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Vegetative Characteristics and Nutritional Components of A New Line (Dwarf) As Compared with Three Commercial Genotypes of Faba Bean

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ABSTRACT

Seeds of Dwarf as a new bean line were subjected to comparing with three commercial genotypes; Assiut 142, Giza 3 and Romy 80 in some vegetative characteristics and nutritional components. The cooking quality and chemical composition as well as, preparation of biscuit with 10% and 20% of whole faba bean seeds flour from the above four genotypes were investigated. The results showed that faba bean seeds are good source of nutrients, such as carbohydrates, minerals and protein, in addition to phenolics and flavonoids compounds. The abundant minerals in the faba bean seeds were magnesium, calcium and phosphorus with among the other minerals. Amino acids analysis showed that faba bean seeds protein is rich in some essential amino acids, such as Lysine, Isoleucine and Leucine. Based on the study results it could be mentioned that Dwarf faba bean as a new line considered as an acceptable to be consumed directly or after processing.

Keywords: Green pods, Dry seeds, Total Phenolics, Flavonoids, Minerals.

INTRODUCTION

Faba bean (*Vicia faba* L.) is considered the fourth important pulse crop in the world. It is used as animal feed in advanced countries and as food for human consumption in developing countries (Kumari and Van Leur 2011). Faba bean is main source of plant protein. In progressing countries in Africa, Latin America and parts of Asia, it considered an important solution against malnutrition, which this crop contained a high amounts of minerals, vitamins, carbohydrates and high lysine-rich protein. The publicity of faba bean may be due to its comparatively sensible prices compared to other food materials. High prices of meat and dairy products are hurdles, especially for young children which boor diets scattered within this group. Plant breeders, consumers or producers have a special interest in the quality of faba bean seeds, which it contained good contents of proteins, carbohydrates and calories. There are many factors that affect the quality of seeds such as environmental conditions and cultivated genotypes which considered the most important of these factors (Elsayed and El-Naim 2015, Maalouf *et al*., 2018).

The crop is also used as an excellent component of crop rotations, something that has been very much neglected in modern cropping, at a time when there is an urgent need to minimize the impact of chemical fertilizers on the environment, reduce emissions of undesirable gasses, and reduce the production cost of the following crops (Kopke and Nemecek 2010). Also, the physical characteristics of faba bean seeds are strongly influenced from one local area to another, which is one of the most important factors affecting preferable the quality cooking of faba beans. The ability of the seeds to absorb water efficiently after soaking expressed as the hydration coefficient is one of the most important quality factors of high value to consumers, which indicates the seeds readiness for cooking processes (Elsheikh and Ahmed 2000, Elsayed and El-Naim 2015).

The whole dried seeds of faba bean contain (per 100g) 344 calories, 10.1g moisture, 1.3g fat, 59.4g total carbohydrate, 6.8g fiber, 3.0g ash, 19.4 g protein, 104mg Ca, 301mg P, 6.7mg Fe, 8mg Na, 1123mg K, 130mg B-carotene equivalent, 0.38 mg thiamine, 0.24mg riboflavin, 2.1mg niacin, and 162mg tryptophan. Flour contains: 340 calories, 12.4g moisture, 25.5g protein, 1.5g fat, 58.8g total carbohydrate, 1.5g fiber, 1.8g ash, 66mg Ca, 354mg P, 6.3mg Fe, 0.42mg thiamine, 0.28mg riboflavin, and 2.7mg niacin. A legume to be used as food is suggested to have proximate contents which comprises of 15 to 25% proteins, 50 to 75% carbohydrates mostly starch and about 1 to 3% fat, 2.9 to 4.2% ash and 3.5 to 6.5% crude fiber (Vioque *et al.*, 2012, Lizarazo *et al.*, 2014).

In Egypt, faba bean is one of the most substantial winter leguminous crops grown in different types of soils. It is considered as one of the basic sources of plant protein for human consumption. The quality of this protein appears to be limited by the low content in sulfur-containing amino acids, tryptophan, valine, isoleucine and threonine. It contains high amounts of lysine, leucine, aspartic acid, glutamic acid and arginine which provide well balanced essential amino acid profiles (Lizarazo *et al.*, 2014).

Phenolic compounds are substances with strong antioxidant activity due to their ability to scavenge free radicals, chelating metals and breaking a chain reaction. In addition, it has an important role in reducing the risk of cardiovascular disease when it consume with high rate.

The antioxidant activity of these compounds especially in vegetables is influenced by many factors, including maturation and cooking. Faba bean (*Vicia faba* L.) seeds are commonly used as both food and feed sources since they are rich in protein, carbohydrate, dietary fiber, dietary minerals, B- group vitamins and phenolic compounds (Maisarah *et al.*, 2013, Turco *et al*., 2016).

