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The Nutritional Composition of Three Cultivars of Okra (*Abelmoschus esculentus* L.) Seeds Flour

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Abstract: This study aimed to evaluate the nutritional analysis of the three Egyptian cultivars of okra (*Abelmoschus esculentus* L.) seeds namely: Balady Assiut (BA), Balady Qena (BQ) and Pusa Sawany (PS). The proximate chemical composition, caloric value, minerals (K, Mg, Ca, Na and P), total phenolics and total flavonoids were determined in okra seeds flour (OSF) and defatted okra seeds flour (DOSF). In the dry weight basis OSF and DOSF significantly ($p<0.05$) contained moisture 1.23-10.54%, ash 5.76-10.84%, protein 22.30-37.02%, oil 2.65-23.99%, crude fiber 9.62-17.00%, total carbohydrates 29.44-44.03% and caloric value 327.29-440.91 kcal/100g. The mean values of total phenolics, total flavonoids revealed that significantly different at ($P<0.05$) between samples of OSF and DOSF. In the present study the PS cultivar recorded higher contents of total phenolics (969.24, 846.82 mg gallic acid/100 g D.W) and total flavonoids (15.14, 19.69 mg catechin/100g D.W) in both OSF and DOSF, respectively, as compared to BA and BQ cultivars. The mineral contents in samples under study were found as potassium 3.13-5.48, phosphorus 0.80-1.31, magnesium 0.44-0.78, calcium 0.25-0.49 and sodium 0.03-0.35 g/100g D.W. In terms of essential amino acids the PS DOSF was higher in leucine (7.42%), lysine (5.77%), valine (5.31%), phenylalanine (5.12%) and threonine (3.37%) when compared to BA and BQ DOSF. The major non-essential amino acids in DOSF of BA, BQ and PS were glutamic (12.73-17.60%), aspartic (8.51-11.66%) and arginine (7.96-10.64%). The highest protein efficiency ratio (PER) in (PS) was (2.47), while the lowest value of protein efficiency ratio was (1.58) found in (BQ). The biological value (BV) of protein was found with values: 75.10, 69.73 and 65.73 in PS, BA and BQ, respectively. The sensory evaluation scores of chicken nuggets were observed to be significantly ($P<0.05$) higher in nuggets with 5% incorporation of BQ and PS DOSF as compared with control. Consequently, it recommended utilizing and consumption in different food formula in order to consider a source of protein and oil.

Key words: Okra seeds · Nutritional · Proximate chemical composition · Mineral composition · Amino acids · Total phenolics · Chicken nuggets

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is one of the most widely known and utilized species of the family Malvaceae and an economically important vegetable crop grown in tropical and sub-tropical parts of the world. Okra plant was previously included in the genus *Hibiscus*. Later, it was designated to *Abelmoschus*, which is distinguished from the genus *Hibiscus*. Okra contains moderate levels of some essential mineral and vitamins which are important for body metabolic processes that utilize carbohydrates, proteins and fats. The immature fruits are eaten in soup either fresh or prepared by boiling or frying and used in soup and stews [1-3]. Okra is a popular home vegetable and a vital source of energy for human body. It is mostly grown for its green leaves and young pods which are consumed as green vegetable. The chief bio-elements are found in okra are magnesium, calcium, sodium, potassium and iron etc., which are often deficient in the diet of developing countries. It contains

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vitamins and is a good source of essential nutrients. It provides proteins, dietary fiber, carbohydrates, minerals and iodine. One hundred grams of edible okra contain moisture 89.6 g, minerals 0.7g, protein 1.9g, carbohydrates 6.4g, fat 0.2g, calcium 66 mg, fiber 1.2g, calories 35, potassium 103 mg, phosphorus 56 mg, magnesium 53.0 mg and sodium 6.9 mg [4, 5]. Okra seeds are small in size and the seed coat is very hard containing a high level of crude fiber.

