WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 5.990
Volume 4, Issue 5, 2345-2357. Research Article ISSN 2277– 7105

AMINO ACID PROFILE IN MARINE CRAB *CHARYBDIS LUCIFERA* (FABRICIUS, 1798).

Ilavarasan. Nachimuthu[1], Stella Irin Kumari. Alphones[2], Murali Shankar. Anaiappan[3], Jaganathan. Kamalesan[3] and Soundarapandian. Peyil[3]*

[1]Department of Zoology, Government Arts College, Karur, Tamil Nadu, India.
[2]Research and Development Centre, Barthiar University, Coimbatore, Tamilnadu, India.
*[3]CAS in Marine Biology, Annamalai University, Parangipettai, Tamilnadu, India.

Article Received on
19 March 2015,

Revised on 08 April 2015,
Accepted on 29 April 2015

***Correspondence for Author**
Dr. Soundarapandian. Peyil
CAS in Marine Biology, Annamalai University, Parangipettai, Tamilnadu, India.

ABSTRACT

The pharmaceutically and economically important *C. lucifera* has an enormous potential that is yet unexploited even though they are mostly consumed and exported. Practically no information is available on the amino acids status of *C. lucifera*. In general, before the introduction of a new species to aquaculture, one should know the nutritional status of that animal. The amino acids in the edible parts of muscle tissue of *C.lucifera* were determined by HPLC. Totally 9 essential amino acids of different sexes (male, female and berried female) were recorded in the present study. Histidine (5.578 g) was abundant and Valine (0.654 g) was minimum in all sexes of the present study. Total essential amino acids were maximum in berried females (12,054g) followed by females (9.507g) and males (6.373g). Totally 11 non essential amino acids were recorded in the present study. Glutamic acid was uniformly maximum in all sexes. However alanine was minimum in all animals irrespective of the sex. Total non essential amino acids were maximum in berried females (15.638g) rather than females (11.866g) and males (8.234g).

KEYWORDS: Amino acids, HPLC, *C. lucifera*, male, female, berried female

INTRODUCTION

Nutritional quality of any animal is determined by the quality and quantity of amino acids. Crab is highly nutritious and healthy owing to its essential amino acids, protein content, unsaturated fatty acids and minerals.[1, 2, 3, 4, 5, 6] Practically all amino acids can be utilized as

chemical signals, although different species using different amino acids as attractants.[7] Among the other compounds amino acids are responsible for the taste of fish flesh while glycine especially is important for the individual taste of different fish species.[8] Amino acids are the micro molecules and building blocks of proteins which are essential organic compounds consisting of amino as well as acidic groups. In general fish proteins had 20 amino acids. Some of these are listed as essential amino acids (EAA) (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine) because they are not synthesized by the body. Cystine and tyrosine are also considered as essential if adequate quantity is not available in the body. Fish and shellfishes proteins are rich in these EAA. Specificity of a protein molecule is due to the number and sequence of amino acids. EAA are required for maintenance of life, growth, synthesis of vitamins and reproduction. The lowest level of any one of the EAA in a protein source, which limits the utilization of that protein, makes it the "first limiting amino acid". The crab is usually recommended for pregnant women, for its nutritionally valuable parts of male and female.[1] High levels of amino acids control many diseases, such as Crohn's and inflammatory diseases. In recent years, crab protein has also assumed great nutritional significance owing to their protective role against the development of cardiovascular disease and rheumatoid arthritis.

In general fish and shellfish meat are considered to be highly nutritious, owing to its content of essential amino acids and proteins. The muscle is apparently the main protein-storage location in crustaceans. In decapods, free amino acids in the tissues reach levels ten times higher than those observed in vertebrates. The crab *C. lucifera* is consumed by the local population without knowing its nutritional status. So the present study is designed to study the amino acid profile of the edible crab of *C. lucifera*, which is very much useful to popularize this species for aquaculture.

MATERIALS AND METHODS

The male, female and berried females of *C.lucifera* were collected from Parangipettai landing centres. After reaching the laboratory they were washed carefully with distilled water to remove the dust and algal particles and ice killed. The carapace of the crabs was opened and the edible parts of muscle tissues were removed with sharp forceps. The removed muscle tissues were homogenized with pestle and mortar. The grounded muscles were then freeze dried and powdered and eventually stored in refrigerator for amino acids analysis.