Biscuits are one of the terminologies of bakery products, which are mainly based on wheat flour. It can be classified as baked foods that belong to the class of ready-to-eat foods. Also, it is an energy-efficient food as an important source of minerals, proteins, carbohydrates and fats. The biscuit should be characterized by containing iron, calcium, protein, B-vitamins and fiber, which meet part of the daily requirements of human (Akubor and Ukwuru 2003, Man *et al*., 2014).

There is a trend due to the competition in the markets and the increasing demand for healthy foods to improve the nutritional value of biscuits and other products. Such effects are very often achieved by increasing the ratio of raw materials other than wheat in the basic recipes with the attempt to increase biscuit's protein, mineral content for quality and availability (Masoodi and Bashir 2012, Egwujeh *et al.,* 2018).

The aim of this investigation was to determine some vegetative characteristics, yield parameters, the gross chemical composition, total phenolics, flavonoids, amino acids and minerals content of a new faba bean line (Dwarf) comparing with three commercial genotypes of faba bean lineAssiut 142, cultivar Giza 3 and line Romy 80), as well as, comparing the resulting preparation of biscuit with 10% and 20% of whole faba bean seeds flour from the above four genotypes.

MATERIALS AND METHODS

Planting material and field trials

The present investigation was done at the experimental farm of the agriculture college, Assiut University, Assiut, on a clay soil during two successive seasons 2017 and 2018. Seeds sown on October 23 and 24 for the first and second year, respectively, to evaluate four faba bean breeding lines namely: Assiut 142, Romy 80, Dwarf and one certified cultivar namely Giza 3. The RCBD (randomized complete block design) was used with three replicates, each represented by 5 plots of the lines. Each experimental plot consisted of three rows, 3.5m long and 60cm wide. All plots were planted by hand with two seeds hill^{-1} along both southern and northern side of ridges.

Hills were spaced 30cm apart. The normal cultural practices of cultivation, irrigation, fertilization, weed and pest control of faba bean were followed as recommended for the region. Harvesting toke place manually on April 18 and 22 in the two growing seasons, respectively.

Vegetative characters were recorded on a random sample of ten guarded plants from each plot: time to flowering (days), plant height(cm), number of branches plant^{-1} and number of remaining plants plot^{-1}. On the other hand yield parameters were recorded as: green pod length (cm), green pod width (cm), number of dry pods/plant, number of dry seeds plant^{-1}, 100 dry seeds weight (g) and total dry seed yield (ton feddan^{-1}).

Sample preparation for chemical analysis:

After ripening of the beans fruits, the seeds are collected manually, dried at 40 ^{o}C, sorted and milled in an electrical mill to obtain whole flour. The flour samples were stored in glass jars in the refrigerator at 4 ^{o}C until analysis.

Methods

Physical characteristics of faba bean seeds

Dried faba bean seeds were analyzed for seed bulk density, swelling capacity, swelling coefficient, hydration coefficient and cook-ability. These physical characteristics were determined according to their specified method (Phirke *et al.,* 1982, Akinyele *et al.,* 1986).

Proximate composition analysis

Chemical composition which including moisture, ash, protein and crude fiber of whole faba bean seeds flour were determined using the standard procedures as described in AOAC (2000). The difference method according to Pellet and Sossy (1970) was used to calculate total carbohydrate. Triplicate determinations were used for each sample and the means were reported. The caloric value (energy) determined according to Wilson *et al.,* (1974) as follows:

Energy (Kcal/100g) = (protein content×4) + (fat content×9) + (carbohydrate content × 4).

Contents of Ca, Fe, Cu, Zn, Mg and Mn in the studied samples were determined by inductively coupled plasma emission spectrometry iCAP6200 (ICP-OES) (Isaac and Johnson 1985). Phosphorus (P) content was determined by spectrophotometer (Jackson 1967) after wet ashing by method described in AOAC (2000).

Amino acids

were determined according to the method described by Olson *et al.,* (1979), using Beckman Amino Acids Analyzer Model 119 C L.

