Utilization of Whole Mantis Shrimp (*Squilla Mantis*) as an Edible Fish Powder for The Preparation of Value-Added Products

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ABSTRACT

The objective of the study was to investigate nutrient and functional properties of edible fish powder prepared from whole mantis shrimp using different heating treatments and its use as a functional food ingredient in some food products such as wheat sticks and potato croquettes. The average weight and length composition of fresh mantis shrimp were carried out. Proximate chemical composition of whole (flesh , head , scale or shell and tail) and flesh of fresh mantis shrimp were 60.23%, 84.42% crude protein, 4.37%, 4.31% crude ether extract, 25.72%, 8.02% total ash and 9.68%, 3.25% carbohydrate (D.W), respectively. The whole body had lower value of crude protein but contained higher level of total ash and carbohydrate which contained the exoskeleton. Na, K, Ca and Mg were 493.48, 292.89, 2946.38 and 865.98 mg/100 g in whole fresh mantis shrimp. A simple process was developed to convert low value mantis shrimp to nutritional rich edible fish powder (EFP). In this study EFP was prepared by four different treatments. The untreated edible fish powder (UnEFP) contained the highest significant protein content (60.18%) followed by steaming edible fish powder (StEFP) (57.70%) and salt edible fish powder (SEFP) (54.90%), while the lowest protein content was (52.60%) in vinegar edible fish powder (VEFP) .So steaming as a method of heating showed the least undesirable effects on protein losses and can be selected as the best treatment in preparing EFP. The yield of EFP obtained by the different treatments ranged from 15.89% to 26.96% and the energy values ranged from 265.54 to 316.99 kcal/100g. The functional properties showed that StEFP had the highest emulsion, foam stability and this is due to higher protein content. Also the result of SDS – PAGE showed that the sample heating in salt solution had the lowest protein content and steaming is the best treatment for producing EFP. Sensory scores for wheat sticks and potato croquettes increased gradually by increasing % of EFP.As a conclution, mantis shrimp can be used as a source of high quality protein, energy and mineral for human consumption.

Key word :Mantis shrimp, edible fish powder, chemical composition, functional properties, utilization

INTRODUCTION

Fish and shellfish meat is considered to be highly nutritious, owing to its content of essential amino acids and proteins (Yanar and Celik, 2005). The edible crustaceans can be beneficial as nutraceutical and may be used in some pharmaceutical industries, as reported by Abdel Salam (2014). Chitin is a major component as a natural biopolymer of the exoskeleton of crustaceans.

Mantis shrimps, shrimps and crabs could be a balanced human diet and could be employed as an alternative dietary supplement of protein, vitamin and mineral matters in the body (Abdel-Salam and Hamdi, 2015). The mantis shrimp (*Squillia mantis*) is common in the diet of local inhabitants in some countries and its fishery has considerable economic importance. It is nowadays captured as a trawl and trammels net by catch (Galil *et al.*, 2002 and McCall, 2008). The *Squilla* forms an important component of the by-catch of the shrimp trawlers (trash fish). Utilization of by-catch resources is strictly necessary, as they constitute significant proportion in marine landings (Clucas, 1997).

The spot-tail mantis shrimp (*Squilla mantis*) is found in Mediterranean waters and it is regular found in the fish market of Spain, Italy, France, Morocco and Egypt (Abello and Martin, 1993). Also, this type of fish is fished through the year and its catches have a marked seasonality, with highest values occurring in winter and lowest in April – July. The total *Squilla* species production in Egypt was around 205 tons during 2013 (GAFRD, 2013).

Squilla mantis is a species which has little economics importance in Egyptian markets. This may be attributed to the unknown nutritional value and its uncommon to the Egyptian people. To the best of our knowledge, little attention has been paid to utilize *Squila mantis* for Egyptian human consumption. Abou Zeed(2016) utilized this type of fish for the production of some value added fishery products such as fish fingers and crackers as well as for producing bioactive compounds such as chitin, chitosan and natural carotenoids mainly astaxanthin.

Therefore, the main objective of the present work was to study the physicochemical properties of fresh mantis shrimp and the suitability of the whole mantis shrimp for preparing fish protein powder and studying its chemical composition, functional properties as well as the sensory attributes of some products prepared from this powder such as wheat sticks and potato croquettes.

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MATERIALS AND METHODS

Materials:

15 kg of fish mantis shrimp (*Squilla mantis*) were purchased from the landing fish center of Alexandria, Egypt in Summer season, 2015. They were directly transported using an insulated ice box to the laboratory of Food Technology Research Institute Sabahia , Alexandria, Egypt.

All other ingredients including wheat flour (72% extraction), salt, sugar, refined sunflower oil, cumin, baking powder, compressed yeast, sesame, potato, curry, bread crumble and pepper were purchased from local market, Alexandria, Egypt.

Methods:

Preparation of sample:

The best technique used in this work to get red of head, shell and tail is to freeze raw *Squilla mantis* at -20°C for 10 – 15 min according to *Squilla* size, then half- thawed and these parts were manually removed.

Fig. (1) shows preparation of samples including flesh, by products (head, scale or shell and tail) as well as the whole fresh mantis shrimp.

