CHEMICAL COMPOSITION (PROXIMATE, MINERALS,VITAMINS),MINERAL RATIOS AND MINERAL SATETY INDEX OF THE INNARDS OF MALE AND FEMALE *NEOPETROLISTHES MACULATUS*

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ABSTRACT

The innards of the male and female *Neopetrolisthes maculatus* were used for the analyses of the proximate, minerals and vitamins compositions,as well as calculations of mineral ratios and mineral safety index (MSI).Total ash and crude protein were high at corresponding levels (g/100g) of 10.8-13.0 and 55.5-56.8. Crude fibre and carbohydrate were low(g/100g):1.60-1.80 and 3.80 - 3.90 respectively. Crude fat was average at 11.8-12.5g/100g. Samples were good sources of energy with total metabolizable energy of 1.45-1.49MJ and also very high levels of utilizable energy due to protein (60% utilization) with values of 38.8 – 39.1. These mineral parameters were high (mg/100g):Cu17.4 -18.6),Mn (5.32 -8.53), Ca (428 -446), Mg (594-614), K (280-322), Na (349-390) and P(969-1144) but low in Fe, Zn, Se, Cd, Pb and Ni. The mineral were more concentrated in female than the male by a level of 13/14 or 92.9%. The following mineral ratios were lower than the reference balance (ideal) and also lower than the minimum in the acceptable ideal range:Ca/Mg, Na/K, Ca/K, Na/Mg, Zn/Cu, Ca/P, Fe/Cu, Zn/Cd, Fe/Co and K/Co whereas Ca/Pb and Fe/Pb were thousands of levels higher than the standards; this could be due to very low level of Pb (0.0005 – 0.0006 mg/100g). In the MSI, the following minerals were lower than the standard values (hence, no deleterious action is expected from them): Fe, P, Zn, Se and Na whereas Mg and Cu were higher in both sexes. The total vitamins content ranged from 11.7-13.1mg/100g with B_3, vitamin C and E predominating and slightly followed by B_6,B_5. Results were significantly different at $r_{=0.01}$ in proximate, metabolizable energy, minerals MSI and vitamins.

Keywords: Chemical composition, heterosexual pair, *Neopetrolisthes maculatus*

No of Tables:11 **No of References**:51

INTRODUCTION

Neopetrolisthes maculatus is a spotted crab.There are two different colour forms, although the ground colour of the bodies of both forms is white. In one form, carapace and chelipeds are white, with an uneven pattern of irregular sizes of red blotches; ambulatory legs also white, with some small red spots on meri of first pair (second pereopod). In the other form, the carapace and chelipeds have a uniform pattern of numerous small, reddish purple spots; meri of ambulatory legs also with numerous small, reddish purple spots (Haig, 1965).

Crab is consumed by many individuals as it is often recommended for pregnant women .On the inside, crabs have a hepatopancreas which is a part of the crab's digestive system. The colour of the organ is usually yellow, quite similar to the deep yellow colour found in high-vitamin butter produced from cows grazing on rapidly growing grass. A common term for this yellow fatty organ is crab ''butter'' or ''mustard''. Judging by its colour, this part of the viscera would be rich in fat-soluble activators (Nagel, 2009). Many indigenous groups understood the necessity for special foods prior to conception, during pregnancy and during lactation; crab was one of these foods.

Crab insides can be used in a variety of ways. In Japanese cuisine, one dish with crab organs involves a blended mixture of the viscera, served in the skull of the crab with a raw egg on top. The natives of Fiji also were aware that a particular species of spider crab fed to mothers during and prior to pregnancy would produce children ''physically excellent and bright mentally''. Special foods of the sea were eaten ''day to day'' during the time of pregnancy. We have, then, a message from many wise traditions around the planet: eat crab during the period of preconception, pregnancy and lactation – and eat the whole crab (Nagel, 2009). The Chinese mitten crab, *Eriocheir sinensis* has been described to have a delicioustaste and unique pleasant aroma, and has high nutritional value (Chen and Zhang, 2006). The meat, hepatopancreas and gonads are all edible parts of the Chinese mitten crab. While consumers in western societies often choose to eat the meat alone, Asiatic consumers greatly prefer consuming the hepatopancreas and gonads. Indeed, this contributes to the popularity of mitten crabs as a delicacy in China with the hepatopancreas of males being especially prized, followed by the gonads of both male and female crabs (Shaoetal., 2013).

There is paucity of information on the nutritional data for the organs of *N. maculatus*. The work reported in this article is an attempt to assess the nutritional composition(proximate, minerals and vitamins) in conjunction with their quality parameters. The colour pattern of the samples was of large and unevenblothes resembling the Pacific Ocean *N. maculatus* population (Haig, 1975).

MATERIALS AND METHODS

Wet samples were collected from trawler catches from the Atlantic Ocean at

Orimedu beach in Ijebu-Lekki area of Lagos, Lagos State, Nigeria. The experiment took place between November 2014 and June 2015. The carbs were washed with distilled water to remove adhering contaminant and transported in ice crushed containers to the laboratory for identification and preservation prior to analysis. The crabs were identified in the Department of Forestry, Wildlife and Fisheries Management of Ekiti State University, Ado-Ekiti, wrapped in aluminium foil and stored in a cool chamber of < 4°C for 2 – 3 days before analysis.