The mature seed is known to have superior nutritional quality. Okra seed is known to be rich in high quality protein especially with regard to its essential amino acids relative to other plant protein sources. Seeds are rich in phenolic compounds with derivatives, catechin oligomers and hydroxycinnamic derivatives. The nutrients content of okra seed showed that okra seed contains 21% protein, 14% lipids and 5% ash. Removal of the seed hulls by grinding and sifting produced a meal with 35% protein, 25% lipids and 6% ash [6, 7]. The chemical composition of okra seeds flour revealed a predominance of moisture (6.96%), total carbohydrates (30.81%), protein (22.14%), oil (14.01%) and crude fiber (27.30%). K, Na, Mg and Ca were found to be the principal elements, with Fe, Zn, Mn and Ni to be also present [8, 9]. The seeds from two varieties namely Sabz Pari, Punjab-8 of Okra (*Hibiscus esculentus*), grown under similar environment, exhibited moisture content 7.26, 8.35%; ash 5.18, 6.23%; oil 11.72, 13.42%, protein 20.00, 23.68% and crude fiber 29.60, 27.41%, respectively [10]. According to Andras *et al*. [11] oil concentration of okra seeds from Greece was found to be 15.9 to 20.7%, depending on the extraction method. The oil was found to contain a high level of linoleic acid (up to 47.4%) and tocopherols isomers. Okra seeds contain about 20 to 40% oil. Okra seed oil yield is comparable to most oil seed crops except oil palm and soybean. Moreover, okra seed oil has potential hypocholesterolemic effect. The potential for wide cultivation of okra for edible oil as well as for cake is very high. All of the crude fiber is retained in the cake when oil is expelled from the whole seed. Since a high level of crude fiber in the diet may interface with the utilization of many nutrients the dehulled seeds seem to be the better form to use.

Okra seed flour could also be used to fortify cereal flour. For example, supplementing maize ogi with okra meal increases protein, ash, oil and fiber content. Okra seed flour has been used to supplement corn flour for a very long time in countries like Egypt to make better quality dough. Okra seed flour has been reported to be rich in minerals and vitamins. Its addition to predominantly high carbohydrate foods might be expected to enrich such foods and improve their nutritional status [12-14]. Proteins play a particularly important role in human nutrition. Okra seed is known to be rich in high quality protein especially with regards to its content of essential amino acids relative to other plant protein sources. Hence, it plays a vital role in the human diet. The amino acid contents, proportions and their digestibility by humans characterize a protein's biological value. The amino acid composition of okra seed protein is comparable to that of soybean, the PER is higher than that of soybean and the amino acid pattern of the protein renders it an adequate supplement to legume or cereal based diets [15, 16]. Natural polyphenols exert their beneficial health effects by their antioxidant activity, these compounds are capable of removing free radicals, chelate metal catalysts, activate antioxidant enzymes, reduce α-tocopherol radicals and inhibit oxidases [17]. The high intake of plant products is associated with a reduced risk of a number of chronic diseases, such as atherosclerosis and cancer [18]. These beneficial effects have been partly attributed to the compounds which possess antioxidant activity. The major antioxidants of vegetables are vitamins C, E, carotenoids and phenolic compounds, especially flavonoids. These antioxidants scavenge radicals and inhibit the chain initiation or break the chain propagation (the second defense line). Flavonoids as well as vitamin C showed a protective activity to α-atocopherol in human LDL and they can also regenerate vitamin E, from the α-chromanoxy radical [19].

The antioxidant activity of phenolics is mainly due to their redox properties, which allow them to act as reducing agents, hydrogen donors and singlet oxygen quenchers [20]. According to Khomsug *et al.* [21] the total phenolic content of pulped and seeds of okra extracts was 10.75 mg GAE/100g extract and 142.48mg GAE/100g extract which corresponds with scavenging activities. Liao *et al*. [22] has done a comparative analysis of total phenolics and total flavonoids and antioxidant ability of different organs (flower, fruit, leaves and seed) and different enrichment fractions of water extracts of the *A. esculentus* plant. They confirmed fruitful presence of total phenolics and total flavonoids related to antioxidant ability in all the extracts of the plant organs although percentage varied. This data suggests Okra as a good contributor to the antioxidant status and promising chemopreventive agent as described in several traditional medicines for human race. Okra is abundant with several vitamins, minerals and nutrients that handles the health advantages the plant provides [22]. The demand for ready to eat and easily

prepared precooked foods is increasing due to the lack of time for food preparation. However, the consumption of such foods has generated health concerns. Meat processing technology has led to the development of variety of convenience and value added products. Among these, chicken nuggets occupy a predominant place worldwide due to their characteristics flavour and pronounced chewy texture. With increase in the cost of meat, certain alternatives in processing technologies have become a necessity. This can be done by incorporation of a range of non-meat ingredients to alter taste, flavor, appearance, colour, texture, water binding, counteracting fat separation and preservation besides reducing the cost and improving yield. These non-meat ingredients could be in the form of extenders, binders or fillers [23, 24].