According to the aforementioned diagram, the edible mantis powder was prepared by four different treatments as follows:

1- Part of the whole mantis shrimp was minced in a meat mincer (Moulinex) and the press cake was dehydrated in an oven at 50°C to a moisture content below 10%.The obtained dehydrated press cake was powdered and sieved to obtain a fine powder (untreated edible fish powder UnEFP).
2- The second part of the whole mantis shrimp was minced in a meat mincer and steam cooked in a steamer for 15 min. The steamed press cake was dehydrated, powdered and sieved as mentioned above to obtain a fine powder (steaming edible fish powder StEFP).
3- The third part was heated in 0.5% glacial acetic acid (1: 2 w/v) for 15 min at 80°C with stirring. The obtained slurry was press filtered. The obtained press cake was dehydrated, powdered and sieved as mentioned above to obtain a fine powder (vinegar edible fish powder VEFP).
4- The fourth part was heated in 5% NaCl solution (1: 2 w/v) for 15 min at 80°C with stirring. The obtained slurry was press filtered. The obtained press cake was dehydrated, powdered and sieved as above to obtain a fine powder (salt edible fish powder SEFP).

The obtained powder from the different treatments was used to prepare the following products:

Wheat sticks:

The control sample was prepared by mixing 54% wheat flour (72% extraction), 23% palm oil, 0.50% sugar, 2.27% NaCl, 1.34% compressed yeast 21%, water, 2.50% sesame and 2.5% cumin. The dough was formulated into sticks (0.2 cm). After fermentation, a mixture of sesame and cumin were added to the sticks, then were baked at 180°C for 10 min.

The other salted sticks were prepared by substituting 3, 6 and 9% of wheat flower with equal amounts of the fine powder obtained as shown previously.

Potato croquettes:

This product (control) was prepared by mashing cooked and peeled potatoes (90%) with 1.5% salt, 1% ginger powder, 3% curry powder, 2.5% milk powder, 1% bread crumble and 1% pepper powder. The battered and breaded potato balls were deep-fat fried in vegetable oil at 160 – 170 °C for 5 min. The other potato croquettes were prepared by substituting 5, 6, 9 and 12% of mashed potato with equal amounts of the fine powder obtained as shown previously.

Analytical methods:

Proximate composition:

Moisture content ,crude protein, crude ether extract and total ash were carried out according to AOAC (2012) procedures unless otherwise stated. The carbohydrate content was estimated by difference.Caloric value based on Atwater factors and expressed as, kcal/ g was calculated (FAO, 2002).

Mineral Content:

Mineral levels including Ca, Mg, Fe, Cu, Zn, Mn, Pb and Cd were determined using an Atomic Absorption Spectrophotometer (Perkin Elmer 2380 Perkin Elmer Ltd, USA) as reported by AOAC (2012).

Flame Photometer (Gallenkamp Flame Analyzen FGA 330) was used for the determination of Na and K as described by AOAC (2012).

pH and TBA values:

pH value was measured after homogenizing 0.5 g sample with 50 ml deionized water for 2 min using digital 500 Eutch cybernetics scan pH meter according to Pacheco-Aguilar *et al*. (1989).

Thiobarbituric acid (TBA) value was determined according to Kirk and Sawyer (1991). Ten g sample were distilled with 47.5 ml of distilled water + 2.5 ml of 4N HCl for 10 min, 5 ml of distilled water were added to 5 ml of TBA solution into stoppered tube, and then heated in a boiling water bath for 35 min. After cooling, absorbance was measured at 538 min by using Spekol 11 Spectrophotometer. The TBA value was calculated by multiplying the absorbance A(OD) by the factor 7.8.

The TBA value was expressed as mg malonaldehyde per kg sample as follows:

