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Technological Characteristics and Quality Attributes of Some Faba Bean (*Vicia Faba*) Varieties

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Abstract

In this study, some faba bean cultivars grown under three irrigation conditions and fertilized with nano-fertilizers were evaluated. The evaluation was carried out on dry seeds, regardless of the physical properties, color index, chemical composition of the seeds and their content of some mineral elements. The soaking process was also carried out to determine the efficiency of its water absorption. The cooking process and the increase in volume after cooking, as well as the chemical composition after cooking, was also carried out. The texture of the seeds of different cultivars was also measured after cooking. Total phenolic and tannins were also estimated before and after cooking to identify the effect of cooking on the content of some anti-nutritional seeds in the studied cultivars. The results show the percentage of hulls, moisture content and crude protein were ranged between 10.22-20.56, 6.55-7.35%, and 29.09-35.93% (based on dry weight), respectively. The hydration coefficient and the weight after cooking ranged between 109.11-135.32% and 175.71-244.08%, respectively. As for the chemical composition after cooking, it was found that the moisture content and protein 77.59-78.37% and 26.90-33.01% (based on dry weight). Respectively the cooking process was reduced the total phenolic compounds ,respectively to 20.50-26.17%, and tannins content to 58.03-64.28%.

Key words: Faba beans - Mariot 2 - Nubaria 2 - Giza 716 - Chemical composition - phenolic substances - tannins.

Introduction

Faba bean (*Vicia faba* L.) is one of the major grain legume crops in Egypt and many other parts of the world. Mediterranean countries, Ethiopia, Egypt, China, Afganistan, India, Northeren Europe, and Northern Africa, are major producers of faba bean **(Rahate *et al.*, 2020)**. Interest in the health and nutritional benefits of faba beans has grown in recent years, as has the development of various meals supplemented with biomolecules that improve functioning, nutrition value, and health benefits. Faba beans are high in lysine, carbohydrate, minerals, vitamins, and a variety of bioactive substances. (**Dhull *et al.*, 2021)**.

It is widely used in the Mediterranean region as source of protein in human nutrition. Its seed consider a cheap source of protein and also a food of high calorific and nutritive value especially in the diet. Moreover, production of faba bean in Egypt is still limited in spite of its increase in local consumption. This is due to its limited cultivated area in Egypt, and the strong competition with other strategic winter crops such as wheat and clover on the limited arable land of Nile valley and Delta. Faba bean production is affected by different factors such soil fertility, varieties or genotypes.

Legume crops, particularly domestic beans, are regarded the most essential food groups. Due to their high nutritional content, as well as their role in improving soil characteristics. The government wants to boost faba bean output to help meet the food shortage while also supplying hard currency. Egyptian imports of beans will increase from about 410 thousand tons in 2018 to about 500 thousand tons in 2025 **(Attia *et al.*, 2019)**.

Green or dried, fresh or cooked/canned, faba beans can be eaten as a vegetable. In the Middle East, the Mediterranean region, China, and Ethiopia, it is a popular breakfast meal. Medamis (stewed beans), Falafel (deep fried cotyledon paste with vegetables and spices), Bissara (cotyledon paste), and Nabet soup (boiled germinated faba beans) are the most popular faba bean meals **(Singh *et al.*, 2013)**.

The most important organic components of faba bean seeds are proteins (20–41% of seed dry matter) and carbohydrates (51–68% of seed dry matter) which depend on cultivars. Most of these proteins comprise of globulins (79%), albumins (7%), and glutamines (6%) (**Hossain and Mortuza, 2006**).

Faba bean (*Vicia faba* L.) is a cool-season legume species, producing protein-rich grain not only for human production (particularly in Western Asia and Northern Africa), but also for livestock feed in developed regions, such as Europe and Australia **(Bohra *et al.*, 2014)**.

Mortuza *et al.* (2009) found that the proximate component in per cent were crude protein 30.57, crude fat 3.22, crude fibre 2.73, ash 3.61 and carbohydrate 59.87.

Gasim *et al* (2015) studied that evaluate seed yield and nutritional quality of five faba bean inbred lines grown under marginal environmental conditions of Sudan. The mean carbohydrate content was very high (50.11%) and negatively correlated with seed yield, whereas the average protein content was relatively

high (25.31%) and positively correlated with seed yield.

Soaking can reduce the level of total sugars, α-galactosides, minerals, phytic acid and proteolytic enzyme inhibitors **(Frias *et al.*, 2000; Vial-Valverde *et al.*, 2002)**, which can be partly or totally solubilised and eliminated with the discarded soaking solution. Soaking is another essential step that allows seed rehydration prior to cooking. This step enables a higher cooking quality, a lower cooking time and the reduction of some antinutrient concentration via endogenous enzyme activation and leaching **(Abdel-Aal *et al.*, 2018)**.