The amino acids were determined by an automatic amino acid in HPLC analyzer (Lachromehitachi). Five micro liter of amino acid standards mixture sample were injected into the column (DENALIC 18 5 MICROMM 4.6 mm x 150mm). The flow rate was about 1 ml per minute, ambient temperature of 23°C was maintained and sample was detected at 254 nm by following the method of [9] Baker and Han (1994).

Statistical Analysis

The data was subjected to One-way analysis of variance (ANOVA) and difference between means were determined by Duncan's multiple range tests ($P<0.05$) using SPSS version 17.0.

RESULTS

Essential amino acids

Totally 9 essential amino acids were recorded in the present study (Table1). Histidine (5.578 g) was abundant and Valine (0.654 g) was minimum in all sexes of the present study. Total essential amino acids were maximum in berried females (12,054g) followed by females (9.507g) and males (6.373g).The amount of essential amino acids showed significant difference between different sexes.

Non essential amino acids: Totally 11 non essential amino acids were recorded in the present study (Table2). Glutamic acid was uniformly maximum in all sexes. However, alanine was minimum in all animals irrespective of the sex. Total non essential amino acids were maximum in berried females (15.638g) rather than females (11.866g) and males (8.234g). The amino acid contents were significantly varied between different sexes.

Table- 1. Essential amino acids (g/100g) in male, female and berried females of *C.lucifera* (Values are mean of three values ± SE).

S.No	Amino acids	Male	Female	Berried female	Total
1	**Histidine**	1.128 ± 0.14^{c}	1.981 ± 0.23^{b}	2.469 ± 0.20^{a}	**5.578±2.14**
2	**Isoleucine**	1.569 ± 0.16^{c}	1.948 ± 0.23^{b}	2.018 ± 0.15^{a}	**5.535±1.87**
3	**Leucine**	0.381 ± 0.12^{c}	0.708 ± 0.18^{b}	0.968 ± 0.17^{a}	**2.057±2.18**
4	**Lysine**	0.281 ± 0.20^{c}	0.362 ± 0.21^{b}	0.468 ± 0.1^{a}	**1.111±0.29**
5	**Methionine**	1.056 ± 0.19^{c}	1.648 ± 0.18^{b}	2.313 ± 0.15^{a}	**5.017±2.81**
6	**Phenylalanine**	0.317 ± 0.19^{c}	0.408 ± 0.14^{b}	0.516 ± 0.22^{a}	**1.241±0.67**
7	**Threonine**	0.518 ± 0.22^{c}	0.619 ± 0.14^{b}	0.816 ± 0.15^{a}	**1.953±1.04**
8	**Tryptophan**	1.002 ± 0.19^{c}	1.618 ± 0.21^{b}	2.168 ± 0.18^{a}	**4.788±2.19**
9	**Valine**	0.121 ± 0.18^{c}	0.215 ± 0.17^{b}	0.318 ± 0.12^{a}	**0.654±1.28**
Total		**6.373 ± 0.10^{c}**	**9.507 ± 0.15^{b}**	**12.054 ± 1.28^{a}**	**27.934±2.18**

Different superscripts in the rows are significantly different ($P<0.05$).

Table 2. Non essential amino acids (g/100g) in male, female and berried females of *C.lucifera* (Values are mean of three values ± SE).

