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Proximate and mineral composition of *Pelusios castaneus* (West African mud turtle) flesh sold in Edo State, Nigeria

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Abstract
This study was undertaken to determine the proximate and mineral composition of Pelusios castaneus (West African-mud turtle) so as to contribute to the availability of data in Nigeria. A total of thirteen (13) male and female each of African mud turtle (Pelusios casteneus) were purchased in Benin City, Nigeria. Specimen were identified to species level, stunned and slaughtered; then each of the turtle were dissected into flanges and Microwave digestion system (Closed Vessels Acid Digestion – MARS System - CEM) procedure was used for the digestion of all the samples based on organic extraction technique before the proximate composition and the mineral contents of the flesh were determined using AOAC methods and standard technique. Data were analyzed using SPSS (version 21) and statistically using ANOVA and DMRT. Result shows that there were significant variations in the different parameters studied; the highest and lowest moisture content values of 67.00% and 52.56% were observed in the male and female respectively. Highest crude protein and lipid values of 26.78% and 15.00%, were observed in the female respectively; while the highest ash content value of 11.33% was observed in the male. While the mean mineral concentrations in the flesh varied among the different elements studied, the overall potassium had the highest value of 4030.82mg while the least value was observed in magnesium (871.04mg). Though Pelusios castaneus has been culturally important to Nigerians, the finding shows that the flesh is a valuable source of mineral elements and proximate components required in diet. Domestication in Nigeria is therefore encouraged to make them commercially available to reduce the pressure on their harvest from the wild thus preventing their going into extinction.

Keywords: *Body parts, Domestication, Minerals, Pelusios castaneus, Proximate composition, Turtle*

Introduction

According to Gunther and Peter (2007), meat is composed of water, fat, protein, minerals and a small proportion of carbohydrate. The most valuable component from the nutritional and processing point of view is protein and it is also the criterion for the quality and value of the finished processed meat products. According to FAO (2016), the amount of carbohydrate in meat is generally too small to be of any significance in the diet; Ángel and Olga (2014) however reported that the main carbohydrate in meat is glycogen.

Proximate composition according to Huss (1995) is affected by both exogenous (composition and frequency of diet) and the environment, and it was observed that the protein and ash tend to decrease with increase in age. Turtles are one of the oldest creatures on earth and have remained essentially unchanged for one hundred and ten (110) million years. Turtles are species found in brackish and marine environment; they nest along the Nigerian beaches and inhabit mainly coastal waters (Adegbile, 2013). Proximate composition has been reported to be a good

pointer of physiology needed for routine analysis in fisheries, as it helps in assessing the nutritional and edible value of species in terms of energy units compared to other species (Cui and Wootton, 2011; Manoharam and Subbulakshmi, 2016).

The potentials of many aquatic resources like water turtles beside fish and fin fishes have not been fully tapped into in Nigeria, as consumption of turtle flesh in Nigeria compared to other animal protein sources is quite low. In consumer`s acceptability of food products, flavour plays a major role according to Elzerman *et al.* (2011), as majority of persons that consume it refer to it as a rare delicacy. The measurements of some proximate profiles are often necessary as this will advance understanding of nutritional requirements, which will help in developing nutrient feed recommendations for various stages of growth.

Terrestrial attacks on nesting females are not uncommon, Jaguars have been reported to smash into the turtle shell with its paws and scoop out the flesh. Human activities such as beach development, poaching, marine debris, oil spills and rehabilitation have also increased the threat to turtles (Saba and Spotila, 2003).

Several authors like FAO (2002), Lezcano (1999) and Pelegrin (1999) have worked on the proximate composition of the muscle of different species of turtle in different part of the world, but there is paucity of data on mineral and proximate composition of turtles found in Nigeria. It has become imperative to carry out this study, to help beef up the existing or otherwise scarce data on the mineral and proximate composition of the flesh of *Pelusios castaneus* found in Nigeria. And where possible assess if significant differences exist between the sexes.

Materials and Methods

Benin City is situated between latitude 7° and 8° north of the equator. The rainfall is between 175cm and 200cm annually with an average temperature of about 34°C.

Collection and analysis of samples

A total of thirteen (13) male and female each of African mud turtle (*Pelusios casteneus*) were purchased at Uselu/Edaiken market in Benin City, Edo state. The turtle specimen were identified to species level in the department of Animal and environmental biology, University of Benin. Preparation and analysis of samples were carried out at Splendid Stan research laboratory, Oluku, Benin city. After collection, the turtle were stunned and slaughtered according to Nwokoro and Egere (1998). The carcass parts were carefully separated from the shell and the viscera removed with a knife. The entire body of the turtle was dissected into four flanges (upper left, upper right, lower left, lower right), fore limb, hind limb and tail before the various flanges of the turtle was analyzed.

The dissected carcasses of *Pelusios castaneus* were analyzed on dry matter basis, *microwave digestion system (Closed Vessels Acid Digestion – MARS System - CEM) procedure was used for the digestion of all the samples based on the organic extraction technique* before the proximate composition according to AOAC (2016) and the mineral contents of the muscles were determined using standard technique described by Sreedevi *et al.* (1992).

