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# Protein and electrophoretic analysis of edible muscle of commercially important crustaceans and mollusks species from Egyptian and Saudi Arabia costs

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**Abstract:** Crustaceans and mollusks are important components of the aquatic fauna. Furthermore, crustaceans and mollusks consumption have been increasing worldwide during the past decades. So, therefore, the present study was investigated the variation between total protein content and protein electrophoretic pattern in edible muscle of commercially important crustaceans (*Erugosquilla massavensis*, *Peaneus semisulcatus*, *Metapenaeus monoceros* and *Portunus pelagicus*) and mollusks (*Sepia* spp., *Cardium edule*) as an attempt to rank them as an alternative rich animal protein source for human. The recorded data declare that the highest protein percentage was observed in males *E. massavensis* followed by *Sepia* spp then *P. pelagicus* and shrimps. On the other hand, females *E. massavensis* and bivalve mollusks (*C. edule*) had less total protein contents in their muscles, additionally, the recorded data showed a variation in band numbers and estimated molecular weight of muscle protein between sexes of each species and among the studied species. The results of the present work clearly indicate that there are differences in the protein structure of the muscles in different species of crustaceans and mollusks with reference to the protein fractions and their molecular weights.

**Keywords:** Protein Content, Electrophoretic Pattern, Edible Muscles, Crustaceans Species, Mollusks Species

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## 1. Introduction

Crustaceans, particularly the edible species have been intensely investigated and used as model organisms in a number of studies on biochemical composition and nutritive quality [1, 2, 3]. Several edible crustaceans constitute one of the major sources of nutrient food materials for human beings and form one of the key points of food chain cycle [4]. In general several crustaceans which are available in the local market for human consumption are very delicious and possess relatively good amount of protein and amino acids, along with other nutrient substances [4, 5]. Protein is the most prominent biochemical component of crustaceans [6, 7]. Furthermore, the elevation of protein percentage in the edible muscles in studied crustaceans samples also indicates their high nutritive quality. Another important commercially marine organisms are represented by mollusks species. Mollusks are very important marine organisms for many reasons.

Apart from their commercial value for use as a human foodstuff and in the feeding of several crustaceans [8, 9]. Biochemical assays and nutrients play a vital role in physical growth, development, maintenance of normal body function of physical activity and health. Moreover, cephalopod mollusks landings and consumption have been increasing worldwide during the past decades. The main reason for this increasing demand is that cephalopods are a good protein source [10, 11].

The proteins are among the most abundant biological macromolecules and are extremely versatile in their function and interaction during metabolism of proteins, amino acids, enzymes and co-enzymes [12]. Protein is essential for the sustenance of life and accordingly exists in the largest quantity of all nutrients as a component of the human body [13, 14]. The protein content is considered to be an important tool for the evaluation of physiological standards [11]. Moreover, protein is essential for normal function, growth and maintenance of body tissues [5]. Any sort of cellular metabolism occurring in body involves one

or many different proteins. Additionally, at cellular level proteins do play both structural and functional role. Being an integral part of the cell membrane, intracellular and extracellular passages are linked through it [15]. Any sort of cellular metabolism occurring in body involves one or many different proteins [7]. The occurrence of high protein and lipid contents in the tissues of crustaceans and mollusks reflects that the tissue is highly rich in energy containing substances. Several authors also emphasized that, the quantities of certain constituents included proteins vary considerably in different stages of life cycle of marine organisms and also differences are observed within genera to genera, species to species, size, sex, condition in the life cycle, feeding season physical activity and reproductive stage... etc [16-18].