The phenolic content and antioxidant activities of faba beans are also affected by cooking **(Amarowicz *et al.*, 2004 and Chaieb *et al.*, 2011)**. However, studies of phenolic content and antioxidant activity of dry faba beans as affected by thermal processes are limited, particularly with regards to faba beans grown in Australia, which contribute to about 20% of the world export market **(FAO, 2010)**.

Abdul Rahim (2004) reported a range of phenolic content was 0.04-0.08% for raw and value of 0.02% for cooked faba bean.

The aime of this study to evaluate chemical, technological characteristics and quality attributes of some faba bean seeds varieties (Maruot 2, Nobaria 2 and Giza 716) to reducing the imports of the Egyptian faba bean.

Materials and Methods

1. Materials:

Faba bean (*Vicia faba*) cultivars (Maruot 2, Nobaria 2 and Giza 716) were obtained from Agriculture Research, Center. The seeds were carefully cleaned and freed from broken and extraneous matter.

This investigation was conducted at the Agricultural Research and Experimental Center of the Faculty of Agriculture, Moshtohor, Kalubia Governorate, Benha University, Egypt, in 2019/2020 season, and Food Technology Research Institute, Agric. Research Center, Giza, Egypt, to study the effect of number of irrigations at different growth stages and nano-P foliar applications on yield and yield components as well as technological characters and nutritive value of three faba bean genotypes.

Chemicals were purchased from El-Gamhoria Company for Drugs and Chemicals, Cairo, Egypt. All chemicals used in this study were analytical grade.

Based on the results obtained, the treatments with the highest productivity per acre were selected, and the treatments that took three irrigations were either without nano-P foliar and with nano-P foliar for the three varieties under study, and a technological evaluation was made for them. Its statement is as follows:

T1	Maruot 2 without nano-P foliar and three irrigations
T2	Maruot 2 with nano-P foliar and three irrigations
T3	Nobaria 2 without nano-P foliar and three irrigations
T4	Nobaria 2 with nano-P foliar and three irrigations
T5	Giza 716 without nano-P foliar and three irrigations
T6	Giza 716 with nano-P foliar and three irrigations

2. The cooking quality of faba bean products such as medammis can be evaluated by the following parameters:

2.1. Physical properties:

2.1.1. Percentage of hulls:

The percentage of hulls affects the nutritional value of products from the whole seeds. The net yields of the dehulled seeds (cotyledons), protein and starch per unit weight of faba beans, are inversely related to the hull content. The percentage of hulls can be determined either on the dry seeds directly or' following a few hours of soaking before removing the hull, followed by drying.

2.1.2. Hydration coefficient:

Seeds were soaked in tap water for 8 hours. The hydration coefficient of raw beans after soaking in distilled water for a defined period, is calculated as the percentage increase in weight of beans:

$$\left[\text{Hydration coefficient} = \frac{\text{Weight of soaked beans}}{\text{Intial weight of beans}} \times 100\right]$$

(Hulse *et al.*, 1977)

The hydration coefficient of cooked beans e.g. stewed whole beans, is calculated by weighing the beans before cooking and after cooking under specified conditions. In case of stewed beans, the raw beans are mixed with tap water (1 : 4) and autoclaved at 120°C for two hours.

2.1.3. Swelling coefficient:

The volume of raw faba bean, before and after soaking, is determined by the absolute displacement method, using water in a graduated cylinder:

$$\text{The swelling coefficient} = \frac{\text{Volume of soaked faba bean (for a defined period)}}{\text{Volume of faba bean before soaking}} \times 100$$

Both consumers and processors prefer faba bean that have high hydration and swelling coefficients as these produce greater quantity.

2.1.4. Color:

According to the Commission Internationale de l'Eclairage (CIE) color parameters (L, a*, b*) were detected by using the colorimeter CR-400 Chroma Meter (Minolta Co., Osaka, Japan). Each measurement was carried out in triplicate on 30 fresh

seeds per sample. The colorimeter was calibrated with a standard reference (a white ceramic plate) with values L, a* and b* of 97.55, 1.32 and 1.41, respectively. Hue angle ($h° = \tan^{-1}(b^*/a^*)$) and saturation or chroma ($C = (a^{*2} + b^{*2})^{1/2}$) were then calculated from the primary L, a* and b* readings **(Abonyi *et al.*, 2002).**

2.1.5. Firmness:

Firmness was measured using Qc-Tech Universal Testing Machine (model B-type, Cometech Ltd, Taiwan) with a flat knife probe (2.5 mm thickness) at a crosshead speed of 100 mm/min. The results were reported as Newton (N) according to the method described by **Silva *et al.* (2011)**.