Chemical scores computation:

The method of Bhanu *et al.,* (1991) was used to define and calculate the chemical score as follows:

$$\text{Chemical score} = \frac{\text{mg of essential amino acid in 1g test protein}}{\text{mg of essential amino acid in 1g reference protein}} \times 100$$

Computation of Protein efficiency ratio (PER):

Protein efficiency ratio was calculated using the equation suggested by Alsmeyer *et al.,* (1974) as follows:

PER = - 0.684 + 0.456 (Leucine) – 0.047 (Proline) (g/100 g protein)

The biological value (BV) computation:

The biological value was calculated using the equation made by Oser (1959) as follows:

BV = 49.09 + 10.53 (PER)

Determination of total phenolics and total favonoids

The total phenolics content of samples was determined according to a colorimetric method using Folin-Ciocâlteu reagent (Singleton *et al.,* 1999). The extracts of samples were solved in methanol 80% and moreover dilution was made to be similar of the gallic acid standard curve reading limits. The total phenolic content in the extracts were oxidized by 120 µl reagent (Folin-Ciocâlteu) and for neutralization a 340 µl of Na_2CO_3 was added after 5 min. In a dark place the samples were kept for 90 min and after that the absorbance at 750 nm was reading. The contents of total phenolics were calculated as mg GAE 100g^{-1} sample (milligram of gallic acid equivalents 100g^{-1} sample).

The aluminium chloride colorimetric evaluation as described by Marinova *et al.,* (2005) was used for flavonoids determination. 2.00g of the sample (n=3) was homogenizing in 50 mL distilled water to extraction the flavonoids. To ensure the full extraction, mixture was transferred into a rotary shaker for 12 hours. After that the mixture was filtered and the extract (filtrate) made up to 50 mL. Exactly, 1 ml of extracts or standard solution of catechin (20, 40, 60, 80 and 100 mg/ L) was added to test tubes containing 4 ml of redistilled water. Then 0.3 ml of 5% $NaNO_2$ was added to this mixture. A 0.3 ml 10% $AlCl_3$ was added after 5 min, immediately, 2 ml NaOH 1M was added and the total volume was made up to 10 ml with redistilled water. The solution was blended thoroughly and the absorbance of both standard and blank was read at 510 nm using UV–Visible spectrophotometer Model UV 1601 version 2.40 (Shimadzu). Total flavonoids amount was recorded as mg catechin 100g^{-1} sample D.W (mg catechin equivalents).

Preparation of biscuit with 10% and 20% of whole faba bean seeds flour

The control and supplemented biscuits (substituted the wheat flour with 10% and 20% whole faba bean seeds flour) dough was made according to the formula showed in Table (1). The corn oil and powdered sugar were creamed for 2 min in Mixer with a flat beater. The sodium chloride, ammonium bicarbonate was dissolved in water then added with rose oil to the cream and mixed for 5 min to obtain a homogenous cream. The flour was added slowly to the above cream and was mixed for 2 min to obtain biscuit dough. The biscuit dough was flattened to a thickness of 3.5 mm, cut using a circular mould (54 mm diameter), and baked at 205 °C for 9–10 min. After baking, biscuits cooled to room temperature, packed in polypropylene pouches and sealed (Saba 1997).

Table 1. Formulation of biscuits containing 0.0, 10 and 20% of whole faba bean seeds flour.

Ingredients (g)	Control	10%	20%
wheat flour	100.00	90.00	80.00
Whole faba bean seeds flour	--	10.00	20.00
Powdered sugar	25.00	25.00	25.00
Corn oil	15.00	15.00	15.00
Salt	1.00	1.00	1.00
Ammonium carbonate	1.00	1.00	1.00
Rose oil	0.01(one drop)	0.01(one drop)	0.01(one drop)
Water	20.00	20.00	20.00

Physical evaluation of biscuits

Thickness (cm), width (cm), spread ratio and spread factor was determined as physical properties of biscuits under study. Five biscuits were chosen for the estimates from each of the nine studied types of biscuits and their means were recorded. The spread ratio and spread factor were counted according to Manohar and Rao (1997) using the following equations:

$$\text{Spread ratio} = \text{Width} / \text{Thickness}$$

$$\text{Spread factor} = \frac{\text{Spread ratio of sample}}{\text{Spread ratio of control}} \times 100$$

Sensory evaluation of supplemented biscuits

The coded pouches with different numbers of biscuit samples were presented to the ten judges from the staff of Food science and Technology department, Faculty of Agriculture, Assiut University, who were asked to assigning a score for surface characteristics (10), surface colour (10), crumb colour (10), texture (20), taste (20) and mouth feel (10) as described by Sudha *et al.,* (2007) to rate each sensory attribute.