In the area of the Suez Canal, Red Sea and Arabian Gulf, many crustaceans and mollusks species are potentially important constituents of the fishery. They comprise a considerable percentage of the commercial catch and are well consumed by local populations of these areas. For example, the mantis shrimp *Erugosquilla massavensis* is an edible crustacean that has a small yet growing economic importance in Egyptian markets. It is a potentially important Egyptian constituent of the fishery for economic crustaceans both in the area of the Suez Canal and in the Mediterranean Sea at Port Said displacing and dominating the local species *Squilla mantis*. Since landings of these mantis shrimps [3,19] are incorporated with those of the penaeid prawns, the nature of its fishery is therefore described as a part of the overall fishery of commercial crustaceans [20]. Furthermore, *E. massavensis* is now important components of our local aquatic fauna [21]. Additionally, *Peaneus semisulcatus*, *Metapenaeus monoceros* are the main commercially exploited penaeid species in Saudi Arabia markets, as well as the blue crab *Portunus pelagicus* is one of the most popular and highly exploited crab species. Regarding mollusks species. This species included cephalopod mollusks (cuttlefish; *Sepia*) and bivalve mollusks (mussel; *Cardium edule*).

Although these crustaceans and mollusks species are economically important and widely consumed along Egyptian Mediterranean and Saudi Arabia Red Sea and Arabian Gulf coasts. There is a gap in information about their protein contents and electrophoretic patterns to evaluate and compare protein concentration of edible muscles of these marine organisms. The purpose of the present study was therefore, to assess the protein concentrations and their electrophoretic bands in the muscles of these crustaceans and mollusks species as an attempt to use them as an alternative animal protein source.

## 2. Material and Methods

### 2.1. Collection of Samples

The study was carried out on the male and female marine crustaceans species that included mantis shrimps, shrimps

and crabs as well as mollusks species. These marine organisms were collected separately from different sites as follows:

1. Males and females marine mantis shrimp *E. massavensis* were collected from the Suez Canal of Suez city, Egypt

2. Red Sea strain crustaceans included : male and female shrimps *P. semisulcatus* and both sexes of crabs *P. pelagicus* that were obtained from local fishermen at Jeddah, Saudi Arabia.

3. Arabian Gulf strain crustaceans : both sexes of *M. monoceros* (shrimps) and *P. pelagicus* (crabs) were collected from local fishermen at Dammam, Saudi Arabia.

4. Red Sea strain mollusks included: cephalopod mollusks (*Sepia* spp.) and bivalve mollusks (*C. edule*) that obtained from local fishermen at Jeddah, Saudi Arabia.

5. Arabian Gulf strain mollusks included: *Sepia* spp. and *C. edule* that obtained from local fishermen at Dammam, Saudi Arabia.

An attempt was made to collect consistent size ranges in each species. Samples were washed with deionized water to remove any adhering contamination and drained using filter paper. Samples were put in insulated containers (containing crushed ice) and brought to the laboratory for preservation prior to analysis. The male and female crustacean samples were segregated, wrapped in aluminum foil and then frozen. The analyses were carried out on composite samples of 5 specimens of each species (in each crustaceans species, 5 males and 5 females were included in each analysis) having uniform size.

### 2.2. Separation of Muscle Away from Exoskeleton

Fresh whole bodies of all samples of studied crustaceans species were stored at  $-20^{\circ}\text{C}$  to facilitate peeling process after thawing when needed as most crustaceans. After defrosting, the samples were separated into the exoskeleton and the endoskeleton (i.e. edible muscles). While, internal shell of *Sepia* and the bivalve shell of *C. edule* were removed from their edible muscles.

### 2.3. Biochemical Analysis

#### 2.3.1. Total Protein Content

Powered samples of muscles were analyzed for total proteins by [22]. The total protein was estimated as per the Folin-Ciocalteu method with bovine serum albumin (BSA) as standard. 1g of wet muscle tissue was homogenized in homogenizer with 10 ml of 0.1 M Phosphate buffer. Take 1 ml of tissue homogenate, 1 ml of 0.1 N NaOH and keep it for 30 minutes, at room temperature, now add 8ml of distilled water and centrifuge at 4000 rpm for 30 minutes. Take only 0.1 ml supernatant and add 0.9 ml of distilled water to make volume 1 ml. Add 5 ml of alkaline reagent (2 g  $\text{Na}_2\text{CO}_3$  124 in 0.1 N Na OH: 4% Na-K tartrate 2%  $\text{CuSO}_4$ , 200:1:1) leave it for 30 minutes at room temperature. Add 0.5 ml of Folin phenol reagent; leave it for 40 to 45

minutes at room temperature. The color intensity was measured at 750 nm against reagent blank.