TBA value (mg malonaldehyde per kg sample) = O.D. × 7.8

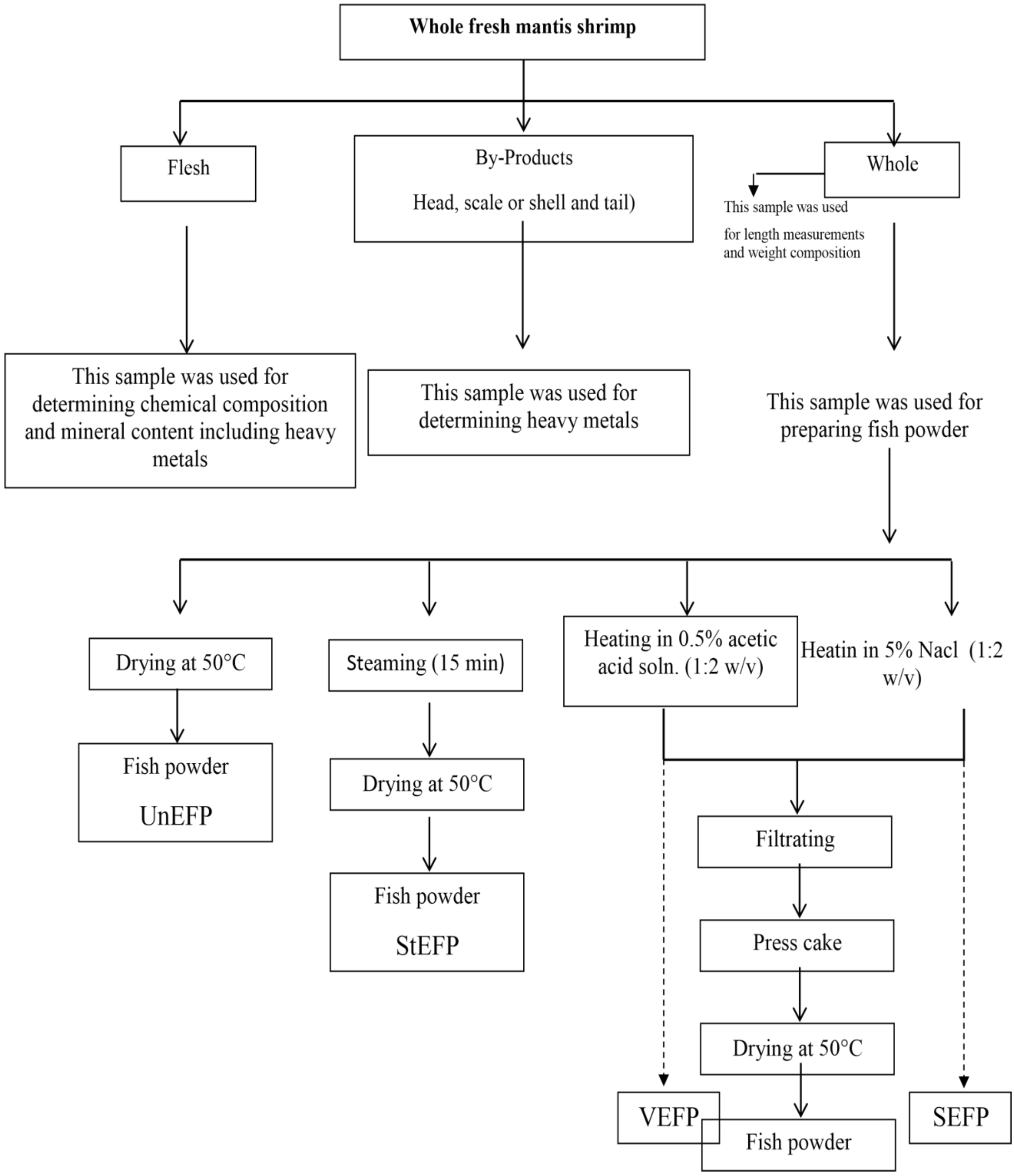

Fig. 1. Preparation of Flesh,by-products and dehydrated whole mantis shrimp powder

Functional properties:

Foam capacity (FC) and foam stability (FS) were measured by the method of Kabirullah and Wills (1982). Water and oil absorption capacities (WAC & OAC) were determined by the methods of Sosulski *et al*. (1976). Bulk density (g/ cm^3) was measures as described by Jones *et al*. (2000). Emulsification capacity (EC) was measured as described by Wang and Kinsella (1976). The emulsion activity (EA) and emulsion stability (ES) were measured as described by Yasumatsu *et al*. (1972).

Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE)

SDS-PAGE (12.5%) technique was conducted using the discontinuous buffer system described by Laemmli (1970), and mentioned by Hames and Rickwood (1990).

Sensory evaluation

The sensory attributes including colour, taste, odour, texture and overall acceptability for both wheat sticks and potato croquettes were evaluated using 10 trained panelists of Food Technology Research Institute, Agricultural Research Center, El-Sahahia station, Alexandria, Egypt. Hedonic scoring scale was used as described by Kramer and Twigg (1970).

Statistical analysis:

All determinations were carried out in triplicates and data were expressed as mean values ± standard deviation (SD). The data were statistically analyzed and the treatments were subjected to analysis of variance (one way ANOVA) followed by L.S.D. test at 0.05 level of probability for comparison between treatments (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Length and weight composition:

The basic data for the fresh mantis shrimp (*Squilla mantis*) including length measurements, weight composition and the number per kilogram are summarized in Table (1). The average total length was 14.7 cm. Length of head, trunk and tail represented 27.39, 59.73 and 12.88% of the total length, respectively.

The average weight of fresh mantis shrimp was 31.17 g and the number per kg was 48. Head, flesh, trunk, shell and tail weight represented 27.47%, 34.14%, 21.76% and 16.63% of the average weight, respectively. Wardiatno *et al*. (2012) found that the value of flesh yield ranged between 39.91 and 40.28% of the mantis shrimp. Lower yield (20%) has been found by Tanuja and Hameed (1998). They reported that peeling of squilla is a difficult task and they also added that manual peeling of the flesh was the best method. Similar results were reported by Abou Zeed (2016), who found that the range of total weight and length of mantis shrimp were 10.46 – 38.49 g and 9.50 – 14.40 cm, respectively.

Chemical composition of flesh and whole fish:

Proximate chemical compositions are carried out on flesh and whole mantis shrimp. The data in Table (2) indicated that moisture content was the major component in flesh and fresh whole mantis shrimp. Generally, flesh of mantis shrimp contained higher levels of crude protein and lower values of total ash and carbohydrate (on dry weight basis) comparing with the whole ones. The protein content of mantis shrimp was high in respect to the other nutrient composition and this agreed with Ehigiator and Oterai (2012). They stated that protein is the most prominent biochemical component of crustaceans. No difference was noted in crude ether extranet content between flesh and whole mantis shrimp. Garg *et al*. (1977) reported that the protein content in mantis shrimp varied from 70.09 to 75.46%.

These results are in accordance with those found by Abou Zeed (2016), who noted that mantis shrimp flesh contained 74.67% protein, 6.40% total lipid, 14.49% ash and 4.44% total carbohydrate (on dry weight basis).

Similar results were reported by Wardiatno *et al*. (2012). They studied the biochemical composition in two populations of the mantis shrimp and found that ranges of chemical composition (on wet weight basis) were 78.27 – 78.49% moisture, 13.11 – 14.39% protein, 0.9 – 1.29% lipid, 1.60 – 1.64% ash and 4.88 – 5.72% carbohydrate content. The ash content was high in the whole sample which containing the exoskeleton (trunk shell, head and tail) with value of 25.72% than flesh (8.02%). This result is comparable with that reported by Abdul-Sahib and Ajeel (2005). High ash content was due to high level of chitin strengthened by a high level of calcium metal in the exoskeleton (Ehigiator and Nwangwu, 2011).

