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# NUTRIENT COMPOSITION OF FRESH WATER CLAMS (*Galatea paradoxa,* BORN 1778) FROM RIVER BENUE, BENUE STATE-NIGERIA

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***ABSTRACT***

***An investigation of the nutritional benefits of freshwater clams was undertaken from River Benue, Nigeria. The method of data collection was the purposive sampling of four (4) locations along the river. The results indicated that freshwater Clams had a crude protein content of 30.63%. Ash content ,22.74%, fat,4.72% and moisture 5.27%. Mineral contents ranged from 2.3 ± 0.02 to 166.2 ± 0.14 ($Mg/kg^{-1}$); with calcium recorded in higher content of 166.2 ± 0.14($Mg/kg^{-1}$) while Cu content was recorded the lowest (2.3 ± 0.02 $Mg/kg^{-1}$) mineral contents from G. paradoxa. The result of this finding also showed other mineral contents in fresh water clam in the study area, these include: Sodium 150.0 ± 0.21 $Mg/kg^{-1}$, followed by Magnesium which content about 139.0 ± 0.07 $Mg/kg^{-1}$, Iron content 15.0 ± 0.04 $Mg/kg^{-1}$ and Potassium content 14.2 ± 0.03 $Mg/kg^{-1}$ while Zinc content 9.9 ± 0.03 $Mg/kg^{-1}$. The vitamins content ranged from 0.4 ± 0.01(mg/g) to 121.5 ± 2.12 (mg/g). Fresh water clam (Galatea paradoxa) from the study area hadt vitamin D with the highest content value of 121.5 ± 2.12 (mg/g), this was followed by vitamin C whose content was 18 ± 0.04 mg/g, vitamin K content 13.9 ± 0.02 (mg/g), vitamin A content 8.5 ± 0.74 mg/g, vitamin $B_6$ content 5.1± 0.02 mg/g, vitamin E content 1.1± 0.02 mg/g while vitamin $B_{12}$ content 0.4 ± 0.01mg/g.It is therefore suggested that sensitization be carried out to promote their consumption among the populace of Benue State for their nutritive values.***

**Keywords:**

***Correct Citation of this Publication***

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## INTRODUCTION

Clams are heterogeneous class of freshwater pearl mussels and other freshwater bivalves, as well as marine bivalves (Ojiako *et al.,* 2018). Large shells are up to 180 mm in length. Clam, as a general term covers all bivalve mollusks. The majority of species of bivalve mollusks live in the sea, but in addition, a number of different families live in freshwater (and in some cases also in brackish water). These families belong to two different evolutionary lineages (freshwater mussels and freshwater clams), and the two groups are not closely related. Freshwater bivalves have a simple morphology that varies among taxa and are distributed around most regions of the world. Freshwater bivalves live in many types of habitat, ranging from small ditches and ponds, to lakes, canals, rivers, and swamps. Putri *et al.* (2018). reported that *Galatea paradoxa* has prospective nutrient contents and that it is an important food source for humans. It is well known that clams are a good source of some important nutrients such as proteins, carbohydrates, steroids, minerals, especially iron,

zinc, and copper, and vitamins such as vitaminB-12 (Ueta *et al.,* 2011; Elkhodary *et al.,* 2018). Mussels are nutritionally rich.Fresh water clams material has a protein content of 7.37 grams and iron of 31.02 mg (Anisa, 2013). Protein in freshwater clams is one of the nutrients Macro consisting of more complete amino acids than vegetable proteins (Muchtadi, 1989). Freshwater clams are used by the community as food and as a source of animal protein, usually available in the freshest form ready to be cooked and processed (Anisa, 2013). Bivalve can provide a rich source of protein with high biological value; as the cheapest source of animal protein consumed by the average Nigerian, it accounts for about 50% of the total protein intake (Espana *et al.,* 2007). Their protein content is superior to that found in fish with fins (Venugopal *et* al., 2017). Protein plays a very role in growth and maintenance of vital bodily functions (Nunes *et* al., 2008). The protein in clams is easy to digest, so the body gets the full benefit. Protein plays multiple roles in overall health of man, building muscle, boosting the immune system, strengthening bone, and healing injuries. Just three ounces of clams provides 40% of the daily protein needed by the average person. Fresh water clams generally store carbohydrates in large amounts during their growing season and use them over the rest of the year.Fresh water clams is a reliable source of fats especially saturated one and have a high content of the omega-3 fatty acids (Elkhodary *et al.,* 2018). Omega-6 and omega-9 fatty acids are most abundant in terrestrial food sources while omega-3 fatty acids are most abundant in aquatic food sources (Ojiako *et al.,* 2018). Long chain omega-3 fatty acids occur in terrestrial animals only at very low levels. In addition, cholesterol levels are higher in terrestrial animals than in aquatic animals. Clams consumption could therefore result in lower amounts of cholesterol and triacylglycerol's (TAG) in the blood of consumers.