### 2.3.2. Electrophoretic Separation of Proteins

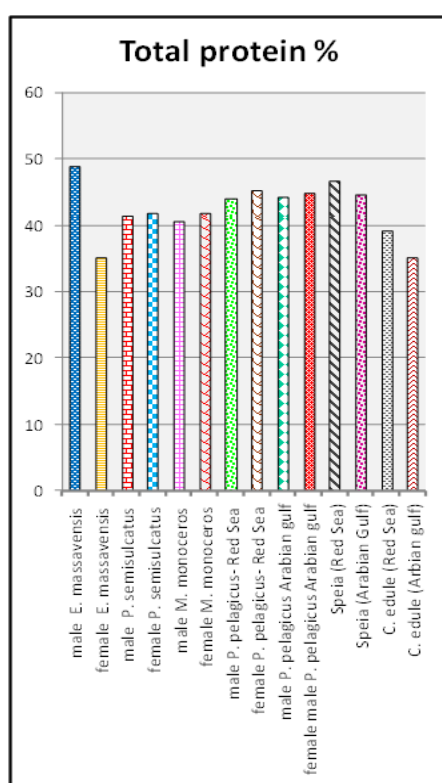
Polyacrylamide gel electrophoresis (SDS-PAGE) electrophoresis was carried out using silver stain protocol [23]. Muscle samples (3g) were homogenized with 27ml of solubilizing agent (2% SDS, 8M urea and 2%  $\beta$ -mercaptoethanol), followed by heating at 85 °C for 1h. Then the homogenate was centrifuged at 10,000g for 15min at room temperature [24]. The protein concentration of supernatant was obtained by the method of Lowry [22]. Protein patterns of different fractions were determined using sodium dodecylsulfate – polyacrylamide gel electrophoresis (SDS-PAGE), with 15% running gel and 4% stacking gel.

### 2.4. Statistical Analysis

The obtained data were used for descriptive statistical analysis consisting of means  $\pm$  standard error of five separated determinations. In order to test the significance of the differences among the mean values of the present studied species one-way ANOVA test were applied. Means with the same letter for each parameter are not significantly different, otherwise they do ( $P < 0.05$ ). SPSS, for Windows (Version 15.0) was used for statistical analysis.

## 3. Results

### 3.1. Total Protein Content



**Fig.1.** Total protein content in edible muscles of male, female crustaceans and mollusks species.

Figure 1 summarize the concentration of total protein in edible muscles of studied male and female crustaceans and mollusks species. The recorded data showed that males mantis shrimps had the highest protein content ( $48.85\% \pm 0.32$ ) than their females ( $35.14\% \pm 0.08$ ) as well as compared with both sexes of shrimp and crab species. On the other hand, the edible muscle of female mantis shrimps had the lowest protein level in comparison with both sexes of shrimps species and crab species from studied regions. Furthermore, it was observed that, male crab species had significant higher protein level ( $44.06\% \pm 0.88$  and  $44.28\% \pm 0.98$  in Red sea and Arabian Gulf strains respectively) than in male shrimps species ( $41.45\% \pm 1.99$  and  $40.53\% \pm 0.89$  in Red sea and Arabian Gulf strains respectively). Similarly, female crabs from two studied areas had higher muscle protein contents ( $45.19\% \pm 1.03$  and  $44.88\% \pm 2.31$  in Red sea and Arabian Gulf species respectively) compared with female shrimps ( $41.84\% \pm 1.22$  and  $41.88\% \pm 0.64$  of Red sea and Arabian Gulf strains respectively). Moreover, the present data showed all female crustaceans (except for mantis shrimps) had higher protein contents in their edible muscles than their males, but this increase was non-significant.