2.2. Cooking:

The seeds were soaked in the dark in tap water for 8 hours. The soaked solution was drained off, then the seeds were cooked in boiling water. Thereafter they cooled and dried at 55°C and then ground to pass a 0.4 mm screen and storage until analysis

3. Methods of analysis:

3.1. Proximate analysis:

Moisture content, crude protein, ether extract, ash and crude fiber were determined according to **A.O.A.O. (2010).**

Available carbohydrates were determined by difference according to the following equation:

Available carbohydrate = 100 – (Moisture content + ash content + ether extract content + crude fiber content + crude protein content)

3.2. Determination of total phenolic content.

Total phenolic content was determined using a Folin Ciocalteu assay according to the method of **Singleton and Rossi (1965)** with slight modification. The reaction mixture contained 1 ml of extract and 0.5 ml of the Folin–Ciocalteu reagent, 1 ml sodium carbonate 7.5% and 7.5 ml of distilled water were added. After 45 min of reaction at ambient temperature, the absorbance at 765nm was measured using a UV-Vis Jenway 6705 Series Spectrophotometer. A blue color indicated the presence of phenols. A calibration curve was applied by using of gallic acid standard (0.1 mg/ml). The total phenolic content of samples was determined in triplicates and the results were expressed on dry weight basis (DW) as mg gallic acid equivalents (Gallic acid), per g of each sample.

3.3. Determination of tannins content:

Determination of Hydrolysable tannins were determined according to the method of **Rooney *et al.* (1981)**.

4. Sensory evaluation of cooked faba bean:

A sensory evaluation of cooked faba bean was conducted immediately after preparation of the six cultivars. Staff members from the Food Technology Department, Faculty of Agriculture, Benha University, comprised ten panelists. To measure consumer acceptability, sensory evaluations were conducted for color, odor, taste texture, mouth feel, and overall acceptability. Sensory evaluation was done using a numerical hedonic scale ranging from 1 to 10 (1 being very unpleasant and 10 being great) **(Larmond, 1977)**.

5. Statistical Analysis:

The statistical analysis was carried out using one-way ANOVA using SPSS, ver. 22 (IBM Corp. Released 2013). Data were treated as a complete randomization design according to **Steel *et al.* (1997).** Multiple comparisons were carried out applying Duncun test The significance level was set at < 0.05

Results and Discussion

Physical properties of raw faba been seeds:

Data presented in Table (1) show the effect of irrigations number, fertilization treatment and varieties on Physical properties (hulls weight, cotyledons weight and loss weight) of raw faba been seeds.

The lowest value of hulls was 10.22% given by T2.While the highest of 20.56% was given by T6 due to the small weight of the 100-seeds, which leads to an increase in the amount of seeds present in a sample weighing 100 grams.

Data in the same table show there is a significant decrease in hulls percent of (T1,T2,T3 and T5) compared with other all treatments, also, there is non significant difference in hulls percent between samples (T1, T2, T3 and T5) While, there is a significant decrease in hulls percent of T4 compared with other treatments (T1 ,T2 ,T3 and T5).

The lowest value of cotyleadons was 74.50% given by T6, while, the highest 83.40% was given by T5.

The lowest loss percent 4.31% was given by T4, while, the highest loss percent 11.57% was given by T2 . These results are in agreement with those obtained by **Kassab (2010) and Hendawey and Younes (2013).**

Table 1. Physical properties of raw faba been seeds (g/100 g) (mean±S.E.).

Treatments	Properties			
	Seeds weight	Hulls	Cotyledons	Loss
T1	**100**	**11.26±0.49^{c}**	**82.58±3.64^{a}**	**6.16±0.95^{b}**
T2	**100**	**10.22±0.18^{c}**	**78.21±2.21^{b}**	**11.57±2.43^{a}**
T3	**100**	**11.37±0.38^{c}**	**80.86±3.19^{ab}**	**7.77±1.83^{b}**
T4	**100**	**15.37±1.08^{b}**	**80.32±3.04^{ab}**	**4.31±2.22^{c}**
T5	**100**	**11.32±0.67^{c}**	**83.40±1.88^{a}**	**5.28±1.14^{bc}**
T6	**100**	**20.56±0.13^{a}**	**74.50±0.21^{c}**	**4.94±1.11^{c}**

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.
T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.

Color index of raw faba been seeds:

Data presented in Table (2) show the effect of irrigations number, fertilization treatment and varieties on color index of raw faba been seeds.

The lowest value of *L** value after cooking 41.54 was given by T3, while, the highest value 64.62 was given by T1.

The lowest value of *a** value after cooking 0.05 was given by T3, while, the highest was 3.66 was given by T1. The lowest value after cooking varied 24.00 was given by T3, while, the highest value 31.03 was given by T1.The lowest value of h value after cooking 81.24 was given by T3, while, the highest of 89.90 was given by T4.

Table 2. Color index of raw faba been seeds.

Treatments	Color				
	L*	***a****	***b****	**c**	**H**
T1	**64.62**	**0.91**	**31.07**	**31.03**	**83.32**
T2	**60.77**	**1.09**	**28.34**	**28.36**	**87.79**
T3	**41.54**	**3.66**	**23.72**	**24.00**	**81.24**
T4	**45.47**	**0.05**	**28.40**	**28.40**	**89.90**
T5	**60.87**	**0.18**	**27.64**	**27.64**	**89.64**
T6	**54.42**	**1.44**	**28.87**	**28.91**	**86.93**

T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.