Statistical Analysis

The collected data were analyzed with analysis of variance (ANOVA) Procedures, using the SAS Statistical Software Package v.9.2, 2008. Differences between means were compared by LSD (least significant difference) at 5% level of significance (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Vegetative characteristics

Number of days to 50% flowering was markedly affected by breeding lines in both seasons. Line Assiut 142 was the earliest in both seasons (38.67, 37.33 days, respectively), while line Dwarf was the latest in both seasons (48, 44.67 days, respectively). The other faba bean genotypes were in between. Plant height was significantly (p<0.05) affected by faba bean breeding lines and ranged from 45.33, 48.67 cm for Dwarf to 148.67, 147.33 cm for Romy 80 in the first and second seasons, respectively. So, line Romy 80 was the tallest line in both seasons and line Dwarf was the shortest one (Table 2).

Table 2.Vegetative characteristics of four faba bean breeding genotypes during 2017 (first) and 2018 (second) seasons.

Genotype	Days to 50% flowering (day)		Plant height (cm)		No. of branches plant^{-1}		No. of remaining plants plot^{-1}		T.S.S	
	First	Second	First	Second	First	Second	First	Second	First	Second
Dwarf	48.00	44.67	45.33	48.67	8.60	8.63	16.33	15.33	19.40	19.40
Assiut 142	38.67	37.33	131.67	136.33	9.00	9.20	22.33	20.33	21.53	21.53
Giza 3	44.33	43.33	116.00	118.00	5.67	5.80	14.33	13.00	21.23	21.23
Romy 80	43.00	37.67	148.67	147.33	9.27	9.67	16.00	15.67	17.23	17.23
L.S.D 0.05	1.464	0.859	3.736	5.048	0.570	0.724	Ns	2.354	Ns	Ns

The variations in the values shown by number of branches plant^{-1} are significant in both seasons. In the first season, it ranged from 5.67 to 9.27 branches. Romy 80 recorded the highest value (9.27 branches) followed by Assiut 142 (9.00 branches), which were significantly different from Dwarf (8.60) and Giza 3 (5.67 branches). In the second season, the values of number of branches plant^{-1} ranged from 5.80 to 9.67 branches. Romy 80 recorded the highest value (9.67 branches), while Giza 3 recorded the lowest one (5.80 branches). The other faba bean genotypes were in between.

The four genotypes of faba bean showed significant differences in number of remaining plants plot^{-1} just in the second season. In the first season, the number of remaining plants ranged from 14.33 to 22.33 plants. Assiut 142 (22.33 plants) followed by line Dwarf (16.33 plants) recorded the highest values, while line Giza 3 recorded the lowest value (14.33 plants). No significantly differences were detected among them. In the second season, the values ranged from 13.00 to 20.33 plants and Assiut 142 recorded the highest value (20.33 plants). For total soluble solids (TSS) there is no significant difference among the lines tested and their values ranging from 17.23% (Romy 80) to 21.53% (Assiut 142) in both seasons. These results are in accordance with some previous studies (Abdalla *et al.,* 2015, Maalouf *et al.,* 2018).

Yield parameters

Green pod length was significantly affected by breeding lines in the first season and ranged from 6.50 cm to 10.80 cm , the pod length of Romy 80 (10.80 cm) was significantly longer than the others and followed by cultivar Giza 3 (9.47 cm) and Assiut 142 (8.50 cm), while Dwarf line recorded the lowest value for pod length (6.50 cm). In the second season, the green pod length of the breeding lines ranged from 6.23cm to 11.23 cm, also in the second season, line Romy 80 was the highest and Dwarf was the lowest. Results of green pod width revealed that there were significant differences between faba bean genotypes lines. In the first season, the values ranged from 1.60 cm to 2.07 cm. Romy 80 recorded the highest value (2.07 cm) and Dwarf line the lowest (1.60 cm) and the same trend for the second season with values ranging from 1.53 to 2.13 cm (Table 3).

Data on number of dry pods plant^{-1} revealed that there were significant differences among faba bean genotypes in both growing seasons under study, with values ranged from 36.92 pods to 60.53 pods and from 44.92 pods to 58.00 pods in the two seasons, respectively. Assiut 142 produced the highest number of dry pods plant^{-1}, while cultivar Giza 3 produced the lowest number of dry pods plant^{-1} in both seasons. The number of dry seeds per pod was differed significantly among faba bean genotypes ranging from 2.07 seeds to 3.53 seeds and from 2.10 seeds to 3.70 seeds in both seasons, respectively. In the first and second seasons, Romy 80 gave the highest values, Dwarf gave the lowest values and the other two genotypes ranged between them.

Table 3. Yield parameters of four faba bean breeding genotypes during 2016/2017 (first) and 2017/2018 (second) seasons.