More than ten matured crabs were caught with the net but three samples were used in this study. The three whole crabs were separated fresh, two were males and only one was female. Typically a crab is killed by boiling it alive; however, in an attempt to give the crab a rapid death, it was preserved under cold temperature. To remove the viscera the crab was stabbed through its lower belly just above the end of the small tail flap. The viscera was then dried in the oven at 105°C and blended after cooling to the laboratory temperature.

The micro-Kjeldahl method (Pearson, 1976) was followed to determine the crude protein. The crude fat was extracted with chloroform/methanol (2:1 v/v) mixture using Soxhlet extraction apparatus (AOAC, 2006). Moisture, ash and crude fibre determination followed AOAC (2006) methods while carbohydrate was determined by difference. The calorific values in kilojoule (kJ) and kilocalorie (kcal) were calculated by multiplying the crude fat, protein and carbohydrate by Atwater factor of (kJ/kcal) 37/9, 17/4 and 17/4 respectively. Determinations were in duplicate. The minerals were analysed from the solution obtained by first dry ashing the samples at 550°C. The filtered solutions were used to determine Na, K, Ca, Mg, Zn, Fe, Mn, Cu, Pb, Co and Se by means of atomic absorption spectrophotometer (Buck Scientific Model – 200A/210, Norwalk, Connecticut 06855) and phosphorus was determined colorimetrically by Spectronic 20 (Gallenkamp, UK) using the phosphovanado molybdate method (AOAC, 2006). All chemicals used were of British Drug House (BDH, London, UK) analytical grade. The detection limits for the metals in aqueous solution had been determined previously using the methods of Varian Techtron (1975). The optimal analytical range was 0.1 – 0.5 absorbance units with coefficients of variation from 0.9% - 2.21%. Ratios of Ca/Mg, Na/K, Ca/K, Na/Mg, Zn/Cu, Ca/P Fe/Cu, Ca/Pb, Fe/Pb, Zn/Cd, Fe/Co, K/Co and [K/(Ca + Mg)] were all calculated (Hathcock, 1985; Watts, 2010; ARL, 2012). Also calculated was the mineral safety index (MSI) (Hathcock, 1985) of Na, Mg, P, Ca, Fe, Se, Zn and Cu using the formula:

Calculated MSI = MSI / RAI x Research data result

where MSI = mineral safety index table (standard); RAI = recommended adult itake. The vitamin content of the samples was analysed following the modified methods of AOAC (2006) [MTHD 992.03, 992.04 and 992.26]. The sample was made to attain laboratory atmospheric condition

on the bench after been removed from the storage chamber at less than 4°C. The sample was pressed and completely homogenized in the mortar carefully with pestle to avoid forming balls. About 0.1g of each sample was weighed into 10ml beaker capacity. The sample was extracted in the container by the above methods. The extracted sample was concentrated to 1.0ml for the chromatographic analysis. The GC conditions for the vitamin analysis: GC: HP 5890 powered with HP ChemStation rev. A 09.01(1206) software; injection type, split injection; split ratio: 20:1; carrier gas: nitrogen; inlet temperature, 250°C; column type, HP 5; column dimensions: 30 m x 0.25 mm x 0.25 µm; oven program, initial temperature at 50°C: first ramping at 10°C/min for 20 min (250°C), maintained for 4 min, second ramping at 15°C/min for 4 min (310°C), maintained for 5 min; detector; PFPD; detector temperature, 320°C; hydrogen pressure, 20 psi; compressed air, 30 psi. All determinations were on dry weight basis.

The statistical analyses carried out included the determination of mean, standard deviation (SD), coefficient of variation in percent (CV %). The linear correlation coefficient (Pearson r), variance (rxy^2) and regression coefficient (Rxy) were calculated whilst r_{xy} was subjected to the Table (critical) value of $r_{=0.01}$ to see if significant differences existed in the values of the proximate, mineral and vitamin compositions as well as in the mineral safety index results (Oloyo,2001). Further calculated for the four major determinations were coefficient of alienation (C_A) and index of forecasting effeiciency (IFE) (Chase, 1976) using the formulae:

$C_A = 1 - (r_{xy})^2$; IFE = $(1 - (r_{xy})^2 x\ 100$

RESULTS AND DISCUSSION

Table 1 shows the proximate values of the *Neopetrolisthes maculatus* male and female samples on dry weight basis. Results of major significance were (g/100g): protein (55.5 – 56.8) with CV% of 1.64; moisture (14.0 – 14.5) with CV% of 2.48; total ash (10.8 – 13.0) with CV% of 13.1 and crude fat (11.8 – 12.5) with CV% of 4.07. The carbohydrate value was moderate at 3.80 – 3.90 g/100g and CV% of 1.84; however, crude fibre was low at 1.60 – 1.80g/100g and CV% of 8.32. All CV% values were generally low at a range of 1.64 – 13.1. The calculation of the organic matter (OM) gave values of (g/100): 89.2 (male) and 87.0 (female) with CV% level of 1.77 with corresponding total solid of 85.5 and 86.0 and CV% of 0.412. The OM values of 87.0 – 89.2 g/100g were higher than the literature values in *Callinectes latimanus* (71.4 g/100g) (a lagoon crab-shellfish) (Adeyeye et al, 2014), the values reported for four fresh water fin fishes of *Mormyrops delicious* (86.4 g/100g), *Bagrus bayad* (75.0 g/100g), *Synodontis budgetti* (84.0 g/100g) and *Hemischronis faciatus* (76.0 g/100g) (Abdullahi and Abolude, 2002), close to the values of 90.9 – 91.42 g/100g in *Acanthurus monroviae* and *Lutjanus goreensis* fishes (lagoon fin fishes) (Adeyeye et al., 2016), trunk fish (91.07 g/100g) (Adeyeye and Adamu, 2005) but lower than the OM in ostrich muscles (98.97 g/100g) (Sales and Hayes, 1996). The crude

