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Effect of Soaking and Cooking on Nutritional and Quality Properties of Faba Bean

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ABSTRACT

Faba bean seeds (Giza 843) were soaked in tap water and different saline solutions (0.5, 1% baking powder and 0.5, 1% sodium bicarbonate) to accelerate the cooking process and improve their nutritional and quality properties. Soaking and cooking parameters of raw and treated cooked beans were investigated. The samples were also evaluated for their nutritional, physical and sensory characteristics and in-vitro protein digestibility (IVPD). The data showed that, water absorption values increased as the soaking time increased (14.39 – 21.99 after 1 hr and 76.96 – 88.17% after 12 hrs). Cooking time decreased as a result of soaking process. It was higher (260 min) for raw bean and lower (40 min) for 1% baking powder. The IVPD improved after soaking and cooking. It was 70.35 for raw bean, 83.47 for control and 87.29% for 1% sodium bicarbonate. Total carbohydrates and phenolic compounds decreased for all cooked samples as compared to the raw one. As a conclusion, soaking for 12 hrs with 1% baking powder, discarding soaking solution and using fresh water for cooking is the best treatment to reduce cooking time and improve the nutritional and quality properties of cooked faba beans.

Keywords: Faba bean, soaking, cooking, IVPD, nutritional and quality properties.

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the major legume crops in Egypt and many other parts of the world. It is widely used in the Mediterranean region as source of protein in human nutrition. However, there is a need to improve its antinutritional factors to be more acceptable for other countries. Soaking could be one of the processes for removal of soluble antinutritional compounds, which can be eliminated with the discarded soaking solution. At the same time, some metabolic reactions take place during the soaking process, affecting the soluble carbohydrate content. In addition, the soaking process helps to soften the seed coat and decrease the time required for cooking (Vidal-Valverde *et al*., 1998; Urbano *et al*., 2000; Rehman *et al*., 2001; Vadivel and Pugalenthi, 2009 and Singh *et al*., 2013).

Due to its hard seed coat, prolonged cooking times are required which increase the cooking cost and reduce the nutritive value of beans (Khalil and Mansour, 1995). To accelerate the cooking process, chefs use additives such as citric acid and sodium bicarbonate. The main effect of sodium bicarbonate is to modify the pH of the soaking solution and cooking water, that in turn softens the hard external shell, reduces cooking times and may alter the percentage of nutrients, flavor and consistence of cooked beans (Vidal-Valverde *et al*., 1998 and Avila *et al*. 2015). Recently, EDTA has been used as an additive to accelerate the cooking process of faba beans and to reduce the cost effective. However, EDTA addition to faba beans during the cooking process decreased their nutritional value (El-Naggar *et al*. 2019).

Baking powder is a dry chemical leavening agent used to increase the volume and lighten the texture of bakery products. It is a pretty simple mixture made of a base (sodium bicarbonate), one or more acid salts (monocalcium phosphate, sodium acid pyrophosphate or sodium aluminum sulfate) and buffering material (starch) to prevent the acid and base from reacting before their intended use (Brodie and Godber, 2001). However, when we go through the literatures it doesn't seem that there are published data about using the baking powder as an additive to accelerate the cooking process of faba beans.

The main objective of this investigation was to evaluate the effect of soaking in tap water and different saline solutions (0.5, 1% baking powder and 0.5, 1% sodium bicarbonate) and cooking on nutritional and quality properties of the Egyptian faba bean cultivar Giza 843. Soaking and cooking parameters of raw and treated cooked beans were investigated. The samples were also evaluated for their nutritional, physical and sensory characteristics and in-vitro protein digestibility.

MATERIALS AND METHODS

Materials:

Faba bean seeds (*Vicia faba* L., Giza 843) were obtained from Mallawy Agricultural Research Station, Minia, Egypt during the season of 2017. The seeds (10 kg) were hand sorted and stored in polyethylene bags at about 4°C until analysis and use. All chemicals used in this investigation were of analytical grade and purchased from Sigma and El-Naser Pharmaceutical Chemicals. Baking powder was purchased from the local market.