Table (3) shows the mineral content of whole, flesh and non-edible parts of fresh mantis shrimp (on dry weight basis). The results showed that Na and K were the highest (506.39, 355.36 mg/ 100 g) in the flesh, which also recorded low Ca, Mg and Fe contents (78.98 , 7.91 and 1.28 mg/ 100 g), respectively. The exoskeleton had the highest amount of Ca (3663.28 mg/ 100 g), Mg (1080.50 mg/ 100 g), Fe (2.58 mg/ 100 g), Mn (0.28 mg/ 100 g) and Zn (1.04 mg/ 100 g) contents, Abou Zeed (2016) reported that nutritive macro and micro elements of squilla flesh arranged in a descending order as follows: Na (1072.63), K (846.22), P (231.70), Ca (73.47), Mg (21.75), Zn (9.13), Fe (8.05), Cu (1.80) and Mn (1.65) mg/ 100 g dry weight. Table (3) further showed that Na, K, Mg, Fe, Cu, Zn and Mn were lower than those reported by Abou zeed (2016) for mantis shrimp flesh.

Chemical composition of EFP prepared by different treatments:

The most critical steps in the preparation of edible fish powder is washing with water to remove blood,soluble proteins and other nitrogenous compounds (Adu *et al.*, 1983).Steam treatment for 30 min destroys microorganismis and their spores.Acetic acid was used to preserve the product for longer time (Jeyasanta et *al*., 2013).Also Kandoran *et al*.(1965) found that 5% brine is the optimum strength that can be used for removing urea retained in the muscle and leaching out into the brine.

Proximate chemical composition, yield and energy value of edible powder from whole mantis shrimp (on dry weight basis) are shown in Table (4).

Table 1. Length measurements and weight composition of fresh mantis shrimp

Parameter	Value		%
	Range	Average	
Length measurements (cm)			
Total length	13.0 – 19.0	14.7 ± 1.64	100
Length of head	4.0 – 5.0	4.15 ± 0.34	27.39
Length of trunk	8.0 – 11.0	9.05 ± 0.8	59.73
Length of tail	1.5 – 3.0	1.95 ± 0.44	12.88
Weight Composition (g)			
Total weight	24.69 – 52.11	31.17 ± 3.18	100
Weight of head	4.43 – 13.82	8.56 ± 2.83	27.47
Weight of flesh	7.29 – 18.64	10.64 ± 3.28	34.14
Weight of trunk shell	5.40 – 10.68	6.78 ± 1.58	21.76
Weight of tail	3.75 – 8.97	5.18 ± 1.47	16.63
Number per kg	33 – 60	48	-

Table 2. Proximate chemical composition of whole and flesh mantis shrimp (on dry weight basis)*

Constituent (%)	Whole	Flesh
Moisture content	74.94 ± 0.32	79.5 ± 0.16
Crude protein (N%×6.25)	60.23 ± 0.37	84.42 ± 0.45
Crude ether extract	4.37 ± 0.22	4.31 ± 0.25
Total ash	25.72 ± 0.76	8.02 ± 0.51
Carbohydrate**	9.68 ± 0.78	3.25 ± 0.53

* Mean ± SD

** Calculated by difference

Table 3. Mineral content in whole, flesh and non-edible parts of fresh mantis shrimp (dwb)

Element (mg/ 100 g)	Whole	Flesh	Non-edible parts
Na	493.48	506.39	484.88
K	292.89	355.36	251.20
Ca	2946.38	78.98	4858.04
Mg	865.98	7.91	1438.03
Fe	2.32	1.28	3.01
Cu	1.27	1.33	1.24
Zn	1.07	1.20	0.98
Mn	0.24	0.08	0.35
Pb	N.D.*	N.D.*	N.D.
Cd	0.032	0.025	0.037

* ND: not detected

Table 4. Proximate chemical composition, yield and energy value of edible fish powder from whole mantis shrimp (dwb).*

Component (%)	Treatments				LSD
	UnEFP	StEFP	VEFP	SEFP	
Moisture content	7.70 ± 0.19	4.90 ± 0.09	4.71 ± 0.05	4.53 ± 0.19	0.286
Crude protein	60.18[a] ± 0.356	57.70[b] ± 0.333	52.60[d] ± 1.192	54.90[c] ± 0.01	1.218
Crude ether extract	3.61[a] ± 0.148	3.26[b] ± 0.027	2.53[c] ± 0.023	2.78[c] ± 0.095	0.169
Total ash	26.94[d] ± .030	30.18[c] ± 0.208	34.51[b] ± 0.151	37.17[a] ± 0.053	0.249
Carbohydrate**	9.27[ab] ± 0.38	8.83[b] ± 0.474	10.25[a] ± 1.150	5.23[c] ± 0.159	1.235
Yield	26.96	23.25	15.89	19.35	-
Energy value (kcal/ 100 g)	316.99	295.46	274.17	265.54	-

* means ± SD
** By difference
UnEFP: Untreated edible fish powder
StEFP: Steaming edible fish powder
VEFP: Vinegar (0.5%) edible fish powder
SEFP: Salt (5%) edible fish powder.

The results indicated that the untreated edible fish powder (UnEFP) had the highest significant moisture content being, 7.70% followed by the steaming edible fish powder (StEFP) (4.90%). On the other hand, Vinegar edible fish powder (VEFP) and salt edible fish powder (SEFP) had 4.71 and 4.53% moisture, respectively. These results are in accordance with the results found by Chattopadhyay *et al*. (2004) in which the moisture content in edible fish powder obtained from small bony fish was 5.55%.