fat when subjected to fatty acid values [crude fat x 0.70; Paul and Southgate (1978)] gave values of 8.75 g/100g (male) and 8.26 g/100g (female) and a ratio of innards to innards as 1.06 : 1.00 (total fatty acids) male and female innards of *N. maculatus* respectively. The crude fat values of 11.8 – 12.5 g/100g were about double the value of 5.15 – 6.25 g/100g in *A. monroviae* and *L. goreensis* (Adeyeye et al., 2016), 7.48 g/100g of the skin of *Pellanula afzeliusi* (Adeyeye and Oyarekua, 2011) and the value of 7.40 g/100g in the skin of barracuda fish (Adeyeye *et al*., 2012); the present fatty acid calculated values were also greater than the skin of *P. afzeliusi* (5.23 g/100g) (Adeyeye and Oyarekua, 2011) and skin of barracuda (5.18 g/100g) (Adeyeye et al., 2012). Both the crude fat and total FAs results were close with each parameter having low value of CV% (4.07) in each case. The average values of the crude fat in the innards showed that the samples were white shell fish whose fat was confined mainly to the liver (Adeyeye, 2015a). The crude fat content gave an indication that the samples would be good for people avoiding animal protein with high level of fat. The protein content of 55.5 to 56.8 g/100g was close to the values of 65.4 – 68.5 g/100g in *A. monroviae* and *L. goreensis* (Adeyeye et al., 2016) but much greater than the literature values of some shell fishes: *Callinectes pallidus* (24.38%), *Cardisoma armatum* (23.94%) (Elegbede and Fasina-Bombatta, 2013); *Callinectes latimanus* (19.1 g/100g) (Adeyeye et al., 2014); protein values were g/100g: 32.5 (whole body, no innards), 24.8 (flesh) and 24.2 (exoskeleton) from the male body of *Sudananautes africanus africanus* (Adeyeye and Kenni, 2008); 17.2 (whole body), 18.3 (endoskeleton) and 19.1 (exoskeleton) from the body of *Pandalus borealis* (Adeyeye, 2015b), however falling within the group of 18.40 – 87.57 g/100g from various parts of male and female West African fresh water crab *S. africanus africanus* (Adeyeye, 2002). The ash level of 10.8 – 13.0 g/100g might have been responsible for some of the high mineral contents observed. The high level of protein might have resulted in the moderate levels of crude fat, ash and low level of carbohydrate. The differences, in the proximate values between the two samples can be seen in Table 1. There were 50/50% sharing in the parameter concentrations of the samples with crude fat, crude protein and moisture (3/6 or 50%) being higher in the male crab innards whereas carbohydrate, total ash and crude fibre being higher in the female (this was 3/6 or 50%). Whilst the least difference was in crude protein (+1.30 or +2.29%), the highest difference was total ash (-2.20 or -20.4%). In Table 2 is depicted the statistical evaluation of the results in Table 1. Both the correlation coefficient (r_{xy}) and variance or coefficient of determination (r_{xy}^2) were high at respective values of 0.9986 and 0.9973. The regression coefficient (Rxy) showed that for every one unit of increase in the proximate value of male crab innards, there was a corresponding increase of 0.5290 in the female crab innards. The mean value was similar as 16.7/16.7 g/100g in each sample, close standard deviation (SD) of 19.7 – 20.3 but slightly different but high CV% (118 – 122) showing the closeness of the spread of the

proximate values. The coefficient of alienation or non-relationship (C_A) was low at 0.0520 (5.20%) but high index of forecasting efficiency (IFE) with a value of 0.9480 (94.8%). The IFE is a value for the reduction of error in the prediction of relationship between the heterosexual samples. This meant that 100 – 94.8 = 5.20 (error of prediction); the prediction here was easy because the error was just 5.20%. The IFE result showed that the male innards can carry out all the biochemical functions of the female sample and vice versa. Significant differences existed in the results at $r_{= 0.01}$.