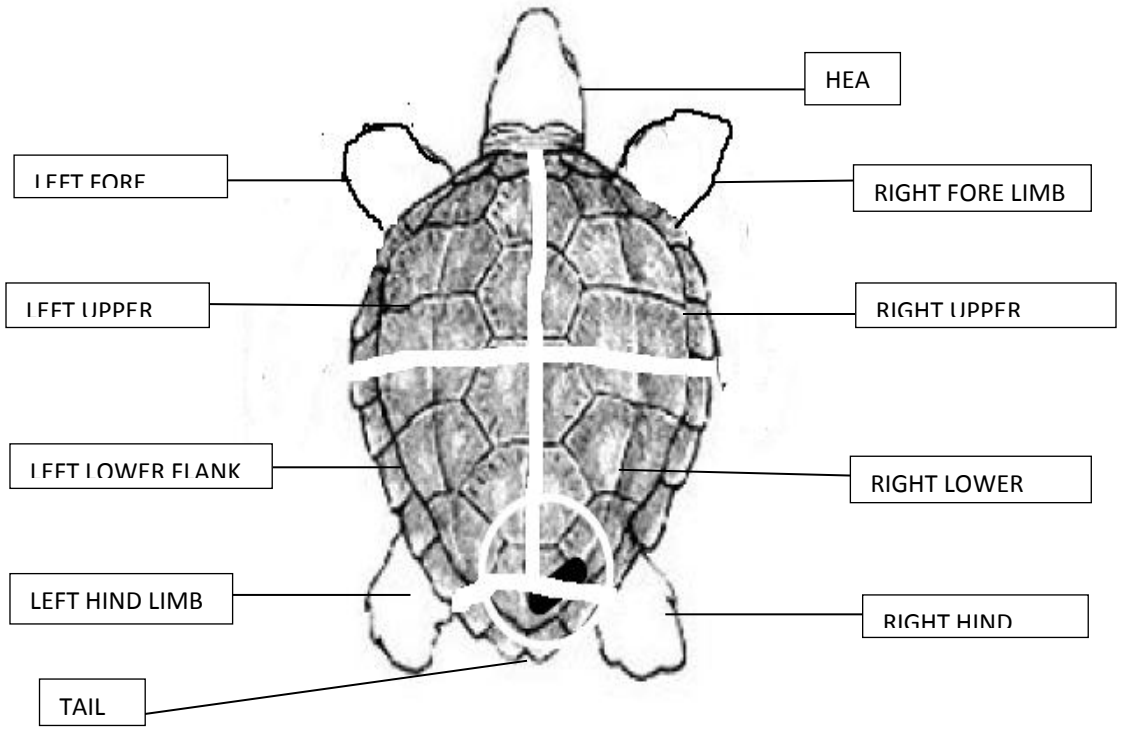

Figure: Sketch of analysed body parts of *Pelusios castaneus*

Results

The results obtained from the laboratory analysis of the proximate and mineral composition of the male and female turtle (*Pelusios castaneus*) flesh are as shown below.

Mineral composition

Potassium: The highest mean potassium content of the muscles of *Pelusios castaneus* (1396.1±422.467mg/kg) was observed in the head of the male while the lowest value (185.78±35.306mg/kg) was observed in the muscle of the left lower body (LLB) of the female (Table 1). In both sexes, potassium had the highest concentration in comparison to the other minerals analyzed. The result also showed that the mean potassium content in the muscles of the male *Pelusios castaneus* had highest value of 1846.56±83.875mg/kg(M) and 946.11±106.678mg/kg(F) in the head and lowest value of 211.00±17.92mg/kg(M in the right lower body (RLB) and 107.44±14.178mg/kg(F in the left upper body (LUB) respectively (Table 2).

Sodium: Highest and lowest value in the overall mean sodium content of 649.33±215.709mg/kg and 138.28±33.501mg/kg was observed in the head and right lower body (RLB) of male *Pelusios castaneus* respectively (Table 1). By sex, the highest value of 849.00±64.832mg/kg(M) and 449.67±70.914mg/kg(F) in the head and lowest value of 155.00±32.867mg/kg(M in the right lower body (RLB) and 88.56±20.231mg/kg(F) in the left lower body (LLB) respectively (Table 2). Analysis of variance showed that there was significant difference ($p<0.05$) in the mean sodium content between them. Comparatively, the mean sodium content of the flesh was higher in the male *Pelusios castaneus* except in the LHL and RFL which was higher in the female

(Table 2).

Calcium: Highest mean calcium values of 2220.61±767.526mg/kg and lowest value of 73.17±24.56mg/kg were observed in the head and tail respectively (Table 1). While by sex, the highest and lowest mean of 2952.56±139.44mg/kg(M) and 1488.67± 164.205mg/kg(F) in the head and 155.00± 32.567mg/kg(M on the RLB) and 38.22± 4.790mg/kg(F in the left upper body (LUB) were observed respectively (Table 2).

Magnesium: For both sexes, magnesium had the least values of all the studied minerals. The overall mean magnesium composition in the muscles had the highest value of 219.67±76.404mg/kg in the head and lowest value of 45.99±10.143mg/kg in the right lower body (RLB). The mean magnesium content in the muscles had the highest value of 292.67 ±12.460mg/kg(M)/and 146.67± 16.109mg / kg(F) in the head and lowest value of 52.56±4.245mg/kg(M right lower body (RLB)) and 24.44±4.531mg/kg(F left upper body (LUB) as shown in Table 2 respectively.

Phosphorus: The overall mean phosphorus content of *Pelusios castaneus* had the highest value of 1541.72±516.346mg/kg in the head and lowest value of 56.06±10.552mg/kg in the right lower body (RLB). Highest value of 2037.56±79.23mg/kg(M) and 1045.85±84.336mg/kg(F) in the head and lowest value (62.89± 6.112mg/kg(M in the RLB) and 32.22±3.667mg/kg(F) in the left upper body (LUB) respectively. Analysis of variance (ANOVA) during the study shows that there was significant differences ($p > 0.05$) in all the mineral composition between the sexes. Further separation of means using Duncan's multiple range test (DMRT) shows that while there was no significant difference ($p<0.05$) between the overall mean mineral content of some of the parts like those in the left fore-limb (LFL) and right fore-limb (RFL); left hind limb (LHL), left lower body (LLB) and right upper body (RUB) as well as between the muscles of the tail and right lower body (RLB) (Table 1); significant differences ($p>0.05$) occurred between different study parts with the flesh of the head having the highest mean concentration of all the minerals analyzed and the right lower body (RLB) and left lower body (LLB) had the least concentrations as shown in Tables 1 and 2. Comparatively, it was observed that the male had a higher mean value of minerals than the females.