On the other hand, Ehigiator and Nwangwu (2011) found that the moisture content of two species of prawn which were dehydrated at 85°C were 7.09 and 7.34%, respectively. The results obtained in the present study are in accordance with those obtained by Shaviklo *et al*. (2010) who found that the moisture content of fish protein powder ranged from 3.9 to 5.8%. Moisture content is a precise pointer of the susceptibility of product to undergo the microbial spoilage. Moisture content also affects the stability and shelf life of the food product (Saritha and Jamila Patterson, 2014). It has been reported that moisture content below 10% level was very good from the microbial safety point of view for fishery products (Saritha and Jamila Patterson, 2014).

Protein is essential for the sustenance of the human body (Sudhaker *et al*., 2009). Table (4) revealed that the crude protein content of the different treatments ranged from 52.60 (VEFP) to 57.70 for (StEFP). On the other hand, the untreated sample had 60.18% protein. The untreated sample (UnEFP) contained the highest significance protein content (60.18%) followed by StEFP (57.70%) and SEFP (54.90%), while the lowest protein content was observed in VEFP (52.60%). These may be due to aggregation and denaturation of protein by heating, leading to the loss in water holding capacity of protein.

Niamnuy *et al*. (2008) reported a drip loss in shrimp protein muscle throughout the boiling in salt solution. Steaming method has less negative effect on the nutritional parameters and had a minimum effect on protein solubility. Steaming as a method of heating showed the least undesirable effects on protein losses and can be selected as the best method in making EFP (Hakimeh *et al*.,2010).

These results are in accordance with those found by Chattopadhyay *et al*. (2004) who showed that the protein content of EFP at zero time of storage was 62.52%. Also, these results are quite close to that found by Ehigiator and Nwangwu (2011) who found that the protein content of the dehydrated species of whole prawn were 53.38% and 56.15% on dry matter, respectively. On the other hand, Jeyasanta *et al*. (2013) showed that the protein content in EFP prepared from trash fish was 55.6% which was higher than that found by Saritha and Jamila Patterson (2014) who observed that seafood health mix powder contained 48.02% protein.

The results in Table (4) showed that there was a significance ($p \leq 0.05$) difference between the untreated sample and the other EFP treatments in their content of crude ether extract. The untreated EFP had the highest crude ether extract (3.91%) followed by StEFP (3.26%), while no significant difference in crude ether extract content was observed between SEFP and StEFP (2.78% and 2.53%), respectively. The lowest crude ether extract content was found in VEFP. These results indicated that some of the crude lipid was lost during the salt-boiled and vinegar-boiled treatments which were more than during steaming processes. These results are in accordance with those found by Solanki *et al*. (1977) in dried whole fish paste, dried steam cooked whole fish pressed, that observed and dried whole fish cooked in water with acetic acid. Also, the results obtained in the present study are similar to those observed by Sathivel *et al*. (2004) in whole herring powder which contained from 3.6 to 3.9. Lipid and also to those found by Shaviklo *et al*. (2010) in saithe (*Pollachius virens*) fish protein powder which contained 2.1 to 3.2 lipid. On the other hand, Saritha and Jamila Patterson (2014) explained that meat powder from trash fish had 3.11% lipid. There were significant differences of ash content between all treatments. The highest content was in SEFP (37.17%) followed by VEEP (34.51%) and by StEFP (30.18%). The lowest ash contant was in the untreated sample (25.64%). These results are quite similar to those reported by Ehigiator and Nwangwu (2011) who observed that the ash content in two fresh water prawn were 25.53% and 22.67%.

No Significant difference was found in carbohydrate content between the UnEFP, StEFP and VEFP. On the other hand, SEFP had the lowest carbohydrate content being 5.23%.

Table (4) revealed that the EFP yield obtained by the different treatments ranged from 15.89% to 26.96%. The untreated sample had the highest processing yield (26.96%) following by steaming (23.25%) and heating(80°C/15 min) in 5% salt (19.35%), while heating (80°C/15 min) in 0.5% vinegar had the lowest processing yield (15.89%). These results are higher than that found by Solanki *et al*. (1977) who mentioned that the processing yield were 17.5, 17.0 and 7.35% in dried whole fish paste, dried steamed whole fish and finally dried minced fillets cooked in water containing acetic acid, respectively. On the other hand, the results obtained in the present study are higher than that mentioned by Chattopadhyay *et al*. (2004) who found that powder from small bony fish varied from 10.0% to 12.0%. The caloric value of the aforementened treatments were 316.99, 295.46, 274.17 and 265.54 kcal/ 100 g, respectively for the UnEFP, StEFP, VEFP and SEFP.

Table (5) shows some different functional properties of edible fish powder such as water absorption, fat absorption, emulsion properties and foaming properties as well as pH and bulk density. The results in Table (5) showed that pH value of the untreated sample was 6.80, while the pH values for the other powder were 6.60, 6.89 and 6.82 for STEFP, VEFP and SEFP, respectively. Acidic products are more shelf stable than non-acidic counterpart (Ihekeronye and Ngoddy, 1985).

Blulk density is a measure of heaviness of a powder sample (Oladele and Aina, 2007). The highest bulk density was observed for SEEP (0.724 g/cm^3) and the lowest for VEFP (0.627g/cm^3). As mentioned by Adeleke and Odedeji (2010), bulk density is affected by the particle size and density of the powder and it is very important in determining the packaging requirement, material handling, and application in wet processing in food industry. The high bulk density of powder suggests their suitability for use in food preparations. On contrast, low bulk density would be an advantage in the formulation of complementary foods (Akpata and Akubor, 1999).