In Table 3, we have the proportion of percentage energy contributed by fat, protein and carbohydrate to the total metabolizable energy. Total metabolizable energy range was 1446 -1493 kJ/100g (1.446 – 1.493 MJ) or 344 – 355 kcal/100g with both kJ and kcal values being very close with CV% range of 2.23 – 2.25. The energy values were higher than in *C. latimanus* (1142 kJ/100g) (Adeyeye et al., 2014); close to 1438 – 1442 kJ/100g (1.438 – 1.442 MJ) or 340 – 341 kcal/100g in *A. monroviae* and *L. goreensis* (Adeyeye et al., 2016), 1.61 – 1.71 MJ/100g from eight organs of guinea-fowl (Adeyeye and Adesina, 2014) but lower than in sheep lean meat (2.06 MJ/100g) and lean pork (2.29 MJ/100g) (Fornias, 1996). The energy obtained was also within the range of 1.3 – 1.6 MJ/100g obtained from cereals (Paul and Southgate, 1978) showing the samples to be good sources of energy. Protein contributed the highest energy values (944 – 966 kJ/100g or 64.7 – 65.2%) with PEF% > PEC%. This trend was as observed in *A. monroviae* and *L. goreensis* fishes (Adeyeye et al., 2016). The daily energy requirement for an adult is between 2500 – 3000 kcal depending on his physiological state while that of infants is 740 kcla (Bingham, 1978). This meant that 704 – 845g (adults) and 208g (infants) of male innards would be needed for full energy production whereas 727 – 872g (adults) and 344 g (infants) of female innards would supply total energy requirement. These values were lower than 733 – 880g (adults) and 220g (infants) of *A. monroviae;* and 735 – 882g (adults) and 221g (infants) of *L. goreensis* (Adeyeye et al., 2016); from *C. latimanus* (915g, adults minimum) and (271g, infants) (Adeyeye et al., 2014); 786 – 944g (muscle) and 761 – 913 (skin) of turkey to meet adults requirement but 233g (muscle) and 325g (skin) in infants (Adeyeye and Ayejuyo, 2007) but close to the values for guinea-fowl organs: 649 – 733g (adult man) and 192g (infants) (Adeyeye and Adesina, 2014). The utilizable energy due to protein (UEDP %) was high at a range of 38.8 – 39.1 (assuming 60% of protein energy utilization). This is higher than the recommended safe level of 8% for adult man who requires about 55g protein per day with 60% utilization.From literature, UEDP% was 46.3-48.5 in *A. monroviae* and *L. goreensis* fishes (Adeyeye et al., 2016); 56.4 (turkey muscle), 40.0 (skin of turkey) (Adeyeye and Ayejuyo, 2007) whereas values were 12.1-28.8% (female and male exoskeleton), 12.5-23.5 %(female and male flesh) and 13.8-17.9% (female and male whole body, no innards) of *S. africanus africanus* (Adeyeye et al., 2010). The UEDP% in *Callinectes latimanus* (a lagoon

crab) was 17.1 (Adeyeye et al., 2014), almost similar to the value of 17.0 in shell + head of *Pandalus borealis* (Adeyeye and Aremu, 2016). The UEDP% of 38.8-39.1 might be far more than enough to prevent energy malnutrition in children and adults fed solely on the samples as the main sources of protein. The samples would also be good to be used to fortify or supplement protein deficient cereal products. The PEF% value of 30.2-31.0% was almost about the value recommended level of 30% (NACNE,1983) or very close to 35% (COMA,1984) for total fat intake (assuming it serves as sole source of fat in the diet), this could be very useful for people wishing to adopt the guidelines for a healthy diet. The statistics in Table 4 showed that the percentage energy distributions had high values of r_{xy}, r_{xy}^2, low negative Rxy (-0.1805), close mean, SD and CV% (a difference of just 0.1%), very low $C_A$but very high IFE with overall results being significantly different at $r_{=0.01}$.

It is known that appreciable shifts in the tissue compartments, water, fat and protein frequently accompany changes in the dietary, nutritional status and age of an animal (Cowgill, 1958). Water is indispensable for the efficient utilization and conservation of food within the body (Snively and Wessner, 1954), this is because the water content of the body changes with the type of diet (White House Conferences, 1932). This important connection of water with other food substances is the fact the biochemical basis for this relationship arises from the fact that the water deficit created by protein metabolism is about seven times that for equivalent calories of carbohydrates or fat. Hence, in young children an increase in calories from carbohydrate causes hydration; whereas an increase in calories from proteins causes dehydration (Pratt and Snyderman, 1953). The increased output of ketones and acids which accompanies a shift to high – fat diets is associated with increased water loss which can be offset by an increase in carbohydrate intake. Protein quality also influences the degree of tissue hydration. Grammes of water needed for complete metabolism of 100 calories of some food substances had been given by Albanese (1959). Food materials (protein, starch and fat) all have preformed water of 0.00 in each case; water gained by oxidation: 10.3 (protein), 13.9 (starch) and 11.9 (fat); lost in dissipating heat: 60.0 for each of the food material; water lost in excreting end products (1 calorie of protein requires 3.0ml of water for the excretion of the urea and sulphate formed from it, 1g of ash requires 65ml of water for its excretion): 300 (protein), both 0.00 in starch and fat; deficit: 350 (protein), 46 (starch) and 48 (fat). From Table 3,227 kcal/100g energy from male crab protein would require 681ml of water for complete metabolism, whereas female crab sample protein of 222kcal/100g energy would require 666ml of water for complete metabolism. Hence, whereas male crab innards would have water deficit of 795ml, female crab innards would have water deficit of 777ml (since 100 calories have a water deficit of 350ml). This means that a lot of water (just below one litre) would always be needed for consumption in taking the diet containing these crab innards, noting that water

deficit in consumption of female crab innards < water deficit in the male.

In Table 5, minerals of major significant levels were (mg/100g): Cu (17.4-18.6), Mn (5.32-8.53), Ca (428-446), Mg (594 – 614), K (280-322), Na (349-390) and P (969-1144) with the female crab innards predominating in each mineral; those of moderate values were Fe, Zn, Co and Ni whereas those lower than 0.1mg/100g were Pb, Se and Cd. These minerals: Fe, Co, Zn, Se and Ni would have to be sourced from other protein (animal) sources when these crabs serve as the main source of animal protein. The very low level of Pb (0.0005-0.0006mg/100g) and Cd (0.004-0.006) could be cheering although their detection could be due to onset of pollution. The contributions of Ca, Mg and Na were significant (even if not adequate) in contributing to body requirements. When the amount of Ca is adequate in the diet, Fe is utilized to better advantage; this is an instance of sparing action (Fleck, 1976). Fe was low in the present samples (2.13-2.36mg/100g) compared to high levels of Ca (428-446mg/100g).