The objective of this work was to determine the proximate chemical composition, caloric value, some minerals, total phenolics and total flavonoids in three cultivars of okra seeds flour namely: Balady Assiut (BA), Balady Qena (BQ) and Pusa Sawany (PS) before and after defatting with n-hexane. Then the defatted okra seeds flour was evaluated for amino acids composition and used for preparation of chicken nuggets substituted with 2.5% and 5% of it.

MATERIALS AND METHODS

Materials: Three matured dried okra (*Abelmoschus esculentus* L. Moench) seeds cultivars: Balady Assiut (BA), Balady Qena (BQ) and Pusa Sawany (PS) were grown under Assiut governorate conditions at the experimental Farm Faculty of Agriculture, Assiut University, Assiut, Egypt, during summer (2014).

Okra Seeds Flour (OSF) Preparation: The seeds were manually removed from ripe fruit, dried at 40°C, selected and milled in an electrical mill to obtain fine flour, then stored in glass containers at 4°C in the refrigerator until analysis.

Defatted Okra Seeds Flour (DOSF): The prepared okra seeds flour was defatted using n-hexane as described by Barnes [25].

Methods

Determination of Proximate Chemical Composition and Caloric Value: Moisture, crude protein, crude oil, crude fiber and ash were determined as described in the *AOAC* methods [26]. The total carbohydrates were calculated by difference according to Pellet and Sossy [27]. The caloric value (energy) determined according to Wilson *et al.* [28] and Seleet [29] as follows:

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

Determination of Amino Acids: Amino acids were determined according to the method described by Olson *et al*. [30], using Beckman Amino Acids Analyzer Model 119 CL.

Computation of Chemical Scores: The chemical score was defined and calculated according to Bhanu *et al*. [31] as follows**:**

$$\text{Chemical score} = \frac{A}{B} \times 100$$

Where:
A = mg of essential amino acid in 1g test protein
B = mg of essential amino acid in 1g reference protein

Computation of Protein Efficiency Ratio (PER): Protein efficiency ratio was calculated using the equation suggested by Alsmeyer *et al*. [32] as follows:

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

Computation of Biological Value (BV): Biological value of okra seeds protein was calculated using the equation worked by Oser [33] as follows:

BV = 49.09 + 10.53 (PER)

Determination of Total Phenolics: The total phenolics content of samples were determined using modified Folin-Ciocβlteu colorimetric method [34]. Samples extracts (25µg each) were dissolved in 80% methanol and further dilution were performed to obtain readings within the standard curve made with gallic acid. The extracts were oxidized by Folin-Ciocβlteu reagent (120µl) and after 5 min; 340µl of Na_2CO_3 was added for neutralization. The samples were kept for 90 min in the dark followed by the reading of the absorbance at 750 nm. The results were expressed as milligram of gallic acid equivalents/100 g sample (mg GAE/100 g sample).

Determination of Total Flavonoids: The aluminium chloride colorimetric assay was used for flavonoids determination, as described by Marinova *et al*. [35].

Extraction of flavonoids in the samples (n=3) was achieved by homogenizing 2.00g of the sample in 50 ml distilled water. The mixture was transferred into a rotary shaker for 12h to ensure full extraction. Thereafter, the mixture was filtered and the extract made up to 50 ml precisely, 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. To this mixture 0.3 ml of 5% $NaNO_2$ was added. After 5 min, 0.3 ml 10% $AlCl_3$ was added. Immediately, 2 ml 1M NaOH was added and the total volume was made up to 10 ml with redistilled water. The solution was mixed thoroughly and the absorbance of both blank and standard was read at 510 nm using UV–Visible spectrophotometer Model UV 1601 version 2.40 (Shimadzu). Total flavonoids content was expressed as mg catechin equivalents (mg catechin/100g sample D.W).