The shellfish have cholesterol concentrations of less than 80 milligrams per 100 grams (edible portion); which, can be consumed by people trying to limit their dietary cholesterol intake (Shetty *et al.,* 2013); Lipid content of bivalves ranged from 3.04-5.23% with high variability. Despite considerable variations between bivalve species, research has shown that fatty acids profile of bivalve mollusk is particularly interesting, as the n-3long chain Polyunsaturated Fatty Acids (PUFA) which are essential nutrients are generally predominant (Belitz *et al*., 2004; Silva and Batista, 2008). There is a strong evidence to suggest protective effect of n-3 PUFA on the risk of cardiovascular disease and stroke (Kris-Etherton *et al*., 2002; Hamed *et al*., 2015). Fresh water clam is a good source for essential minerals (such as Selenium, Calcium, Iron and Phosphorus among others) to the population of the Niger Delta who depend on them as their main delicacies (Ukwo *et al*., 2019). The nutritional characteristics of bivalves vary among species and between individuals of same species. These variations may be attributed to the effects of environment and species as well as other intrinsic factors (Osibona *et al*., 2009). There is high iron and zinc content as reported by Prihartini (1999). The following is the result of laboratory tests on freshwater clams.The edible portions of bivalve shellfish are rich in macro minerals ( Venugopal *et al.,* 2017). Macro minerals such as Na, K, Mg and P were detected in significant level in bivalve shellfish (freshwater clam.

Sodium and Potassium are important in osmo-regulation, balance and membrane potential of cells as well as transport across membranes. Sodium and potassium are also needed to activate amylase, an enzyme which is important in glucose metabolism in human body (Belitz *et al*., 2004). Calcium is a major component in bones and constitutes over 95% of bivalve shell in the form Calcium carbonate. Calcium is involved in structure of muscle system and controls essential processes like muscle contraction, blood clothing and actively involves in brain cells and their growth (Belitz *et al*., 2004). Magnesium just as calcium formed a greater part of human bones as well as prosthetic group in enzyme that hydrolysis and transfer phosphate groups, consequently, Mg is essential in energy requiring biological functions such as membrane transport, generation and transmission of impulses, contraction of muscles and oxidative phosphorylation (Ukwo *et al*., 2019). Phosphorus, the main structural element found in shellfish is usually found equal amount with

sulphur. Bivalve shellfish was found to be rich in micro mineral such as Zinc, Copper, Manganese Iron and Selenium. Trace elements play significant role of functional elements in several metallo enzymes, which possess catalytic functions in living organisms. As observed, bivalve mollusk shellfish in this study were rich sources of trace element when consumed. Variations in trace element content within species could be attributed to factors such as habitat of the organisms, dietary pattern, other ecological interactions and overall body size of the bivalve species. Copper is a component of a number of enzymes involve in glucose metabolism, synthesis of haemoglobin, connective tissue and phosphor lipid. Several authors have reported higher concentration of Copper in shellfish from Niger Delta (Celik and Oehlenschlager, 2004). Zinc is an essential element for human and its presence in bivalve species analyzed is in agreement that Zinc is always presence in shellfish and that the concentration presents in bivalve is usually higher (Celik and Oehlenschlager, 2004). The important function of zinc is based on its role as an integral part of a number of metallo enzymes and as a catalyst in regulating the activity of specific Zinc-dependent enzyme.

## MATERIALS AND METHODS

The study was carried out in the University of Agriculture Makurdi, Nigeria, college of Animal science, department of Animal nutrition laboratory, located between latitude $7.732^0$N and longitude $8.5391^0$E. University Agriculture lies in guinea savanna with an annual rainfall of 1000 mm – 1500 mm with two seasons, the dry and wet seasons. Site selection was achieved through a preliminary inspection of the sites for easy access to the snails. These sites include; site A (Wadata market), site B (modern market), site C (Wurukum market), and site D (North Bank market).