Chemical composition of raw faba been seeds:

Data presented in Table (3) show the effect of irrigations number, fertilization treatment and varieties on chemical composition of raw faba been seeds.

The lowest value of moisture content 6.55% was given by T3, while, the highest value 7.35% was given by T3. The obtained data there is non significant difference in moisture content between all treatments.

These values disagree with those obtained by **Ali *et al*. (1982)** and **Eltinay *et al*. (1993),** they reported a range of 8.25-8.84%.

The lowest value of total solid (T.S.) content 92.65% was given by T1, while, the highest value of 93.45% was given by T1. The obtained data there is non significant difference in T.S. content between all treatments.

The lowest value of crude protein content 29.09% was given by T6, while, the highest value of 35.93% was given by T1. The obtained data there is a significant difference in crude protein content between all treatments.

The results are in agreement with the those obtained by **Elsayed (1994)** and **Elsheikh *et al*. (1999),** they reported that the crude protein 28.0-37.8%.

Table 3. Chemical composition of raw faba been seeds (on dry weight basis).

Treatments	Components (%)						
	Moisture	**T.S.**	**Crude protein**	**Ether extract**	**Ash**	**Crude fiber**	**Available carbohydrate**
T1	**7.35 ±0.48^{a}**	**92.65 ±0.48^{a}**	**35.93 ±0.27^{a}**	**1.45 ±0.02^{c}**	**2.42 ±0.12^{c}**	**5.77 ±0.21^{ab}**	**54.43 ±0.34^{d}**
T2	**6.89 ±0.19^{a}**	**93.11 ±0.19^{a}**	**29.92 ±0.05^{d}**	**1.66 ±0.01^{ab}**	**2.76 ±0.03^{ab}**	**5.95 ±0.03^{ab}**	**59.71 ±0.07^{b}**
T3	**6.55 ±0.23^{a}**	**93.45 ±0.23^{a}**	**29.15 ±0.24^{e}**	**1.72 ±0.03^{a}**	**2.86 ±0.05^{ab}**	**6.15 ±0.05^{a}**	**60.12 ±0.24^{b}**
T4	**6.71**	**93.29**	**31.06**	**1.64**	**2.94**	**5.69**	**58.68**

	±0.16[a]	±0.16[a]	±0.01[c]	±0.03[b]	±0.12[a]	±0.17[b]	±0.08[c]
T5	6.58	93.42	31.79	1.66	2.35	5.61	58.59
	±0.23[a]	±0.23[a]	±0.10[b]	±0.01a[b]	±0.10[c]	±0.07[b]	±0.14[c]
T6	6.73	93.27	29.09	1.67	2.56	5.86	60.83
	±0.37[a]	±0.37[a]	±0.15[e]	±0.03[ab]	±0.13[bc]	±0.06[ab]	±0.28[a]

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.

T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.

The lowest value of ether extract content was 1.45% given by T1, while, the highest value 1.72% was given by T3. The obtained data there is non significant difference in ether extract content between T2, T3, T5 and T6. But, there is a significant decrease in extract content between T1 compared with other treatments.

The obtained results in this study were in agreement with **Eltinay *et al*. (1989)** and **Elsheikh *et al*. (1999),** they reported that the ether extract content ranged from 1.1-2.2%.

The lowest value of ash content 2.35% was given by T5, while, the highest value 2.96% was given by T4. The obtained data there is non significant difference in ether extract content between T2, T3 and T4. Also, there is non significant difference in ether extract content between T2, T3 and T6. So, that there is non significant difference in ether extract content between T1, T5 and T6.

The results are in agreement with **Elsheikh *et al*. (1999)** and **Rehman and Shah (2005),** they reported 3.6%. **Abdul Rahim (2004)** who reported 3.6% and **Eltinay *et al*. (1993)** who found the ash 2.7-7.4% and disagree with those obtained by who reported 2.81% for raw faba bean.

The lowest value of crude fiber content 5.61% was given by T5 while, the highest of 6.15% was given by T3. The obtained data there is non significant difference in ether extract content between T1, T2, T4, T5 and T6.

The results obtained are in agreement with **Elsheikh *et al*. (1999) Abdul Rahim (2004),** who reported that the crude fiber content ranged from 5.17-8.08 %.

The lowest value of available carbohydrate content 54.43% was given by T1, while, the highest of 60.83% was given by T6. The obtained data there is a significant increase in available carbohydrate content between T6 compared with other treatments. While, there is a significant decrease in available carbohydrate content between samples of T1 compared with other treatments .

The results are in agreement with **Eltinay *et al*. (1989), Abdul Rahim (2004), Gasim *et al* (2015) and Robinson *et al*. (2019)**, **Mortuza *et al*. (2009)**they reported that the available carbohydrate content ranged from 48.12-54.8%.