S.No	Amino acids	Male	Female	Berried female	Total
1	**Alanine**	0.038 ± 0.17^{c}	0.145 ± 0.18^{b}	0.250 ± 0.16^{a}	**0.433±1.25**
2	**Arginine**	0.796 ± 1.43^{c}	0.953 ± 0.12^{b}	1.468 ± 0.40^{a}	**3.217±2.91**
3	**Aspartic acid**	1.653 ± 0.25^{c}	1.968 ± 0.15^{b}	2.248 ± 0.17^{a}	**5.869±1.32**
4	**Aspargine**	0.106 ± 0.21^{c}	0.148 ± 0.29^{b}	0.250 ± 0.18^{a}	**0.504±1.08**
5	**Cystine**	0.898 ± 0.24^{c}	1.998 ± 0.19^{b}	2.510 ± 0.19^{a}	**5.406±1.02**
6	**Glutamic acid**	2.225 ± 0.18^{c}	3.620 ± 0.17^{b}	4.235 ± 0.29^{a}	**10.080±2.18**
7	**Glutamine**	0.360 ± 0.15^{c}	0.413 ± 0.10^{b}	0.515 ± 0.11^{a}	**1.288±1.20**
8	**Glycine**	0.390 ± 0.19^{c}	0.518 ± 0.25^{b}	0.615 ± 0.14^{a}	**1.523±3.25**
9	**Proline**	0.815 ± 0.29^{c}	0.986 ± 0.19^{b}	2.014 ± 0.18^{a}	**3.815±3.21**
10	**Serine**	0.097 ± 0.12^{c}	0.125 ± 0.15^{b}	0.218 ± 0.18^{a}	**0.440±1.00**
11	**Tyrosine**	0.856 ± 0.29^{c}	0.992 ± 0.12^{b}	1.315 ± 0.17^{a}	**3.163±0.38**
Total		**8.234 ± 0.18^{c}**	**11.866 ± 0.10^{b}**	**15.638 ± 1.24^{a}**	**35.738±2.34**

Different superscripts in the rows are significantly different (P<0.05)

DISCUSSION

The most abundant essential amino acids in all sexes of the present study are histidine, isoleucine, methionine and typtophan. These amino acids constituted 50% of the total essential amino acids. Glutamic acid, alanine, arginine and glycine might be responsible for the taste of mud crab *S.serrata.*[10] Almost similar amino acids are also reported in all sexes of *C.lucifera* of the present study and also previous studies in *C.natator*[11]and *P.vigil.*[12] The amino acids histidine and arginine are particularly essential for children[13] and the present investigation also *C.lucifera* tissues had rich source of these amino acids.

The total essential amino acids in the berried females, females and males of *C.lucifera* are 12.054g, 9.507g and 6.373g respectively. However, total non essential amino acids in the berried females, females and males are 15.638g, 11.866g and 8.234g respectively.[14] Chen and Zhang (2007) reported that total amino acids in Chinese mitten crab (*E. sinensis*) was 20.9 mg/g.[5] Kucukgulmez and Celik (2008) observed 7.24 to 7.83 g/ 100 g of essential amino acids and 9.276 to 8.713 g/100 g of non essential amino acids in the blue crab (*C.sapidus*).[15] Yalcin Kaya *et al.* (2009) were recorded 7.458% of total essential amino acids and 11.381% of non essential amino acids in warty crab (*Eriphis verrucosa*).[16] Manivannan *et al.* (2010) reported that the total essential and non essential amino acids were 55.54% and 42.64% when fed with *Acetes* sp. whereas it was 54.55% and 40.17% in clam meat fed crabs of *S. tranquebarica.* The total essential amino acids in *C.natator* [11]) and *P.vigil* [12] are 25.409g and 34.41g respectively. The limiting amino acids are often different

among different species. For example, sulphur containing amino acids (methionine and cystine) were reported as the limiting amino acids in Chinese mitten crab meat.[17] However, tryptophan appears to be the limiting amino acid in the meat of both the blue swimming crab and the green crab.[6] Methionine and histamine were found to be the first and second limiting amino acids in shrimps [18] Histidine was limiting amino acid in *P.sanguinolentus* [19] and *S. tranquebarica.*[20] In the present study serine, valine, aspargine and alanine are limiting amino acids.

Several studies suggest that these amino acids may participate in osmoregulation, and in the control of cellular volume.[21, 22, 23] Besides free glutamic acid and aspartic acid, free aromatic amino acids such as L-phenylalanine and L-tyrosine also play an important role in enhancing savory or maim taste at their sub threshold concentrations in the presence of salt and free acidic amino acids.[24]