As regards, the muscle protein content in mollusks species, Fig. 1 illustrated that the maximum percentage of protein was detected in cephalopod species ( $46.77\% \pm 1.51$  and  $44.68\% \pm 0.85$  in *Speia* spp. from Red Sea and Arabian Gulf respectively). On the other hand, the lowest protein percentage was recorded in muscles of bivalve mollusks ( $39.17\% \pm 0.34$  and  $35.1\% \pm 0.68$  in *C. edule* from Red Sea and Arabian Gulf respectively).

Comparing protein percentage in edible muscles of crustaceans and mollusks species in the present study, this decreasing order was recorded: males *E. massavensis* > *Speia* spp. from Red Sea > females *P. pelagicus* from Red Sea > females *P. pelagicus* from Arabian Gulf > *Speia* spp. from Arabian Gulf > males *P. pelagicus* from Arabian Gulf > males *P. pelagicus* from Red Sea > females *M. monoceros* > females *P. semisulcatus* > males *P. semisulcatus* > males *M. Monoceros* > *C. edule* from Red Sea > females *E. massavensis* > *C. edule* from Arabian Gulf.

### 3.2. SDS-Gel Electrophoresis

The electrophoretic analysis of edible muscle proteins of male and female crustaceans species was illustrated in Photo 1 & 2 and Table 1 & 2. Considerable variations in band numbers were estimated at molecular weight and intensity of protein band. In male crustaceans as shown in Photo 1 and Table 1, the number of protein bands were 16, 14, 12, 14 and 14 bands around molecular weight 189.8 to 9.10, 128.48 to 13.90, 179.64 to 12.39, 114.66 to 13.67 and 184.66 to 5.41 KD for *E. massavensis*, *P. semisulcatus*, *M. monoceros*, *P. pelagicus* from Red Sea and *P. pelagicus* from Arabian Gulf respectively. Regarding, female crustaceans, the recorded data in Photo 2 and Table 2, showed that the electrophoretic bands of edible muscle proteins included 14, 15, 13, 14 and 14 bands with molecular weight ranged from 150 to 14.80,

202.07 to 13.73, 122.88 to 13.67, 121.07 to 13.38, and 188.20 to 5.55 KD for females of *E. massavensis*, *P. semisulcatus*, *M. monoceros*, *P. pelagicus* from Red Sea and *P. pelagicus* from Arabian Gulf respectively.

Regarding the protein bands of edible muscles of mollusks species, as shown in Photo 3 and Table 3 the total number of electrophoretic bands in *Sepia* spp. from Red

Sea and Arabian Gulf were 13 bands around molecular weight 133.01 to 13.67 and 154.20 to 10.10 KD respectively. Furthermore, it was found that the total number of muscle protein bands of *C. edule* mollusks was 14 bands ranged from 154.43 to 13.80 KD from Red Sea region and from 160 to 14.80 KD from Arabian Gulf respectively.

