaty2015@gmail.com (A. A. Ahmed)

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which is necessary for a balanced diet as well as its high content of vitamins, minerals and carbohydrates rich in lysine, making it one of the best solutions to malnutrition, especially in developing countries and source of income for smallholder farmers.[6,7] From an environmental point of view, when introduced into an intercropping system with cereals, it contributes to the fixation of nitrogen from the soil, improving soil fertility, and thus increasing crop yield.[8] It is an excellent component of crop cycles, something that has been largely ignored in modern crops, at a time when there is an urgent need to reduce the impact of chemical fertilizers on the environment, and to minimize the emissions of unwanted grasses.[9]

In Egypt, faba beans (*Vicia faba* L.) constitute one of the oldest major food crops that were cultivated by the Egyptians nearly 5,000 years ago, and the population relied on them to provide them with sufficient dietary protein. Nearly 75 percent of the daily per capita consumption of protein in Egypt is of vegetable source, mostly from cereals and beans. Egyptians consume about 14 grams per capita per day of beans, which is about 3 grams of protein. The pathogens (fungal and viral diseases) are one of the main obstacles that have affected plant growth and have contributed significantly to causing significant yield loss in terms of quantity and quality. The yield loss due to diseases is estimated to be around (25-80%) and the protein content decrease is about 4%. However, some control efforts are available to reduce these pathogens. The analysis of variance for protein content and tannin content revealed significant differences among genotypes. Their results indicated a wide genetic variability for all variables in the material under study. The chemical composition of seeds of 11 field grown faba bean cultivars in two cultivation periods was evaluated. It was found that the variation among genotypes was always highly significant and most cultivars exhibited a consistent rank in protein concentration.[10]

Increasing crop yields or preserving productivity at acceptable levels has become a primary objective of breeding and improvement programs,[11] but the mechanization of farming and agribusiness model has found new demands on improvement programs, comprising technological quality of the cereals traded.[12]Consequently, the testing of technological quality traits such as the cookability of the seeds, the percentage of whole seeds, the total soluble solids of the seeds, the protein content and the hydration coefficient before and after cooking, became a requirement for the inclusion of bean genotypes in the National Registers of Food Varieties.[13] Also, market acceptance of new varieties depends on other traits, comprising seed shape, seed contractility, percentage of seed hard, seed coat ratio, and soaking capacity.[14-20] Evaluation of technological characteristics is an important aspect of selecting and recommending new varieties, to increase farmer and consumer acceptance. So, this study assessed the technological quality of bean seeds from different genotypes from different locations in Egypt.

2. Experimental

2.1. Materials and Methods

Twenty-four faba bean genotypes of *Vicia faba* L were used in this study. Seeds were obtained from the Bahtim Research Station, Kalyopia , Egypt and four improved varieties (Misr 1, Giza 429, Giza 716 and Giza 843) were used as controls from Legumes Crops Department, Field Crops Research Institute, ARC, Egypt. The experiments were arranged in a randomized complete block design with three replications during two growing seasons.

Table 1. Faba bean varieties and landraces collected from Middle and Upper Egypt to characterize during growth seasons.

Serial No.	Source	Code	Origin	Location
1	Bahtim	63	35 km N of Idfu by El Sabaya village	**Qena**
2	Bahtim	97	Armant local market	**Qena**
3	Bahtim	153	Benifeez - Near Sidfa	**Assiut**
4	Bahtim	165	Beni – Rafi	**Assiut**
5	Bahtim	172	Qena	**Qena**
6	Bahtim	173	Qena	**Qena**
7	Bahtim	193	4 km W of Qena on the road to Dandara temple	**Qena**
8	Bahtim	233	14 km E of Nag Hammadi	**Qena**
9	Bahtim	243	Nag Hammadi	**Qena**
10	Bahtim	250	20 km NW of Nag Hammadi	**Qena**
11	Bahtim	276	El Balyana	**Sohag**
12	Bahtim	290	El Ma' Sara-Dakhla	**New valley**
13	Bahtim	298	21 km N of Girga	**Sohag**
14	Bahtim	305	19 km N of Sohag	**Sohag**
15	Bahtim	307	25 km N of Sohag	**Sohag**
16	Bahtim	332	Ezbat El Haga – El Kharga	**Sohag**
17	Bahtim	485	3 km S of BeniMazar	**Minia**
18	Bahtim	514	11 km S of Ihnasya El Madina	**Benisuef**
19	Bahtim	637	3 km of El Fayoum (El Karadisa)	**Fayoum**
20	Bahtim	233	El Abbada (Tameia)	**Fayoum**
21	Giza	Misr 1	Giza 3 X 123 A/45/76	**Egypt**
22	Giza	Giza 429	Individual selection from Giza 402	**Egypt**
23	Giza	Giza 716	461/842/83 X 503/453/83	**Egypt**
24	Giza	Giza 843	561/2076/85 Sakha X 461/845/83	**Egypt**

2.2 Technological characteristics

Seeds of genotypes were bulked from three replication to determine the following technological characteristics. The samples seeds were dried at 130°C for 1 hr.[21]

2.2.1 Soaking stage

The seeds were soaked and cooked.[22] Briefly, ten grams of dry seeds from each genotype were soaked in tap water for 24 hr at room temperature. The following measurements were determined in soaked seeds.

- Hydration coefficient of seeds before cooking (H.C.B.):

$$H.C.B = [(W_2 - W_1) / W_1] \times 100$$

where, W_1 = weight of dry seeds (g); and W_2 = weight of soaked seeds (g).

- Cotyledons to hull ratio (C/H ratio):

The soaked seeds was separated manually into cotyledons and hull. Every separation was dried at 40°Cover night, then it was weighted. The percent for each content was calculated.

2.2.2. Cooking stage

Other samples (10 g seeds/each) of dry seeds from each genotype were placed in glass tube (100cm^3) containing enough water (50 cm^3) for each. The tubes were put in oven for 24 hr at 100°C.The following measurements were determined in cooked seeds.[22]

- Hydration coefficient after cooking (H.C.A.):

The measurements were recorded according the following formulas:

$$H.C.A = [(W_2 - W_1) / W_1] \times 100$$

where, W_1 = weight of dry seeds (g); and W_2 = weight of cooked seeds (g).

Total soluble solids of the seeds (T.S.S.):-

The solution containing soluble material was poured into a porcelain pot placed in an oven at 60^{0}C over night until all water was evaporated. The pot was weighted before and after putting and the T.S.S. was calculated as follow:

$$T.S.S. = [(W_3 - W_2) / W_1] \times 100$$

where, W_1= Initial weight of seeds; W_2 = weight of empty pot; and W_3 = weight of pot after drying.