Essential amino acids (EAA) are widely used for evaluation of protein quality[17] (Chen *et al*., 2007).[5] Naczk *et al.* (2007) reported that the green crab (*C. maenas*) meat was well balanced in its amino acid composition which is comparable with blue swimming crab *P. trituberculatus*[25] and Chinese mitten crab.[17] There are 9 essential amino acids reported in the present study. Each amino acid has its own physiological role once it is consumed. Histidine is one of the major contributors in the crab *C.lucifera* irrespective of the sex. However, among different sexes, histidine is maximum in berried females (2.469 g) than females (1.981 g) and males (1.128 g). This is in agreement with the result of[26] Siva Sankar and Yogamoorthi (2012) in *Ocypoda platytarsis*. Histidine was already reported in *E.sinensis*[17], *S. tranquebarica*[16], *C. natator*[11], *P.vigil*[12, 30] and *C.lophus.*[28] However, it was reported in minimum quantity in *S. tranquebarica*[20] and *P. sanguinolentus.*[19] Histidine is an indispensable amino acid involved in many metabolic functions including the production of histamines, which take part in allergic and inflammatory reactions. It plays a very important role in maintaining the osmoregulatory process and is related to energy production or is used in other metabolic pathways during certain emergencies harsh conditions.[29]

Isoleucine is one of the major contributors in the crab, *C.lucifera.* Isoleucine is maximum in berried females (2.018g) than females (1.948g) and males (1.569g) of *C.lucifera.* Isoleucine was already reported in *E.sinensis* [17], *P. sanguinolentus* [19], *S.tranquebarica* [16, 20] and *C. lophus.*[28] Isoleucine is needed for the heamoglobin formation, stabilizes and regulates blood

sugar and energy levels. It is valuable for athletes because it aids in the healing and repair of muscle tissue, skin and bones. Isoleucine is found to be deficient in people suffering from certain mental and physical disorders. Leucine is maximum in berried females (0.968 g) that followed by females (0.708 g) and males (0.381 g) of *C.lucifera*. Leucine was already reported in various crabs[11, 12 16, 17, 19, 20, 28] and shrimps.[18] Leucine with Isoleucine and Valine is to promote the healing of muscle tissue, skin, and bones. Leucine is recommended for those recovering from surgery, lowers blood sugar levels and aids in increasing growth hormone production. Leucine is a ketone-producing amino acid. It could be transformed into acetyl-CoA and acetyl-acetic acid, which are important intermediates in carbohydrate and lipid metabolism.[30] Lysine is maximum in berried females (0.468 g) than females (0.362 g) and males (0.281 g) of *C.lucifera.* Lysine was already reported in various crabs[11, 12 16, 17, 19, 20, 28] and shrimps.[18] Lysine ensures adequate calcium absorption and maintains a proper nitrogen balance in adults and helps to form collagen (which makes up cartilage and connective tissue). It also aids in the production of antibodies which have the ability to fight cold sores and herpes outbreaks. It also lowers high serum triglyceride levels.

Methionine is one of the major contributors in the crab *C.lucifera.* Methionine is maximum in berried females (2.313 g) followed by females (1.648 g) and males (1.056 g) of *C.lucifera*. Methionine is maximum in the males of *P.pelagicus.*[31] However, methionine contribution was moderate in *S.tranquebarica* [20], *E.sinensis* [14], *C.natator* [11], *P.vigil* [12] and shrimps.[18] It was and totally absent in *P.sanguinolentus.*[19] Methionine is a powerful anti-oxidant and a good source of sulfur, which prevents disorders of the hair, skin, and nails; assists the breakdown of fats, thus helping to prevent a buildup of fat in the liver and arteries that might obstruct blood flow to the brain, heart, and kidneys. It helps to detoxify harmful agents such as lead and other heavy metals; helps diminish muscle weakness; prevents brittle hair; protects against the effects of radiation; beneficial for women who take oral contraceptives because it promotes the excretion of estrogen; reduces the level of histamine in the body which can cause the brain to relay wrong messages; helpful to individuals suffering from schizophrenia. Phenylalanine is maximum in berried females (0.516 g) than females (0.408 g) and males (0.317 g) of *C.lucifera.* Phenylalanine was already reported in various crabs [11, 12 16, 17, 19, 20] and shrimps.[18] Phenylalanine is used by the brain to produce norepinephrine, a chemical that transmits signals between nerve cells in the brain; promotes alertness and vitality; elevates mood; decreases pain; aids memory and learning; used to treat arthritis, depression, menstrual cramps, migraines, obesity, Parkinson's disease, and schizophrenia.