Table 1: General Mean Mineral Composition (mg/kg) in the muscles of *Pelusios castaneus*

Minerals (mg/Kg)	LHL	RHL	LFL	RFL	RUB	LUB	RLB	LLB	Head	Tail
Potassium	281.00± 41.203^{b}	291.06± 44.876^{ab}	334.11± 42.078^{c}	328.94± 32.850^{c}	288.33± 47.563^{b}	441.33± 145.503^{d}	185.78± 35.306^{a}	277.61±1 77.450^{b}	1396.33± 422.467^{e}	206.33± 68.193^{a}
Sodium	198.83± 40.207^{ab}	207.67± 40.720^{ab}	232.89± 35.053^{b}	328.94± 32.850^{b}	216.94± 55.971^{b}	331.22± 120.161^{C}	138.28± 33.501^{a}	206.44±1 32.848^{ab}	649.33±2 15.769^{d}	142.56± 46.839^{a}
Calcium	99.83±1 4.415^{b}	103.44± 15.120^{b}	118.89± 15.072^{b}	235.00± 38.666^{d}	102.33± 16.266^{b}	156.61± 51.940^{c}	66.00±1 2.367^{a}	98.33±62 .771^{b}	2220.61± 767.526^{e}	73.17±2 4.567^{a}
Magnesium	70.11±1 0.352^{b}	72.44±1 0.689^{bc}	82.44±1 2.812^{c}	80.83±9 .345^{c}	71.50±1 3.925^{b}	108.83± 37.791^{d}	45.94±1 0.143^{a}	67.89±45 .344^{b}	219.67±7 6.404^{e}	51.39±1 7.188^{a}
Phosphorus	85.39±1 1.469^{b}	88.17±1 3.268^{b}	101.22± 13.176^{b}	99.56±9 .575^{b}	89.33±1 4.931^{b}	135.78± 47.365^{c}	56.06±1 0.552^{a}	84.17±54 .226^{b}	1549.72± 516.346^{d}	62.28±2 0.536^{a}

Note: Means in the same row with similar superscripts are not significantly different ($p<0.05$).

Table 2: Mean Mineral Composition (mg/kg) in *Pelusios castaneus* Flesh in Relation to Sex

Male	Minerals (mg/Kg)	LHL	RHL	LFL	RFL	RUB	LUB	RLB	LLB	Head	Tail
	Potassium	277.67±16.194^{ab}	329.11±27.002^{cd}	368.67±29.069^{d}	324.11±46.429^{c}	329.33±23.404^{cd}	581.67±22.187^{f}	211.00±17.923^{a}	447.78±39.487^{e}	1846.56±83.815^{g}	254.33±58.125^{b}
	Sodium	194.56±20.311^{b}	233.33±38.994^{bc}	258.78±27.752^{c}	232.44±46.242^{bc}	243.78±52.690^{bc}	438.67±70.210^{e}	155.00±32.867^{a}	327.33±64.900^{d}	849.00±64.832^{f}	174.78±40.109^{a}
	Calcium	99.00±4.950^{ab}	116.44±9.057^{abc}	131.22±10.710^{bc}	116.11±15.672^{abc}	115.89±8.937^{abc}	206.78±6.760^{d}	74.33±6.185^{a}	158.44±14.833^{c}	2952.56±139.448^{e}	90.56±21.161^{ab}
	Magnesium	69.33±3.841^{b}	81.44±7.091^{c}	92.67±7.500^{d}	81.33±11.336^{c}	82.56±6.616^{c}	144.89±5.840^{f}	52.56±4.275^{a}	111.33±10.100^{e}	292.67±12.460^{g}	63.67±14.577^{b}
	Phosphorus	85.22±4.604^{abc}	99.00±10.025^{bc}	112.78±7.345^{cd}	99.44±13.685^{bc}	101.44±8.338^{bc}	181.44±7.230^{e}	62.89±6.112^{a}	136.11±12.811^{d}	2037.56±79.231^{f}	76.67±17.727^{ab}
Female	Potassium	284.33±57.622^{cd}	253.00±17.081^{c}	299.56±15.191^{de}	333.78±9.217^{e}	247.33±21.846^{c}	301.00±13.638^{de}	160.56±29.938^{b}	107.44±14.178^{a}	946.11±106.078^{f}	158.33±36.321^{b}
	Sodium	203.11±54.604^{bcd}	182.00±22.820^{b}	207..00±18.241^{bcd}	237.56±32.000^{d}	190.11±47.549^{bc}	226.78±34.763^{cd}	121.56±25.991^{a}	85.56±20.231^{a}	449.67±70.91^{e}	110.33±26.782^{a}
	Calcium	100.67±30.384^{bc}	90.44±4.851^{abc}	106.56±5.077^{bc}	116 78±5.387^{c}	88.78±8.303^{abc}	106.44±4.953^{bc}	57.67±11.424^{ab}	38.22±4.790^{a}	1488.67±164.205^{d}	55.78±12.428^{ab}
	Magnesium	70.89±14.547^{d}	63.44±3.206^{c}	72.22±7.757^{de}	80.33±7.517^{e}	60.44±9.658^{c}	72.78±8.700^{de}	39.33±10.100^{b}	24.44±4.531^{a}	146.67±16.109^{f}	39.11±8.724^{b}
	Phosphorus	85.56±16.071^{bc}	77.33±3.082^{b}	89.67±3.868^{c}	99.67±2.739^{c}	77.22±8.64^{b}	90.11±4.781^{c}	49.22±9.705^{a}	32.22±3.667^{a}	1045.89±84.330^{c}	47.89±10.775^{a}

Note: Means in the same row with similar superscripts are not significantly different ($p<0.05$).

Proximate Analysis

Moisture: The mean moisture content varied between 53.00±0.87% in the head and 67.00±0.87% in the left upper flank of the male, while the mean moisture content of the female turtle flesh ranged from 52.56±1.236% to 72.89±1.616%. However, the mean moisture content in the flesh of the female *P. castaneus* had the highest value of 72.89% and lowest value of 52.56% in the tail and lower hind limb respectively (Table 3 and 4). Analysis of variance (ANOVA) showed that there was significant difference ($p<0.05$) in the overall mean moisture content among the body parts of both sexes. Duncan Multiple Range Test (DMRT) further showed specific parts where significant differences ($p<0.05$) existed within the sexes as shown in Tables 3 and 4.

Protein: The mean protein content ranged from 25.11±1.76% in the right forelimb to 13.67±2.18% in the head of the male, while the female mean protein content in the female *Pelusios castaneus* had the highest value of 26.78% in the lower hind limb and lowest value of 14.33% in the tail (Table 3 and 4). ANOVA and DMRT showed that significant differences ($p <0.05$) existed in the mean protein content between the various parts analyzed.

Lipid: The mean lipid composition of the male turtle flesh ranged from 12.33±0.50% for the right hind limb to 4.67±0.50% for the head; and 7.00±0.866 to 15.00±0.866 in the female. The right upper body had the highest mean of 15.00% while the tail had the lowest mean of 7.00%. ANOVA showed that significant differences ($p <0.05$) existed in the mean lipid composition between the different body parts.