- Seed cookability (Stewing):

The ability of cooked seeds was measured by means of using the normal press of fingers and comparing between the cooked seeds for their hardness (Stewing).

2.3. Statistical Analyses

Statistical analysis of the obtained data was carried out for analysis of variance using computer Statistical program MSTAT-C.[23] Means were compared by the L.S.D. values at 5% level.

3. Results

3.1 Technological characteristics

3.1.1 Hydration coefficient before cooking (H.C.B %)

Hydration coefficient before cooking of faba bean genotypes under study are summarized in table (2). H.C.B was the highest in genotype 10 at 112.4% than control varieties, followed by genotypes 1-20 at 98.6-108.4% which are approximately nearby and equaled those found in control cultivars (Misr 1 and Gize 716). The highest values of H.C.B. due to lack genotypes of hard seeds. It displayed a higher H.C. and required short cooking times. Some researchers have found an association between higher HC and shorter cooking times,[24-25] while others have not.[26-27] The lowest H.C. may be related to low seed coat permeability. Differences in hydration capacity among varieties may be associated with differences in seed coat hardness, porosity, elasticity, cotyledon adherence, and colloidal properties across seeds from different varieties (**Fig. 1**).[28]

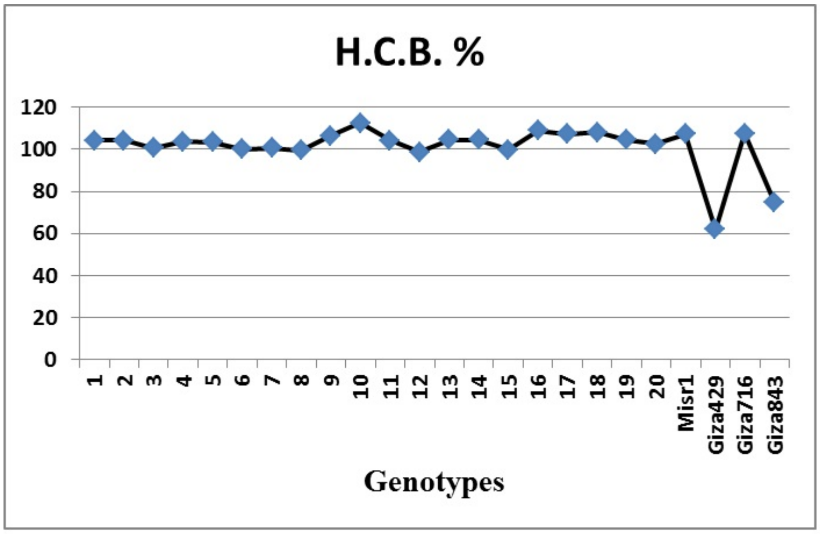

Fig. 1. Hydration coefficient before cooking (H.C.B %) for 24 Faba bean genotypes.

3.1.2 Cotyledons %

Cotyledons % values of faba bean seeds genotypes under study were obtained and the highest values for genotypes 9 (88.30%) and 20 (88.0%) while the lowest value was found in genotypes 6 and 2(84.8 and 85.0%, respectively). The cotyledons of the other genotypes ranged from 84.8 to 88.3% (**Fig. 2**).

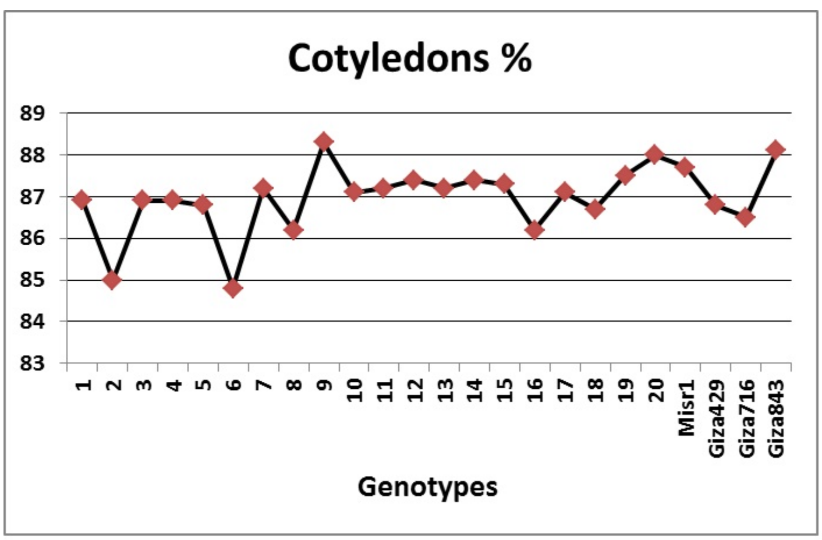

Fig. 2. Cotyledons percentage for 24 Faba bean genotypes.

3.1.3 Hulls %

Data in **Table 2** showed that the hulls% was significant between genotypes. The highest value for genotypes 6 (15.2%) and 2 (14.9%) whereas, genotypes 9 and Giza 843 had the lowest values (11.7 and 11.9%, respectively). Hulls% content of the other genotypes ranged from 11.7 to 15.2% (**Fig. 3**).

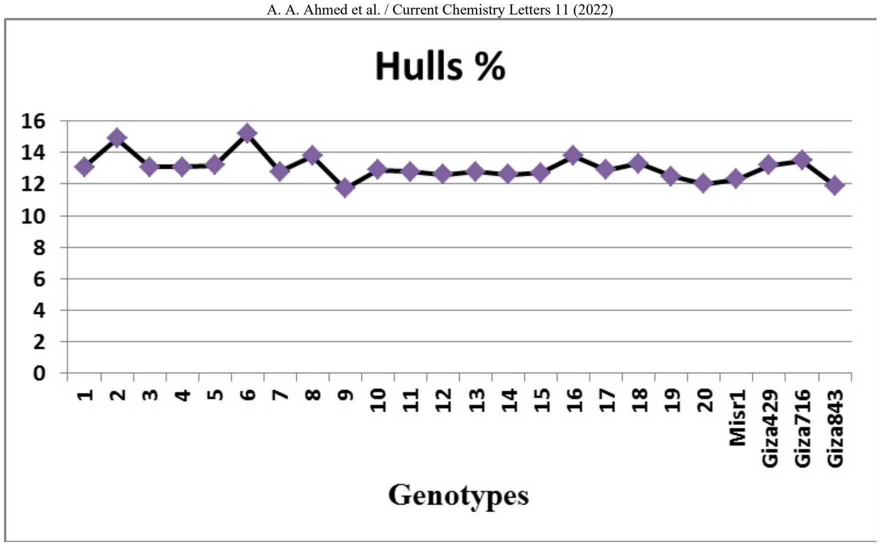

Fig. 3. Hulls percentage for 24 Faba bean genotypes.