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Methods:

Preparation of raw seeds for soaking and cooking: Faba bean seeds manually cleaned from broken or damaged seeds, dust, stones and other foreign materials. The cleaned seeds (200g) were soaked for 12 hrs at room temperature (~ 25°C) (Avila et al. 2015) in different solutions: 0.5, 1% baking powder (BP), 0.5, 1% sodium bicarbonate (SB) and tap water used as control. A ratio of 1 : 4 (w/v) seeds to water was used. After soaking, the unimbibed water was discarded. The soaked seeds were washed with ordinary water then cooked in tap water using the ratio of 1 : 4 (w/v) on a hot plate (~ 100°C.) until they became soft (~ 90% of bean seeds) when felt between the fingers at various intervals. Cooking time was taken when the seeds became soft (Shehata, 1982). The cooked seeds were cooled and dried at 55°C, then ground separately in an electric laboratory mill and sifted through a 60 mesh screen to obtain fine powders. The obtained powders were stored in airtight containers at 4°C for analysis and use.

Water absorption during soaking was determined using the method of weight gain until equilibrium conditions were attained (Abu-Ghannam and McKenna, 1997 and Turhan *et al*., 2002).

Water absorption of cooked faba beans was determined by weighing the soaked bean samples before and after cooking and expressed as percentage of the original sample weight as follows:

$$\text{Water absorption (\%)} = \frac{\text{weight after cooking} - \text{weight before cooking}}{\text{weight before cooking}} \times 100$$

Hydration coefficient of faba beans was determined using the weight measurements of bean samples before and after soaking under specified conditions (as mentioned before) and expressed as the percentage increase in weight as follows:

$$\text{Hydration coefficient (\%)} = \frac{\text{weight of beans after soaking}}{\text{weight of beans before soaking}} \times 100$$

The hydration coefficient of cooked beans was calculated using the weight measurements of bean samples before and after cooking as above (Shehata, 1982 and El-Refai *et al*., 1988).

Swelling coefficient of faba beans was determined using the volume measurements of bean samples before and after soaking under specified conditions (as mentioned before) and expressed as the percentage increase in volume as follows:

$$\text{Swelling coefficient (\%)} = \frac{\text{volume of beans after soaking}}{\text{volume of beans before soaking}} \times 100$$

The swelling coefficient of cooked beans was calculated using the volume measurements of bean samples before and after cooking as above (Shehata, 1982 and El-Refai *et al*., 1988).

Chemical analysis: Moisture and crude protein contents were determined according to the methods of the AOAC (2000). The phenol-sulfuric acid method described by Dubois *et al*. (1956) was used in the determination of total soluble sugars (TSS). Total reducing sugars (TRS) were extracted with 70% ethanol and assessed by the DNS method (Miller, 1959). Total non-reducing sugars (TNRS) were calculated as the difference between the total soluble sugars (TSS) content and the total reducing sugars (TRS) content as follows:

$$[\ \text{TNRS} = \text{TSS} - \text{TRS}\ ]$$

Total carbohydrates (TC) were determined by phenol-sulfuric acid method (Dubois *et al*., 1956) after complete acid hydrolysis with 2.5% HCl for 3 hrs. All determinations were performed in triplicates and the means were reported.

In vitro protein digestibility (IVPD) was determined according to Maliwal (1983). The trichloroacetic acid (TCA) soluble fraction was assayed for nitrogen according to AOAC (2000). Digestibility was obtained by using the following equation:

$$\text{Protein digestibility (\%)} = \frac{N_2 \text{ in supernatant} - N_2 \text{ in pepsin}}{N_2 \text{ in sample}} \times 100$$

Total phenolic compounds (TPC) were determined according to Zielinski and Kozlowska (2000) with some modifications.

Total tannin content was determined using the colorimetric method described by Linskens and Jackson (1995).

Total antioxidant capacity was done according to the phosphomolybdenum method (Prieto *et al*., 1999).

Determination of color: The color characteristics of samples were measured by a color difference meter (model color Tec-PCM, USA) using different color parameters (L, a, b) according to Francis (1983).

Sensory evaluation for the color, texture, taste, odor and overall quality were done in order to determine consumer acceptability. A numerical hedonic scale which ranged from 1 to 10 (1 is very bad and 10 for excellent) was used for sensory evaluation (Larmond, 1977).

RESULTS AND DISCUSSION

Water absorption during soaking of faba beans:

The water absorption curves (water absorption capacity versus soaking time) during soaking of faba beans are shown in Fig (1).