Fibre: Fibre content ranged from 0.00±0.00% in all the other body parts to 14.56±0.73% and 11.22±0.441 in the head of the male and female respectively. ANOVA showed that there were no significant difference ($p<0.05$) in the mean fibre composition between the parts except between the head and the other parts.

Ash: The mean ash content of male turtle flesh varied between 11.33±1.58% for the head to 3.00±0.00% for the right lower flank. The flesh of the female *Pelusios castaneus* head had the highest mean ash content of 8.78±1.202% and the left lower body had the lowest value of 1.56±0.527% as shown in Table 3 and 4. ANOVA showed that significant difference ($p <0.05$) existed in the

mean ash content between body parts.

Nitrogen Free Extract (N.F.E)

The mean NFE composition of male turtle flesh varied between 2.56±1.01% in the head to 0.00±0.00% in the right lower flank. The highest and lowest mean value of 2.44±0.527% and 0.33±0.707% were recorded in the head and right upper body respectively in the female (Table 3 and 4). ANOVA showed that significant difference ($p<0.05$) existed in the mean N.F.E composition between the body parts.

Table 3: Means (±SD) of Proximate Composition of Male *Pelusios castaneus* During Study

Body parts	Moisture (%)	Protein (%)	Lipid (%)	Fibre (%)	Ash (%)	NFE (%)
LHL	56.33±1.00^{bc}	24.44±0.53^{fg}	12.00±0.86^{h}	0.00±0.00^{a}	7.22±0.67^{bc}	0.44±0.53^{ab}
RHL	55.00±1.73^{a}	24.22±0.67^{fg}	12.33±0.50^{h}	0.56±0.53^{b}	7.44±0.53^{cd}	0.89±0.33^{b}
LFL	57.11±1.45^{b}	22.89±0.33^{de}	10.33±0.50^{f}	0.56±0.523^{b}	8.44±0.73^{e}	0.89±0.33^{b}
RFL	53.44±2.74^{a}	25.11±1.76^{fg}	11.33±1.32^{g}	0.33±0.50^{ab}	8.33±1.80^{de}	0.67±0.71^{b}
RUF	63.00±0.87^{d}	22.22±1.4^{d}	5.67±0.50^{b}	0.00±0.00^{a}	8.78±0.83^{e}	0.33±0.50^{ab}
LUF	67.00±0.87^{g}	17.33±0.507^{b}	7.11±0.78^{c}	0.00±0.00^{a}	8.22±0.44^{de}	0.33±0.50^{ab}
RLF	64.89±0.78^{ef}	22.89±0.78^{de}	8.67±0.50^{d}	0.11±0.33^{a}	3.00±0.00^{a}	0.00±0.00^{a}
LLF	63.67±1.32^{de}	23.44±1.33^{ef}	5.67±0.50^{b}	0.00±0.00^{a}	6.44±0.73^{b}	0.11±0.33^{a}
HEAD	53.00±0.87^{a}	13.67±2.18^{a}	4.67±0.50^{a}	14.56±0.73^{d}	11.33±1.58^{f}	2.56±1.01^{c}
TAIL	66.00±1.50^{fg}	18.67±0.50^{c}	9.33±0.50^{e}	1.00±0.00^{c}	3.67±1.00^{a}	2.11±0.33^{c}

Note: Means with the same superscript are not significantly different ($p> 0.05$) along column.

Table 4: Mean (±SD) of Proximate Composition of Female *Pelusios castaneus* During Study

Body Parts	Moisture(%)	Protein(%)	Lipids(%)	Fibre(%)	Ash(%)	NFE (%)
LHL	52.56±1.236^{h}	26.78±0.667^{a}	14.00±0.866^{b}	0.00±0.000^{d}	5.44±0.527^{d}	0.67±0.500 ^{cd}
RHL	58.67±1.000^{e}	25.44±0.527^{b}	8.33±0.500^{f}	0.00±0.000^{d}	5.78±0.441^{d}	1.11±0.333^{bc}
LFL	55.00±0.866^{f}	25.44±0.866^{b}	12.00±0.000^{e}	0.00±0.000^{d}	6.78±0.441^{e}	0.44±0.726^{d}
RFL	52.67±0.500^{h}	25.00±0.866^{b}	13.67±0.500^{bc}	0.00±0.000^{d}	7.44±0.726^{b}	1.11±0.333^{bc}
RUB	63.44±0.527^{d}	14.56±1.130^{d}	15.00±0.866^{a}	1.00±0.000^{b}	5.56±0.527^{d}	0.33±0.707^{d}
LUB	66.67±1.323^{b}	14.56±0.527^{d}	12.89±0.782^{d}	1.00±0.000^{b}	4.22±0.441^{e}	1.00±0.500^{bc}
RLB	65.00±0.866^{c}	18.11±0.333^{c}	13.00±0.866^{cd}	0.67±0.500^{c}	2.33±0.500^{f}	1.00±0.000^{bc}
LLB	65.56±1.236^{c}	17.78±1.481^{c}	13.33±0.500^{bcd}	1.00±0.000^{b}	1.56±0.527^{g}	1.00±0.000^{bc}
Head	53.78±0.441^{g}	17.67±0.500^{c}	7.33±0.500^{g}	11.22±0.441^{a}	8.78±1.202^{a}	1.33±0.500^{b}
Tail	72.89±1.616^{a}	14.33±0.500^{d}	7.00±0.866^{g}	1.00±0.000^{b}	2.33±0.500^{f}	2.44±0.527^{a}

Note: Means in the same column with the same superscript are not significantly different ($p<0.05$).

Discussion

The importance of proximate and mineral composition of any edible organism cannot be over emphasized; as the nutritive value is reflected in its biochemical contents. There was significant variation in the proximate composition of the various body parts studied for both male and female *P. castaneus*.