Threonine is maximum in berried females (0.816 g) followed by females (0.619g) and males (0.518 g) of *C.lucifera*. Threonine was already reported in various crabs [11, 12 16, 17, 19, 20] and shrimps.[18] Threonine helps to maintain proper protein balance in the body; important for the formation of collagen, elastin and tooth enamel; aids liver and lipotropic function when combined with aspartic acid and methionine; prevents the buildup of fat in the liver; assists metabolism and assimilation.

Tryptophan is one of the major contributors in the crab *C.lucifera.* In individual contribution tryptophan is maximum in berried females (2.168 g) than females (1.618 g) and males (1.002 g). Tryptophan was already reported in *E. sinensis* [14], *C.natator* [11], *P.vigil* [12] and totally absent in *P.sanguinolentus* [19], *S.tranquebarica* [16, 20] and shrimps.[18]Tryptophan is a natural relaxant, helps alleviate insomnia by inducing normal sleep; reduces anxiety and depression and stabilizes mood; helps in the treatment of migraine headaches; helps the immune system function properly; aids in weight control by reducing appetite; enhances the release of growth hormones; helps to control hyperactivity in children. The amino acid tryptophan plays an important role in the brain as a precursor of the neurotransmitter, serotonin, which has a major effect on the feeding behavior of animals.[32]

Valine contribution is minimum when compared to other amino acids in *C.lucifera*. In individual contribution valine is maximum in berried females (0.318 g) than females (0.215 g) and males (0.121 g). Valine was already reported in various crabs[11, 12 16, 17, 19, 20] and shrimps.[18] Valine is needed for muscle metabolism and coordination, tissue repair, and for the maintenance of proper nitrogen balance in the body; used as an energy source by muscle tissue; helpful in treating liver and gallbladder disease; promotes mental vigor and calm emotions. Valine is involved in many metabolic pathways and is considered indispensable for protein synthesis and optimal growth.[33]

Alanine contribution is minimum when compared to other amino acids in *C.lucifera*. In individual contribution alanine is maximum in berried females (0.250 g) than females (0.145 g) and males (0.038 g) in *C.lucifera.* Alanine was already reported in various crabs[11, 12 16, 17, 19, 20] and shrimps.[18, 34] Alanine is a non essential amino acid that plays a major role in the transfer of nitrogen from peripheral tissue to the liver; aids in the metabolism of glucose, a simple carbohydrate that the body uses for energy; guards against the buildup of toxic substances that are released into muscle cells when muscle protein is broken down quickly to meet energy needs, such as what happens with aerobic exercise; strengthens the immune

system by producing antibodies. Arginine is maximum in berried females (1.468 g) than females (0.953 g) and males (0.796 g) of *C.lucifera.* Arginine contribution was already reported to be maximum in various crabs[11, 12 16, 17, 19, 20, 31] and shrimps.[18] Arginine is considered "The Natural Viagra" by increasing blood flow to the penis; retards the growth of tumors and cancer by enhancing the immune system; increases the size and activity of the thymus gland, which manufactures T cells, crucial components of the immune system; aids in liver detoxification by neutralizing ammonia; reduces the effects of chronic alcohol toxicity; used in treating sterility in men by increasing sperm count; aids in weight loss because it facilitates an increase in muscle mass and a reduction of body fat; assists the release of growth hormones, which is crucial for "optimal" muscle growth and tissue repair; is a major component of collagen which is good for arthritis and connective tissue disorders; aids in stimulating the pancreas to release insulin.

Aspartic acid is maximum in berried females (2.248 g) than females (1.968 g) and males (1.653 g) of *C.lucifera.* Aspartic acid was already reported in various crabs [11, 12 16, 17, 19, 20] and shrimps.[18] Aspartic acid increases stamina and is good for chronic fatigue and depression; rejuvenates cellular activity, cell formation and metabolism, which gives a person younger looking appearance; protects the liver by aiding the expulsion of ammonia; combines with other amino acids to form molecules that absorb toxins and remove them from the bloodstream; helps to facilitate the movement of certain minerals across the intestinal lining and into the blood and cells; aids the function of RNA and DNA, which are carriers of genetic information. Aspargine is maximum in berried females (0.250 g) than females (0.148 g) and males (0.106 g) of *C.lucifera.* Aspargine was already reported in various crabs [16, 20] and shrimps.[18]