Phosphorus is always found with Ca in the body, both contributing to the supportive structures of the body. It is present in cells and in the blood as soluble phosphate ion, as well as in lipids, proteins, carbohydrates and energy transfer enzymes (NAS, 1974). Phosphorus is an essential component in nucleic acids and the nucleoproteins responsible for cell division, reproduction and the transmission of hereditary traits (Hegsted, 1973). Potassium is primarily an intracellular cation, in large part this cation is bound to protein and with sodium influences osmotic pressure and contributes to normal pH equilibrium (Sandstead, 1967). Plants and animal tissues are rich sources of potassium, thus a dietary lack is seldom found. The Table 5 also contained the differences in the mineral composition of the samples. Of the whole lot of minerals, it was onlyPb that was more concentrated in male than female (0.0006-0.0005mg/100g) having a fractional value of 1/14 or 7.14% whereas female minerals were more concentrated from 13 minerals (13/14 or 92.9%) than in the male. The percentage difference values were low to high (3.22-117%). The mineral values in Table 5 were subjected to statistical analysis as shown in Table 6. The r_{xy} was positively high and significant at $r_{=0.01}$; these other values were high: r_{xy}^2, mean, SD, CV% and IFE putting the samples into a position where each can perform the biochemical functions of the other.

The ratios of the minerals are shown in Table 7. The mineral ratios are often more important than the individual mineral levels themselves and this had been illustrated by the following statements by Vitale et al., as quoted by Watts (2010): "Determining nutritional interrelationships is much more important than knowing minerals levels alone. From a global standpoint, although dietary deficiency is at the more serious end of the spectrum, the opposite end, dietary excess and aberrations contribute to the burden of disease." "Mild and subclinical deficiencies of nutrients outnumber overt syndromes ten to one." Significant ratios – The section depicting

the significant ratios included calculations of the following mineral relationships; Calcium relative to Phosphorus (Ca/P), Sodium relative to potassium (Na/K), Calcium relative to Potassium (Ca/K), Zinc relative to Copper (Zn/Cu), Sodium relative to Magnesium (Ca/Mg) and Iron relative to Copper (Fe/Cu). These select mineral ratios reveal not only the important balance between these elements, but they also provide information regarding the many possible factors that may be represented by a distruption of their relationships, such as disease states, physiological and developmental factors, the effects of diet, drugs, would also predispose a person with parasympathetic dominance to certain health conditions if severe or chronic (Watts, 2010).

Na/K ratio- Ideally there should be a 2.4:1 ratio of sodium relative to potassium with a range of 1.4 to 3.4 being acceptable. The sample results gave ratios of 1.21-1.25 which were below the ideal range. All the significant ratios have their values in the results being less than the ideal and also not falling within the acceptable ideal range. Toxic metal ratios in these results were Fe/Pb, Ca/Pb and Zn/Cd whilst additional ratios were Fe/Co and K/Co. The [K/ (Ca+Mg)] is good in nutritional discussion. It should be noted that these ratios are being reported solely for the purpose of gathering research data. Mineral ratios analyses have been very important in analysis of hair as a biochemical marker.

The mineral safety index (MSI) as calculated for the samples is in Table 8. The standard MSI for the minerals are Na (4.8), Mg (15), P (10), Ca (10), Fe (6.7), Zn (33), Cu (33) and Se (14). The explanation of the MSI can be understood as follows taking Ca as an example: the recommended adult intake (RAI) of Ca is 1200mg, its minimum toxic close (MTD) is 12000 mg or 10times the recommended daily average (RDA) which is equivalent to MSI of Ca. This reasoning goes for the other minerals whose MSI were determined. Only two MSI values in both samples had their calculated MSI values greater than the standard values thereby giving negative differences whilst others gave positive differences. Minerals that gave negative differences were Mg with values of -7.29 (-48.6%) in male and -8.01 (-53.4%) in female which meant that the male crab might be overloading the consumer to the tune of 48.6% (Mg) and the female to the tune of 53.4% (Mg). Also Cu would overload the consumer to the tune of -159 (-481%) 481% in the male and to the tune of -171 (-519%) 519% in the male. The calculated MSI < standard MSI meant that such minerals would not constitute mineral overload or become toxic to the samples consumers. The very high level of Cu might impair the metabolism of Fe, Zn and Mn. Table 8 still showed that the MSI values in the two samples were close for each mineral with CV% ranging between 2.24-36.4; Mg (2.24%) and Cu (4.54%) being among MSI with low CV%. The statistical analysis in Table 9 came from the results in Table 8. It could be noticed that values of r_{xy}, r_{xy}^2, Rxy, SD, CV% and IFE were all high but mean and C_A were both low. The results were significantly different at $r_{=0.01}$ and prediction of relationship was also easy

having high reduction of error value of 97.67%.