### Data Collection

The study was carried out between the months of March to July, 2021. Reconnaissance visit was made to identify possible sources of *G. paradoxa* along River Benue in Makurdi. Purposive sampling technique was used to source for *G. paradoxa;* The samples were labeled and transported in perforated polythene bags (Uthpala *et al.,* 2010). Proximate experimental analysis was done at college of Animal Science in Department of Animal Nutrition laboratory; while the minerals and vitamin analysis was carried out in College of Agronomy, Department of soil science Laboratory, all in Joseph Sarwuan Tarka University, Makurdi.

### Data Analysis

Data collected was subjected to statistical analysis using descriptive statistic (such as mean, charts, standard deviation among others). Results are presented in tables and graphs for understanding and for decision making.

## RESULTS

Figure 2 shows the result on proximate analysis of fresh water clams (*Galatea paradoxa)* from river Benue in Makurdi metropolis, Benue state-Nigeria. Based on the result of this finding, crude protein was recorded as the highest proximate contents in fresh water clam, this had about 30.63%; this was followed by Ash content which about 22.74% and moisture content was recorded with an estimated value of 5.27%; while Fat/oil had 4.72&%.

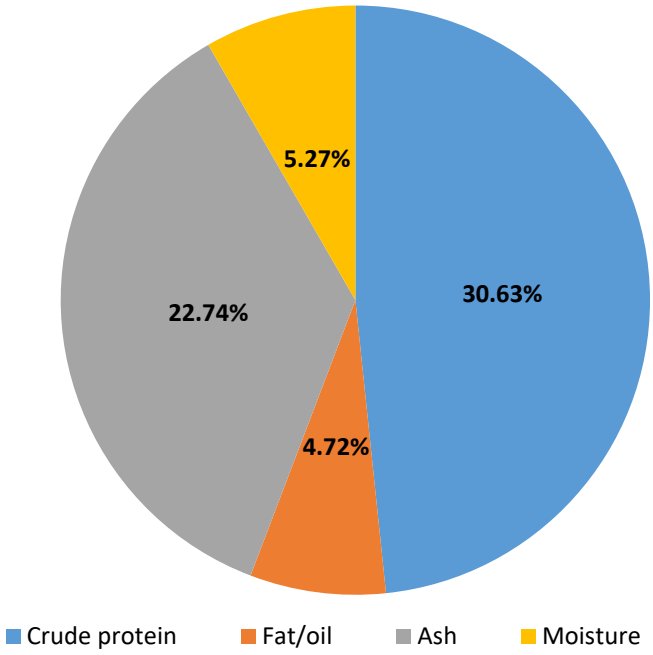


**Figure 1: Result on Proximate Analysis of Fresh Water Clams (*Galatea paradoxa)* from River Benue-Nigeria**
Source: Laboratory work, 2021

**The Mineral Composition of *Galatea paradoxa* from River Benue-Nigeria**

Table 1 present the result of mineral contents of fresh water clam sourced from river Benue, Makurdi metropolis in Benue state Nigeria. Based on the result recorded, mineral contents ranged from 2.3 ± 0.02 to 166.2 ± 0.14 (Mg/kg$^{-1}$); with calcium recorded in higher content of 166.2 ± 0.14(Mg/kg$^{-1}$) while Cu content was recorded the lowest (2.3 ± 0.02 Mg/kg$^{-1}$) mineral contents from G. *paradoxa.* The result of this finding also showed other mineral contents in fresh water clam in the study area, these include: Sodium 150.0 ± 0.21 Mg/kg$^{-1}$, followed by Magnesium which content about 139.0 ± 0.07 Mg/kg$^{-1}$, Iron content 15.0 ± 0.04 Mg/kg$^{-1}$ and Potassium content 14.2 ± 0.03 Mg/kg$^{-1}$ while Zinc content 9.9 ± 0.03 Mg/kg$^{-}$