Determination of Minerals: Ca and Mg contents in the samples were determined by iCAP6200 (ICP-OES) Inductively Coupled Plasma Emission Spectrometry [36]. Na, K contents were determined by a flame photometer corning 400; however, P content was determined by spectrophotometer [37] after wet ashing by method described in AOAC [26].

Preparation of Chicken Nuggets Substituted with 2.5% and 5% of DOSF: Chicken meat is cleaned from the skin and bone, then cut into small cubes approximately 2 cm^3 minced it. Mixed the minced chicken meat formula (100% meat, 97.5% meat + 2.5% DOSF, 95% meat + 5% DOSF), flour, water and seasonings. After that samples coated with breading materials. Coated and breaded nuggets were cooled at freezer and then placed in aluminum foil and stored for approximately six hour. The samples were removed from the freezer then fried for 2-3 minutes, until the colour is light yellow [38].

Sensory Evaluation: The fried products were evaluated for their cohesiveness, flavour, texture, juiciness, tenderness and overall acceptability by a panel of the judges from the staff of Food and Technology department, Faculty of Agriculture; Home Economic Department, Nutrition and Food Science, Faculty of Specific Education, Assiut University, using a 10-point hedonic scale, where 10 represents the highest score.

Statistical Analysis: The data collected were analyzed with analysis of variance (ANOVA) Procedures using the Duncan test. Differences between means were compared by LSD at 5% level of significant [39].

RESULTS AND DISCUSSION

Proximate Chemical Composition of Three Varieties of OSF and DOSF: The chemical composition of three cultivars of okra seeds both OSF and DOSF are shown in Fig. 1 and Table 1. The data in Fig. 1 revealed a significant ($p<0.05$) variation (1.23-10.54%) in moisture content among three cultivars of okra seeds (Fig. 1). Significantly ($p<0.05$) the lowest moisture contents were recorded for DOSF of BA, BQ, PS with values 2.69%, 2.40%, 1.23%; respectively, as a result of defatting. The highest moisture content was recorded with BQ OSF (10.54%) which was at parallel with BA OSF (10.31%) and the same with DOSF moisture for BA was 2.69%, for BQ was 2.40%. our results was so close with Nzikou *et al*. [40] who studied the compositions of *A. esculentus* seed of the two okra cultivars and found that the okra seeds from Brazzaville and Dolisie cultivars contained 9.6 and 11.7% moisture, respectively.

From the data in Table 1 the ash content was recorded significantly ($p<0.05$) maximum in BQ DOSF (10.84%), which was followed by BA DOSF (10.69%) and PS DOSF (9.05). The ash content was recorded the lowest value in OSF of three cultivars (BA: 8.29%, BQ: 9.02%, PS: 5.76%) when compared with DOSF. Ash content was recorded 5.84 and 5.52 percent in Dolisie and Brazzaville okra seeds, respectively [40].The seed oil content varied between 16.06 to 23.99% among three okra seeds cultivars (Table 1). Significantly ($p<0.05$) higher oil content was observed in PS OSF (23.99%), while lower seed oil content was recorded with BA OSF (16.06%). As a result of defatting with n-hexane to remove the oil as possible from okra seeds flour the content of oil was decreasing after extraction. The values of oil were 2.65%, 2.71% and 3.68% for DOSF of BA, BQ and PS cultivars, respectively. The PS OSF recorded significantly ($p<0.05$) the highest content of protein (26.81%) after defatting the protein content was increased to reach 37.02% for the same cultivar (Table 1). Also the protein content of two another cultivars BA, BQ was increased from 22.52, 22.30% to 31.83%, 33.25%, respectively, as a result of defatting. The okra seed is a rich source of protein and oil so it has been utilized as a source of oil and protein to fortify cereal flour products [13].

The crude fiber content was significantly ($P<0.05$) higher (13.00-17.00%) in OSF than DOSF (9.62-10.80%) of studied cultivars. The BA cultivar contained the highest contents of crude fiber both of OSF (17.00%) and DOSF (10.80%) when compared to other two cultivars of okra seeds. The crude fiber of okra seeds both OSF and DOSF is a valuable nutrient for intestine microorganisms.