Genotype	Green pod length (cm)		Green pod width (cm)		No. of dry pods plant^{-1}		No. of dry seeds pod^{-1}		100-dry seed weight (g)		Total dry seed yield (ton fed^{-1})	
	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second
Dwarf	6.50	6.23	1.60	1.53	43.33	46.33	2.07	2.10	96.67	96.67	1.40	1.26
Assiut 142	8.50	8.50	1.77	1.70	60.53	58.00	3.07	3.40	96.67	104.00	3.60	2.47
Giza 3	9.47	9.57	2.00	1.93	36.92	44.92	3.13	3.20	93.33	97.00	1.38	1.88
Romy 80	10.80	11.23	2.07	2.13	52.30	54.30	3.53	3.70	125.00	130.33	2.56	2.06
L.S.D 0.05	0.651	0.622	0.111	0.094	5.333	4.158	0.287	0.234	5.263	5.041	0.650	0.234

The weight of 100-dry seeds (g) confirming significantly ($p<0.05$) the genetic variation among the studied genotypes. In the first season, the values ranged from 93.33 to 125.00g. Romy 80 recorded the highest value (125.00g) and Dwarf recorded the lowest value (96.67g) which was not significantly different from line Assiut 142. In the second season, the values ranged from 96.67 to 130.33 g for Dwarf and Romy 80, respectively.

The data in Table 3 recorded significant differences in total dry seed yield (ton fed^{-1}) among the tested genotypes in both seasons which ranging from 1.38 to 3.60 ton fed^{-1} and from 1.26 to 2.47 ton fed^{-1} in the first and second seasons, respectively. In the first season, the highest yield was obtained from line Assiut 142 (3.60 ton fed^{-1}) followed by Romy 80 (2.56 ton fed^{-1}) and Dwarf (1.40 ton fed^{-1}) yield was not significant different from the yield of cultivar Giza 3 (1.38 ton fed^{-1}). In the second season, the highest yield was obtained from line Assiut 142 (2.47 ton fed^{-1}) but the lowest yield was given by Dwarf line (1.26 ton fed^{-1}). The others were in between. From the data in Tables 2 and 3 it could be concluded that Dwarf as a new faba bean genotype was closer to the others under the conditions of this study in their vegetative and yield parameters which confirming the importance of having it in our production and breeding programs. Our results were in the same trend with previous studies (Temesgen *et al.*, 2015, Maalouf *et al.*, 2018).

Physical characteristics

The seed density of bean seeds was found to be 0.64; 0.68; 0.68; 0.71(g mL^{-1}) for Romy 80; Assiut 142; Dwarf and Giza 3, respectively. The swelling coefficient, hydration coefficient and cook-ability (g 100g^{-1}) were significantly ($P<0.05$) higher in Dwarf with values 281.56%, 205.21% and 23.22%, respectively, as compared with other three genotypes. The swelling capacity was ranged from 56.57% to 60.10% in the studied genotypes (Table 4). The differences in the above properties are mainly due to genetic factors or external factors such as environmental treatments and climatic factors. It is clear that the difference in seed density as a result of differences in weight and volume of the seed has a significant effect on the physical characteristics, especially the cook-ability, and this is consistent with findings of (Elsayed and El-Naim 2015)

Gross chemical composition

Fig. 1 showed the moisture content of faba seeds samples. The results revealed that there are significant ($P<0.05$) differences among moisture content of Assiut 142, Dwarf and Giza 3. No significance was found between Assiut 142 and Romy 80 cultivars.

Table 4. Cooking quality of four genotypes of faba bean seeds.

Genotype	Seed density	Swelling capacity	Swelling coefficient	Hydration coefficient	cook-ability%
Dwarf	0.68	57.99	281.56	205.21	23.22
Assiut 142	0.68	60.10	247.93	184.99	20.35
Giza 3	0.71	56.57	268.27	200.47	22.21
Romy 80	0.64	57.83	241.80	198.30	21.35
L.S.D 0.05	0.094	0.941	5.213	3.25	1.25

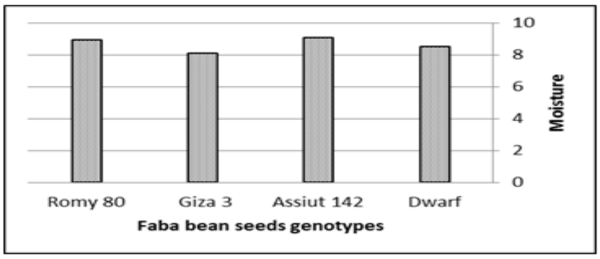

Fig .1. Moisture content of faba bean seeds for Dwarf, Assiut 142, Giza 3 and Romy 80 genotypes.