**Table 1: Mineral Contents of Fresh Water Clams (*Galatea paradoxa*) in the Study Area**

| Mineral elements | Mean ± std. deviation (Mg/kg$^{-1}$ DM) |
|---|---|
| Calcium | 166.2 ± 0.14 |
| Sodium | 150.0 ± 0.21 |
| Potassium | 14.2 ± 0.03 |
| Copper | 2.3 ± 0.02 |
| Magnesium | 139.0 ± 0.07 |
| Iron | 15.0 ± 0.04 |
| Zinc | 9.9 ± 0.03 |

*Source: Laboratory work, (2021)*

**The Vitamins Composition of *Galatea paradoxa* from River Benue-Nigeria**

The result of vitamins composition of *Galatea paradoxa* from river Benue in Makurdi-Nigeria is presented on Table 2. Based on the result of this

finding, it showed that G. *paradoxa* content vitamins A, B6, B12, C, D, E and K respectively. The vitamins content ranged from 0.4 ± 0.01(mg/g) to 121.5 ± 2.12 (mg/g). Fresh water clam (*Galatea paradoxa)* from the study area content vitamin D with the highest content value of 121.5 ± 2.12 (mg/g), this was followed by vitamin C which content 18 ± 0.04 mg/g, vitamin K content 13.9 ± 0.02 (mg/g), vitamin A content 8.5 ± 0.74 mg/g, vitamin $B_6$ content 5.1± 0.02 mg/g, vitamin E content 1.1± 0.02 mg/g while vitamin $B_{12}$ content 0.4 ± 0.01mg/g.

**2: Result on Vitamins of Fresh Water Clams in the Study Area**

| Vitamins | Mean value ± std. deviation (mg/g) |
|---|---|
| A | 8.5 ± 0.74 |
| $B_6$ | 5.1 ± 0.02 |
| $B_{12}$ | 0.4 ± 0.01 |
| C | 18 ± 0.04 |
| D | 121.5 ± 2.12 |
| E | 1.1 ± 0.02 |
| K | 13.9 ± 0.02 |

*Source: Laboratory work, (2021)*

## DISCUSSION

### The proximate composition of the clams (*Galatea paradoxa*)

The result of this finding on proximate composition revealed that, crude protein was the highest (30.63%) proximate contents in fresh water clam. This result implied that fresh water clam is a very good source of protein for human being. The protein content of 30.63% in fresh water clams in the study area was more than the protein content (7.37 %) reported by Anisa (2013). Protein in freshwater clams is one of the nutrients consisting of more complete amino acids than vegetable proteins (Muchtadi, 1989). Freshwater clams are used by the community as food and as a source of animal protein, usually available in the freshest form ready to be cooked and processed (Anisa, 2013). Bivalve can provide a rich source of protein with high biological value; as the cheapest source of animal protein consumed by the average Nigerian, it accounts for about 50% of the total protein intake (Espana *et al.*, 2007). Their protein content is superior to that found in fish with fins (Venugopal *et al*., 2017). Protein plays a very role in growth and maintenance of vital bodily functions (Nunes *et al.*, 2008). The protein in clams is easy to digest, so the body gets the full benefit. Protein plays multiple roles in overall health of man, building muscle, boosting the immune system, strengthening bone, and healing injuries. Just three ounces of clams provides 40% of the daily protein needed by the average person.

Result on Fat/oil revealed 4.72% content in fresh water clam in the study area; this result is in line with the report of Elkhodary *et al.* (2018), who reported that, fresh water clams is a reliable source of fats especially saturated one and have a high content of the omega-3 fatty acids. Omega-6 and omega-9 fatty acids are most abundant in terrestrial food sources while omega-3 fatty acids are most abundant in aquatic food sources (Ojiako *et al.,* 2018). Long chain omega-3 fatty acids occur in terrestrial animals only at very low levels. In addition, cholesterol levels are higher in terrestrial animals than in aquatic animals. Clams consumption could therefore result in lower amounts of cholesterol and triacylglycerol's (TAG) in the blood of consumers. There is a strong evidence to suggest protective effect of n-3long chain Polyunsaturated Fatty Acids on the risk of cardiovascular disease and stroke (Hamed *et al*., 2015). Omega-3 fatty acids which are major constituents of aquatic animals have several physiological effects, such as protecting against coronary heart disease (Singleton *et al*., 2000). They keep your heartbeat regular, lower blood pressure, and help blood vessels work as they should. Mussels are rich in the marine Omega-3s, EPA and DHA. The shellfish have cholesterol concentrations of less than 80

milligrams per 100 grams (edible portion); which, can be consumed by people trying to limit their dietary cholesterol intake (Shetty *et al.*, 2013); Lipid content of bivalves ranged from 3.04-5.23% with high variability.