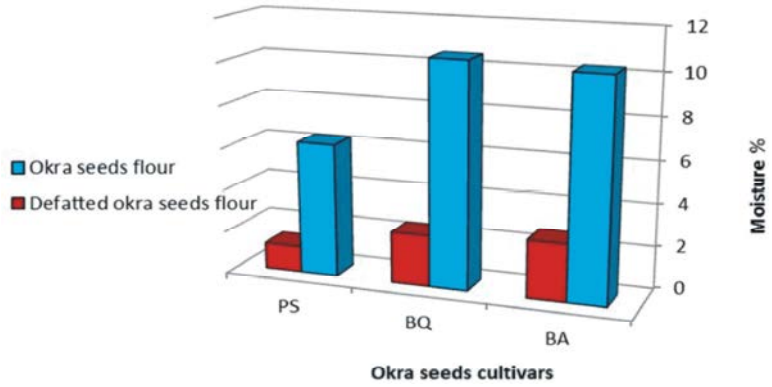

Fig. 1: Moisture content of okra seeds flour and defatted okra seeds flour. BA= Balady Assiut, BQ= Balady Qena, PS= Pusa Sawany

Table 1: Proximate chemical composition of three varieties of OSF and DOSF (g/100g) on dry weight basis*.

Okra seeds	Ash	Oil	Protein	Crude fiber	**Total carbohydrates	The caloric value (Kcal/100g)
				Okra seeds flour (OSF)		
BA	8.29b	16.06c	22.52b	17.00a	36.13b	379.14c
BQ	9.02a	17.32b	22.30b	13.00c	38.36a	398.52b
PS	5.76c	23.99	26.81a	14.00b	29.44c	440.91a
				Defatted okra seeds flour (DOSF)		
BA	10.69b	2.65b	31.83c	10.80a	44.03a	327.29b
BQ	10.84a	2.71b	33.25b	10.34b	42.86b	328.83b
PS	9.05c	3.68a	37.02a	9.62c	40.63c	343.72a

* Mean of three replicates. ** Calculated by difference.

Means having different superscripts within the column are significantly different at $p < 0.05$.

BA= Balady Assiut, BQ= Balady Qena, PS= Pusa Sawany

Sathish and Eswar [41] revealed that okra contains special fiber which takes sugar levels in blood under control, providing sugar quantity, acceptable for the bowels. The three cultivars of okra seeds samples under study were significantly ($P<0.05$) had high value of total carbohydrates content ranged between 29.44 – 44.03%. The total carbohydrates content in DOSF was higher (40.63-44.03%) when compared to OSF (29.44-36.13%) as a result of defatting. Changes in fiber content may attribute to the fact that crude fiber of the OSF may be solubilized during extraction with the solvent. So the total carbohydrates were increased as a result of those changes in crude fiber. The caloric value (Kcal/100g) of PS OSF was 440.91, followed by 398.52 for BQ OSF and least in BA OSF 379.14. Defatting (removal of seed oil) resulted in a significant ($P<0.05$) decrease in the caloric value for all cultivars. That's because of decrease of oil content in samples after defatting so when calculate the caloric value was decreased to 343.72, 328.83 327.29 Kcal/100g for PS, BQ and BA cultivars, respectively. Generally, it was clearly observed that there was a significant difference ($P<0.05$) in proximate chemical composition of the three cultivars both okra seeds flour and defatted okra seeds flour. Ndangui *et al*. [15] showed that the okra seeds contained 9.45% moisture, 23.85% crude oil, 24.85% crude proteins, 36.83% carbohydrate (by difference), 9.7% crude fiber, 5.68% ash and 385.13 Kcal/100 g caloric values. Those variations may be due to the differences in variety of plant, cultivation climate, ripening stage and the harvesting time of the seeds.