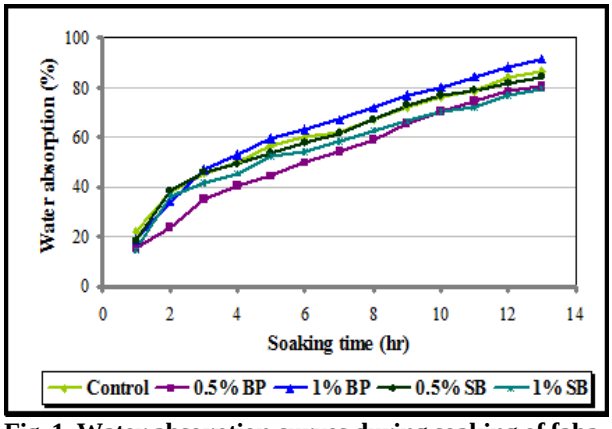

Fig. 1. Water absorption curves during soaking of faba beans.

From which, it could be seen that the water absorption rate was fast at the beginning and slow at the end of soaking process for all samples. It is evident from these curves that the values of water absorption increase continuously with soaking time. There were ranged from 14.39 (1% SB) to 21.99% (control) after 1 hr and from 76.96 (1% SB) to 88.17% (1% BP) after 12 hrs. The samples

soaked with 1% BP had higher values than those soaked in 1% SB. It is well known that the water absorption of seeds is a very complex physicochemical phenomenon. More extraction of solid matter from seeds at the end of soaking time was a negative factor of water absorption. Similar observations were reported by Abdel Kader (1995); Abu-Ghannam and McKenna (1997); Turhan *et al*. (2002); Haladjian *et al*. (2003); Kinyanjui *et al*. (2015) and Shafaei *et al*. (2016) for various agricultural materials.

Water absorption of cooked faba beans:

Understanding the behavior of water absorption during cooking is industrially important in order to optimize processing conditions. Water absorption of faba beans after soaking and cooking are shown in Fig (2). The results showed that water absorption increased after cooking and ranged from 125.20 for 1% SB to 157.10% for 1% BP. The corresponding values after soaking for 12 hrs were 76.96 and 88.17%. However, beans soaked in water (control) had the value of 144.30% after cooking as compared to 84.35% after soaking. This indicates that soaking with baking powder (BP) is more effective than soaking with sodium bicarbonate (SB). Similar observations were reported by Kinyanjui *et al*. (2015).

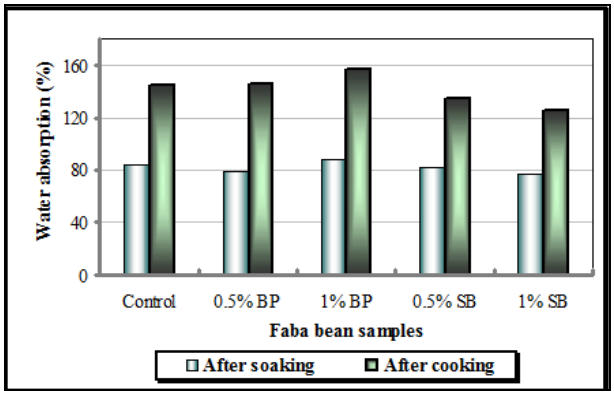

Fig. 2. Water absorption after soaking and cooking of faba beans.

Cooking time of faba bean samples:

Cooking time is important in determining the energy cost for preparation of beans and evaluating their cooking quality. A long cooking time reduces the nutritive value of legumes as compared with a short treatment. The obtained results for cooking time of faba beans are shown in Fig (3).

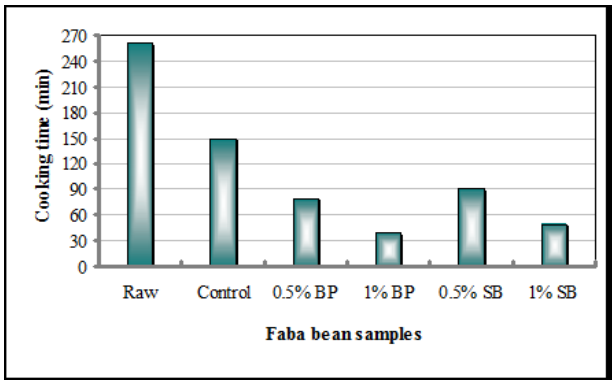

Fig. 3. Cooking time (min) of faba bean samples.