Water absorption capacity describes powder-water association ability under limited water supply (Oladele and Aina, 2002). The highest water absorption was in SEFP (197.04) followed by VEEP (184.73), STEEP (112.77) and the lowest was in UnEFP (93.96 g/ 100 g)..

The mechanism of fat absorption is attributed mainly to the physical entrapment of oil and the binding of fat

Table 5. Functional properties of edible fish powder from whole mantis Shrimp

Property (%)	Treatments			
	UnEFP	**StEFP**	**VEFP**	**SEFP**
pH	6.80	6.60	6.89	6.82
Bulk density (g/ cm^3)	0.715	0.645	0.627	0.724
Water absorption (g/ 100 g powder)	93.96	112.77	184.73	197.04
oil absorption (g/ 100 g powder)	105.01	60.07	141.58	115.94
Emulsion capacity (ml oil/g powder)	20.71	18.90	19.15	21.08
Emulsion activity (%)	31.75	30.16	28.57	30.60
Emulsion stability (%)	6.78	10.52	8.62	5.00
Foaming capacity (%)	7.69	3.85	9.62	7.69
Foaming stability:				
After 30 min	75	100	40	50
After 60 min	75	100	20	25

* UnEFP: Untreated edible fish powsder
* StEFP: Steaming edible fish powder
* VEFP: Vinegar (0.5%) edible fish powder
* SEFP: Salt (5%) edible fish

to the polar chain of protein as mentioned by Adeleke and Odedeji (2010). While the lower oil absorption capacity of tiger nut powder might be due to low hydrophobic proteins which show superior binding of lipids (Kinsella, 1976). The results in Table (5) also showed that the highest value of fat absorption was observed for VEFP (141.58) followed by SEFP (115.94), UnEFP (105.01) and the lowest STEFP (60.07 g/ 100 g).

The ability of proteins of these powder to bind with oil makes it useful in food system where optimum oil absorption is desired. This makes powder to have potential functional uses in foods such as sausage production. The oil absorption capacity (OAC) also makes the powder suitable in facilitating enhancement in flavour and mouth feel when used in food preparation. Due to these properties, the protein probably could be used as functional ingredient in foods such as whipped toppings, sausages, chiffon dessert, angel and sponge cakes (Chandra and Samsher, 20l3).

Emulsion properties are influenced by solubility, pH and concentration play a significant role in many food system where the protein have the ability to bind fat such as in meat products batter, dough and salad dressing as mentioned by Adeleke and Odedeji (2010). Emulsion capacity showed that SEFP had 21.08% which was higher than the UnEFP (20.71), VEFP (19.15) and STEFP (18.90). Highest emulsifying activity was observed in UnEFP (31.75) then followed by SEFP (30.60), StEFP (30.16) and VEFP (28.57%). Differences in the emulsion activity of protein may be related to their solubility exhibited the lowest emulsifying activity and highest emulsion stability as mentioned by Chandra and Samsher (2013). The results showed that STEFP had the highest emulsion stability (10.52%) followed by VEFP (8.62), UnEFP (6.78) and SEFP (5.00). Increasing the emulsion activity, emulsion stability and oil absorption (binding) during processing are primary functional properties of protein in such foods as comminuted meat products, salad dressing, frozen desserts and mayonnaise (Chandra and Samsher, 2013).

The highest foam capacity was observed for VEFP (9.62 %) followed by UnEFP, SEFP and StEFP, (7.69, 7.69 and 3.85%), respectively. The highest foam stability after 30 min was observed for STEFP (100%) and the lowest for VEFP (50%). The low foam capacity may be attributed to the low protein content of the flour since formability is related to the amount of solubilized Protein (Narayana and Narasinga Rao, 1982) and the amount of polar and non-polar lipids in a sample (Nwokolo, 1985).

The results in Fig (2) showed that the higher molecular weight (MW) protein fraction was the major component in fresh mantis shrimp (FMS – No6) 180 kDa (66.49%),135 kDa (18.29%) and 245 kDa (15.22%). The electrophoretic patterns of protein showed that the low MW protein were the major component in all dehydrated mantis shrimp 48 kDa (46.98%) followed by 35 kDa (16.33%) and 63 kDa (10.78%) in pattern No. (5) (UnEFP), while steaming edible fish powder (StEFP) had 35 kDa (39.36%) followed by 25 kDa (12.09%) and 48 kDa (10.36%) in pattern No. (4). Also vinegar edible fish powder (VEFP) protein had 17 kDa (33.54%), 20 kDa (11.28%) followed by 35 kDa (9.92%) in pattern No. (3). on the other hand salt edible fish (SEFP) had the lowest MW protein 11 kDa (20.21%), 20 kDa (11.26%) followed by 17 kDa (10.21%) in pattern No. (2). All dehydrated samples showed that degradation of the myosin heavy chain and an increase in the number and intensity of bands of low MW protein. These results also agreed with those reported by Raghunath *et al*. (1995) who found that higher MW protein fractions were more sensitive to drying and disappeared much earlier than the lower MW protein fraction. While Gao *et al*. (2016) showed that denaturation of shrimp protein began after heating for 10 min at 50°C and protein denaturation and aggregation induced by heat. Unlusayin *et al*. (2010) who found that 9 bands for fresh shrimp were detected by just three on them were found after boiling due to salt concentration. These results are in accordance with the chemical composition which explained that the sample boiled in salt solution had the lowest protein content and steaming is the best method for producing edible fish powder.