Cystine is maximum in berried females (2.510 g) than females (1.998 g) and the males (0.898g) of *C.lucifera.* Cystine was already reported in various crabs [11, 12 16, 17, 19, 20] and shrimps.[18] Cystine functions as a powerful anti-oxidant in detoxifying harmful toxins; protects the body from radiation damage; protects the liver and brain from damage due to alcohol, drugs, and toxic compounds found in cigarette smoke; has been used to treat rheumatoid arthritis and hardening of the arteries; promotes the recovery from severe burns and surgery; promotes the burning of fat and the building of muscle; slows down the ageing process.

Glutamic acid contribution is maximum when compared to other amino acids in *C.lucifera*. It is maximum in berried females (4.235 g) than females (3.620 g) and males (2.225 g). Glutamic acid contribution was already reported to be maximum in various crabs[11, 12 16, 17, 19, 20, 28] and shrimps.[18] Glutamic acid is an excitatory neurotransmitter for the central nervous system, the brain and spinal cord; important in the metabolism of sugars and fats; aids in the transportation of potassium into the spinal fluid; acts as fuel for the brain; helps correct personality disorders, and is used in the treatment of epilepsy, mental retardation, muscular dystrophy, and ulcers. Glutamine is maximum in berried females (0.515 g) than females (0.413 g) and males (0.360 g) of *C.lucifera*. As per the literature glutamine is not common amino acid in crabs and shrimps. It is reported in crab *C.lophus* [28] and the prawn *M. vollenhovenii*.[35] Glutamine is usually found in muscles; helps build and maintain muscle tissue; helps to prevent muscle wasting that can accompany prolonged bed rest or diseases such as cancer and AIDS. Glycine is maximum in berried females (0.615 g) than females (0.518 g) and males (0.390 g) of *C.lucifera*. Glysine was already familiar amino acids in crabs [11, 12 16, 17, 19, 20, 28] and shrimps.[18, 34]Glycine retards muscle degeneration; improves glycogen storage, thus freeing up glucose for energy needs; promotes a healthy prostate, central nervous system, and immune system; useful for repairing damaged tissue and promotes healing.

Proline is maximum in berried females (2.014 g) than females (0.986 g) and males (0.815 g) of *C.lucifera*. Proline was already reported in crabs [11, 12, 16, 19, 28] and shrimps.[18, 34] Proline improves skin texture by aiding the production of collagen and reducing the loss of collagen through the ageing process; helps in the healing of cartilage and the strengthening of joints, tendons, and heart muscle; works with Vitamin C to promote healthy connective tissues. Serine is minimum when compared to other amino acids in C.*lucifera*. It is maximum in berried females (0.218 g) than females (0.125 g) and males (0.097 g) of *C.lucifera*. Serine was already reported in crabs[11, 12, 16, 28] and shrimps.[18] Serine is needed for the proper metabolism of fats and fatty acids, the growth of muscle, and the maintenance of a healthy immune system; is a component of the protective myelin sheaths that cover nerve fibers; is important in RNA & DNA function and cell formation; aids in the production of immunoglobulins and antibodies.

Tyrosine is maximum in berried females (1.315 g) than females (0.992 g) and males (0.856 g) of *C.lucifera*. Tyrosine was already reported in crabs[11, 12 16, 17, 19, 20, 28] and shrimps.[18]

Tyrosine is important for overall metabolism; is a precursor of adrenaline, nor epinephrine, and dopamine, which regulate mood and stimulates metabolism and the nervous system; acts as a mood elevator, suppresses the appetite, and helps to reduce body fat; aids in the production of melanin (the pigment responsible for hair and skin colour) and in the functions of the adrenal, thyroid, and pituitary glands; has been used to help chronic fatigue, narcolepsy, anxiety, depression, low sex drive, allergies and headaches. Proline showed an important adjustment necessary for osmoregulation, following changes in osmotic stress. The ratio of EAA to NEAA in the present study is 0.781. This value is almost similar to the value obtained by[5, 36] Kucukgulmez and Celik (2008) and Iwasaki and Harada (1985). From the study it could be confirmed that amino acids contributed maximum in berried females followed by females and males.