Table 5 showed the chemical composition of Dwarf as compared with other studied genotypes. The ash content was ranged from 4.01 to 4.29% and insignificant differences were detected among the studied Dwarf, Giza 3 and Romy 80 genotypes. Line Dwarf has ash content (4.22%) more than Assiut 142 cultivar. The oil content was ranged from 1.45% in Romy 80 to 2.61% in Dwarf.

Table 5. Chemical composition (Dry weight basis) of four genotypes of faba bean seeds.

Genotype	Ash	Oil	Protein	Crude fiber	Total carbohydrates	The caloric value(Kcal $100g^{-1}$)
Dwarf	4.22	2.61	24.69	5.83	62.65	372.85
Assiut 142	4.01	2.15	24.21	6.05	63.58	370.51
Giza 3	4.18	2.01	21.77	6.75	65.29	366.33
Romy 80	4.29	1.45	24.76	6.17	63.33	365.41
L.S.D 0.05	NS	NS	0.931	0.24	3.115	1.27

There were significant (P<0.05) differences in the contents (g $100g^{-1}$ D.W.) of protein, crude fiber, total carbohydrates with values ranging from 21.77-24.76%, 5.83-6.75% and 62.65-65.29%, respectively, for the studied genotypes . On the other hand, line Dwarf recorded 372.85 of the caloric value (kcal $100g^{-1}$ D.W) compared to 370.51, 366.33 and 365.41 for Assiut 142, Giza 3 and Romy 80 genotypes , respectively. Such results for chemical composition were similar to those obtained previously by Vioque *et al.,* (2012) and Lizarazo *et al.,* (2014).

Total phenolics, total flavonoids and minerals contents

Table 6 showed the results of total phenolics, total flavonoids and minerals contents of four genotypes of faba bean seeds. The Dwarf line had significantly (P<0.05) highest content of total flavonoids (23.70 mg catechin $100g^{-1}$ D.W.) and the lowest content of total phenolics (421.25 mg GAE $100g^{-1}$ D.W.) when compared to the other three genotypes. Also Dwarf recorded significantly (P<0.05) higher contents (mg $100g^{-1}$ D.W.) of Ca: 1341.51 and Mg: 186.95 than the others. The P content (mg $100g^{-1}$) was ranged from 659.96 to 812.61 for the studied genotypes. No significant difference was found in the contents (mg $100g^{-1}$) of Zn, Cu, Mn among the tested genotypes cultivars with values range 5.28–7.43, 1.74–3.31 and 1.57–1.90, respectively. Our results were agree with the similar findings of Turco *et al*., (2016) who mentioned that faba bean seeds are good source of phenolic compounds and minerals.

Table 6. Total phenolics (mg GAE $100g^{-1}$ D.W.), total flavonoids (mg catechin $100g^{-1}$ D.W.) and minerals (mg $100g^{-1}$ D.W.) contents of four genotypes of faba bean seeds*.

Genotype	Total phenolics	Total flavonoids	Ca	P	Mg	Fe	Zn	Cu	Mn
Dwarf	421.25	23.70	1341.51	715.86	186.95	6.97	5.58	2.77	1.66
Assiut 142	692.92	15.71	682.21	659.96	180.25	7.40	5.92	3.09	1.90
Giza 3	683.24	13.78	886.47	745.65	171.54	5.80	7.43	3.31	1.59
Romy 80	703.61	16.64	1033.02	812.61	159.34	8.84	5.28	1.74	1.57
L.S.D 0.05	12.58	2.17	14.25	9.85	5.95	0.942	NS	NS	NS

Changes in amino acid composition and protein quality

Data in Table 7 present the amino acid composition of four faba bean genotypes under study. The results indicated that faba bean protein is rich in some essential amino acids such as Leucine and Lysine; they are comparable with that of the FAO/WHO (2007) references. The total essential amino acids of whole faba bean seeds samples formed 34.72% (Dwarf), 34.09% (Assiut 142), 34.69% (Giza 3) and 35.02% (Romy 80) of the total amino acid content. However, the contents of Isoleucine, Valine, Threonine, Phenylalanine and Histidine are slightly lower in faba bean protein compared with the reference pattern. The total-non essential amino acids of whole faba bean seeds samples ranging from 63.43% to 64.32% of the total amino acid content, with Glutamic and Aspartic acids recorded the highest content.