Potassium: Like sodium, potassium is also important for muscle contractions, transmission of impulses in the nerves and sugar metabolism (Mogobe *et al*., 2013). Overall, potassium was found to be the mineral with the highest concentration in all the fleshy tissues compared to other minerals analyzed. The mean potassium values obtained in this study are comparable to potassium values of

1276.4mg/kg and 2064.8mg/kg reported by Oksuz *et al*. (2011) for gold band goatfish and stripped red mullet respectively. The potassium values obtained in this study are also comparable to the studies of Mohammed *et al*. (2010) and Luczyiska *et al*. (2009) who reported mean potassium concentrations ranges of 954-1210mg and 1429-2387mg in species of freshwater fish in Sudan and Poland respectively. However, this study showed significantly higher potassium values (185.78 – 1393.33mg/kg) compared to previous values of 4.949 – 9.454mg/kg reported by Meiling *et al*. (2008) in species of geoemydid turtle in China. Other studies by Eneji *et al*. (2008) and Soundarapandian *et al*. (2014) showed potassium concentration in the ranges of 69.39 – 72.40mg for species of freshwater snails (*Lanistes varicus* and *Nucella lapillups*) and 8.52 – 10.52mg for edible crab (*Podophalmus vigil*), which were significantly lower compared to the mean potassium values obtained in this study.

The marked variation in the potassium content observed in this study may be attributed to seasonal and biological differences (species, size, dark/white muscles, age, sex and sexual maturity), area of catch, processing method, food source and environmental conditions (Soundarapandian *et al*., 2014). The high potassium concentrations reported in the muscles of *Pelusios castaneus* in this study compared to other minerals analyzed could be an indication of high levels of potassium in the water body where the turtle were collected and therefore high trophic transfer and accumulation of the mineral in the flesh as well as the ability of the species to absorb and assimilate the mineral from the diet.

Calcium: The mean calcium values obtained in this study were significantly higher than the mean calcium values of 1.18 – 7.404mg/kg reported by Meiling *et al.* (2008) in species of geoemydid turtle. The mean calcium values obtained in this study were also significantly higher than values of 0.176 – 0.198mg/kg reported by Adebayo-Tayo *et al.* (2011) for species of freshwater snail in the Niger Delta. However, the mean calcium values obtained in this study are comparable with the findings of Mogobe *et al.* (2013), Moeller *et al.* (2003), Mohammed *et al.* (2010) and Luczyiska *et al.* (2009) who obtained calcium ranges of 413 – 1290mg, 760 – 2200mg, 107 – 588mg and 53 – 103mg in freshwater fish species. Oksuz *et al.* (2011) also reported calcium values of 617.4mg/kg for gold band goatfish and 398.6mg/kg for stripped red mullet which were within the range obtained in this study. According to Meiling *et al*. (2008), in order to meet the requirement of calcium, humans should ingest sufficient food with high calcium content.

Magnesium: magnesium was found to be the mineral with the lowest concentration of all the minerals analyzed. The magnesium values obtained in this study are higher than the magnesium values of 0.7768 – 0.987mg/kg reported by Meiling *et al*. (2008) for turtles in China and 0.279 – 0.297mg/kg reported by Adebayo-Tayo *et al*. (2011) for freshwater snails. Achionye-Nzeh *et al*. (2011) reported magnesium values of 18.33 – 20.28mg/kg for *Katsuwonus paleamus*, which were also significantly lower than values obtained in this study. The magnesium values in *Pelusios castaneus* flesh are also significantly lower than values reported by Nurnadia *et al*. (2011) in golden snapper, Indian mackerel, large – scale tongue sole, prawn, cockles and oysters with concentrations of 660.67mg, 710.99mg, 670.14mg, 1220.60mg, 1480.50mg and 1534.80mg respectively. Mogobe *et al*. (2015), Mohammed *et al*. (2010) and Luczyiska *et al*. (2009) reported magnesium values of 34 – 48mg, 68 – 75mg and 84 – 143mg in freshwater fish species which are comparable with values obtained in *Pelusios castaneus* flesh. The low magnesium contents

observed could be due to low levels of magnesium in the water or less trophic transfer and accumulation due to the inability to absorb the element from the water (Mogobe *et al*., 2013).

Phosphorus: The mean phosphorus concentration values obtained in the flesh of *Pelusois castaneus* are similar to phosphorus values of 1754.9mg/kg for gold band goatfish and 2065.8mg/kg for stripped red mullet reported by Oksuz *et al*. (2011). These values are also similar to the findings of Fagbenro *et al*. (2005) who reported values of 883.02mg for *Clarias gariepinus*, 912.04mg for *Heterobranchus bidorsalis*, 913.14mg for *Gymnarchus niloticus* and 1199.90mg for *Malapterus electricus*. Achionye-Nzeh *et al*. (2011) reported phosphorus values of 588.75-866.4mg/kg for *Genorpnermus lineatus*, 740-758.75mg/kg for *Trachurus trachurus*, 533.75-713.75mg/kg for *Scomber scumbrus* and 752.5-795.0mg/kg for *Katsuwonus peleamus*, which were within the values obtained in this study. However, the phosphorus values obtained in this study were significantly higher than the range of 3.552 – 6.001mg/kg reported by Meiling *et al*. (2008) for geoemydid turtle. The phosphorus values were also significantly higher than the values of 60.19 – 62.59mg for freshwater snail, 0.31 – 0.44mg/kg for Pebbly fish (*Alestes baremoze*) and 6.98mg for white leg shrimp (*Litopenaeus vannamei*) reported by Eneji *et al*. (2008), Kasozi *et al*. (2015) and Gunalan *et al*. (2013) respectively.

Sodium: The values of sodium observed during this study are comparable to studies by Mogobe *et al*. (2013), Moeller *et al*. (2003), Mohamed *et al*. (2010) and Luczyiska *et al*. (2009) who obtained values of 86-145mg, 36-400mg, 180-280mg and 148-328mg in freshwater fish in Botswana, USA, Sudan and Poland. However, the mean sodium values obtained in this study were significantly higher compared to the mean sodium values of 2.544 – 5.537mg/kg reported in species of geoemydid turtle by Meiling *et al*. (2008). And also significantly higher than sodium values of 0.136 –0.419mg/kg, 11.5 – 15.89mg and 67.7mg in freshwater snail, edible crab and white leg shrimp, reported by Adebayo-Tayo *et al*. (2011), Soundarapandian *et al*. (2014) and Gunalan *et al*. (2013). Sodium is the principal cation of extracellular fluid and is involved primarily in the maintenance of osmotic equilibrium and extracellular fluid volume (National Institute of Nutrition, 2009). Sodium is also good for muscle functioning (Alas *et al*., 2014).