The sensory quality of StEFP was evaluated in terms of appearance, colour, texture, odour, taste and overall acceptability as shown in table (6). StEFP was incorporated as a fortified to wheat sticks (100% wheat flour) with 4,6 and 9% edible fish powder and potato croquettes (100% potato paste) with 3, 6, 9 and 12% of steaming edible fish powder. Sensory scores for the two products increased gradually by increasing % of StEFP compared with the control (100% wheat flour) and it was highly acceptable by the panelists. Wheat sticks which fortified with 9% StEFP had the best average composite score (8.52) compared with the other samples, while the average composite score was the same for the 9% and 12% StEFP for potato croquettes. Chattopadhyay *et al.* (2008) found that vegetable curry fortified with 10% edible fish powder from small size Indian major carps was very acceptable by the panelist.

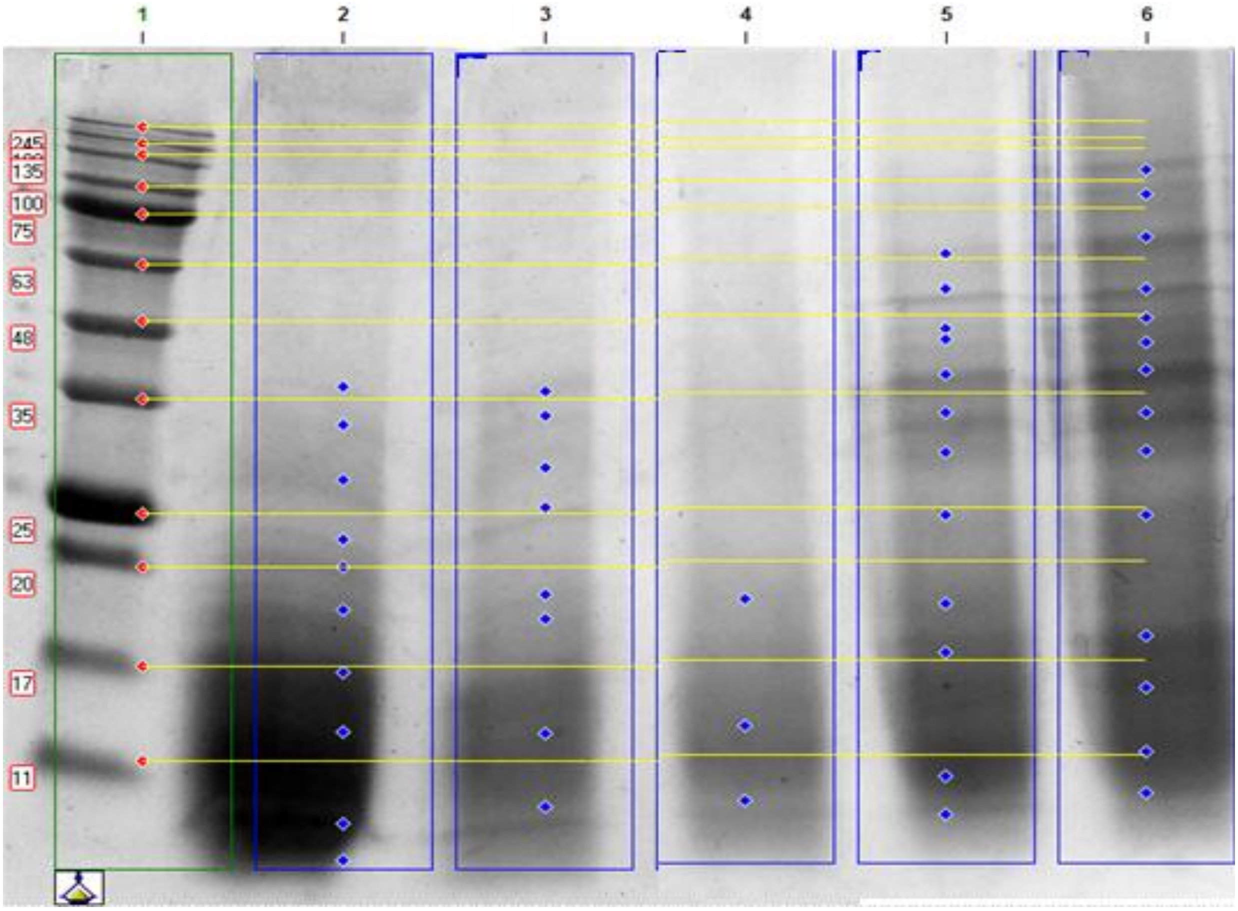

Fig. 2. SDS – PAGE pattern of total protein from dehydrated whole mantis shrimp prepareds by at different treatments

1- Marker protein.
2- SEFP: Salt (5%) edible fish powder.
3- VEFP: Vinegar (0.5%) edible fish powder.
4- StEFP: Steaming edible fish powder.
5- UnEFP: Untreated edible fish powder.
6- Fresh mantis shrimp.