Table 1. SDS-PAGE gel electrophoresis of muscle of male crustaceans species

Lanes	MARKER		male <i>E. massavensis</i> Suez		male <i>P. semisulcatus</i> Red Sea		male <i>M. monoceros</i> Arabian gulf		male <i>P. pelagicus</i> Red Sea		male <i>P. pelagicus</i> Arabian gulf	
Bands	KD	%	KD	%	KD	%	KD	%	KD	%	KD	%
1	260	2.98	189.80	2.8	128.48	3.73	179.64	3.02	114.66	11.36	184.66	5.96
2	135	2.42	171.80	3.4	103.85	3.45	115.23	1.50	71.83	6.89	170.31	1.09
3	95	3.17	119.70	4.9	88.05	3.91	75.29	3.20	59.97	15.50	155.11	3.30
4	72	13.20	72.20	4.6	70.65	2.41	59.82	8.73	53.12	2.39	121.42	18.8
5	52	12.50	61.10	7.1	59.68	11.72	57.87	5.98	48.86	4.96	92.53	6.18
6	42	5.70	54.30	6.4	51.36	10.70	52.87	3.75	42.53	3.35	86.97	14.30
7	34	4.99	46.80	9.7	49.65	2.33	44.30	1.40	36.97	3.70	65.31	17.61
8	26	22.70	38.70	11.4	46.07	2.39	32.54	21.70	32.47	10.40	59.84	7.89
9	17	12.30	34.60	10.1	43.29	1.47	27.57	23.20	29.84	5.65	40.25	7.59
10	10	19.90	30.80	1.9	32.78	18.60	15.98	14.10	27.49	6.06	27.33	4.35
11			29.00	2.3	30.24	6.21	13.78	11.80	23.98	5.87	23.05	3.62
12			25.60	3.5	27.70	10.50	12.39	1.41	19.15	10.50	15.11	3.02
13			22.40	6.5	16.12	11.30			15.81	4.89	7.05	1.89
14			21.40	3.7	13.90	11.60			13.67	8.44	5.41	3.57
15			17.50	4.6								
16			9.10	17.31								
Sum		100		100		100		100		100		100
In lane		100		100		100		100		100		100

Table 2. SDS-PAGE gel electrophoresis of muscle of female crustaceans species

Lanes	MARKER		female <i>E. massavensis</i> Suez		female <i>P. semisulcatus</i> Red Sea		female <i>M. monoceros</i> Arabian gulf		female <i>P. pelagicus</i> Red Sea		female <i>P. pelagicus</i> Arabian gulf	
Bands	KD	%	KD	%	KD	%	KD	%	KD	%	KD	%
1	260	2.98	150.00	2.8	202.07	3.24	122.88	8.57	121.07	13.00	188.20	5.99
2	135	2.42	116.60	3.4	100.81	1.61	82.70	7.72	102.32	2.51	176.20	2.01
3	95	3.17	75.50	4.9	74.62	1.92	59.82	9.69	70.48	2.12	156.12	3.30
4	72	13.20	76.40	4.6	59.40	9.39	57.73	8.54	55.31	14.30	125.42	18.7
5	52	12.50	58.20	7.1	57.59	5.13	43.68	5.45	51.27	4.48	97.55	7.10
6	42	5.70	54.62	6.2	55.05	2.86	36.17	14.50	48.08	8.34	86.70	14.22
7	34	4.99	46.93	9.7	51.36	2.80	34.48	4.38	37.27	3.20	66.43	17.20
8	26	22.70	39.50	11.4	44.30	2.59	30.35	16.40	32.08	15.10	59.00	7.80
9	17	12.30	39.60	10.1	38.28	2.61	28.36	9.82	29.84	5.31	40.88	6.98
10	10	19.90	32.00	1.9	32.22	19.80	21.29	3.55	27.09	8.41	28.44	4
11			29.60	2.3	29.81	10.00	18.35	2.94	22.60	4.87	23.10	3.7
12			27.50	3.5	27.23	12.90	16.01	3.19	19.81	1.26	15.55	3.60
13			15.72	6.5	24.29	1.71	13.78	5.45	16.71	7.62	7.32	2
14			14.80	3.7	15.85	12.70			13.38	9.96	5.55	3.4
15					13.73	10.50						
Sum		100		100		100		100		100		100
In lane		100		100		100		100		100		100

M: Protein marker; Mol. Wt.: Molecular weight in KD.