3.1.4 Cotyledons to hulls ratio (C.\H. ratio).

Results in **Table 2** show the Cotyledons to hulls ratio of faba beans for the genotypes under investigation. Presented results indicated that the genotypes 3 and 20 gave the highest values (8.14 and 7.55%, respectively), while genotype 6 and 2 gave the lowest values (5.58 and 5.71%, respectively). Whereas, most of the other genotypes conformed to commercial standards (7.41-6.41%). A low cotyledons to hulls ratio is a desirable character, as a high cotyledons to hulls ratio affects the supposed stimulus of chewing and decreases consumer acceptance (**Fig. 4**).[29]

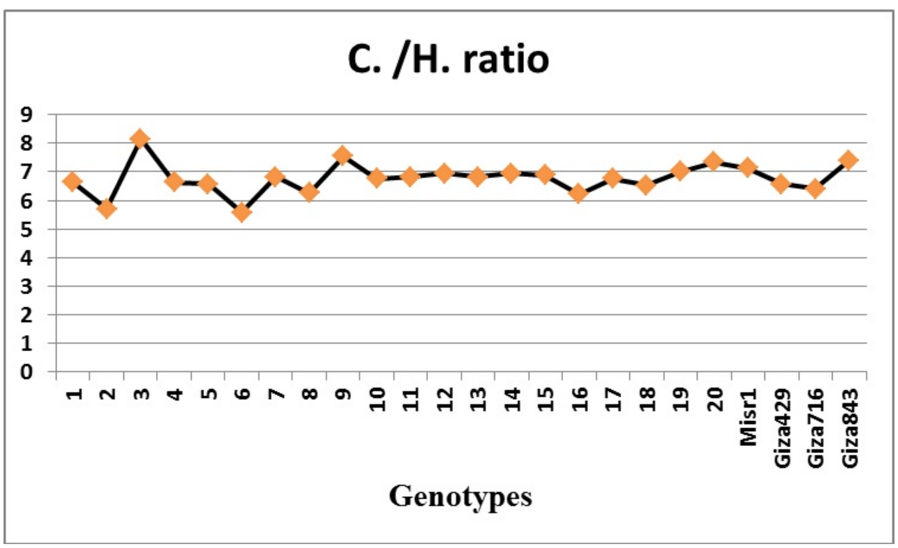

Fig. 4. Cotyledons to hulls ratio (C.\H. ratio) for 24 Faba bean genotypes.

3.1.5 Hydration coefficient after cooking (H.C.A %)

Data present in **Table 2** show the hydration coefficient after cooking of the tested faba bean seeds. The highest value was recorded for genotypes 11, 20 and 9 (199.7, 197.3 and 195.9%, respectively), whereas the lowest value was found for genotype 6 (145.6%). H.C.A % in the other genotypes under study ranged from 145.6 to 199.7% (**Fig. 5**).

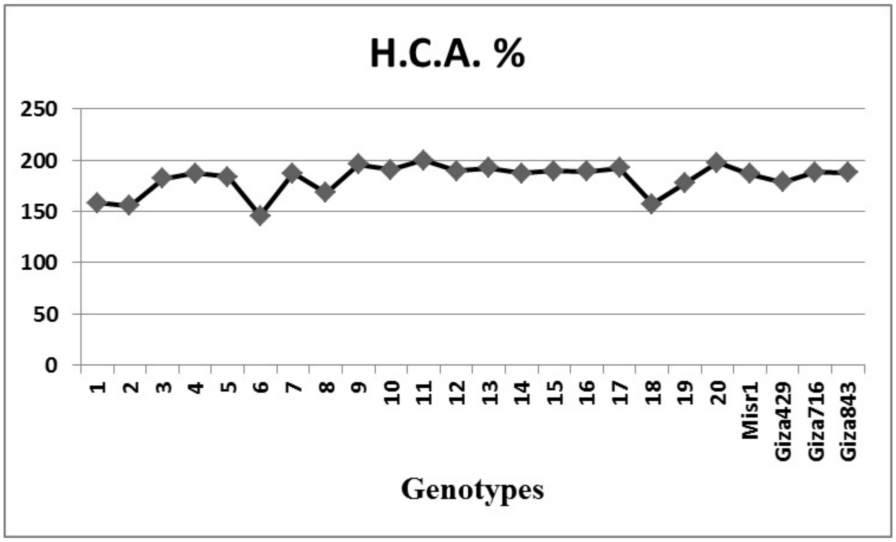

Fig. 5. Hydration coefficient after cooking (H.C.A %) for 24 Faba bean genotypes

3.1.6 Total soluble solids (T.S.S. %)

Total soluble solids content was highest in genotypes 1 to 17 (**Table 2**). T.S.S. in these genotypes exceeded those found currently in the market. T.S.S. is an important character in determining soup quality of cooked beans and consumer studies indicate a preference for viscous soup after cooking, which should favor the new varieties with similar or higher soluble solid content compared to current varieties (**Fig. 6**).[30]

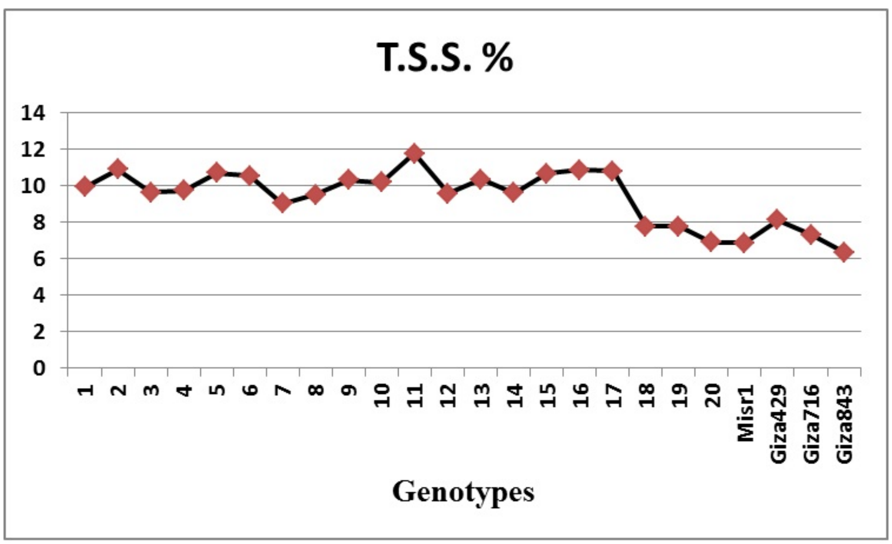

Fig. 6. Total soluble solids (T.S.S. %) for 24 Faba bean genotypes.