Minerals content of faba been seeds:

Data presented in Table (4) show the effect of irrigations number, fertilization treatment and varieties on minerals content of faba been seeds.

The lowest value of K content 939.68 mg/100 g was given by T2, while, the highest value 1073.92 mg/100 g was given by T4. The lowest value of Na content 260.84 mg/100 g was given by T2, while, the highest value 335.37 mg/100 g was given by T4. The lowest value of Ca content 330.83 mg/100 g was given by T1 and T5, while, the highest value 334.21 mg/100 g was given by T4.

On the other hand, The lowest value of Mg content 144.38 mg/100 g was given by T5, while, the highest value 159.25 mg/100 g was given by T1. These results are in agreement with those results obtained by **Chavan *et al*. (1989).**

Table 4. Minerals content of faba bean seeds (mg/100 g).

Treatments	K	Na	Ca	Mg
T1	**997.21**	**335.37**	**330.83**	**159.25**
T2	**939.68**	**260.84**	**351.50**	**156.50**
T3	**1054.74**	**316.73**	**372.18**	**154.25**
T4	**1073.92**	**335.37**	**434.21**	**153.25**
T5	**958.86**	**279.47**	**330.83**	**144.38**
T6	**1016.39**	**298.10**	**351.50**	**149.00**

T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.

T6. Giza 716 with nano-P foliar and three irrigations.

Effect of soaking on rehydration of raw seeds faba bean:

The seeds were soaked in the dark in tap water for 8 hours. The soaked solution was drained off. Thereafter they cooled and dried at 55°C and then ground to pass a 0.4 mm screen.

Data presented in Table (5) show the effect of irrigations number, fertilization treatment and varieties on soaking of faba been seeds in tap water.

Table 5. Rehydration of raw seeds (100) (mean±S.E).

Treatments	Parameters			
	Weight seeds before soaking (g)	Weight seeds after soaking (g)	Increase in weight (g)	Increase of weight (%)
T1	**100**	**215.98±6.37^{a}**	**116.02±2.46^{a}**	**129.30±2.36^{a}**
T2	**100**	**193.80±2.11^{b}**	**93.80±2.40^{de}**	**109.11±4.80^{b}**
T3	**100**	**206.80±3.58^{b}**	**106.80±4.00^{cd}**	**130.23±7.40^{ab}**
T4	**100**	**216.70±2.07^{a}**	**116.75±0.75^{ab}**	**135.32±3.89^{a}**
T5	**100**	**202.60±4.89^{a}**	**102.60±1.74^{bc}**	**112.69±3.49^{ab}**
T6	**100**	**197.06±3.67^{c}**	**96.99±2.79^{e}**	**125.36±3.04^{b}**

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.

T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.

Results in Table (5) show there is non significant difference in percent increase in weight after soaking between T1, T3, T4 and T5, also, there is non significant difference in hulls percent between T1, T2, T3 and T5. While, there is a significant decrease in increase in weight after soaking percent T2 and T6 compared with other T1 and T4.

These results are agreement with those reported by **Avila *et al.* (2015), Abdel-Aal *et al.* (2018)** and **Shi *et al.* (2018)**

Effect of cooking on the physical properties of faba bean seeds :

The seeds were soaked in the dark in tap water for 8 hours. The soaked solution was drained off, then the seeds were cooked in boiling water. Thereafter they cooled and dried at 55°C and then ground to pass a 0.4 mm screen.

The data presented in Table (6) shown that the effect of irrigations numbers, fertilization treatment and varieties on increase of weight after cooking of faba been seeds.

The increase in the weight of 100 grams of seeds after soaking was more than doubled in all samples except for T2 and T6, the increase was less than double.

The lowest value of percent of weight increase after soaking 109.11% was given by T2, while, the highest value 135.32% was given by T4.

The increase in the weight of 100 grams of seeds after cooking was more than 200% for samples of T1, T2 and T5, while the increase samples of T3, T4 and T6 was less than 200%.

The lowest value percent of weight increase after cooking 175.11% was given by T4, while, the highest value 244.08% was given by T2.

Results in Table (6) show there is non significant difference in percent increase in weight after cooking between T2, T3 and T5, also, there is non significant difference in hulls percent between T1, T3 and T5. While there is a significant decrease in increase in weight after cooking percent of T4 compared with other treatment .

These results are agreement with those reported by **Shi *et al.* (2018) and Lafarga *et al.*, 2019).**

Table (6): Physical properties of cooked seeds (100 g) (mean±S.E).