From which, it could be seen that the cooking time decreased as a result of soaking process. It was higher (260 min) for raw bean and lower (40 min) for 1% BP. This indicates that soaking process helps to soften the seed coat and decrease the time required for cooking. Cooking time of various legumes may vary according to their size, age and moisture content. Also, it was affected by water hardness, water absorption and using acidic or alkaline solutions for soaking or cooking (Singh *et al*., 2000; Emire, 2006; Avila *et al*., 2015; Kinyanjui *et al*., 2015).

Hydration and swelling coefficients of faba beans:

Hydration and swelling coefficients of faba beans after soaking and cooking are presented in Table (1). The results revealed that hydration coefficient increased after cooking and ranged from 225.20 for 1% SB to 257.10% for 1% BP compared to 176.96 and 188.17% for the same uncooked faba beans. The swelling coefficient followed similar pattern as hydration coefficient because it depends mainly on the amount of water absorbed. It was ranged from 226.15 for 1% SB to 243.08% for 1% BP compared to 207.69 and 218.46% for the same uncooked faba beans. This indicates that soaking with baking powder (BP) is more effective than soaking with sodium bicarbonate (SB). The cooked raw beans had lower hydration (220.47%) and swelling (212.31%) coefficients than pre-soaked cooked beans. It was reported that hydration and swelling coefficients which reflect the capacity to absorb water during soaking process was substantially affected by storage temperature. Both consumers and processors prefer beans that have high hydration and swelling coefficients as these produce greater quantity with better quality (Shehata, 1982; Noaman *et al*., 1988; Wood and Harden, 2006 and Nasar-Abbasa *et al*., 2008).

Table 1. Hydration and swelling coefficients of faba beans.

Samples		Parameters (%)*			
		Hydration coefficient		Swelling coefficient	
		After soaking	After cooking	After soaking	After cooking
Raw bean		-	220.47 ± 0.29	-	212.31 ± 0.74
Soaked beans	Control	184.35 ± 0.32	244.30 ± 0.17	215.38 ± 0.22	241.54 ± 1.03
	0.5% BP	178.51 ± 0.29	245.40 ± 0.12	209.23 ± 0.16	238.46 ± 0.62
	1% BP	188.17 ± 0.34	257.10 ± 0.52	218.46 ± 0.30	243.08 ± 0.85
	0.5% SB	181.85 ± 0.41	234.50 ± 0.33	213.85 ± 0.27	230.77 ± 0.93
	1% SB	176.96 ± 0.18	225.20 ± 0.37	207.69 ± 0.18	226.15 ± 0.54

***Means of three determinations ± SD, BP = Baking powder, SB = Sodium bicarbonate.**

Total protein and in-vitro protein digestibility of faba beans:

Digestibility is a measure of protein hydrolysis and absorption of the liberated amino acids.Therefore, any factor that alters digestibility would in turn affect the nutritional value of the protein. The total protein content and in-vitro protein digestibility (IVPD) of raw and cooked faba beans are presented in Table (2). From the data, it could be seen that there were no much changes in the protein content of cooked beans as compared to raw beans. It was 29.13 for raw bean, 28.69 for control and 28.31% for 0.5% SB. However, IVPD improved as a result of both soaking and cooking processes. Their values were 70.35 for raw bean,

83.47 for control, 86.51 for 1% BP and 87.29% for 1% SB. These results indicated that, the IVPD of 1% SB was slightly higher than 1% BP. The addition of baking powder (BP) or sodium bicarbonate (SB) up to 1% during soaking did not cause much change in the protein content of cooked faba beans but improved their IVPD. This could be due to the denaturation of protein, destruction of trypsin inhibitor or the reduction of other antinutrients such as tannins and polyphenols, which interact with protein to form complexes (Khalil and Mansour, 1995; Alonso *et al*., 2000; Abd El-Hady and Habiba, 2003; Vadivel and Pugalenthi, 2009 and Osman *et al*., 2014).

Table 2. Total protein and In-vitro protein digestibility of faba beans.