The vitamin composition as determined in the samples is shown in Table 10. Vitamins of significance in the samples were niacin (B_3) (3.01-3.18mg/100g), ascorbic acid (vitamin C) (6.68-7.54mg/100g) and tocopherol (vitamin E) (1.14-1.34mg/100g); those greater than 0.10mg/100g range were pyridoxamine (B_6) (1.25e-1 to 1.40e-1mg/100g), thiamine (B_1) (1.07e-1 to 1.22e-1mg/100g), riboflavin (B_2) (2.25e-1 to 2.60e-1mg/100g) and pantothenic acid (B_5) (3.17e-1 to 4.19e-1mg/100g). There was evidence of closeness in the vitamin results between the heterosexual pairs as shown in their CV% values (3.84-19.6). It could also be noticed that the difference between each parameter value was negative meaning that the female crab innards had higher vitamin concentration than the corresponding male results. The percentage differences were generally low with values of 5.59 to 32.2%.

Vitamin B_2 deficient person has the accumulation of fat in the liver which resembles changes observed in the liver of chronic alcoholics. In humans with liver cirrhosis, decreased concentration of vitamin B_2 is found mostly in necrotic regions (Chen and Liano, 1960). The values of vitamin B_2 in the present report were generally low and would require supplementation with riboflavin- rich foods. The niacin (vitamin B_3) levels in the samples were 3.01-3.18mg/100g. The term niacin has been used generally to encompass the active forms of this vitamin, nicotinic acid and nicotinamide; however, estimates of niacin requirements take into account preformed niacin as well as that obtained as niacin equivalent in the body from tryptophan (Trp) metabolism. Hence it was estimated that when 60mg of Trp is consumed by an adult, enough of Trp is oxidized to produce 1.0mg of niacin (NRC, 1980). In 1980, RDA of niacin was 6.6 niacin equivalent (NE) per 1000kcal and intake not less than basic NE had been recommended when the calorie intake is less than 2000kcal; one NE is equivalent to 1.0mg niacin (or 60mg Trp) (NRC,1989). The Trp levels in the current report (not yet published) were 9.75e-1g/100g (975mg/100g) in male and 1.50g/100g (1500mg/100g) in the female. This meant the samples would be both good sources of vitamin B_3 either directly or indirectly. The concentrations of vitamin B_6 were in the range of 1.25e-1 to 1.40e-1mg/100g. Vitamin B_6 is a generic name used for pyridoxine, pyridoxal and pyridoxamine, the co-enzyme forms of which are pyrodixal phosphate and pyridoxamine phosphate (NRC, 1989). Vitamin B_6 is needed in the synthesis of DNA bases; it is a co-enzyme in the biosynthesis of thymedine. A dietary vitamin B_6 deficiency or an increase in the thymedine requirement at a critical time during cell division could result in initial cell mutations that develop into a tumor (Prior, 1985). The RDAs were based on a ratio of 0.02mg of vitamin B_6 per gram of protein consumed. From this estimate, the vitamin B_6 required to satisfy the protein composition (assuming as being main protein source) from the crab innards would be $0.02 \times 56.8 = 1.36$mg (male) and $0.02 \times 55.5 = 1.11$mg (female). The present

levels generally fell below the RDA standards but higher than the levels reported for rosmas variety seeds (0.046-0.049mg/100g) and sassako variety seeds (0.044-0.045mg/100g) (Gwana et al., 2014). Folic acid (vitamin B_9) has been reported to inhibit growth of tumors (Prentice et al., 1985; Lee, 2000). Folacin, the co-enzyme of vitamin B_9 is needed for the synthesis of purine and methionine, for the catabolism of histidine, and for the conversion of serine to glycine (NRC, 1989). It is however of no consequence in the present results. Vitamin B_5 is otherwise called pantothenic acid. Recommended dietary allowances (male, age 19-70) is 5.0mg (The National Academies, 2001) which was much higher than the present results of 3.17e-1 to 4.19e-1mg/100g. Vitamin C is active in the body either as ascorbic acid or as dehydro ascorbic acid. There is a clear link between the functions of vitamin C and its reversible oxidation and reduction properties. It plays important roles in many biochemical reactions, such as mixed-function oxidation involving incorporation of oxygen into the substrate (Lee, 2000). Also, tissue defence mechanism against free radical damage generally involve vitamin C, vitamin E and B-carotone as the major vitamin anti-oxidants in extracellular fluids (Stocker and Frei, 1991). The RDA of vitamin C for adults (60mg/day) maintains a body pool of 1.5g and 10mg/day is sufficient to prevent or cure scurvy (NRC, 1980). The present vitamin C results ranged as 6.68-7.54mg/100g which were low to the expected standard. Vitamin E levels were 1.14-1.34mg/100g. It is otherwise called tocopherols, tocotrienols. The RDA for male (19-70years) is 15.0mg per day; this is much higher than the crab innards results (The National Academies, 2001). Deficiency is said to be very rare; sterility in males and abortions in females, mild hemolytic anemia in newborn infants. The statistical analysis of the results from Table 10 is depicted in Table 11. These values were high: r_{xy}, r_{xy}^2, CV% and IFE whereas these values were low; Rxy, mean, SD and C_A. Results were significantly different at $r_{=0.01}$ and prediction of relationship was also easy.