3.1.7 Seed cookability (Stewing)%

Stewing %in these genotypes equaled or exceeded those found in control cultivars. Especially, genotypes10, 11, and 17 had the highest stewing and were superior to control cultivars, while genotypes 6, 8, and 18 had the shortest stewing at 60 – 70%. The highest stewing is suitable for bean cultivars, because it means maintaining energy and resources.[31] In addition, beans that require very long stewing to become delicious may have lower nutritional qualities as protein, vitamin, and mineral contents.[32-33] Lastly, the development of fast-cooking bean cultivars conforms requirements of consumer.[29] The presence of hard seeds is linked to the "hard to cook" phenomenon which defines the condition in which seeds take longer to soften through cooking or do not soften even after extended cooking in boiling water (**Fig. 7**).[34]

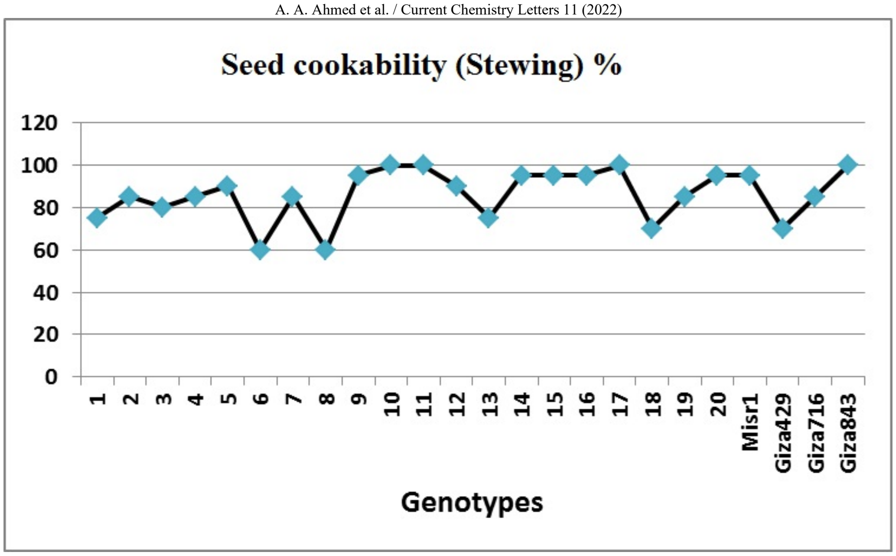

Fig. 7. Seed cookability (Stewing) percentage for 24 Faba bean genotypes

Table 2. Technological characters of some faba bean genotypes

Characters Studied	H.C.B. %	Cotyledons %	Hulls %	C. /H. ratio	H.C.A. %	T.S.S. %	Stewing %
Genotypes							
1	104.2	86.9	13.1	6.64	158.4	9.94	75
2	104.1	85.0	14.9	5.71	155.2	10.9	85
3	100.6	86.9	13.1	8.14	181.7	9.64	80
4	103.7	86.9	13.1	6.64	186.9	9.74	85
5	103.4	86.8	13.2	6.58	183.7	10.69	90
6	100.1	84.8	15.2	5.58	145.6	10.54	60
7	100.7	87.2	12.8	6.82	187.0	9.03	85
8	99.5	86.2	13.8	6.25	168.4	9.525	60
9	106.5	88.3	11.7	7.55	195.9	10.31	95
10	112.4	87.1	12.9	6.75	190.7	10.18	100
11	104.2	87.2	12.8	6.82	199.7	11.78	100
12	98.6	87.4	12.6	6.94	189.2	9.58	90
13	104.4	87.2	12.8	6.82	192.1	10.34	75
14	104.4	87.4	12.6	6.94	187.0	9.62	95
15	99.8	87.3	12.7	6.88	189.2	10.68	95
16	108.8	86.2	13.8	6.21	188.8	10.88	95
17	107.1	87.1	12.9	6.75	192.3	10.79	100
18	108.1	86.7	13.3	6.52	157.1	7.785	70
19	104.5	87.5	12.5	7.00	177.5	7.755	85
20	102.6	88.00	12.0	7.34	197.3	6.90	95
Misr1	107.1	87.7	12.3	7.13	186.4	6.88	95
Giza 429	61.9	86.8	13.2	6.58	178.7	8.14	70
Giza 716	107.5	86.5	13.5	6.41	188.0	7.32	85
Giza 843	74.5	88.1	11.9	7.41	187.9	6.335	100
LSD 5%	1.18	1.35	1.33	1.61	6.13	0.74	12.1

3.2 Seed chemical composition

The gross seed chemical composition analysis (on dry matter basis) of 24 faba bean genotypes under study is given in **Table 3**. All genotypes differed significantly in all seed chemical characters.

Moisture content ranged from 9.15 to 10.45% the highest value was recorded by line No. 6, while the lowest one for Misr 1. Results in **Table 3** show the crude protein content of faba bean genotypes under investigation. Presented results indicated that line 20 was the highest in protein content (30.72%), while line 5 gave the lowest value (26.65 %). However, protein content behaved a similar trend of 29.82, 29.70 and 29.70% for lines 19, 17 and 18, respectively. Seed crude fat content values of faba bean genotypes under study are presented in **Table 3**. Results showed that the highest values of fat content were obtained for line 9 (2.05%) and line 19 (2.04%), while the lowest value was found in line 7 (1.93%). Data present in **Table 3** show the ash content of the tested faba bean seeds. The highest ash content was recorded for faba bean variety Giza 429 (3.35%), whereas the lowest ash content was found for faba bean seeds of line 11(3.00%). Carbohydrates contents of faba bean genotypes under study are presented in **Table 3**. Results indicated that the line 5 (62.25%) showed the highest value, however the lowest carbohydrate content was obtained in seeds of line 20 (58.00%). Carbohydrate content for seeds of the other genotypes ranged between the previously mentioned limits, i.e. the highest and the lowest values.