Table 6. Sensorial properties of some products fortified with steaming edible fish powder from mantis shrimp

Product	Property							
	Appearance	**Colour**	**Texture**	**Odour**	**Taste**	**Overall acceptability**	**Composite score***	**Average**
Wheat sticks								
Control	7.30 ± 1.05[c]	6.80 ± 0.63[c]	7.00 ± 0.81[b]	6.80 ± 0.63[c]	7.00 ± 0.66[c]	6.68 ± 0.42[d]	41.58	6.93
Fortified with 3% StEFP	7.80 ± 0.78[bc]	7.60 ± 0.69[b]	7.30 ± 0.48[b]	7.30 ± 0.48[bc]	7.30 ± 0.48[bc]	7.46 ± 0.44[c]	44.76	7.46
Fortified with 6% StEFP	8.30 ± 0.48[ab]	8.20 ± 0.42[a]	8.00 ± 0.47[a]	7.80 ± 0.63[ab]	7.80 ± 0.63[b]	8.02 ± 0.26[b]	48.12	8.02
Fortified with 9% StEFP	8.70 ± 0.48[a]	8.70 ± 0.48[a]	8.50 ± 0.52[a]	8.20 ± 0.87[a]	8.50 ± 0.52[a]	8.52 ± 0.39[a]	51.12	8.52
LSD	0.67	0.52	0.54	0.58	0.53	0.35		
Potato croquettes								
Control	7.20 ± 0.42[c]	7.30 ± 0.48[b]	7.20 ± 0.42[bc]	6.90 ± 0.57[b]	7.40 ± 0.52[b]	7.20 ± 0.31[c]	43.20	7.20
Fortified with 3% StEFP	7.80 ± 0.78[b]	8.00 ± 0.66[ab]	6.90 ± 0.57[c]	7.50 ± 0.52[ab]	7.80 ± 0.42[ab]	7.60 ± 0.21[b]	45.60	7.60
Fortified with 6% StEFP	8.30 ± 0.48[ab]	7.40 ± 0.96[b]	7.20 ± 0.78[bc]	8.00 ± 0.81[a]	7.70 ± 0.42[ab]	7.72 ± 0.35[ab]	46.32	7.72
Fortified with 9% StEFP	8.40 ± 0.69[a]	8.00 ± 0.82[ab]	7.90 ± 0.56[a]	7.60 ± 0.84[a]	8.10 ± 0.99[a]	8.00 ± 0.35[a]	48.00	8.00
Fortified with 12% StEFP	8.00 ± 0.66[ab]	8.40 ± 1.17[a]	7.70 ± 0.67[ab]	7.60 ± 0.84[a]	8.30 ± 0.42[a]	8.00 ± 0.45[a]	48.00	8.00
LSD	0.56	0.77	0.55	0.66	0.67	0.31		

+Composite score =∑score of (appearance Colour+texture+odour+taste+overall acceptability).
Control =100%wheat flour. StEFP:steaming edible fish powder

As a conclusion, edible fish powder (EFP) obtained by the different treatments can be used from whole mantis shrimp to prepare wheat sticks and potato croquettes as a new ready-to-eat products. These products had good properties from the nutritional point of view and are accepted favorably by the panelists.

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الملخص العربي

الاستفادةّ من سمك الشيكال الكامل كمسحوق صالح للأْكل لنحضير المنتجات ذات القيمةّ الْمضافةّ

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كان الهدف من الدراسة هو التحقق من الخصائص الغذائية والوظيفية لمسحوق السمك القابل للأكل والمحضر من سمك الشيكال الكامل باستخدام معاملات التسخين المختلفة واستخدامه كمكون غذائي وظيفي في بعض المنتجات الغذائية مثل باتون ساليه وكروكيت البطاطس.وقد وجد أن التركيب الكيماوي للشيكال الطازج الكامل (اللحم + الرأس+ القشر + الذيل) واللحم فقط يحتوى على 60.23% و 84.42% بروتين و 25.72% و 8.02% رماد و 9.68% و 3.25% فى الكربوهيدرات (على أساس وزن جاف). وقد وجد أن محتوى الشيكال الكامل منخفض في البروتين مع ارتفاع مستوى الرماد والكربوهيدرات وذلك لوجود القشرة الخارجية. وكانت مستويات الصوديوم والبوتاسيوم والكالسيوم والمغنسيوم في الشيكال الكامل 493.48 ، 292.89 ، 2946.38 ، 865.98 ملجم/100 جم. ولقد استخدمت معاملات بسيطة لتحويل الشيكال ذو القيمة المنخفضة إلى مسحوق السمك الصالح للأكل .يحتوى مسحوق السمك غير المعامل على أعلى قيمة للبروتين (60.18%) يليها مسحوق السمك المعامل بالبخار (57.70%) ثم المعامل بالمحلول الملحي (59.90%). وقد احتوى مسحوق السمك المعامل بحمض الخليك على أقل قيمة للبروتين (52.60%). ولهذا يعتبر مسحوق السمك المعامل بالبخار أفضل الطرق للتقليل من فقد البروتينات. ويتراوح الناتج من مسحوق السمك بالمعاملات المختلفة من 15.89% إلى 26.96% ومحتوى الطاقة من 265.54 إلى 316.99 كيلوكالوري/100 جم.

وأظهرت دراسة الخصائص الوظيفية المختلفة أن المسحوق المعامل بالبخار قد حصل على أعلى قيم لثبات المستحلب والرغوة وهذا يرجع لمحتواه العالي من البروتين. كما أظهرت نتيجة SDS – PAGE أن المسحوق المعامل في المحلول الملحي يحتوي على أقل نسبة من البروتين وأن المعاملة بالبخار هي أفضل طريقة لإنتاج مسحوق السمك القابل للاستهلاك الآدمي. وأظهرت الخواص الحسية للباتون ساليه وكرات البطاطس زيادة الإقبال على المنتج بزيادة تركيز مسحوق السمك. وأظهرت الدراسة للشيكال أنه يمكن استخدامه كمصدر عالِ فى محتواه من البروتين والطاقة والمعادن للاستهلاك الآدمي.