Treatments	Parameters				
	Weight seeds before cooking (g)	Weight seeds after cooking (g)	Increase in weight (g)	Increase of weight (%)	Cooking (%)
T1	**100**	**286.79±5.78^{c}**	**122.94±4.45^{c}**	**230.21±2.42^{bc}**	**100**
T2	**100**	**303.76±6.55^{bc}**	**141.82±5.03^{b}**	**244.08±3.34^{a}**	**100**
T3	**100**	**293.49±5.19^{a}**	**187.61±1.42^{a}**	**197.01±6.49^{ab}**	**96.7**
T4	**100**	**261.13±1.53^{cd}**	**135.56±0.38^{c}**	**175.71±3.45^{d}**	**100**
T5	**100**	**290.54±5.66^{c}**	**118.93±4.17^{c}**	**241.34±3.77^{abc}**	**93.3**

T6	**100**	**278.43±4.12^{b}**	**151.56±2.79^{b}**	**193.66±3.85^{c}**	**86.7**

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.

T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.

Chemical composition of cooked faba bean seeds:

Data presented in Table (7) show the effect of cooking on chemical composition of raw faba been seeds.

The lowest value of moisture content 77.59% was given by T5, while, the highest value 78.58% was given by T6. The obtained data there is non significant difference in moisture content between T1, T2, T4 and T6. Also, there is non significant difference in moisture content between T3 and T5. Cooking caused a significant increase in moisture content for faba bean cultivars

The lowest value of total solid (T.S.) content 21.42% was given by T6, while, the highest value 22.41% was given by T5. The obtained data there is non significant difference in moisture content between T3 and T5. Also, there is non significant difference in moisture content between T1, T2, T4 and T6.

The lowest value of crude protein content 26.90% was given by T6, while, the highest value 33.01% was given by T1. The obtained data there is a significant increase in crude protein content between T1 compared other Treatments. But, there is non significant difference between T4 and T5. Also, there is non significant difference between T2, T3 and T6.

Table 7. Chemical composition of cooked faba been seeds.

Treatments	Components (%)						
	Moisture	T.S.	Crude protein*	Ether extract*	Ash*	Crude fiber*	Available *@ carbohydrate
T1	78.37 ±0.13^{a}	21.63 ±0.13^{b}	33.01 ±0.21^{a}	1.15 ±0.05^{c}	2.00 ±0.13^{b}	4.99 ±0.42^{a}	58.85 ±0.66^{b}
T2	78.46 ±0.17^{a}	21.54 ±0.17^{b}	27.12 ±0.46^{c}	1.32 ±0.04^{b}	2.15 ±0.12^{ab}	5.51 ±0.11^{a}	63.90 ±0.42^{a}
T3	77.69 ±0.11^{b}	22.31 ±0.11^{a}	27.18 ±0.03^{c}	1.41 ±0.02^{ab}	2.27 ±0.12^{ab}	5.59 ±0.06^{a}	63.55 ±0.19^{a}
T4	78.13 ±0.12^{a}	21.87 ±0.12^{b}	27.99 ±0.36^{b}	1.34 ±0.05^{b}	2.41 ±0.08^{a}	5.23 ±0.04^{a}	63.03 ±0.46^{a}
T5	77.59 ±0.14^{b}	22.41 ±0.14^{a}	28.38 ±0.12^{b}	1.39 ±0.03^{ab}	1.96 ±0.09^{b}	5.03 ±0.10^{a}	63.24 ±0.10^{a}
T6	78.58 ±0.16^{a}	21.42 ±0.16^{b}	26.90 ±0.03^{c}	1.49 ±0.03^{a}	2.13 ±0.12^{ab}	5.33 ±0.03^{a}	64.16 ±0.11^{a}

***: on dry weight basis** **$^{@}$: Available carbohydrate calculated by difference**

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.

T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.

The lowest value of ether extract content 1.15% was given by T1, while, the highest value 1.49% was given by T6. The obtained data there is non significant difference in ether extract content between T3, T5 and T6. But, there is a significant decrease in extract content between T1 compared with other treatments. Cooking caused a significant reduction in fat content for faba bean cultivars.

The lowest value of ash content 1.96% was given by T5, while, the highest value 2.41% was given by T4. The obtained data there is non significant difference in ether extract content between T1, T2, T3, T5 and T6.

The lowest value of crude fiber content 4.99% was given by T1, while, the highest value 5.59% was given by T3. The obtained data there is non significant difference in ether extract content between all treatments.

Also, the lowest value of available carbohydrate content 58.85% was given by T1, while, the highest value 64.16% was given by T6. The obtained data there is a significant decrease in available

carbohydrate content between T1 compared with other samples. While, there is non significant difference in available carbohydrate content between T2, T3, T4, T5 and T6.

These results are in agreement with those results obtained by **Abdul Rahim (2004), Mortuza *et al.* (2009), Gasim *et al* (2015) and (Robinson *et al.*, 2019).**

Effect of cooking on texture for faba bean seeds:

Texture is one of the most important cooking characteristics of faba beans. Farmers, processors and consumers value seeds that can be cooked quickly and cooked products which become homogeneously soft without any granulation. Methods of assessment are based on measuring or evaluating the texture of beans, subjectively or objectively, after cooking under standard specified procedure either for a definite time or for various successive intervals to determine the cooking time.