Data in **Table 3** show that the tannin content was highly significant by difference between genotypes. The highest value was in seed of Giza 716 (157.45 mg/100g), whereas line 5 had the lowest content (70.67 mg/100g). Total tannin content of the rest of the genotypes ranged between these two limits. Seed phenols content values of faba bean genotypes under study are presented in **Table 3**. Results indicated that the highest value of phenols content was obtained for line 3 (51.02 mg/100g) while the lowest value was found in line 11 (35.23 mg/100g).

Table 3. Chemical composition analysis of some faba bean germplasm

Characters Studied	Moisture%	Crude protein%	Crude fat %	Ashe%	Total Carbohydrate%	Tannins%	Phenols %
Genotypes							
1	10.2	29.63	1.96	3.20	59.22	91.74	45.10
2	10.6	29.25	1.99	3.30	59.47	61.99	44.50
3	10.25	26.70	1.97	3.15	62.18	78.10	51.02
4	10.05	27.45	1.97	3.25	61.33	76.86	42.20
5	9.65	26.65	1.95	3.15	62.25	70.67	36.22
6	10.45	29.31	1.97	3.25	60.47	105.4	39.56
7	9.9	27.70	1.93	3.15	61.22	122.7	36.08
8	9.9	28.26	1.97	3.25	60.51	111.6	38.43
9	9.8	26.80	2.05	3.20	61.95	96.70	39.18
10	9.8	26.75	1.98	3.30	61.97	136.4	28.68
11	9.45	27.33	1.97	3.00	61.70	85.54	35.23
12	9.3	27.89	1.95	3.25	60.92	124.0	43.94
13	10.2	28.47	2.02	3.10	60.42	147.5	43.06
14	10	28.51	1.95	3.20	60.33	121.5	41.54
15	10	28.35	2.04	3.10	60.51	100.4	49.47
16	10.05	28.50	1.95	3.20	60.35	131.4	40.84
17	9.85	29.70	2.10	3.15	59.05	147.5	46.55
18	10.4	29.70	1.97	3.25	59.08	150.0	36.47
19	9.5	29.82	2.04	3.20	58.94	114.1	40.15
20	10.05	30.72	1.99	3.30	58.00	106.6	40.69
Misr1	9.15	27.67	1.96	3.25	60.12	107.9	41.01
Giza429	10.4	29.23	1.98	3.35	59.44	127.7	45.69
Giza716	9.5	27.26	1.97	3.20	61.58	157.4	44.31
Giza843	9.3	26.97	1.97	3.30	61.76	112.8	43.28
LSD 5%	**0.24**	**4.25**	**0.09**	**0.21**	**4.16**	**25.28**	**5.91**

4. Discussions

The data presented in this study on the technological characteristics and chemical composition of the genotypes under the study are in agreement with many studies that dealt with the different technological characteristics of the faba bean cultivars. For instance, a slight variation between varieties for hulls to seed ratio which was found in the range of 11.4 and 14.51% stewing percentage ranged from 20 to 90%. Also, the hydration coefficient of the dried seeds ranged between 93.95 and 116.55. Hull percentage ranged from 10.75-13.74%. The ratio between cotyledon and hull showed an opposite trend of hull percentage. The percentage of stewed faba bean seeds ranged from 50 to 100% when the autoclaving method was used, while it ranged from 30 to 100 % due to the oven method. The analysis of variance for all studied chemical and technological characters such as (C/H ratio, stewing % and TSS %) revealed significant differences among genotypes for all characters. Significant variations were found for most physical and cooking properties such as, density, imbibed water after soaking %, imbibed water after cooking %, cotyledons %, seed coat % and total soluble solids % in six faba bean cultivars with their F1 crosses.

Seed proteins are deficient in some amino acids that are essential for humans and other mono-gastric animals, so, the most economic approach is through breeding programs to develop promising genotypes with high yield, quality and good agronomic performance. Protein content of faba bean seeds depended on cultivars and oscillated from 23.9 to 29.8%. These results indicated wide genetic variability for all variables in the material under study. Beside to these genotypes are suitable for Faba bean breeding programs to improve Faba seed quality and fulfill consumer's requirements. This work can confirm the previous data that clarify the importance of science in the world.[35-67]

5. Conclusion

The data presented in this study on the technological characteristics of the genotypes under study are in agreement with many studies that dealt with the different technological characteristics of the faba bean cultivars. For example, hydration coefficients in all of the genotypes had values ranging from 98.6-112.4% equaled and/or exceeded those found in control cultivars. With regard to the property of the Cotyledons to hull ratio, the decrease is a desirable trait and most genotypes meet consumer standards. Only genotypes 3 and 20 gave the highest values (8.14 and 7.55%, respectively). Hydration coefficient after cooking (H.C.A %) was superior with germplasm as 9, 11, 13, 17 and 20 compared with other germplasm and check varieties. Whereas, most of the other genotypes ranged from (7.41-6.41%). The total soluble solids character was the highest in all of the genotypes, ranging from 6.90-11.78%and were superior to control cultivars (6.33-8.14%). Finally, genotypes 6, 8, and 18 displayed the shortest percentage of seed cookability, ranging from 60 -70%, while the highest was observed in most of genotypes, ranging from (75-100%) and conforming to the needs of consumers. The seeds chemical composition analysis showed that the genotypes differed in their composition as follows: protein (from 26.65 to 30.72%), carbohydrate (from 58.00 to 62.25%), crud fat (from 1.93 to 2.05%), ash (from 3.00 to 3.35 %.), tannin (from 70.67 to 157.45%), phenols (35.23-51.02 %), and moisture (9.15 to 10.45%). Based on the above results, these genotypes are suitable for the Faba bean breeding program to improve Faba seed quality and fulfill consumer's requirements.