Total Phenolics, Total flavonoids and Minerals of OSF and DOSF: The data on total phenolics and total flavonoids content of okra seeds samples are presented in Table 2. It is obviously that there were significantly ($P<0.05$) differences between flour samples in phenolics and flavonoids. The total phenolics contents in OSF were higher than DOSF. The phenolics was decreased from 916.63, 937.27, 969.24 mg GAE/100 g D.W in OSF to reach 789.59, 802.20, 846.82 mg GAE/100 g D.W in DOSF for BA, BQ and PS okra seeds cultivars, respectively. The flavonoids contents of the DOSF were significantly ($P<0.05$) higher (14.97-19.69 mg catechin/100g D.W) than the flavonoids contents in OSF (11.80-15.14mg catechin/100g D.W) for three cultivars under study. The PS okra seed cultivar was recorded the highest

Table 2: Total phenolics (mg GAE/100 g D.W), total flavonoids (mg catechin/100g D.W), minerals (g/100g D.W) contents of three varieties of OSF and DOSF.

Okra seeds	Total phenolics	Total flavonoids	Ca	Mg	Na	K	P
			Okra seeds flour (OSF)				
BA	916.63c	13.09b	0.25b	0.78ns	0.33ns	5.48a	1.31a
BQ	937.27b	11.80c	0.35a	0.68ns	0.30ns	4.53b	0.88b
PS	969.24a	15.14a	0.27b	0.69ns	0.35ns	4.07c	0.80b
			Defatted okra seeds flour (DOSF				
BA	789.59c	16.37b	0.40a	0.49ns	0.04ns	5.31a	1.31a
BQ	802.20b	14.97c	0.49a	0.45ns	0.03ns	4.94b	0.88b
PS	846.82a	19.69a	0.31b	0.44ns	0.09ns	3.13c	0.80b

Means having different superscripts within the column are significantly different at $p < 0.05$.
BA= Balady Assiut, BQ= Balady Qena, PS= Pusa Sawany.

contents of phenolics: 969.24, 846.82 mg GAE/100 g D.W; flavonoid: 15.14, 19.69 mg catechin/100g D.W for OSF and DOSF, respectively, as compared with other okra seeds cultivars.

As a result of defatting the content of total phenolics was decreased in DOSF as compared with OSF, this could be attributed to extraction of the oil from OSF using n-hexane. Also as a result of defatting the flavonoids content was increased in DOSF when compared with OSF. Plant phenolics have multiple biological effects as they constitute one of the major groups of compounds acting as primary antioxidant or free radical terminator [42]. Minerals content in three cultivars of OSF and DOSF (g/100 g) are shown in Table (2). The results on the basis of dry weight revealed that no significant differences were found between OSF and DOSF in their contents of Magnesium and Sodium. As shown in Table 2 the K content was the highest mineral in studied cultivars both of OSF and DOSF. The values of K were: 5.48, 4.53, 4.07 in OSF; 5.31, 4.94, 3.13 in OSF, DOSF for BA, BQ and PS okra seeds cultivars, respectively. The contents of P in okra seeds samples was found with same values (BA: 1.31, BQ: 0.88, PS: 0.80 g/100g) for OSF and DOSF. The contents of Mg; Na was decreased from 0.78, 0.68, 0.69; 0.33, 0.30, 0.35 g/100g in OSF to 0.49, 0.45, 0.44; 0.04, 0.03, 0.09 g/100g in DOSF of the BA, BQ and PS okra cultivars, respectively. Analysis of variance indicated that there were significant ($p<0.05$) varietal effect on Ca, K, P contents in OSF and DOSF. The Ca content in DOSF: 0.40, 0.49, 0.31g/100g was higher as compared with OSF: 0.25, 0.35, 0.27g/100g of BA, BQ and PS okra cultivars, respectively. Potassium is an essential nutrient and has an important role in the synthesis of amino acids and proteins [43]. Magnesium is essential mineral for enzyme activity, like Calcium; magnesium also plays a role in the maintaining of acid alkaline balance in the body. Phosphorus is needed for bone growth, kidney function and cell growth. It also plays a role in maintaining the body's acid-alkaline balance [44].

From the above mentioned data the defatting of OSF have a different effect (increase or decrease) on minerals under study except P which did not change like K, Mg, Na and Ca. Al-Wandawi [8] and Moyin-Jesu [9] reported that the defatted flour of Emerald okra seeds variety contained K: 1591.40, Na: 647.20 and Ca: 375.5 mg/100g. Those variations in phenolics, flavonoids, minerals could be a result of differences in grown cultivars, cultivation area and the extraction method used.