Table 3. SDS-PAGE gel electrophoresis of muscle of mollusks species

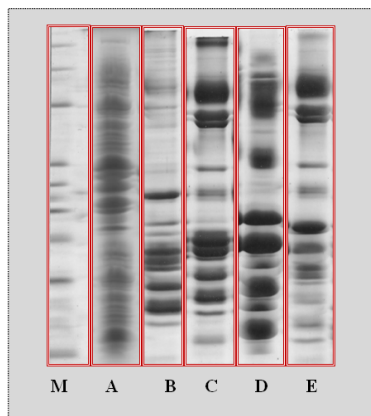
MARKER		<i>Sepia</i> Red Sea		<i>Sepia</i> Red Sea		<i>C. edule</i> Red Sea		<i>C. edule</i> Arabian gulf	
KD	%	KD	%	KD	%	KD	%	KD	%
260	2.98	133.01	10.20	145.20	9.99	154.43	2.58	160.00	2.45
135	2.42	114.66	5.36	112.99	4.55	114.66	2.11	116.00	2.24
95	3.17	70.31	1.23	78.60	2.77	79.80	2.84	75.50	2.55
72	13.20	59.54	11.10	62.00	10.08	71.32	2.74	76.40	3.74
52	12.50	52.75	3.06	50.88	4.02	59.26	10.70	58.20	10.80
42	5.70	43.60	11.10	49.55	10.46	52.62	5.35	54.62	5.41
34	4.99	41.09	5.34	41.00	5.02	43.91	1.49	46.93	2.39
26	22.70	38.40	3.02	37.77	2.5	41.42	2.19	39.50	2.11
17	12.30	32.16	13.50	39.00	14	38.20	2.82	39.60	2.62
10	19.90	29.77	6.97	28.00	5.99	32.07	16.50	32.00	15.99
11		27.29	10.10	27.88	9.88	29.81	9.21	29.60	9
12		15.88	8.60	16.00	8.77	27.37	14.60	27.50	14.20
13		13.67	10.10	10.23	12.20	15.72	12.70	15.72	12.73
14						13.80	13.80	14.80	13.77
Sum	100		100		100		100		100
In lane	100		100		100		100		100

## 4. Discussion

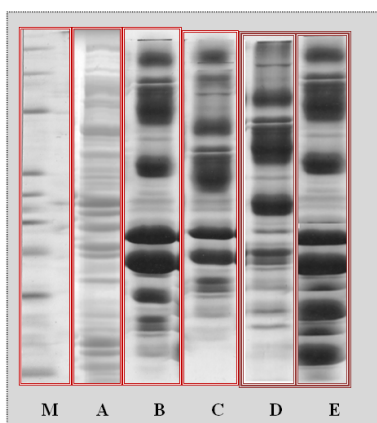
The present study is an attempt to evaluate the protein content and to study the differences in the electrophoretic patterns of muscle proteins of commercially important species of crustaceans and mollusks. The present results show that significant differences in total protein content among crustaceans and mollusks species were observed. The highest concentration of edible muscle protein was recorded in male mantis shrimps followed by cephalopod mollusks and crabs then shrimps. While less mean values were detected in female mantis shrimps and bivalve mollusks. Furthermore, it was observed that in the present study, all studied female samples of crustacean species had high level of muscle protein (non-significant increase) in comparison with their males except for mantis shrimps whose males had significantly higher total protein concentration than in their females. The recorded data are in agreement with the findings of [3] in that males *E. massavensis* recorded highest protein levels in their muscles compared to their females. [3] attributed the decrease of protein content in females as the result of gonads and digestive gland of females have the ability to mobilize reserves from the muscle tissue to the gonads to meet the demands of the reproductive process. In this respect, another hypothesis was suggested by [25, 26, 27]. They attributed the significant differences between the muscle protein content of female and male crustaceans due to males do not invest much energy for reproduction per se, but rather use most of it for somatic growth, i.e., males have lower energetic requirements than females to form a fully developed gonad. While, in view of the fact that some males of decapod crustaceans grow faster than females some studied suggested that [28, 29]. In general, the elevation of protein percentage in edible muscles of marine organisms may be due to the fact that protein is the main component of the contractile elements of the striated