References

1. Sharan S., Zanghelini G., Zotzel J., Bonerz D., Aschoff J., Saint-Eve A., and Maillard M. N. (**2021**) Fava bean (Vicia faba L.) for food applications: From seed to ingredient processing and its effect on functional properties, antinutritional factors, flavor, and color. *Compr. Rev. Food Sci. Food Saf.*, 20 (1) 401-428.
2. Kumari S. G., and Van Leur J. A. G. (**2011**) Viral diseases infecting faba bean (Vicia faba L.). *Grain legumes*, 56 24-26.
3. Li X., and Yang Y. (**2014**) A novel perspective on seed yield of broad bean (Vicia faba L.): differences resulting from pod characteristics. *Sci. Rep.*, 4 (1) 1-6
4. Nadal S., Suso M. J., and Moreno M. T. (**2003**) Management of Vicia faba genetic resources: changes associated to the selfing process in the major, equina and minor groups. *Genet. Resour. Crop Evol.*, 50 (2) 183-192.
5. Hauggaard-Nielsen H., Mundus S., and Jensen E. S. (**2009**) Nitrogen dynamics following grain legumes and subsequent catch crops and the effects on succeeding cereal crops. *Nutr. Cycl. Agroecosystems*, 84 (3) 281-291.
6. Crépon K., Marget P., Peyronnet C., Carrouée B., Arese P., and Duc G. (**2010**) Nutritional value of faba bean (Vicia faba L.) seeds for feed and food. *Field Crops Res.*, 115 (3) 329-339.
7. Hacıseferoğulları H., Gezer İ. B. R. A. H. İ. M., Bahtiyarca Y. C. H. O., and Mengeş H. O. (**2003**) Determination of some chemical and physical properties of Sakız faba bean (Vicia faba L. Var. major). *J. Food Eng.*, 60 (4) 475-479.
8. Carrillo-Perdomo E., Vidal A., Kreplak J., Duborjal H., Leveugle M., Duarte J., Desmetz C., Deulvot C., Raffiot B., Marget P., Tayeh N., Pichon J., Falque M., Martin O., Burstin J., and Aubert G. (**2020**) Development of new genetic resources for faba bean (Vicia faba L.) breeding through the discovery of gene-based SNP markers and the construction of a high-density consensus map. *Sci. Rep.*, 10(1) 1-14.
9. Köpke U., and Nemecek T. (**2010**) Ecological services of faba bean. *Field Crop Res.*, 115 (3) 217-233.
10. (a) Sharan S., Zanghelini G., Zotzel J., Bonerz D., Aschoff J., Saint-Eve A., and Maillard M. N. (**2021**) Fava bean (Vicia faba L.) for food applications: From seed to ingredient processing and its effect on functional properties, antinutritional factors, flavor, and color. *Compr. Rev. Food Sci. Food Saf.*, 20(1) 401-428, (b) Sabah A. M. and, Somaya M. M. (**2001**) Diallel analysis of some yield and technological characters among four faba bean genotypes with their crosses. *Annals Agric. Sci.*, 39 (1) 65-75, (c) Karamanos A. J., Papadouls G., Avgoulas C. E., and Papastylianou P. (**1994**) Chemical composition of seeds of 11 field bean cultivars in two cultivation periods. *FABIS Newsletter*, 34/35 39-47.
11. de Faria L. C., Melo P. G. S., Pereira H. S., Del Peloso M. J., Brás A. J. B. P., Moreira J. A. A., de Carvalho H. W. L., and Melo L. C. (**2013**) Genetic progress during 22 years of improvement of carioca-type common bean in Brazil. *Field Crops Res.*, 142 68-74.
12. Melo L. C., Peloso M. J. D., Pereira H. S., Faria L. C. D., Costa J. G. C. D., Díaz J. L. C., Rava C. A., Wendland A., Abreu A. D. B., and Abreu Â. D. F. B. (**2010**) BRS Estilo: common bean cultivar with Carioca grain, upright growth and high yield potential. *Crop Breed. Appl. Biotechnol.*, 10 377-379.
13. Nielsen K. L., Eshel A., and Lynch J. P. (**2001**) The effect of phosphorus availability on the carbon economy of contrasting common bean (*Phaseolus vulgaris* L.) genotypes. *J. Exp. Bot.*, 52 (355) 329-339.
14. Furlani Â. M. C., Furlani P. R., Tanaka R. T., Mascarenhas H. A. A., and Delgado M. D. D. P. (**2002**) Variability of soybean germplasm in relation to phosphorus uptake and use efficiency. *Sci. Agric.*, 59 (3) 529-536.
15. Escribano M. R., Santalla M., and De Ron A. M. (**1997**) Genetic diversity in pod and seed quality traits of common bean populations from northwestern Spain. *Euphytica*, 93 (1) 71-81.
16. Lemos L. B., Oliveira R. S. D., Palomino E. C., and Silva T. R. B. D. (**2004**) Agronomic and technologic characteristics of common bean genotypes from Carioca commercial group. *Pesqui. Agropecu. Bras.*, 39 319-326.
17. Reyes-Moreno C., Paredes-López O., and Gonzalez E. (**1993**) Hard-to-cook phenomenon in common beans—A review. *Crit. Rev. Food Sci. Nutr.*, 33 (3) 227-286.
18. Zilio M., Souza A. C., Coelho M. C., and Jose D. (**2014**) The genotype and crop environment affect the technological quality of common beans grains. *Am.-Eurasian j. agric. environ. sci.*, 14 (3) 212-220.
19. de Barros M., and Prudencio S. H. (**2016**) Physical and chemical characteristics of common bean varieties. *Semina:Cienc. Agrar.*, 37 (2) 751-761.
20. El-Moniem G. M. A. (**1999**) Sensory evaluation and in vitro protein digestibility of mung bean as affected by cooking time. *J. Sci. Food Agric.*, 79 (14) 2025-2028.
21. AOAC (**2003**) Official methods of analysis of AOAC International. 17^{th}edition, Association of the Official Analytical Chemists, Gaithersburg, MD, USA.