Amino Acid Composition, PER, BV, Chemical Score and Limiting Amino Acids Contents of DOSF: All needed amino acids cannot be synthesized by human and animal as such some amino acids must be supplied through dietary intake [45]. The amino acid compositions PER and BV of DOSF for BA, BQ and PS cultivars are presented in Table 3, the FAO/WHO [46] recommended mode of the essential amino acid for child and adult are also given in the Table for reference purpose. The data indicated that, the total essential amino acids were 30.93, 26.28, 35.80 g amino acid/ 100 g protein for BA, BQ and PS DOSF, respectively. Generally the amounts of amino acids in PS cultivar were higher than other samples (BA and BQ). The quality of proteins as source of amino acids can usually be assessed by comparison with the FAO/WHO [46] recommended pattern of essential amino acids (Table 3). In terms of essential amino acids, the PS DOSF exhibited higher amounts of leucine (7.42%), valine (5.31%), histidine (4.40%) and isoleucine (3.55%) compared to FAO/WHO [46] requirements for (2–5 years old) child, while methionine (0.86%) was in non-adequate levels. The major non-essential amino acids in DOSF of BA, BQ and PS were glutamic (12.73-17.60%), aspartic (8.51-11.66%) and arginine (7.96-10.64%).

One of the widely used methods for assessing protein quality was the protein efficiency ratio (PER). PER measures the ability of test protein to support the growth of young, rapidly growing rats. The quality of the test protein is reported relative to the casein control.

Table 3: Amino acid composition (g Amino acid/ 100g protein), Protein efficiency ratio (PER) and Biological value (BV) contents of DOSF

					FAO/WHO [46]	
Amino acids	BA	BQ	PS	Casein	Child	Adult
Lysine	4.77	3.94	5.77	6.99	5.80	1.60
Threonine	3.00	2.52	3.37	3.72	3.4	0.90
Methionine	0.74	0.54	0.86	2.59	2.70	1.70
Valine	5.02	4.50	5.31	5.70	3.50	1.50
Isoleucine	3.09	2.60	3.55	4.46	2.80	1.30
Leucine	6.41	5.35	7.42	8.27	6.60	1.90
Phenylalanine	4.32	3.71	5.12	4.47	6.30	1.90
Histidine	3.58	3.12	4.40	2.65	1.90	1.60
Total Essential A.A	30.93	26.28	35.80	38.85	--	--
Serine	4.06	3.31	4.35	5.03	--	--
Proline	5.56	3.83	4.92	9.32	--	--
Glycine	5.14	4.20	6.01	1.65	--	--
Cystine	N.D	N.D	N.D	0.33	--	--
Alanine	3.96	3.27	4.39	2.61	--	--
Tyrosine	2.22	1.72	2.56	4.79	--	--
Aspartic Acid	10.33	8.51	11.66	6.18	--	--
Glutamic Acid	15.21	12.73	17.60	9.00	--	--
Arginine	9.93	7.96	10.64	3.22	--	--
Total-Non Essential A.A	56.41	45.53	62.13	42.13	--	--
PER	1.96	1.58	2.47	--	--	--
BV	69.73	65.73	75.10	--	--	--

Table 4: Chemical score and limiting amino acids of defatted okra seeds flour

Essential amino acids	BA	BQ	PS	Casein
Lysine	86.73	71.64	104.91	127.09
Threonine	75.00	63.00	84.25	93.00
Cystine+Methionine	21.14	15.43	24.57	83.43
Valine	100.40	90.00	106.20	114.00
Isoleucine	77.25	65.00	88.75	111.50
Leucine	91.57	76.43	106.00	111.80
Tyrosine+Phenylalanine	109.00	90.50	128.00	154.33