The mineral composition of the *Pelusios castaneus* flesh showed significant variability in the parts analyzed, with low magnesium content, higher calcium and potassium contents in all the muscles. Overall, the highest mineral concentrations were observed in the head while lower values were observed in the right lower body of the male and left lower body in the female. Comparatively, males had higher minerals, though with significantly lower magnesium content, other minerals analyzed were significantly higher than values reported in previous studies on turtle and some species of freshwater fish and shellfish. The study shows that the flesh of *Pelusios castaneus* to be a valuable source of the much needed essential macro mineral elements (potassium, sodium, calcium, magnesium and phosphorus).

Moisture: Moisture is the largest constituent of almost all tissues thus the substratum in which all other components are also incorporated. Changes in its concentration in any tissue affect the general biochemical functioning of the animal. There were varied values of moisture content in all the parts analysed for both sexes of *P. castaneus*, the moisture content was higher at the tail than at the head; this higher moisture content in the tail explains the reason for its low protein content. The moisture values obtained during this study were lower than that of FAO (2002)

who reported moisture content of green turtles as 78.5%. The mean moisture content observed during this study were not significantly different from the 70.7 observed by Achaglinkame *et al.* (2020) but lower than that 82.96±2.12 observed in the studies of the proximate and mineral composition of snail (*Achatina achatina*) by Felix *et al.* (2013). Low moisture content in the sample is desirable, as this will positively impact on its stability during storage.

Protein: Variations in protein content of meat from different sources can be due to a number of factors such as types of species, diet, age, location and portion of flesh sampled (Van Heerden *et al*., 2002; Sales and Hayes, 1996). In this study, protein was found to be the most dominant biochemical constituent beside water. The levels of protein were found to be higher in the limbs containing high amounts of collagen (a long, stiff protein that is the most prevalent protein in mammals) than in other parts of the flesh. It may therefore be inferred that since the limbs are locomotive organs containing high amounts of collagen with weight-bearing muscles, used frequently and for support maybe responsible for this. The protein values obtained during this study were similar to that of several researchers, Olmedo and Farnes (2004) reported protein content of 15.7-19.01% for the hawksbill turtle, 16 – 20% for the green turtle and 17.75% for the loggerhead turtle. The mean protein value observed during this study was also similar to that of *Calinectes palidus* and *Cardisoma armatum* (24.38% and 23.94% respectively) by Elegede and Fashima (2013). The relatively high protein in the flesh of *P. castaneus* indicates that it can be used to supplement other sources of protein for man and animal.

Nitrogen Free Extract (N.F.E): They serve as precursors for some amino acids and other nutrients (NRC, 1993; Owen *et al.,* 2010). The presence of NFE in the flesh indicates the availability of such an important and immediate energy precursor for the survival and growth of *Pelusios castaneus*. The very low values of NFE observed in the different body parts of both sexes is an indication that turtles being a poor NFE sources invariably indicative of being low in carbohydrates (Osibiona *et al.,* 2009). This was to be expected as turtle meat is basically animal protein, and with the slow nature of its locomotion, it only needs to store small amounts of glycogen for this purpose (Das and Sahu, 2001). Animals have limited capacity to store glycogen in their bodies and excess amounts are metabolized into fat (Berg *et al.,* 2002). The relatively low values of NFE could also be due to higher values of moisture and relatively high value of protein contents.

Fibre: Aquatic organisms generally contain very little fibre (Suhenden *et al.,* 2008). In the present study, fibre content was significantly higher in the head and absent in some of the analyzed parts. This may be due to the presence of resistant starch and other indigestible carbohydrates insoluble in digestive juices found in would-be predators and so cannot be easily digested (Guillon *et al*., 2010). Similar observation has been reported for aquatic crabs, lobsters, prawns and sharks (Gopalan *et al.,* 2004). Non-detectable amount of crude fibre in all meat types supports their high digestibility on consumption.

Lipid: Crude fat is regarded as one of the most important food reserves in animal; this has led to the use of fat indices as a measure of percentage water and fat relationship (Salam and Davies, 1994). Lipids are extremely important in maintaining structural and physiological integrity of cellular and sub-cellular membranes. A strong indicator of reproductive potential in some turtle stocks, it also affects the taste of their flesh (Marshall *et al*., 1999). Results of the lipid content of the different parts of the turtle`s flesh showed that there was no significant difference between the

fat content in the head and tail. This means that whether a consumer relish the head or tail, he consumes the same quantity of the available fatty acids. Similar results has been reported by Akhirevbulu and Okonji (2013) who observed no difference in fat content in the head and tail of *Heterobranchus bidorsalis*. However there were significant variation in the lipid concentration of the other body parts, this is in agreement with Thakur *et al*. (2003) who stated that the total lipid and its composition in aquatic species vary more than any other nutrient component.

It should be noted that the low values of fat may be as a result of the high values of moisture. The higher fat content observed in the female during this study may be due to the fact that female aquatic turtle generally require higher fat reserves during sexual maturation and gestation for gonad and embryonic development respectively (Love, 1980). It may also be because of the type of diet the turtle feeds on.

Ash: Ash is mainly composed of inorganic materials. Ash content of the flesh was found to be significantly highest at the head region and lowest in the left lower body region which could be as a result of the bone to flesh ratio in these parts. Thus, turtle head is a good source of minerals; similar values have been reported for the ash content of the head of cod (Fataneh, 2015). Ash content values obtained during this study were not in agreement with values earlier reported by Ellen *et al.* (2006) who reported a mean ash content of 18.5±2.5% in the flesh of *Sternotherus odoratus.* It must be noted however that the total ash content of any sample greatly depends on the specimen weight, sexual maturity and the environment where they were harvested (Roy and Lall, 2006).

The limbs (LHL, RHL, RFL and LFL) were relatively rich in crude protein, crude fat and ash but with normal amounts of NFE. The upper body (left and right) were relatively low in crude protein but with high crude fat and normal amounts of minerals, ash, NFE and fibre. The lower portions of the body (left and right) were high in moisture, fat and lipids but possessed normal amounts of fibre, ash and NFE. The head was low in moisture and crude fat but with high amounts of protein, fibre, minerals (ash) and NFE. The tail had high moisture and NFE content but with low levels of crude protein, crude fat, fibre and ash.

Conclusion and Recommendations

This study was carried out primarily to determine the proximate and mineral composition of the flesh of *Pelusios castaneus*, which from this study can be said to be a rich source of these components irrespective of sex. Although there was variability in these components among the various body parts studied.