Samples		Parameters (%)*	
		Total protein content	In-vitro protein digestibility
Raw bean		29.13 ± 0.06	70.35 ± 0.13
Cooked beans	Control	28.69 ± 0.05	83.47 ± 0.08
	0.5% BP	28.44 ± 0.05	85.90 ± 0.11
	1% BP	28.58 ± 0.03	86.51 ± 0.10
	0.5% SB	28.31 ± 0.04	86.77 ± 0.06
	1% SB	28.56 ± 0.05	87.29 ± 0.17

***Means of three determinations ± SD, BP = Baking powder, SB = Sodium bicarbonate.**

Carbohydrates of raw and cooked faba beans:

The results of total carbohydrates (TC), total soluble sugars (TSS), total reducing sugars (TRS) and total non-reducing sugars (TNRS) for raw and cooked faba beans are presented in Table (3).

Table 3. Total carbohydrates (TC), TSS, TRS and TNRS of faba beans.

Samples		Parameters (%)*			
		TC	TSS	TRS	TNRS**
Raw bean		60.27 ± 1.07	11.55 ± 0.14	1.80 ± 0.03	9.75 ± 0.10
Cooked beans	Control	54.29 ± 1.55	7.26 ± 0.06	3.59 ± 0.19	3.67 ± 0.13
	0.5% BP	53.25 ± 0.73	7.55 ± 0.24	3.21 ± 0.16	4.34 ± 0.08
	1% BP	52.97 ± 0.94	7.49 ± 0.18	3.28 ± 0.07	4.21 ± 0.11
	0.5% SB	50.00 ± 0.91	7.19 ± 0.02	3.59 ± 0.06	3.60 ± 0.04
	1% SB	52.11 ± 0.49	6.46 ± 0.05	3.46 ± 0.04	3.00 ± 0.01

***Means of three determinations ± SD, BP = Baking powder, SB = Sodium bicarbonate.**
TC= total carbohydrates, TSS=total soluble sugars, TRS=total reducing sugars ,TNRS= total non-reducing sugars ** TNRS = TSS – TRS.

From the data, it could be seen that both soaking and cooking processes caused a decrease in total carbohydrates, total soluble sugars and total non-reducing sugars for all cooked samples as compared to the raw one. The TC values decreased from 60.27% for raw bean to 54.29, 52.97 and 52.11% for control, 1% BP and 1% SB, respectively. TSS decreased from 11.55% for raw bean to 7.49, 7.26 and 6.46% for 1% BP, control and 1% SB, respectively. TNRS decreased from 9.75% for raw bean to 4.21, 3.67 and 3.00 for 1% BP, control and 1% SB, respectively. These data revealed that, the highest decrease was recorded for TNRS (56.82 – 69.23%) followed by TSS (35.15 – 44.07%), whereas, TC recorded the lowest decrease values (9.92 – 13.77%). The reduction was higher for beans soaked with 1% SB than those soaked with 1% BP. Contrary to these results, the TRS revealed an increase after soaking and cooking processes. Compared to raw bean (1.80%), TRS had the values of 3.59, 3.46 and 3.28% for control, 1% SB and 1% BP, respectively. This could be due to their water soluble nature and leaching out during soaking into the discarded soaking solutions. It could also be due to the thermal degradation of these compounds which may occur during cooking process. Similar observations were reported by Abdel-Gawad (1993); Rehman *et al*., (2001) and Vadivel and Pugalenthi (2009).

Phytochemicals of raw and cooked faba beans:

The obtained results for the phytochemicals (total phenolic compounds (TPC), total tannins and total antioxidant capacity(TAC) of raw and cooked faba beans are shown in Table (4). From which, it could be seen that both soaking and cooking processes caused a decrease in the phytochemicals content for all cooked samples as compared to the raw one. The TPC values decreased from 832.43 mg/100g for raw faba bean to 709.47, 658.89 and 636.96 mg/100g (as gallic acid) for control, 1% SB and 1% BP, respectively. Total tannins decreased from 640.29 mg/100g for raw faba bean to 309.81, 235.79 and 213.15 mg/100g (as tannic acid) for control, 1% BP and 1% SB, respectively. Total antioxidant capacity (TAC) decreased from 923.58 mg/100g for raw faba bean to 97.93, 83.90 and 77.87 mg/100g (as ascorbic acid) for control, 1% BP and 1% SB, respectively. These data revealed that, the highest decrease was recorded for total antioxidant capacity (89.40 – 91.57%) followed by total tannins (51.61 – 66.71%), whereas, TPC recorded the lowest decrease values (14.77 – 23.48%). This reduction could be due to the removal of soluble antinutritional compounds during soaking process, which eliminated with the discarded soaking solution. It could also be due to the thermal degradation of these compounds and changes in their chemical reactivity or formation of insoluble complexes which may occur during cooking process. Similar observations were reported by Gdala (1998); Alonso *et al*. (2000); Abd El-Hady and Habiba (2003); Vadivel and Pugalenthi (2009) and Mehanni *et al*. (2017) for various agricultural materials.