22. Fahmy H.M.,Srivastava S., and Uebersax M.A. (**1996**) Physical and textural characteristics of soaked and cooked American Common Beans. *Egypt. J. Food Sci.*, 24 (2) 105-118.
23. Steel R. G. D., and Torrie J. H. (**1982**) Principals and Procedures of Statistics A Biometrical Approach. McGraw Hill Book Company, New York. USA.
24. Siqueira B. S., Bassinello P. Z., Malgaresi G., Pereira W. J., and Fernandes K. F. (**2016**) Analyses of technological and biochemical parameters related to the HTC phenomenon in carioca bean genotypes by the use of PCA. *LWT - Food Sci. Technol.*, 65 939-945.
25. Sandhu K. S., You F. M., Conner R. L., Balasubramanian P. M., and Hou A. (**2018**) Genetic analysis and QTL mapping of the seed hardness trait in a black common bean (Phaseolus vulgaris) recombinant inbred line (RIL) population. *Mol. Breed.*, 38 (3) 1-13.
26. Wafula E. N., Wainaina I. N., Buvé C., Kinyanjui P. K., Saeys W., Sila D. N., and Hendrickx M. E. (**2021**) Prediction of cooking times of freshly harvested common beans and their susceptibility to develop the hard-to-cook defect using near infrared spectroscopy. *J. Food Eng.*, 298 110495.
27. Paesani C., Degano A. L., Zalosnik M. I., Fabi J. P., and Pérez G. T. (**2021**) Enzymatic modification of arabinoxylans from soft and hard Argentinian wheat inhibits the viability of HCT-116 cells. *Food Res. Int.*, 147 110466.
28. Parmar N., Singh N., Kaur A., and Thakur S. (**2017**) Comparison of color, anti-nutritional factors, minerals, phenolic profile and protein digestibility between hard-to-cook and easy-to-cook grains from different kidney bean (Phaseolus vulgaris) accessions. *J. Food Sci. Technol*., 54 (4) 1023-1034.
29. Crépon K., Marget P., Peyronnet C., Carrouée B., Arese P., and Duc G. (**2010**) Nutritional value of faba bean (Vicia faba L.) seeds for feed and food. *Field Crops Res.*, 115 (3) 329-339.
30. Tigist M., WorknehT. S., and Woldetsadik K. (**2013**) Effects of variety on the quality of tomato stored under ambient conditions. *J. Food Sci. Technol.*, 50 (3) 477-486.
31. Garrity D. P., Watts D. G., Sullivan C. Y., and Gilley J. R. (**1982**) Moisture Deficits and Grain Sorghum Performance: Evapotranspiration-Yield Relationships 1. *Agron. J.*, 74 (5) 815-820.
32. Hasstedt S. J., Leppert M., Filloux F., van de Wetering B. J., and McMahon W. M. (**1995**) Intermediate inheritance of Tourette syndrome, assuming assortative mating. *Am. J. Hum. Genet*., 57 (3) 682.
33. Peters W. S., and Bernstein N. (**1997**) The determination of relative elemental growth rate profiles from segmental growth rates (a methodological evaluation). *Plant Physiol*., 113 (4) 1395-1404.
34. Lieberman L. (**2001**) How "Caucasoids" got such big crania and why they shrank: from Morton to Rushton. *Curr. Anthropol.*, 42 (1) 69-95.
35. Abd-Ella A. A., Metwally S. A., Abdul-Malik M. A., El-Ossaily Y. A., Abd Elrazek F. M., Aref S. A., Naffea Y. A., and Abdel-Raheem Sh. A. A. (**2022**) A review on recent advances for the synthesis of bioactive pyrazolinone and pyrazolidinedione derivatives. *Curr. Chem. Lett.*, 11 (2) 157-172.
36. Abdel-Raheem Sh. A. A., Kamal El-Dean A. M., Zaki R. M., Hassanien R., El-Sayed M. E. A., Sayed M., and Abd-Ella A. A. (**2021**) Synthesis and toxicological studies on distyryl-substituted heterocyclic insecticides. *Eur. Chem. Bull*., 10 (4) 225-229.
37. Kamal El-Dean A. M., Abd-Ella A. A., Hassanien R., El-Sayed M. E. A., and Abdel-Raheem Sh. A. A. (**2019**) Design, Synthesis, Characterization, and Insecticidal Bioefficacy Screening of Some New Pyridine Derivatives. *ACS Omega*, 4 (5) 8406-8412.
38. Tolba M. S., Sayed M., Kamal El-Dean A. M., Hassanien R., Abdel-Raheem Sh. A. A., and Ahmed M. (**2021**) Design, synthesis and antimicrobial screening of some new thienopyrimidines. *Org. Commun.*, 14 (4) 334-345.
39. Abdel-Raheem Sh. A. A., Kamal El-Dean A. M., Hassanien R., El-Sayed M. E. A., and Abd-Ella A. A. (**2020**) Synthesis and biological activity of 2-((3-Cyano-4,6-distyrylpyridin-2-yl)thio)acetamide and its cyclized form. *Alger. j. biosciences*, 01 (02) 046-050.
40. Abdel-Raheem Sh. A. A., Kamal El-Dean A. M., Abdul-Malik M. A., Hassanien R., El-Sayed M. E. A., Abd-Ella A. A., Zawam S. A., and Tolba M. S. (**2022**) Synthesis of new distyrylpyridine analogues bearing amide substructure as effective insecticidal agents. *Curr. Chem. Lett.*, 11 (1) 23-28.
41. Bakhite E. A., Abd-Ella A. A., El-Sayed M. E. A., and Abdel-Raheem Sh. A. A. (**2017**) Pyridine derivatives as insecticides. Part 2: Synthesis of some piperidinium and morpholiniumcyanopyridinethiolates and their Insecticidal Activity. *J. Saud. Chem. Soc.*, 21 (1) 95–104.
42. Kamal El-Dean A. M., Abd-Ella A. A., Hassanien R., El-Sayed M. E. A., Zaki R. M., and Abdel-Raheem Sh. A. A. (**2019**) Chemical design and toxicity evaluation of new pyrimidothienotetrahydroisoquinolines as potential insecticidal agents. *Toxicol. Rep.*, 6 (2019) 100-104.
43. Gad M. A., Aref S. A., Abdelhamid A. A., Elwassimy M. M., and Abdel-Raheem Sh. A. A. (**2021**) Biologically active organic compounds as insect growth regulators (IGRs): introduction, mode of action, and some synthetic methods. *Curr. Chem. Lett.*, 10 (4) 393-412.
44. Abdel-Raheem Sh. A. A., Kamal El-Dean A. M., Hassanien R., El-Sayed M. E. A., and Abd-Ella A. A. (**2021**) Synthesis and characterization of some distyryl-derivatives for agricultural uses. *Eur. Chem. Bull.*, 10 (1) 35-38.
45. Tolba M. S., Sayed M., Abdel-Raheem Sh. A. A., Gaber T. A., Kamal El-Dean A. M., and Ahmed M. (**2021**) Synthesis and spectral characterization of some new thiazolopyrimidine derivatives. *Curr. Chem. Lett.*, 10 (4) 471-478.