Moisture content was recorded with an estimated value of 5.27%. Knowledge of the moisture content of food stuff, serves as a useful index of their keeping qualities and susceptibility to fungi infection. Heat treatment significantly reduced moisture content. Ash content recorded was about 22.74% from this study. The ash content represents the mineral content and is generally known that the mineral content varies with the type of soil or environment.

**The Mineral Composition of *Galatea paradoxa* from River Benue Nigeria**

The result recorded on mineral contents of freshwater clam revealed that fresh water clam in the study area content macro and micro minerals composition which include: Calcium, Potassium, Magnesium, Iron, Zinc, Copper and Sodium. This finding is in line with the report of Ukwo *et al*. (2019), who reported that, fresh water clam is a good source for essential minerals (such as Calcium, Iron and Phosphorus among others) to the population of the Niger Delta who depend on them as their main delicacies. The edible portions of bivalve shellfish are rich in macro minerals (Venugopal *et al*., 2017). Macro minerals such as Na, K, Mg and P were detected in significant level in bivalve shellfish (freshwater clam) (Sunday *et al*., 2020).

Prihartini (1999) reported that, there is high iron and zinc content in clams; while the result of this finding contradicted the report of Prihartini (1999); Iron and Zinc had values of 15.0 ± 0.04 $Mg/kg^{-1}$ and content 9.9 ± 0.03 $Mg/kg^{-1}$, respectively. Variations in element content within species could be attributed to factors such as habitat of the organisms, dietary pattern, other ecological interactions and overall body size of the bivalve species (Davies *et* al., 2016). Zinc is an essential element for human and its presence in bivalve species analyzed is in agreement that Zinc is always presence in shellfish and that the concentration presents in bivalve is usually higher (Celik and Oehlenschlager, 2004). The important function of zinc is based on its role as an integral part of a number of metallo enzymes and as a catalyst in regulating the activity of specific Zinc-dependent enzyme.

Sodium and Potassium are important in osmo-regulation, balance and membrane potential of cells as well as transport across membranes. Sodium and potassium are also needed to activate amylase, an enzyme which is important in glucose metabolism in human body (Belitz *et al*., 2004). Calcium is a major component in bones and constitutes over 95% of bivalve shell in the form Calcium carbonate. Calcium is involved in structure of muscle system and controls essential processes like muscle contraction, blood clothing and actively involves in brain cells and their growth (Belitz *et al.*, 2004). Magnesium (Mg) just as calcium formed a greater part of human bones as well as prosthetic group in enzyme that hydrolysis and transfer phosphate groups, consequently, Mg is essential in energy requiring biological functions such as membrane transport, generation and transmission of impulses, contraction of muscles and oxidative phosphorylation (Ukwo *et* al., 2019). Phosphorus, the main structural element found in shellfish is usually found equal amount with Sulphur. Bivalve shellfish was found to be rich in micro mineral such as Zinc, Copper, Manganese Iron and Selenium.

Copper is a component of a number of enzymes involve in glucose metabolism, synthesis of hemoglobin, connective tissue and phosphor lipid. Several authors have reported higher concentration of Copper in shellfish from Niger Delta (Celik and Oehlenschlager, 2004). Clams are an excellent source of iron. One three-ounce serving provides about one-third of the daily value for iron. Iron prevents the most common form of anemia, which can cause fatigue and weakness. Many women, including about half of pregnant women, do not get enough iron in their diet. Mussels are also high in vitamin B12, needed for the production of red blood cells. The nutritional characteristics of bivalves vary among species and between individuals of same species. These variations may be attributed to the effects of environment and species as well as other intrinsic factors (Osibona *et al.*, 2009).