Table 4. TPC, total tannins and total antioxidant capacity (TAC) of raw and cooked faba beans.

Samples		Parameters (mg/100g)*		
		TPC	Total tannins	TAC
Raw bean		832.43 ± 1.43	640.29 ± 1.24	923.58 ± 32.18
Cooked beans	Control	709.47 ± 1.71	309.81 ± 4.30	97.93 ± 6.40
	0.5% BP	673.37 ± 0.60	246.14 ± 1.95	89.61 ± 1.11
	1% BP	636.96 ± 1.85	235.79 ± 2.80	83.90 ± 1.63
	0.5% SB	680.82 ± 8.05	223.60 ± 4.90	85.09 ± 1.19
	1% SB	658.89 ± 11.44	213.15 ± 3.35	77.87 ± 1.25

***Means of three determinations ± SD, BP = Baking powder, SB = Sodium bicarbonate. TPC=total phenolic compounds , TAC= total antioxidant capacity**

Color characteristics of raw and cooked faba beans:

The results of color parameters (L, a, b, ΔE, hue angle and chroma) for raw and cooked faba beans are shown in Table (5). The results showed that raw faba bean had the color values of 82.86, 6.27 and 8.07 for "L", "a" and "b", respectively. These values changed after cooking and became 61.48, 7.54 and 12.93 for control, 55.17, 8.86 and 12.25 for 1% BP and 56.40, 10.15 and 9.32 for 1% SB. Hue angle and chroma values were found to be 52.15 and 10.22 for raw bean. These values changed in cooked beans and ranged from 59.75 to 40.03 for hue angle and from 12.80 to 15.36 for chroma. The ΔE values of cooked beans ranged from 3.59 for 0.5% BP to 6.76 for 1% SB. Nevertheless, this minute total color difference can not be distinguished by the

naked eye in some cases. In the light of the obtained results, it could be concluded that samples soaked with 0.5 or 1% BP before cooking revealed optimum color values. However, those soaked with 0.5 or 1% SB revealed less acceptable color values. It was reported that the Hunter color parameters (L), (a) and (b) are widely used to describe color changes of food materials. However, it is recommended to use hue angle and chroma as more practical measures of color. The color changes can also be expressed as a single numerical value ΔE. This value defines the magnitude of the total color difference. Preferred colors are those closest to the original color of samples (McGuire, 1992; Albanese *et al*., 2007 and Shih *et al*., 2009).

Table 5. Color parameters of raw and cooked faba beans.

Color parameters*	Raw bean	Cooked faba beans				
		Control	Baking powder (BP)		Sodium bicarbonate (SB)	
			0.5 %	1 %	0.5 %	1 %
L (Lightness)	82.86 ± 2.42	61.48 ± 1.88	62.83 ± 0.89	55.17 ± 0.72	60.94 ± 0.26	56.40 ± 1.67
a (redness/greenness)	6.27 ± 2.44	7.54 ± 1.73	7.47 ± 2.81	8.86 ± 2.39	11.76 ± 2.36	10.15 ± 0.72
b (yellowness/blueness)	8.07 ± 1.61	12.93 ± 2.89	10.39 ± 0.51	12.25 ± 2.10	9.88 ± 1.39	9.32 ± 0.36
ΔE**	-	00.00	3.59	6.48	5.23	6.76
Hue angle***	52.15	59.75	54.28	54.12	40.03	42.56
Chroma****	10.22	14.97	12.80	15.12	15.36	13.78

***Means of three determinations ± SD.**

****Hue angle = [tan⁻¹ (b/a)].**

*****ΔE = $[(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2]^{½}$**

******Chroma = $[(a^2 + b^2)]^{½}$**

Sensory characteristics of cooked faba beans:

Sensory evaluation for color, texture, taste, odor and overall acceptability of the cooked faba bean samples as influenced by soaking in different salt solutions were done in order to determine consumer acceptability. The results are shown in Fig. (4). It could be seen that faba beans soaked with 0.5 or 1% BP before cooking recorded the highest sensory quality in terms of color (90%), texture (90%), taste (100%), odor (100%) and overall acceptability (90%). Faba beans soaked in water (control) had same values as 0.5 or 1% BP for taste and odor (100%) and lower values (80%) for the rest of sensory attributes. However, those soaked with 0.5 or 1% SB revealed less acceptable (50 – 60%) overall quality. On the other hand, raw faba bean recorded the lowest sensory quality in terms of color (50%), texture (50%), taste (60%), odor (60%) and overall acceptability (50%). This indicates that soaking with baking powder (BP) is more effective than soaking with sodium bicarbonate (SB). The photographs of raw, soaked and cooked faba beans are shown in Fig. (5).

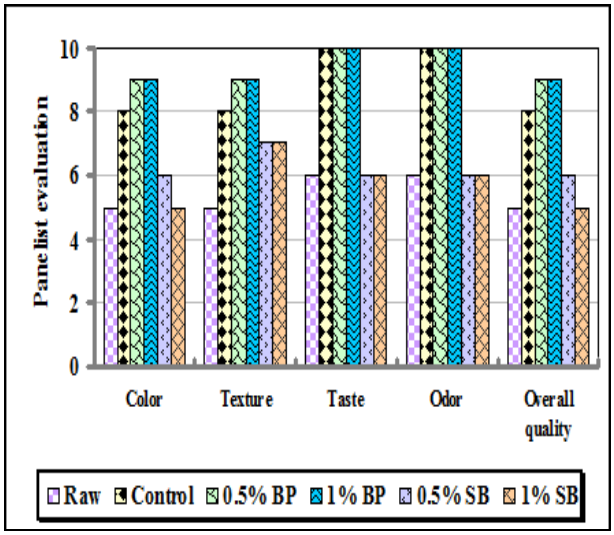

Fig. 4. Sensory characteristics of cooked faba beans.

Fig. 5. Photographs of raw, soaked and cooked faba beans.

CONCLUSION

In the light of the obtained results, it could be concluded that soaking for 12 hrs with 1% BP, discarding soaking solution and using fresh water for cooking is the best treatment to reduce cooking time and improve the nutritional and quality properties of cooked faba beans.

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تأثير النقع والطهي على الخواص الغذائية والجودة للفول البلدي

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تم نقع بذور الفول البلدي (جيزة ٨٤٣) في ماء عادي ومحاليل ملحية مختلفة (٠،٥ و ١ % بيكنج بودر ، ٠،٥ و ١ % بيكربونات الصوديوم) وذلك بهدف الإسراع من عملية الطهي وتحسين الخواص الغذائية والجودة للعينات. تم دراسة خواص النقع والطهي للفول الخام والفول المعامل المطهي. تم أيضاً تقييم العينات من حيث خواصها الغذائية والفيزيائية والحسية ومدى قابلية البروتين للهضم معملياً. أوضحت النتائج أن قيم امتصاص الماء زادت بزيادة زمن النقع (١٤،٣٩ – ٢١،٩٩% بعد ساعة ، ٧٦،٩٦ – ٨٨،١٧% بعد ١٢ ساعة). أدت عملية النقع إلى تقليل الزمن اللازم للطهي وكان أعلى زمن في الفول الخام (٢٦٠ دقيقة) وأقل زمن لعينة ١% بيكنج بودر (٤٠ دقيقة). تحسنت قابلية البروتين للهضم معملياً بعد النقع والطهي حيث سجلت ٧٠،٣٥% للفول الخام ، ٨٣،٤٧% للكنترول ، ٨٧،٢٩% لعينة ١% بيكربونات الصوديوم. انخفض محتوى الفول من الكربوهيدرات الكلية والمركبات الفينولية الكلية بعد الطهي مقارنة بالفول الخام. في ضوء النتائج المتحصل عليها يتضح أن النقع لمدة ١٢ ساعة في محلول ١% بيكنج بودر ثم التخلص من محلول النقع واستخدام ماء جديد للطهي هو أفضل معاملة لتقليل زمن الطهي وتحسين الخواص الغذائية والجودة للفول المطهي.