Table 1: Proximate composition (g/100g) of the innards of the male and female *Neopetrolisthes maculatus* on dry weight basis

Parameter	Male crab	Female crab	Mean	SD	CV%	Male minus(-) Female values	%difference
Crude fat	12.5	11.8	12.2	0.495	4.07	+ 0.70	+ 5.60
Crude protein	56.8	55.5	56.2	0.919	1.64	+ 1.30	+ 2.29
Carbohydrate	3.80	3.90	3.85	0.071	1.84	- 0.10	- 2.63

Total ash	10.8	13.0	11.9	1.56	13.1	- 2.20	- 20.4
Crude fibre	1.60	1.80	1.70	0.141	8.32	- 0.20	- 12.5
Moisture	14.5	14.0	14.3	0.354	2.48	+ 0.50	+ 3.45

Table 2: Statistical analysis of the results from Table 1

Statistics	**Male crab**		**Female crab**
r_{xy}		0.9986	
r_{xy}^2		0.9973	
Rxy		0.5290	
Mean	16.7		16.7
SD	20.3		19.7
CV%	122		118
C_A		0.0520	
IFE		0.9480	
Remark		*	

r_{xy}= correlation coefficient; Rxy= regression coefficient; $C_{A=}$ coefficient of alienation; IFE= index of forecasting efficiency; *= results significantly different at n-2(df) (6-2=4) and $r_{= 0.01}$; [r_T= 0.917 (critical value)].

Table 3: Proportion of percentage energy contribution from fat, protein and carbohydrate to total energy

Parameter	**Male crab**	**Female crab**	**Mean**	**SD**	**CV%**
Total energy (E) (E in kJ/100g) (E in kcal/100g)	 1493 355	 1446 344	 1470 349	 32.7 7.85	 2.23 2.25
PEF% (E in kJ/100g)	31.0 (463)	30.2 (437)	450	18.3	4.07

(E in kcal/100g)	31.7 (113)	30.9 (106)	109	4.45	4.07
PEP% (E in kJ/100g) (E in kcal/100g)	64.7 (966) 64.0 (227)	65.2 (944) 64.6 (222)	955 225	15.6 3.68	1.64 1.64
PEC% (E in kJ/100g) (E in kcal/100g)	4.33 (64.6) 4.28 (15.2)	4.58 (66.3) 4.54 (15.6)	65.5 15.4	1.20 0.283	1.84 1.84
UEDP% (due to kJ) (due to kcal)	38.8 38.4	39.1 38.8	39.0 38.6	0.212 0.255	0.544 0.660

PEF= proportion of total energy due to fat.; PEP = proportion of total energy due to protein.; PEC = proportion of total energy due to carbohydrate.; UEDP = utilization of 60% of PEP%.

Table 4: Statistical analysis of the results from Table 3

Statistics	**Male crab**		**Female crab**
r_{xy}		0.9999	
r_{xy}^2		0.9998	
Rxy		−0.1805	
Mean	713		692
SD	541		526
CV%	75.9		76.0
C_A		0.0142	
IFE		0.9858	
Remark		*	

Results significantly different at n-2 (df) (5-2=3) and $r_{=0.01}$; [r_T = 0.959 (critical value)].

Table 5: Mineral composition (mg/100g dw) of the innards of the male and female *Neopetrolisthes maculatus*

Parameter	**Male crab**	**Female crab**	**Mean**	**SD**	**CV%**	**Male-Female values**	**%difference**
Fe	2.13	2.36	2.25	0.164	7.30	-0.232	-10.9
Cu	17.4	18.6	18.0	0.817	4.54	-1.15	-6.63
Co	0.143	0.185	0.164	0.030	18.2	-0.042	-29.5
Mn	5.32	8.53	6.92	2.27	32.8	-3.22	-60.5
Zn	1.79	1.95	1.87	0.109	5.84	-0.154	-8.61
Pb	0.0006	0.0005	0.0006	0.00007	12.9	+0.0001	+16.7
Ca	428	446	437	12.7	2.91	-18.0	-4.20
Mg	594	614	604	13.6	2.24	-19.2	-3.22
K	280	322	301	30.1	10.0	-42.6	-15.2

Na	349	390	369	28.9	7.83	-40.9	-117
P	969	1144	1057	124	11.8	-176	-18.1
Se	0.036	0.046	0.041	0.007	16.5	-0.010	-26.4
Cd	0.004	0.006	0.005	0.001	24.5	-0.002	-41.9
Ni	0.112	0.149	0.130	0.026	20.0	-0.037	-32.9

Table 6: Statistical analysis of the results from Table 5

Statistics	Male crab		Female crab
r_{xy}		0.9976	
r_{xy}^2		0.9953	
Rxy		-4.01	
Mean	189		211
SD	301		342
CV%	159		162
C_A		0.0688	
IFE		0.9312	
Remark		*	

Results significantly different at n-2 (df) (14-2=12) r = $_{0.01}$; [r_T = 0.661 (critical value)].

Table 7: Calculated mineral ratios of the innards of *Neopetrolisthes maculatus* heterosexuals

Parameter	**(Ref. balance) Ideal**	**Acceptable ideal range**	**Male crab**	**Female crab**	**Mean**	**SD**	**CV%**
Ca/Mg	7.00	3 to 11	0.721	0.728	0.725	0.005	0.683
Na/K	2.40	1.4 to 3.4	1.25	1.21	1.23	0.028	2.30
Ca/K	4.20	2.2 to 6.2	1.53	1.38	1.46	0.106	7.29
Na/Mg	4.00	2 to 6	0.587	0.635	0.611	0.034	5.56
Zn/Cu	8.00	4 to 12	0.103	0.105	0.104	0.001	1.36
Ca/P	2.60	1.5 to 3.6	0.442	0.390	0.416	0.037	8.84
Fe/Cu	0.90	0.2 to 1.6	0.122	0.127	0.125	0.004	2.84
Ca/Pb	84.0	126 to 168	714029	8928172	4821101	5808276	120
Fe/Pb	4.40	6.60 – 8.80	3553	4727	4140	830	20.1
Zn/Cd	500	750 to 1000	417	319	368	69.3	18.8
Fe/Co	440	__[a]	14.9	12.8	13.9	1.48	10.7

K/Co	2000	___	1961	1745	1853	153	8.24
[K/(Ca+Mg)]	2.2	___	0.547	0.608	0.578	0.043	7.47

a__ = not available.