**The Vitamins Composition of *Galatea paradoxa* from River Benue-Nigeria**

The result of vitamins composition of *Galatea paradoxa* from the study area revealed that, G. *paradoxa* content vitamins A, $B_6$, $B_{12}$, $B_6$, D, E and K respectively. The vitamin A, C and E contents of this aquatic species were adequate to supplement other dietary sources. Vitamin A is a good treatment for people suffering from eye problem while deficiency of vitamin C leads to scurvy and gingivitis (Dau *et al.,* 2016). Fresh water clam can be a profound solution to the problem of diets among Nigerians, where mostly carbohydrate with little of protein, vitamins and minerals are frequently consumed. Clam is an alternative nutrient source (minerals and vitamins) in Nigeria and Africa at large. The result of this finding on fresh water clams consumption could possibly reduce critical food shortage among the people of Benue state, if given adequate sensitization and research attention.

The adequate intake of vitamins and minerals such as iron, zinc, copper, selenium, vitamin B12 and folate is essential for optimal health (Truswell, 2003); for instance, Vitamin B12 and folate are involved in single-carbon transfer and DNA synthesis (Truswell, 2003), and are particularly important for young women. Long-term, vitamin B12 deficiency impairs cognitive function and it is important in the prevention of neural tube defects (NTD) (O'Leary and Samman, 2010). Vitamin B12 is a cofactor in the metabolic transformation of homocysteine to methionine, a reaction that also requires folate (O'Leary and Samman, 2010). Vitamin B12 deficiency has been linked to megaloblastic and pernicious anaemia (Flavia *et al.,* 2014) and a decline in cognitive function in older age (O'Leary *et al.,* 2012). Serum vitamin B12 is a biomarker of vitamin B12 deficiency, and the metabolites, methylmalonic acid (MMA) and homocysteine are functional indicators (O'Leary and Samman, 2010).

**CONCLUSION**

The results of this finding showed that freshwater clam (*G. paradoxa)* is a good source for essential minerals (such as Calcium, Iron and Phosphorus among others) and vitamin contents. The results implied that fresh water clam is a very good source of protein for human being; protein content of 30.63g in fresh water clams was recorded in the study area. Fat/oil revealed 4.72g content in fresh water clam in the study area; moisture content was recorded with an estimated value of 5.27g. Knowledge of the moisture content of food stuff, serves as a useful index of their keeping qualities and susceptibility to fungi infection. The result recorded on mineral contents of freshwater clam revealed that fresh water clam in the study area content macro and micro minerals composition which include: Calcium, Potassium, Magnesium, Iron, Zinc, Copper and Sodium. The result of vitamins composition of *Galatea paradoxa* from the study area revealed that, the aquatic species content vitamins, these include: A (8.5 ± 0.74 mg/g), $B_6$ (5.1 ± 0.02mg/g), $B_{12}$ (0.4 ± 0.01mg/g), B (18 ± 0.04 mg/g), D (121.5 ± 2.12 mg/g), E (1.1 ± 0.02mg/g) and K (13.9 ± 0.02mg/g). The vitamin contents of this aquatic species were adequate to supplement other dietary sources.

**Recommendations**

Based on this study, it is recommended that: - sensitization and enlightenment should be carried out by Nutritionists and stakeholders to encourage the production of G. *paradoxa* for a more availability; also to promote their consumption among the populace of Benue State for their nutritive values; the marketing and income generation of *G. paradoxa* species should be studied in order to encourage youth go into the business of clam's culture in Nigeria.

**REFERENCES**


Anisa, Adi AC (2013): Effect of Added Meat Meat Shrimp (*Pilsbryoconcha exilis*) and Carrot (*Daucus carota* L) to the Acceptance and Nutritional Feeding of Mocaf (Modified Cassava Flour) Nutrient Fluid. *Indonesian Nutrition Media 9 84-88*

Belitz, H.D., W. Grosch and P. Schieberle (2004): Food Chemistry. Springer, Berlin, Germany. 22.

Celik, U. and J. Oehlenschlager, (2004): Determination of zinc and copper in fish samples collected from Northeast Atlantic by DPSAV. *Food Chem., 87: 343-347*

Dau, J.H; Kuje, E. D. and Dawaki, S. A. (2016): Nutritive values of some edible forest tree seeds in Makurdi-Benue, Nigeria; *European Journal of Biological Research*; 6 (2): 112-118.