In general, a protein with a PER of >2.00 is of high quality, 1.5 -2.0 is of intermediate quality and <1.5 is of poor quality [47]**.** The data in Table 3 showed the PER values of three DOSF cultivars. From these data it is clear that the PER>2.00 in PS defatted flour and in the two other cultivars PER>1.5, so DOSF protein was consider as a good source of protein. The biological value (BV) is a very important nutritional parameter because it is directly related to the biological metabolism. It also shows the rate of utilization of the proteins absorbed into the body. Proteins that show BV of (90) or more, are considered as good source of nitrogen such as whole egg protein (93.7) and milk (91) [48]**.** The BV of DOSF flour protein is presented in Table 3. From these data, the BV of BA, BQ, PS DOSF is 69.73, 65.73, 75.10, respectively, as compared with casein (77), it was found that the BV of DOSF proteins is good quality proteins. The nature and quantity of amino acids contained in a dietary protein, determined the efficiency with which an organism could use the protein. The results given in Table 4 showed the chemical score and limiting amino acids of DOSF for BA, BQ and PS cultivars. The chemical score of DOSF was found to be 21.14, 15.43 and 24.57 for the BA, BQ and PS cultivars, respectively. Based on chemical score, the first limiting amino acid was cysteine + methionine, when compared with casein patterns was used as the reference. Meanwhile, the second limiting amino acid was threonine compared with casein.

Sensory Evaluation of Chicken Nuggets: The studied chicken nuggets were made from three formulations with partial substitution of the meat by DOSF. The three formulations were: Control (A): commercial formulation, formula (B): 97.5% meat + 2.5% DOSF and formula (C): 95% meat + 5% DOSF. The sensory quality of chicken nuggets prepared with or without incorporation of DOSF is presented in Table 5. The scores for sensory attributes, colour, odor, taste, hardness, juiciness and overall all acceptability of chicken nuggets differed significantly ($P<0.05$) between the samples made with 2.5% and 5%

Table 5: Sensory evaluation of chicken nuggets

Sample		Colour (10)	Odor (10)	Taste (10)	Hardness (10)	Juiciness (10)	Over all acceptability (50)
Control BA	A	8.2b	8.7a	9.0a	8.3b	8.4b	42.6a
	B	8.5a	8.0b	8.7b	8.5a	8.6a	42.3a
	C	8.0c	7.8c	8.5c	8.3b	8.6a	41.2b
BQ	B	8.2b	8.0b	8.0d	8.0c	7.8d	40.0d
	C	8.0c	8.1b	8.4c	8.4ab	8.0c	40.9c
PS	B	7.6d	8.0b	8.5c	8.5a	8.5ab	41.1b
	C	7.4e	7.7c	8.0d	8.4ab	8.4b	39.9e

*Means having different superscripts within the column are significantly different at $p < 0.05$.

BA= Balady Assiut, BQ= Balady Qena, PS= Pusa Sawany

A = Control chicken nuggets, B = Chicken nuggets with 2.5% DOSF, C = Chicken nuggets with 5% DOSF

replacement of chicken meat. It is important to point out that all the parameters analysed obtained over all acceptability from 39.9 to 42.6 according to the hedonic scale compared to 42.6 for control. As shown in Table 5, the nuggets made from BA DOSF recorded higher acceptability with scores 42.3 for 2.5% and 41.2 for 5% replacement by consumers than the other DOSF samples. The sensory attributes scores were observed to be significantly higher in nuggets with 5% incorporation of BQ and PS DOSF as compared with control. Regarding to the sensory acceptance test, we can conclude that it is possible to partially replace meat by DOSF in chicken nuggets, without altering the sensory acceptance.

CONCLUSION

The nutritional analysis of the three Egyptian cultivars of okra seeds showed that OSF and DOSF contain valuable protein, oil, crude fiber and required carbohydrates in the seeds. Therefore, consumption of okra seeds will provide the necessary energy to the body and important phenolics and flavonoids that could rise immune body system and prevent diseases. In the present study the PS cultivar of okra seeds recorded higher contents of protein (26.81and 37.02%), total caloric value (440.91 and 343.72 Kcal/100g) Total phenolics (969.24 and 846.82 mg GAE/100 g D.W), total flavonoids (15.14 and 19.69 mg catechin/100g D.W) both in OSF and DOSF, respectively. From the results of amino acid composition and protein quality the defatted okra seeds flour (especially PS cultivar) is rich in good quality protein with regards to its content of essential amino acids, PER and BV. Based on sensory evaluation of chicken nuggets samples, the partial replacement of chicken meat with DOSF were acceptable to the panelists. So DOSF could be useful application in different food formulations.

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