Data in Table (8) show the lowest value of texture 1.00N was given by T1 and T2, while, the highest value 1.89N was given by T5. The obtained data there is non significant difference in texture between all treatments**.**

Table 8. Texture of cooked faba bean seeds.

Treatments	Texture (N)
T1	**1.00±0.02^{a}**
T2	**1.00±0.08^{a}**
T3	**1.35±0.33^{a}**
T4	**1.73±0.36^{a}**
T5	**1.89±0.59^{a}**
T6	**1.42±0.40^{a}**

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.

T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.
***N = Newton**

Effect of cooking on phenolic compounds for faba bean seeds:

Cooking changes the chemical composition of vegetables, which alters the concentration and bioavailability of bioactive compounds including total phenolics and antioxidants. Results in Table (9) show the total phenolic compounds of faba bean cultivar ranged from 7.85±0.26 to11.32±0.13 mg/g (as Gallic acid) .The obtained results are confirmed by the data obtained by **Khan *et al.* (2015)** who reported that the total phenolic contents of various faba bean genotypes ranged from 5.84 to 11.43 mg GAE/g.

Also, data in the same table show the cooking process reduced the phenolic compounds of all cooked samples when compared to the raw samples. The lowest phenolic compounds was 7.85 mg/g before cooking was given by T6, while the highest value 11.32 mg/g was given by T1. The obtained data before cooking there is non significant difference in phenolic compounds between T1 and T2, T3 and T4. While, there is a significant decrease in phenolic compounds in T5 or T6 compared to T1, T2, T3 and T4. After cooking process was decreased from 20.50 to 25.94% in phenolic compounds. The lowest decrease value of phenolic compounds 20.50% after cooking was given by T5, while, the highest decease value 25.94% was given by T4. These results are in agreement with those obtained by **Abdel-Aleem *et al.* (2019)** who reported that the processing methods, soaking and cooking processes caused decrease in phytochemicals compounds.

Table 9. Phenolic compounds of faba bean seeds (mg/g as Gallic acid) on dry weight basis (mean±SE).

Treatments	Phenolic compounds		Decrease of phenolic compound (%)
	Before cooking	After cooking	
T1	**11.32±0.13^{a}**	**8.90±0.18^{a}**	**21.37±0.97^{a}**
T2	**11.26±0.16^{a}**	**8.31±0.09^{b}**	**26.17±1.80^{a}**
T3	**10.25±0.07^{b}**	**7.96±0.17^{bc}**	**22.38±1.49^{a}**
T4	**10.28±0.08^{b}**	**7.61±0.20^{c}**	**25.94±1.78^{a}**
T5	**8.31±0.11^{c}**	**6.60±0.14^{d}**	**20.50±2.56^{a}**
T6	**7.85±0.26^{d}**	**6.03±0.18^{e}**	**22.98±3.45^{a}**

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.

T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.

4.2.10. Effect of cooking on tannins for faba bean seeds:

The obtained results for the tannins (as mg tannic acid/g DW) of raw faba beans before cooking and after cooking are shown in Table (10). From which, it could be seen that cooking processes caused a decrease in the total tannins for all cooked samples as compared to the raw samples .

The lowest tannins was 2.14 mg/g before cooking given by T6, while, the highest value 5.06 mg/g was given by T1. The obtained data before cooking there is non significant difference in tannins content between T1, T2, T3 and T4. While, there is a significant decrease in tannins in T5 or T6 compared to T1, T2, T3 and T4. After cooking it was decreased from 58.03 to 64.28% in tannins. The lowest decrease of tannins was found 58.03% after cooking was given by T1. The highest value 64.28% was given by T3. Soaking and boiling were shown to lower the level of tannins in faba beans. A significant amount of active compounds was leached to the soaking and cooking **(Siah *et al.*, 2012)**.

Elsheikh *et al.* (2000) reported that cooking significantly ($P<0.05$) decreases tannins of faba bean. Also, it could be due to the cooking thermal degradation of these compounds and changes in their chemical reactivity or formation of insoluble complexes which may occur during cooking process.

Table 10. Tannins of faba bean seeds (mg/g as tannic acid) on dry weight basis (mean±SE).

Treatments	Tannins		Decrease of tannins (%)
	Before cooking	After cooking	
T1	5.06±0.05^{a}	2.12±0.03^{a}	58.03±0.12^{b}
T2	5.02±0.03^{a}	1.93±0.03^{b}	61.53±0.32^{ab}
T3	4.76±0.35^{a}	1.68±0.04^{c}	64.28±2.98^{a}
T4	4.63±0.02^{a}	1.76±0.03^{c}	61.96±0.58^{ab}
T5	2.69±0.03^{b}	1.07±0.01^{d}	59.98±0.61^{ab}
T6	2.14±0.02^{c}	0.86±0.03^{e}	59.50±1.82^{ab}

a, b & c: There is no significant difference ($P>0.05$) between any two means, within the same column have the same superscript letter.
T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.