muscles [28]. Furthermore, to judge over the nutritive quality, the protein percentage of the edible muscles of aquatic organisms should be calculated. So, therefore, the recorded data of the present study declare that males mantis shrimps, cuttlefish mollusks, both sexes crab species and both sexes of shrimp species appeared as the richest marine organisms which in turn drew the attention to the need of the considering these protein rich edible organisms as good competitor among their counterparts in studied areas. This confirms the findings of [3] who reported that mantis shrimp *E. massavensis* and blue crab *P. pelagicus* which collected from the Egyptian Mediterranean, coast off Port Said are ranked as protein rich crustaceans. On the other hand, the results of [3] ranked *E. massavensis* as second protein rich edible crustaceans after *P. pelagicus*. Regarding, the cephalopod mollusks and shrimp crustaceans, the present study is consistent with that of results of other studies which indicate that protein was found as the major constituent in the muscle of shrimp and cuttlefish (*Sepia*) [3, 4, 6, 7, 9, 10, 11, 21, 24, 27, 30, 31, 32, 33, 34]. In comparison the mean values of total muscle protein in the current study with other previous studies in different regions of world. Variations in protein percentage were also recorded. The variations in protein contents in edible muscles of marine organisms may be attributed to that the proteins are subject to periodic fluctuations influenced by environmental variables like temperature [35], or may be due to the physiological, genotype and phenotype differences [36]. Another explanation attributed the variation in protein percentage in edible muscles of aquatic organisms particularly in crustaceans species to their omnivorous feeding habit [37]. While, the dependence of the deep-sea crustacean species on food resources that fluctuate in their availability could be an explanation for the species protein content differences as explained by [38, 39]. Furthermore, Several authors [40, 41, 42] also emphasized

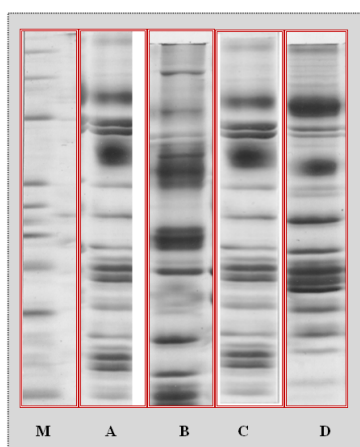
that, the quantities of protein constituents in muscle vary considerably in different stages of life cycle of aquatic organisms, moreover variations are observed within genera to genera, species to species, size, sex and condition in the life cycle, feeding season physical activity and reproductive stage... etc



**Photo (1).** electrophoretic pattern of muscle proteins of male crustaceans. M: marker; A: *E. massavensis* B: *P. semisulcatus*; C: *M. monoceros*; D: Red Sea *P. pelagicus*; E: Arabian Gulf *P. pelagicus*.



**Photo (2).** Electrophoretic pattern of muscle proteins of female crustaceans. M: marker; A: *E. massavensis* B: *P. semisulcatus*; M .*monoceros*; C:; D: Red Sea *P. pelagicus*; E: Arabian gulf *P. pelagicus*.



**Photo (3).** electrophoretic pattern of muscle proteins of mollusks species. M: marker; A: *Sepia* from Red Sea, B: *Sepia* from Arabian Gulf, C: *C. edule* from Red Sea, D: *C. edule* from Arabian Gulf.