46. Al-Taifi E. A., Abdel-Raheem Sh. A. A., and Bakhite E. A. (**2016**) Some reactions of 3-cyano-4-(*p*-methoxyphenyl)-5-oxo-5,6,7,8-tetrahydroquinoline-2(1*H*)-thione; Synthesis of new tetrahydroquinolines and tetrahydrothieno[2,3-*b*]quinolines. *Assiut University Journal of Chemistry (AUJC)*, 45 (1) 24-32.
47. Abdel-Raheem Sh. A. A., Kamal El-Dean A. M., Hassanien R., El-Sayed M. E. A., Sayed M., and Abd-Ella A. A. (**2021**) Synthesis and spectral characterization of selective pyridine compounds as bioactive agents. *Curr. Chem. Lett.*, 10 (3) 255-260.
48. Abdel-Raheem Sh. A. A., Kamal El-Dean A. M., Abdul-Malik M. A., Abd-Ella A. A., Al-Taifi E. A., Hassanien R., El-Sayed M. E. A., Mohamed S. K., Zawam S. A., and Bakhite E. A. (**2021**) A concise review on some synthetic routes and applications of pyridine scaffold compounds. *Curr. Chem. Lett.*, 10 (4) 337-362.
49. Tolba M. S., Kamal El-Dean A. M., Ahmed M., Hassanien R., Sayed M., Zaki R. M., Mohamed S. K., Zawam S. A., and Abdel-Raheem Sh. A. A. (**2022**) Synthesis, reactions, and applications of pyrimidine derivatives. *Curr. Chem. Lett.*, 11 (1) 121-138.
50. Abdelhafeez I. A., El-Tohamy S. A., Abdul-Malik M. A., Abdel-Raheem Sh. A. A., and El-Dars F. M. S. (**2022**) A review on green remediation techniques for hydrocarbons and heavy metals contaminated soil. *Curr. Chem. Lett.*, 11 (1) 43-62.
51. Tolba M. S., Abdul-Malik M. A., Kamal El-Dean A. M., Geies A. A., Radwan Sh. M., Zaki R. M., Sayed M., Mohamed S. K., and Abdel-Raheem Sh. A. A. (**2022**) An overview on synthesis and reactions of coumarin based compounds. *Curr. Chem. Lett.*, 11 (1) 29-42.
52. Bakhite E. A., Abd-Ella A. A., El-Sayed M. E. A., and Abdel-Raheem Sh. A. A. (**2014**) Pyridine derivatives as insecticides. Part 1: Synthesis and toxicity of some pyridine derivatives against Cowpea Aphid, Aphis craccivora Koch (Homoptera: Aphididae). *J. Agric. Food Chem.*, 62 (41) 9982–9986.
53. Abdelhamid A. A., Elsaghier A. M. M., Aref S. A., Gad M. A., Ahmed N. A., and Abdel-Raheem Sh. A. A. (**2021**) Preparation and biological activity evaluation of some benzoylthiourea and benzoylurea compounds. *Curr. Chem. Lett.*, 10 (4) 371-376.
54. Elhady O. M., Mansour E. S., Elwassimy M. M., Zawam S. A., Drar A. M., and Abdel-Raheem Sh. A. A. (**2022**) Selective synthesis, characterization, and toxicological activity screening of some furan compounds as pesticidal agents. *Curr. Chem. Lett.*, 11 (3) 285-290.
55. Kaid M., Ali A. E., Shamsan A. Q. S., Salem W. M., Younes S. M., Abdel-Raheem Sh. A. A., and Abdul-Malik M. A. (**2022**) Efficiency of maturation oxidation ponds as a post-treatment technique of wastewater. *Curr. Chem. Lett.*, Accepted Manuscript (DOI: 10.5267/j.ccl.2022.4.005).
56. Mohamed S. K., Mague J. T., Akkurt M., Alfayomy A. M., Abou Seri S. M., Abdel-Raheem Sh. A. A., and Abdul-Malik M. A. (**2022**) Crystal structure and Hirshfeld surface analysis of ethyl (3*E*)-5-(4-chlorophenyl)-3-{[(4-chlorophenyl)formamido]imino}-7-methyl-2*H*,3*H*,5*H*-[1,3]thiazolo[3,2-a]pyrimidine-6-carboxylate. *Acta Cryst.*, Accepted Manuscript (DOI: 10.1107/S205698902200603X).
57. Ahmed A. A., and El-Mahdy A. A. (**2022**) Improving seed germination and seedling growth of maize (Zea mays, L.) seed by soaking in water and moringa oleifera leaf extract. *Curr. Chem. Lett.*, 11 (2) 147-156.
58. Ahmed A. A., Attya A., Harb A. H., and Mostafa S. (**2021**) Genetic variation of barley enotypes using morphological, yield components and molecular markers. *Journal of Global Agriculture and Ecology*, 12 (2) 29-39.
59. Abo-Hegazy S. R. E., Ashrei A. A. M., and Ahmed A. A. (**2020**) Evaluation of Some Lupin Genotypes Using Different Agro-morphological, Statistical and Chemical Methods. *Asian J. Crop Sci.*, 12 72-83.
60. Ashrei A. A. M., Ahmed A. A., Behairy R. T., and Abdel-Wahab E. I. (**2018**) Identification of some lupine genotypes using morphological, chemical methods and yield components. *Egypt. J. Plant Breed.*, 22 (3) 579– 595.
61. Ahmed A. A., Aboel-Komsan S. M., and Mostafa S. (**2018**) Morphological and biochemical identification of some flax genotypes. *Egypt. J. Plant Breed.*, 22 (3) 597– 612.
62. Ahmed A. A., Reiad M. S., and Ibrahim H. S. (**2014**) Characterization of some faba bean genotypes using morphological and chemical methods. *Egypt. J. Plant Breed.*, 17 (2) 161-179.
63. Yassin O., Ismail S., Gameh M., Khalil F., and Ahmed E. (**2022**) Evaluation of chemical composition of roots of three sugar beets varieties growing under different water deficit and harvesting dates in Upper Egypt. *Curr. Chem. Lett.*, 11 (1) 1-10.
64. Abdelgalil A., Mustafa A. A., Ali S. A. M., and Yassin O. M. (**2022**) Effect of irrigation intervals and foliar spray of zinc and silicon treatments on maize growth and yield components of maize. *Curr. Chem. Lett.*, 11 (2) 219-226.
65. Yassin O. M., Ismail S., Ali M., Khalil F., and Ahmed E. (**2021**) Optimizing Roots and Sugar Yields and Water Use Efficiency of Different Sugar Beet Varieties Grown Under Upper Egypt Conditions Using Deficit Irrigation and Harvesting Dates. *Egypt. J. Soil Sci.*, 61 (3) 367-372.
66. Abdelgali A., Mustafa A. A., Ali S. A. M., Yassin O. M. (**2018**) Irrigation intervals as a guide to surface irrigation scheduling of maize in Upper Egypt. *J. Biol. Chem. Environ. Sci.*, 13 (2) 121-133.
67. Abdelgalil A., Mustafa A. A., Ali S. A. M., and Yassin O. M. (**2022**) Effect of different water deficit and foliar spray of zinc and silicon treatments of chemical composition of maize. *Curr. Chem. Lett.*, 11 (2) 191-198.