PER (protein efficiency ratio) and BV (the biological value) are used for protein evaluation as an important quality parameters (FAO/ WHO 2007). In addition BV is shows the rate of use of absorbed proteins in the body. PER and BV was ranging 2.54 - 2.62, 75.84 – 76.68, respectively, in the faba bean samples (Table 8). The chemical score, protein quality index was estimated by comparing the contents of the essential amino acid of faba bean seeds flours with a reference amino acid pattern (casein). Methionine+Cystine were the first limiting amino acid in Dwarf, Assiut 142, Giza 3, Romy 80 with chemical scores 78.89%, 80.74%, 80.00% and 77.03%, respectively (Table 8). However, the second limiting amino acid was Threonine for Dwarf (108.24%), Assiut 142 (108.24%), Giza 3 (104.41%) and Romy 80 (110.00%). These results were in accordance with those found in previous research works (Lizarazo *et al.,* 2014), who confirmed that faba bean protein had well-balanced essential amino acid profiles, as well as, Dwarf protein is are comparable with the highly rated proteins, such as casein, beef, and fish.

Table 7. Amino acid composition (g Amino acid 100g^{-1} protein) of Dwarf, Assiut 142, Giza 3 and Romy 80 seeds ganotypes.

Amino acids	Dwarf	Assiut 142	Giza 3	Romy 80	Casein	FAO/WHO (2007)	
						Child	Adult
Lysine	6.86	6.64	7.01	6.92	6.99	5.80	1.60
Threonine	3.68	3.68	3.55	3.74	3.72	3.4	0.90
Methionine	0.81	0.88	0.86	0.79	2.59	2.70	1.70
Valine	4.58	4.50	4.62	4.69	5.70	3.50	1.50
Isoleucine	4.32	4.30	4.29	4.36	4.46	2.80	1.30
Leucine	7.65	7.52	7.58	7.69	8.27	6.60	1.90
Phenylalanine	4.27	4.19	4.28	4.34	4.47	6.30	1.90
Histidine	2.55	2.38	2.50	2.49	2.65	1.90	1.60
Total Essential A.A	34.72	34.09	34.69	35.02	38.85		
Serine	4.92	4.96	4.80	5.01	5.03		
Proline	4.21	4.30	4.32	4.28	9.32		
Glycine	4.28	4.22	4.20	4.12	1.65		
Cystine	1.32	1.30	1.30	1.29	0.33		
Alanine	4.20	4.10	4.19	4.23	2.61		
Tyrosine	3.18	3.21	3.06	3.10	4.79		
Aspartic Acid	12.38	12.21	11.96	12.05	6.18		
Glutamic Acid	20.02	19.81	19.88	19.96	9.00		
Arginine	9.81	10.02	9.72	9.86	3.22		
Total-Non Essential A.A	64.32	64.13	63.43	63.90	42.13		

Table 8. Protein quality of Dwarf, Assiut 142, Giza 3 and Romy 80 faba bean seeds genotypes.

Genotype	PER	BV	Chemical score%	Limiting amino acids	
				First	Second
Dwarf	2.61	76.57	78.89	Methionine +Cystine	Threonine (108.24)
Assiut 142	2.54	75.84	80.74	Methionine +Cystine	Threonine (108.24)
Giza 3	2.57	76.15	80.00	Methionine +Cystine	Threonine (104.41)
Romy 80	2.62	76.68	77.03	Methionine +Cystine	Threonine (110.00)

Sensory evaluation and physical properties of supplemented biscuits.

Sensory evaluation and physical properties of supplemented biscuit samples are shown in Table 9 and Fig. 2. It was observed that there were significant (P<0.05) differences in colour, surface character; crumb colour, texture, taste and mouth feel for all the studied samples as compared with control. Also, there were significant (P<0.05) differences among the biscuits supplemented with 10% whole faba bean seeds flour and the biscuit supplemented with 20% whole faba bean seeds flour in sensory attributes. The total score (80) for supplemented studied biscuit samples varied from 66.92 to 72.18. Among the faba bean genotypes, the highest score (72.18) in all sensory attributes was recorded for Romy 80 at 10% supplementation. Widths of the biscuit samples ranged from 7.00 to 7.40 cm. The increasing in width was observed with increasing levels of supplementation. The same trend was significantly recorded on spread ratio and spread factor. The spread ratio was ranged from 9.00 to 9.87 for supplemented biscuit by faba bean flour as compared with 7.78 for control (100% wheat flour). The data in Table 9 revealed that the spread factor was increased in all supplemented biscuits ranged from 115.68 to 126.86 as compared with 100 for control biscuits which made from wheat flour only. However, biscuit thickness was decreased as a result of increasing level of substitution. The results are in the same trend with Egwujeh *et al.*, (2018).

Table 9. Sensory evaluation of supplemented biscuits.