The implication of these findings is that *Pelusios castaneus* where available, can be an important food source because of its richness in proteins and lipids which are indices of nutritional quality of food items that are beneficial to man. Awareness therefore, on these nutritive values should be propagated by fisheries managers so as to encourage relevant stakeholders especially those in aquaculture with a view to discouraging the capture and utilization of these economically and nutritionally healthy species from the wild. By promoting their commercial availability via its culture and improving the domestication management techniques to prevent them from going into extinction.

References

Achaglinkame, M. A., Owusu-Mensah, E., Boakye, A. A. and Oduro, I.(2020). Effect of Size and Drying Time on the Rehydration and Sensory Properties of Freeze-Dried Snails (*Achatina achatina*). *International Journal of Food Science*, 5**;** 21-27.

Achionye-Nzeh, I.G., Adedoyin, O.M., Oyebanji, S. and Mohammed, O.M. (2011). Mineral composition of some marine and freshwater fishes. *Agriculture and Biology Journal of North America*. **2(7):** 1113-1116.

Adebayo-Tayo, B.C., Onilude, A.A. and Etuk, F.I. (2011). Studies on Microbiological, Proximate Mineral and Heavy Metal Composition of Freshwater Snails from Niger Delta creek in Nigeria. A U J.T. 14(4): 290-298.

Adegbile, O. M. (2013). National Report: Sea Turtles in Nigeria. Marine Biology Section, Nigerian Institute for Oceanography and Marine Research. pp. 1-9.

Akhirevbulu, C. J. and Okonji, V. A. (2013). Variation of proximate composition, amino acid and fatty acid profiles of parts of cultured *Heterobranchus bidorsalis* (Geoffroy Saint-Hilaire, 1809). *Nigerian Journal of Agriculture, Food and Environment*. 9(4):7-12

Alas, A., Ozcan, M.M. and Harmankaya, M. (2014). Mineral contents of head, caudal, central fleshy part, and spinal columns of some fishes. *Environ. Manit Assess.* 186: 889-894.

American Meat Science Association, AMSA (2016, October 25). Composition of Meat -Water, Carbohydrates, Minerals and Vitamins. Retrieved from: http://www.meatscience.org/students/ meat-judging-program/meat-judging news/article/2015/07/31/composition-of-meat---water-carbohydrates-minerals-and-vitamins.

Ángel, C. and Olga, D. (2014). Chemical Composition of Meat and Meat Products. *Handbook of Food Chemistry*. Pp 19 -32

Association of Official Analytical Chemistry (AOAC), (2016). Official methods of analysis. of AOAC International. Horwitz, W (20th ed.). Dallas, Texas.

Berg, A. H., Combs, T. P. and Scherer, P. E. (2002). Arcp30/adiponectin: An adipokine regulating glucose and lipid metabolism. Trends in Endocrinology and Metabolism 13:84–89.

Brett, J.R. and Groves, T.D.D. (1979). Physiological energetics. In: W.S. Hoar, D.J. Randall and J.R. Brett (Editors), Fish Physiology, VIII. Academic Press, New York, NY, pp. 280-352.

Cui, Y. and Wootton, R. J. (2011). Effects of ration, temperature and body size on the body composition, energy content and condition of the minnow, *Phoxinus phoxinus* (L). *Journal of Fish Biology*, **32**: 749-764.

Das, S. and Sahu, B. K. (2001). Biochemical composition and calorific content of fishes and shellfishes from Rushikulya estuary, south Orissa coast of India. *Indian Journal* of *Fisheries*. 48: 297-302.

Elegede, I.O. and Fashina-Bombata, H.A. (2013). Proximate and minera composition of common crabs (*Callinectes paidus and Cardisoma armatum*) of Badagry creek, Nigeria. *Poultry, fish, wildlife science* **2**:110

Elzerman, J.E., Hoek, C.A., Martinus, A.J.S. and Luning, A.P. (2011). Consumer acceptance and appropriateness of meat substitutes in a meal context. *Food quality and preferences* 22(3): 233-240

Eneji, C.A., Ogogo, A.U., Emmanuel-Ikpeme, C.A and Okon, O.E. (2008) Nutritional assessment of some Nigerian land and water snail species. *Ethiopian Journal of Environmental Studies and Management.* 1(2): 56-60

Felix, N. E., Newlove, A.A., Patricia, O.D. and

Wilfred, S. (2013). Proximate and Mineral Composition of Snail (*Achatina achatina*) Meat; Any Nutritional Justification for Acclaimed Health Benefits? *Journal of Basic and Applied Scientific Research*. **3**(4)8-15.

Food and Agriculture Organization (2002). Fishery Statistics. Aquaculture Production. 90 (2).

FAO/WHO. (2015). Maximizing the contribution of fish to human nutrition. ICN2 Second International Conference on Nutrition: better nutrition better lives. Rome, FAO

FAO, Food and Agriculture Organization of the United Nations. (2016). *The State of World Fisheries and Aquaculture: Opportunities and Challenges*. Rome: FAO.

Fagbenro, A.O., Akinbulumo, O. M., Adeparusi, E.U. and Raji, A.A. (2005). Flesh Yield, Waste Yield, Proximate and Mineral Composition of Four Commercial West African Freshwater Food Fishes. *Journal of Animal and Veterinary Advances*, 4(10):848-851

Fataneh, M. (2015). *Hydrolysis of Marine cod (Gadus morhua) head: Utilisation of rest raw material from cod for production of ingredients for human consumption*. (Unpublished master's thesis). Norwegian University of Science and Technology, Norway.

Federal republic of Nigeria official gazette, (1992). Export (incentives and citation miscellaneous provisions) Decree 1992.

Fergus, C. (2007). Turtles wild guide. Wild guide. Mechanicsburg, PA: stackpole books. p.viii. ISBN 9780811734202

Goddard, D. R. and Michaelis, L. (1934). A study on keratin. *Journal of Biological Chemistry*, 106: 605–614

Gopalan, C., Rama-Sastri, B. V. and Balasubramanian, S. C. (2004). Nutritive Value of Indian Foods, National Institute of Nutrition, ICMR, Hyderabad.