Elkhodary GM, Omran NE, Hassan AA, El-Saidy SA, Mona MH (2018): Nutritional Value of the Egyptian Freshwater Bivalve *Spathopsis rubens arcuata* Under the Effect of Depuration. *J Aquac Res Development 9: 551. doi: 10.4172/2155-9546.1000551*

Espana, M.S.A., E.M.R. Rodriguez and C.D. Romero (2007): Comparison of mineral and trace element concentrations in two molluscs from the Strait of Magellan (Chile*). J. Food Compos. Anal., 20: 273-279.*

Hamed, I., F. Ozogul, Y. Ozogul and J.M. Regenstein (2015): Marine bioactive compounds and their health benefits: A review. *Compr. Rev. Food Sci. Food Saf., 14: 446-46.*

Kris-Etherton, P.M., W.S. Harris and L.J. Appel, 2002. Fish consumption, fish oil, omega-3 fatty acids and cardiovascular disease. Circulation 106: 2747-2757. 24.

Muchtadi D (1989) Evaluation of Food Nutrition Value. Inter-University Center for Food and Nutrition, Bogor Agricultural University, Bogor

Nunes, M.L., I. Batista, N.M. Bandarra, M.G. Morais and P.O. Rodrigues, (2008). Produtos da pesca: Valor nutricionale importância para a saúde e bem-estar dos consumidores. Publicações Avulsas do IPIMAR No. 18, Instituto Português do Mar e Atmosfera (IPIMAR), Lisbon, Portugal, pp: 1-77. 20.

Ojiako, O.A; Ujowundu, C.O; Alisi, C.S.; Igwe, C.U and Ogbuji, C.A (2012): South Eastern Nigerian Seafood Diets Have Desirable Effects on Biochemical Indices of Experimental Rabbits; *Pakistan Journal of Nutrition 11 (x): xx-xx, (Asian Network for Scientific Information): 1-6.*

Osibona, A.O., K. Kusemiju and G.R. Akande, (2009). Proximate composition and fatty acids profile of the African Catfish *Clarias gariepinus. Acta SATECH, 3: 85-89.*

O'Leary F, and Samman S. (2010) Vitamin B12 in health and disease. Nutrients. *2(3):299-316. doi: 10.3390/nu2030299. Epub 2010 Mar 5. PMID: 22254022; PMCID: PMC3257642.*

Prihartini W (1999) Diversity of Types and Ecobiology of Freshwater Shellfish Family Unionidae (Mollusca: Bivalvia) Multiple Situ in Bogor District and Municipality Bogor Postgraduate Program Bogor Agricultural University.

Putri, S.R; Gemala Anjani; Hartanti Sandi Wijayanti Nuryanto (2018): Freshwater Clams (*Pilsbryoconcha Exilis*) as and Potential Local Mineral Sources in Weaning Food to Overcome Stunting in Grobogan, Central Java, Indonesia; 3rd International Conference on Tropical and Coastal Region Eco Development 2017 IOP Publishing; IOP Conf. Series: Earth and Environmental Science 116: 012077 doi :10.1088/1755-1315/116/1/012077

Shetty S, Tharavathy NC, Lobo RO, Shafakatullah N (2013) Seasonal changes in the biochemical composition of freshwater bivalves, *Parreysia spp*. from Tungabhadra river, Karnataka. *Int. J Pharm Sci Res. 4: 94-99.*

Silva, H.A. and I. Batista, 2008. Produção, salubridade e comercialização de moluscos bivalves em Portugal. Publicações avulsas do IPIMAR No. 20, Instituto Português do Mar e Atmosfera

(IPIMAR), Lisbon, Portugal, pp: 1-171. 23.

Singleton, C.B., B.D. Walker and T.J. Campbell, (2000): N- 3 polyunsaturated fatty acids and cardiac mortality. *Aust. NZ J. Med., 30: 246-251*

Truswell, S. A. (2003) ABC of Nutrition. International Kindle paperback.pp 34

Ueta, K., S., Takenaka, Y., Yabuta and F. Watanabe, (2011): Broth from canned clams. J. Agric. *Food Chem., 59: 12054-12058.*

Ukwo, S.P., C.F. Ezeama and G. Onwuka, (2019): Nutritional composition of selected bivalve mollusc shellfish consumed in the Niger Delta, *Nigeria. Ann. Food Sci. Technol., 20: 591-602. 15.*

Venugopal, V. and K. Gopakumar (2017): Shellfish: Nutritive value, health benefits and consumer safety. *Compr. Rev. Food Sci. Food Saf., 16: 1219-1242. 21*.