Sample		Sensory evaluation							Physical properties			
		Colour (10)	Surface character (10)	Crumb colour (10)	Taste (20)	Texture (20)	Mouth feel (10)	Total score (80)	Thickness (cm)	Width (cm)	Spread ratio (W/T)	Spread factor
Control	A	9.18	8.32	8.50	17.95	17.26	9.16	70.37	0.90	7.00	7.78	100.00
Dwarf	B	9.18	8.26	8.83	18.00	17.86	8.82	70.95	0.80	7.20	9.00	115.68
	C	8.86	8.16	8.36	17.76	17.58	8.67	69.39	0.75	7.40	9.87	126.86
Assiut 142	B	8.50	8.10	8.24	17.52	17.03	8.63	68.02	0.74	7.10	9.60	123.39
	C	8.35	7.92	7.88	17.34	16.89	8.54	66.92	0.76	7.20	9.47	121.72
Giza 3	B	8.65	8.00	8.34	17.50	17.00	8.76	68.25	0.75	7.30	9.73	125.06
	C	8.31	7.86	8.10	17.21	16.86	8.59	66.93	0.74	7.20	9.73	125.06
Romy 80	B	9.26	8.38	9.00	18.34	18.00	9.20	72.18	0.80	7.20	9.00	115.68
	C	9.12	8.20	8.82	18.06	17.84	8.74	70.78	0.76	7.40	9.74	125.19
L.S.D 0.05		0.08	0.095	0.076	0.230	0.432	0.08	1.231	0.04	NS	0.06	1.63

A = Control Biscuits. B = Biscuits supplemented with 10% of whole faba bean seeds flour. C = Biscuits supplemented with 20% whole faba bean seeds flour.

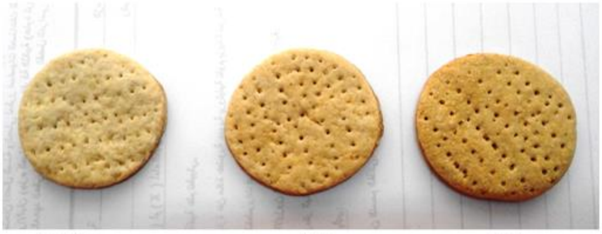

Fig. 2. Showing control (100% wheat flour), 10% and 20% supplemented biscuit with whole faba bean seeds flour.

CONCLUSION

Results of the present study indicated that Dwarf as a new line was closer to the other genotypes under study in their vegetative and yield parameters of faba bean which confirming the importance of including in our program. The Dwarf line of faba bean is rich in protein and total carbohydrates like other local cultivars. The Dwarf seeds are good source of nutrients, such as minerals, essential amino acids, phenolic compounds and flavonoids which possess potential health benefits. In addition, the Dwarf seeds can be used in various food applications due to their good cooking properties. From the PER, BV, and chemical score data, it could be suggested that Dwarf seeds protein is comparable with the highly rated proteins. The sensory evaluation of the supplemented biscuit with whole faba bean seeds flour showed that the 10% of supplementation could be considered as an acceptable treatment with good edible and quality to be consumed as snacks or the flour of faba bean could be used in food industry.

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الخصائص الخضرية والمكونات الغذائية لسلالة الفول الجديدة (دوارف) بالمقارنة مع ثلاثة تراكيب وراثية تجارية من الفول البلدى.

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قورنت بذور الدوارف كسلالة جديدة مع ثلاثة تراكيب وراثية من الفول البلدى سلالة أسيوط 142 ، صنف جيزة 3 وسلالة رومى 80 فى بعض الصفات الخضرية والمكونات الغذائية. كما تم دراسة صفات جودة الطهي والتركيب الكيميائي وكذلك تحضير البسكويت بخلط 10٪ و 20٪ من دقيق بذور الفول الكامل من التراكيب الوراثية الأربعة المذكورة أعلاه. أظهرت النتائج أن بذور الفول مصدر جيد للعناصر الغذائية ، مثل الكربوهيدرات والمعادن والبروتينات ذات القيمة الغذائية العالية ، بالإضافة إلى المركبات الفينولية والفلافونيدية. ووجد أن أكثر المعادن تواجدا في بذور الفول بكميات عالية هى المغنيسيوم والكالسيوم والفوسفور. كما أظهر تحليل الأحماض الأمينية أن بروتين بذور الفول البلدى غني ببعض الأحماض الأمينية الأساسية ، مثل الليسين والأيسوليوسين والليوسين. ودلت نتائج الدراسة ، على أن بذور السلالة الجديدة الدوارف تعتبر مقبولة وذات جودة صالحة للأكل ويمكن استهلاكها مباشرة كما يمكن استخدام دقيق هذه البذور فى صناعة البسكويت. .