REFERENCES

1. Adeyeye EI. Determination of chemical composition of the nutritionally valuable parts of male female common West African freshwater crab. Sudanautes africanus africanus. Int.J. Food Sci.Nutr., 2002; 52(3): 189-196.
2. Adeyeye EI, Kenni AM. The Relationship in the amino acid of the whole body, flesh and exoskeleton of common West African fresh water male crab Sudananautes africanus africanus.Pakistan J.Nut., 2008.7(5):748-752.
3. Celik K, Tureli C, Celik M, Yanar Y, Erdem U, Kucukgulmez A. Fatty acid composition of the blue crab (Callinectus sapidus Rathbun, 1896) in th north eastern Mediterrean. Food Chem., 2004; 88: 271-273.
4. Gokoglu N, Yerlikaya P. Determination of proximate composition and mineral contents of blue crab (Callinectus sapidus) and swim crab (Portuns pelagicus) caught off the Gulf of the antalya. Food Chem., 2003; 80: 495-498.
5. Kucukgulmez A, Celik M. Amino acid composition of blue crab (Callinectes sapidus) from the North Eastern Mediterranean Sea. J.Appl. Biolog.Sci., 2008; 2(1): 39-42.
6. Naczk M, Williams J, Brennam K, Liyanaspathiramma, Shahidi F. Compositional characteristics of green crab (Carcinus sapidus). Food Chem., 2007; 88: 429-434.
7. Zimmer Faust RK. The relationship between chemoreception and faraging behaviour in crustaceans. Linnol. Ocenogr., 1998; 34: 1367-1374.
8. Standsby ME. Proximate compostion of fish. In: Heen,M. E and R.Kreuzer (Ed.). Fish nutrition.fishimng News (Book)Ltd.,London. 1962; 55-60.

9. Baker DH, Han Y. Ideal amino acid profile for chicks during the first three weeks post hatching. J .Poultry Sci., 1994; 73: 1441-1447.
10. Prasad PN, Neelakandan B. Proximate and essential amino acid composition in edible crab Scylla serrata. Comp. Physiol. Ecol., 1989; 14(1): 34-37.
11. Sivasubramanian C. Nutritional status of commercially important crab Charybdis natator (Herbst, 1794).Ph.D.Thesis, Kuppam University, India, 2011; 1-132.
12. Ravichandran S. Studies on the nutritional quality of edible crab Podophthalmus vigil (Fabricius,1798).Ph.D Thesis, Kuppam University, India, 2011; 160.
13. FAO/WHO/UNU. Expert consultation. Energy and protein requirements. Technical report series 724. World Health Organization, Geneva: 1985.
14. Chen HP, Zhang M, Shrestha S. Compositional characteristics amd nutritional quality of Chinese mitten crab (Eriocheir sinensis). Food Chem., 2007; 103: 1343-1349.
15. Yalcin Kaya, Huiya Turan, Emin Endren M. Determination of nutritional quality of warty crab (Eriphyis verrucosa Forskal, 1775).J. Ani. Vet. Adv., 2009; 8(1): 120-124.
16. Manivannan K, Sudhakar M, Murugesan R, Soundrapandian P. Effect of feed on the Biochemical composition of commercially important mud crab Scylla tranquebarica (Fabricius, 1798). Int. J. Anim. Vert. Adv., 2010; 2(1): 16-20.
17. Chen HP, Zhang M, Shrestha S. Compositional characteristics amd nutritional quality of Chinese mitten crab (Eriocheir sinensis). Food Chem., 2007; 103: 1343-1349.
18. Yannar Y, Celik M. Seasonal amino acid profiles and mineral contents of green tiger shrimp (Penaeus seminsulcatus De Haan, 1844) and speckled shrimp (Metapenaeus monoceros, Fabricius, 1789) from the eastern Mediterrranean. Food Chem., 2006; 94: 33-36.
19. Sudhakar M, Manivannan K, Soundarapandian P. Nutritive value of hard and soft shell crabs of Portunus sanguinolentus (Herbst). Internat. J. Ani. Vet.Adv., 2009; 1(2): 44-48.
20. Thirunavukkarasu N. Biology, nutritional evaluation and utilization of mud crab Scylla tranquebarica (Fabricius, 1798). Ph.D. Thesis, Annamalai University, India, 2005; 126.
21. Gilles R. Osmoregulatory process in molluscs and crustacean form media with fluctuating salinity regime. Biol. fisiol Anim., 1982; 6: 1-36.
22. Chang E, Oconnor JD. Metabolism and transport of carbohydrates and lipids; In. mantel, L.H.(Ed.). The biology of Crustacea. Internal Anatomy and Physiology regulation, Academic Press, New York, 1983; (5): 263-287.