Sensory evaluation of cooking faba bean seeds:

Sensory evaluation of food products is an important criterion by which its consumer acceptability can be assessed. Data in Table (11) show the all cooked faba bean recorded mean scores higher than 7 for all tested parameters. The color, taste and texture of cooked faba bean showed higher mean scores for T1, T2 and T3, respectively. The most preferable color for the panelists was recorded for T1, T2 and T3, respectively. Results for odor and mouthfeel as the most important organoleptic property showed that all samples were preferred significantly.

Moreover, the overall acceptability scores indicated that the different treatments could be arranged as T1 > T2 > T3 > T6 > T4 > T5.

Table 11. Sensory evaluation of cooked faba bean seeds **.**

Treatments	Properties					
	Color (10)	Odor (10)	Taste (10)	Texture (10)	Mouth feel (10)	Overall acceptability (10)
T1	8.50 0.27^{a}	9.00 ±0.19^{a}	8.50 ±0.19^{a}	8.88 ±0.13^{a}	8.75 ±0.25^{a}	8.75 ±0.16^{a}
T2	8.50 0.38^{a}	8.63 ±0.32^{a}	8.25 ±0.25^{ab}	8.75 ±0.16^{a}	8.63 ±0.26^{a}	8.25 ±0.25^{ab}
T3	8.00 ±0.33^{ab}	8.63 ±0.32^{a}	8.13 ±0.30^{ab}	8.13 ±0.23^{ab}	8.50 ±0.33^{a}	8.00 ±0.27^{ab}
T4	7.50 ±0.46^{ab}	8.50 ±0.27^{a}	7.75 ±0.31^{abc}	7.75 ±0.37^{b}	8.50 ±0.33^{a}	7.75 ±0.41^{ab}

T5	**7.25 ±0.37^{b}**	**8.13 ±0.35^{a}**	**7.13 ±0.35^{c}**	**7.50 ±0.27^{b}**	**8.25 ±0.37^{a}**	**7.25 ±0.37^{b}**
T6	**7.38 ±0.42^{ab}**	**8.25 ±0.16^{a}**	**7.50 ±0.38^{bc}**	**7.75 ±0.41^{b}**	**8.13 ±0.35^{a}**	**7.88 ±0.40^{ab}**
LSD at 0.05	**1.07**	**0.80**	**0.86**	**0.80**	**0.90**	**0.92**

a, b & c: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.

T1: Maruot 2 without nano-P foliar and three irrigations .
T2. Maruot 2 with nano-P foliar and three irrigations.
T3. Nobaria 2 without nano-P foliar and three irrigations.
T4. Nobaria 2 with nano-P foliar and three irrigations.
T5. Giza 716 without nano-P foliar and three irrigations.
T6. Giza 716 with nano-P foliar and three irrigations.

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الخصائص التكنولوجية ومميزات الجودة لبعض أصناف الفول

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تم فى هذه الدراسة تقييم بعض أصناف الفول البلدى (ماريوت 2، نوبارية 2 وجيزة 716) المزروعة تحت ظروف ثلاث ريات والمسمدة بالأسمدة النانوية. حيث أجرى التقييم على البذور الجافة بتقدير بغض الخواص الطبيعية ومؤشر اللون والتركيب الكيماوى للبذور ومحتواها من بعض العناصر المعدنية. كما تم إجراء عملية النقع لها للتعرف على كفاءة تشربها للماء كما تم إجراء عملية الطهى وتقدير الزيادة فى الحجم بعد الطهى وكذلك التركيب الكيماوى بعد الطهى. أيضا تم قياس القوام لبذور الأصناف المختلفة بعد الطهى كما تم تقدير الفينولات الكلية والتانينات قبل وبعد الطهى للتعرف على تأثير الطهى على محتوى تلك البذور من بعض مضادات التغذية فى الأصناف محل الدراسة. وقد أظهرت النتائج أن نسبة القشور تراوحت من 10.22إلي 20.56%، كما تراوح كل من المحتوى الرطوبى من 6.55إلي7.35%، والبروتين الخام من 29.09إلي35.93% (على أساس الوزن الجاف). أيضا تراوحت نسبة التشرب من 109.11إلي135.32% والزيادة فى الوزن بعد الطهى من 175.71إلي244.08%. وبالنسبة للتركيب الكيميائى بعد الطهى تراوحت نسبة الرطوبة من 77.59إلي78.37% والبروتين الخام من 26.90إلي33.01% (على أساس الوزن الجاف). وقد أدت عملية الطهى إلى خفض محتوى المركبات الفينولية الكلية بنسبة تراوحت من 20.50إلي26.17% فى حين أنخفض محتوى البذور من التانينات بنسبة تراوحت من 58.03إلي64.28%.

الكلمات الدالة: الفول البلدى – مريوت 2 – نوبارية 2 – جيزة 716 – التركيب الكيماوى – المواد الفينولية – التانينات.