In the present study, the electrophoretic pattern of edible muscle proteins of crustaceans and mollusks species reveals significant variations in protein bands among studied species and between sex of crustaceans of each species. In male crustaceans species the number of bands were 16, 14, 12, 14 and 14 bands. While, in females the muscle proteins included 14, 15, 13, 14 and 14 bands for *E. massavensis*, *P. semisulcatus*, *M. monoceros*, *P. pelagicus* from Red Sea and *P. pelagicus* from Arabian Gulf respectively. Furthermore, the recorded data declare the electrophoretic bands for all studied samples of cuttlefish (cephalopod mollusks) were included 13 bands while in bivalve mollusks, the number of protein bands increased where 14 bands were observed. Differences in the banding pattern of the male and female crustaceans may be attributed to the female limited protein as reported by a number of workers [43 - 45]. While, the study of [46] reported that the variation in protein bands might be due to sex variation or to physiological factors such as size, molting cycle, season, nutritional state etc... Another suggestion was in accordance with that of [46] who reported the differences in electrophoretic protein bands might be to an increased synthesis of acute phase proteins (new polypeptide chain) which act as buffer or as protective protein against toxicity with heavy metals. The present study do not support this suggestion, because from the results of the previous study [47] which was carried out on the heavy metal bioaccumulation in edible muscles of these marine organisms, it was observed that *E. massavensis* and *C. edule* are more vulnerable to metal pollution than *P. semisulcatus*, *M. monoceros*, *P. pelagicus* and *Sepia*. However, in females *P. semisulcatus* less amount of heavy metals accumulate in their muscles, the recorded data of the present study show that they have protein bands more than in female *E. massavensis* and bivalve mollusks *C. edule* which accumulated the highest concentrations of essential and non-essential heavy metals in their muscles. So, therefore, the variation in protein level and electrophoretic protein bands might be attributed to type of sex, species variation and nutritional state, differences in the protein structure of the muscles of the different species and to location where the animal lives.

## 5. Conclusion

The present work is represented the first attempt to provide holistic evaluation of total protein content and the electrophoretic pattern of edible muscles of the frequently consumed forms of crustaceans and mollusks species included both sexes of mantis shrimps (*Erugosquilla. massavensis*), shrimps (*Peaneus semisulcatus* and *Metapenaeus monoceros*) and crabs (*Portunus pelagicus*). In addition to cephalopod mollusks (*Sepia*) and bivalve mollusks (*Cardium edule*). These marine organisms are selected in this study according to their economic importance, abundance and use pattern in the study areas. The results of the present work show that the selected marine organisms are represented source of animal protein.



Significant variations in protein percentage in muscles of crustaceans and mollusks were recorded. Furthermore, protein concentration in edible muscles had the following decreasing order males *E. massavensis* > *Sepia* spp. from Red Sea > females *P. pelagicus* from Red Sea > females *P. pelagicus* from Arabian accumulated Gulf > *Sepia* spp. from Arabian gulf > males *P. pelagicus* from Arabian Gulf > males *P. pelagicus* from Red Sea > females *M. monoceros* > females *P. semisulcatus* > males *P. semisulcatus* > males *M. Monoceros* > *C. edule* from Red Sea > females *E. massavensis* > *C. edule* from Arabian Gulf. In terms of nutritive quality, males *E. massavensis*, *Sepia*, crabs and shrimps can stand as animal protein source thus a highly protein nutritious food that represents an alternative to over exploited fish and red meat resources which in turn drew the attention to the need of considering these protein rich marine invertebrates as good competitor among their counterparts in Mediterranean Sea, Red Sea and Arabian Gulf areas.

Moreover, in the present work the electrophoretic pattern of muscle proteins reveals 16, 14, 12, 14 and 14 bands for males of *E. massavensis*, *P. semisulcatus*, *M. monoceros*, *P. pelagicus* from Red Sea and *P. pelagicus* from Arabian Gulf respectively. While, their females had 14, 15, 13, 14 and 14 bands respectively. The results of the present work clearly indicate that there are differences in the protein structure of the muscles of the different species of crustaceans and mollusks with reference to the protein fractions and their molecular weights.

In conclusion, electrophoretic studies help to compare the protein fractions of crustaceans species and mollusks species. Further the results of electrophoretic pattern in this study would provide the ground work for better monitoring of the biochemical or physiological state of the animal under various conditions.

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