23. Schein V, Wache Y, Etgens R, Kucharski LK, Wormhoudt AV, Da silva R.S.M. Effect of hyperosmotic shock on phosphoenolpyruvate carboxykinase gene expression and glucogenic activity in the crab muscle. FEBS.Lett., 2004; 561: 202-206.
24. Lioe HN, Apryantono A, Takara K, Wada K, Naoki H, Yasuda M. Low molecular weight compounds responsible for savory taste of Indonesian soy sauce. J. Agricul. Food Chem., 2004; 52(19): 5950-5956.
25. Su XR, Li TW, Oyang F, Li P. Study on the nutritive composition of Portunus trituberculatus.Acta Nutrimenta Sinica, 1996; 18(3): 342-346.
26. Siva Sankar R, Yogamoorthi A. Free amino acid composition in hemolymph and muscle of the ghost crab, Ocypode platytarsis. Pakistan J. Biol. Sci., 2012; 15: 490-495.
27. Sudhakar M, Raja K, Ananthan G, Sampathkumar P. Compositional charecteristics and nutritional quality of Podopthalamus vigil (Fabricius). Asian J.Biol. Sci., 2011; 4(2): 166-174.
28. Kathirvel K, Eswar A, Manikandarajan T, Ramamoorthy K, Sankar G, Anbarasu R. Proximate composition, amino acid, fatty acid and mineral analysis of box crab, Calappa lophus (Herbst, 1782) from Parangipettai, Southeast Coast of India. J. Environ. Sci. Toxicol. Food Technol., 2014; 8(5): 50-57.
29. Abe H, Ohmama S, Effect of starvation and sea-water acclimation on the concentration of free l-histidine and related dipeptides in the muscle of eel, rainbow trout and Japanese dace. Compar. Bioch. Physiol. Part B: Comp. Biochem., 1987; 88(2): 507–511.
30. Shen T, Wang JY, Biochemistry [M], Higher Education Publisher, 1990; 67–86.
31. Hala Ali Abdel-Salam. Amino acid composition in the muscles of male and female commercially Important crustaceans from Egyptian and Saudi Arabia Coasts. American J.BioSci., 2014; 2(2): 70-78.
32. Mullen BJ, Martin RJ, The effect of dietary fat on diet selection may involve entral serotonin. Am.J.Physiol.Regul. Integr. Comp.Physiol., 1992; 263: 559-563.
33. Wilson JA. 'Scientific Uncertainty, Complex Systems, and the Design of Common-pool Institutions.' In The Drama of the Commons, National Research Council, Committee on the Human Dimensions of Global Change, eds E. Ostrom, T. Dietz, N. Dolšak, P. C. Stern, S. Stonich and E. Weber, Washington, DC: National Academy: 2002; 327–59. Press.
34. Takada K, Aoki T, Kunisaki N. Proximate composition, free amino acid, fatty acid, mineral and cholesterol contents in imported frozen shrimps. Nippon Suisan Gakkaishi Bull. Jap. Soc. Sci. Fish., 1998; 54(12): 2173-2179.

35. Ehigiator FAR, Oterai EA. Chemical composition and amino acid profile of a Caridean prawn (Macrobrachium vollenhovenii) from Ovia river and tropical periwinkle (Tympanotonus fuscatus) from Benin river, Edo state, Nigeria. Int. J. Res. & Rev. in App. Sci., 2012; 11(1): 162 – 167.
36. Iwasaki M, Harada. Proximate and amino acid composition of the roe and muscle of selected marine species. J. Food Sci., 1985; 50(6): 1585–1587.