Table 8: Mineral safety index (MSI) of Fe, Ca, P, Mg, Zn, Cu, Se and Na of *Neopetrolisthes maculatus* male and female

Mineral	RAI (mg)	TV of MSI	Male crab			Female crab			Mean	SD	CV%
			CV	D	%D	CV	D	%D			
Fe	15	6.70	0.952	5.75	85.8	1.06	5.64	84.2	1.00	0.073	7.30
Ca	1200	10.0	3.57	6.43	64.3	3.72	6.28	62.8	3.65	0.106	2.91
P	1200	10.0	8.07	1.93	19.3	9.54	0.463	4.63	8.80	1.04	11.8
Mg	400	15.0	22.3	-7.29	-48.6	23.0	-8.01	-53.4	22.6	0.502	2.24
Zn	15	33.0	3.94	29.1	88.0	4.28	28.7	87.0	4.11	0.240	5.84
Cu	3	33.0	192	-159	-481	204	-171	-519	198	8.98	4.54
Se	0.07	14.0	7.20	6.80	48.6	12.2	1.80	12.9	9.70	3.54	36.4
Na	500	4.80	3.35	1.45	30.3	3.74	1.06	22.1	3.54	0.277	7.83

CV = calculated value; TV = Table value; D = difference; RAI = recommended adult intake. No MSI standard for K, Mn, Co and Pb.

Table 9: Statistical analysis of the results from Table 8

Statistical	Male crab		Female crab
r_{xy}		0.9997	
r_{xy}^2		0.9995	
Rxy		0.7360	
Mean	30.l		32.7
SD	65.6		69.7
CV%	218		213
C_A		0.0233	
IFE		0.9767	
Remark		*	

Results significantly different at n-2 (df) (8-2=6) and r = $_{0.01}$; [r_T = 0.834 (critical value)].

Table 10: The vitamin composition (mg/100g) of innards of the male and female *Neopetrolisthes maculatus* on dry weight basis

Parameter	Male crab	Female crab	Mean	SD	CV%	Male-Female values	%difference
B_3 (Niacin)	3.01	3.18	3.10	0.119	3.84	-0.168	-5.59
B_4 (Adenine)	3.23e-3	3.55e-3	3.39e-3	2.25e-4	6.64	-3.19e-4	-9.86
B_6 (Pyridoxamine)	1.25e-1	1.40e-1	0.133	0.011	8.50	-0.016	-12.8
C (Ascorbic acid)	6.68	7.54	7.11	0.607	8.54	-0.859	-12.9
A (Retinol)	5.52e-2	6.49e-2	0.060	0.007	11.5	-9.72e-3	-17.6
B_1 (Thiamine)	1.07e-1	1.22e-1	0.115	0.010	9.05	-0.015	-13.7
B_2 (Riboflavin)	2.25e-1	2.60e-1	0.243	0.025	10.2	-0.035	-15.6
E (Tocopherol)	1.14	1.34	1.24	0.135	10.9	-0.191	-16.7
B_9 (Folic acid)	3.86e-7	4.50e-7	4.18e-7	4.50e-8	10.8	-6.40e-8	-16.6
K (Phylloquinone)	7.81e-4	9.47e-4	8.64e-4	1.17e-4	13.6	-1.66e-4	-21.3
B_5 (Pantothenic acid)	3.17e-1	4.19e-1	0.368	0.072	19.6	-0.102	-32.2
Totals	11.7	13.1	12.4	0.988	7.98	-1.40	-12.0

Table 11: Statistical analysis of the results from Table 10

Statistics	Male crab		Female crab
r_{xy}		0.9999	
r_{xy}^2		0.9997	
Rxy		0.0013	
Mean	1.95		2.18
SD	3.64		4.08
CV%	187		187

C_A		0.0161	
IFE		0.9839	
Remark		*	

Results significantly different at n-2 (df) (12-2=10) and $r_{=0.01}$; [r_T = 0.708 (critical value)].

CONCLUSION

The samples of *Neopetrolisthes maculatus* male and female innards have good nutritional properties. They were high in protein, total ash and crude fat but very moderate in carbohydrate and low in crude fibre. The samples would serve as good sources of protein utilization. Some major and trace minerals were highly concentrated in the samples, they included: Cu, Mn, Ca, Mg, K, Na and P; the toxic minerals were very low and negligible. All mineral ratios were below the ideal (reference balance) and outside the acceptable ideal range. The MSI showed that the minerals would not be deleterious in their consumption except Mg and particularly Cu. The only vitamins of note were niacin (this may require no supplement), vitamin C and vitamin E. The male crab innards was better concentrated in crude fat, crude protein, metabolizable energy, but the female crab innards was better in minerals, MSI and vitamins. From these results both the male and female innards of*Neopetrolisthes maculatus* could be said to be nutritionally good.

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