Guillon, J., Boulouard, M., Lisowski, V. Stiebing S., Lelong, V., Dallenmagne, I. and Rault, S. (2010). Synthesis of New 2- (Aminomethyl)4-phenylpyrrolo [1,2,-a]-quinoxalines and their preliminary In-vivo Central Dopamine Antagonist Activity Evaluation in Mice, *Journal of Pharmacy and Pharmacology*. 52(11): 1369-1375.

Gunalan, B., Nina, S., Suondarapandian, P. and Anand, T. (2013). Nutritive value of cultured white leg shrimp *Litopenaeus vannamei*. *International Journal of Fisheries and Aquaculture*, 5(7):166-171.

Gunter, H. and Peter, H. (2007). Meat Processing Technology for Small to Medium-Scale Producers. Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific Bangkok, *RAP Publication* p20

Huss, H.H. (1995). Quality and quality changes in fresh fish. FAO Fisheries Technical paper No. 348, Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy.

Jaffe, A. L., Slater, G. J. and Alfaro, M. E. (2011). "The evolution of island gigantism and body size variation in tortoises and turtles". *Biology Letters*. **7**(4): 558-561pp.

Kasozi, N., Degui, G.I., Agizua, D., Mukalazi, J andKalany, E. (2014). Proximate composition and mineral content of Pebbly fish, *Alestesbaremoze* (Joanis, 1835) fillets in relation to fish size. *Uganda Journal of Agricultural Science*, 15(1): 41-50.

Lezcano, M. (1999). Informe Técnico

"*Características Nutricionales de los Quelonios marinos*", Centro de Investigaciones Pesqueras, La Habana, Cuba (unpublished data).

Love, R. M. (1980). The Chemical Biology of fishes. 2nd Ed. Academic press 1 London, UK. P.212-232.

Luczyiska, J., Touska, E. and Luczyiski, J. (2009).Essential mineral components in muscles of six freshwater fish from the Mazurian Great Lakes (Northern Poland). *Arch. Pol. Fish*. **17**: 171-178.

Manoharam, J. J. and Subbulakshmi, S. (2016). Habitat impact on the proximate composition of some food fishes. *South Indian Journal Of Biological Sciences* **2**(**2**): 264-267

Marshall, W. L., Cripps, E., Anderson, D. and Cortoni, F. (1999). Self-esteem and coping strategies in child molesters. *Journal of Interpersonal Violence.* **14**(9): 955-962.

Meiling, H., Haitao, S., Lirong, F., Shiping, G., Fong, J.J. and Parham, J.F. (2008). Scientific refutation of traditional Chinese medicine claims about turtles. *Applied Herpetology*.5: 173-187.

Moeller, A., MacNeil, S.D., Ambrose, R.F. and Hee, S.S.Q. (2003).Elements in fish of Malibu Creek and Malibu Lagoon near Los Angeles, California. Mar. Pollut. Bull. 46: 424-429.

Mogobe, O., Mosepele, K. and Masamba, W.R.L. (2013). Essential Mineral Content of Common Fish Species in Chanoga, Okavango Delta, Bostwana. *African Journal of Food Science*. 9:480-486

Mohammed, E.H.H., Al-Maqbaly, R. and Mansour, M.H. (2010). Proximate composition, amino acid and mineral contents of five commercial Nile fishes in Sudan. *Africa Journal of Food Science*, 10:650-654.

National Institute of Nutrition (2009). Report of an Expert Group: Indian Council of Medical
Research, New Delhi, Indian

National Marine Fisheries Service, NMFS (2015). "Sea Turtles". *www.nmfs.noaa.gov*. Retrieved 2019-12-20

National Research Council. (1993). Nutrient requirements of fish. Committee on Animal Nutrition. Board on Agriculture. National Research Council. National Academy Press. Washington DC, USA. P. 114.

Nurnadia, A.A., Azrina, A. and Amin, I. (2011). Proximate composition and energetic value of selected marine fish and shellfish flesh from the West coast of Peninsular Malaysia. *International Food Research Journal*. 18:161-289.

Nwokoro, S. O. and Egere, H. O. (1998). Handling, carcass characteristics and chemical composition of tortises (*Testudo spp.*) under captivity. In: proceeding of the 8th world conference of animal production, Seoul, Korea. 278-279.

Oksuz, A., Ozyilmaz, A. and Kuver, S. (2011). Fatty Acid Composition and Mineral Content of *Upeneusmoluccensis* and *Mullussurmuletus*.*Turkish Journal of Fisheries and Aquatic Science*. **11:** 69-75.

Olmedo, G. G. and Farnes, O. C. (2004). Research report: Cultural, social and nutritional value of sea turtles in Cuba. Universidad de la Habana. *World Wildlife Fund*, Washington D.C., USA. 1 – 44p.

Osibiona, A. O., Kusemeju, K. and Akande, G. R. (2009). Proximate composition and fatty acid profile of the African cat fish (*Clariasgariepinus*). *Acta SACEA*, 3: 85-89pp.

Owen, O. E., Reichard Jr, G. A., Patel, M. S. and Boden, G. (2010). Energy

metabolism in feasting and fasting. Advances in Experimental Medicine and Biology 1979 (111):169-188.

Pelegrín, E. (1999). Informe Técnico "*Composición aminoacídica del músculo de las tortugas marinas*" (*Eretmochelys imbricata y Chelonia mydas*) (unpublished data).

Roy, P. K. and Lall, S. P. (2006). Mineral nutrition of haddock *Melanogrammus aeglefinus* (L.): a comparison of wild and cultured stock. *Journal of Fish. Biol*. 68: 1460-1472.

Saba, V. S. and Spotila, J. R. (2003). Survival and behavior of freshwater turtles after rehabilitation from an oil spill. *Environmental Pollution*. 126: 213-223.

Salam, A. and Davies P. M. C. (1994): Body composition of Northern Pike (*Esox licius*) in relation to body size and condition factor. *Fish Res*. 19:193 – 204.

Sales, J. and Hayes, J. P. (1996). Proximate, Amino Acid and Mineral Composition of Ostrich Meat. *Food Chemistry* 56: 167-170.

Soundarapandian, P., Varadharajan, D. and Ravichandran, S. (2014). Mineral composition of edible crab *Podopthalmus vigil* Fabricus (Crustacea: Decapoda). *International Academy of Ecology and Environmental Sciences*

Sreedevi, P.A., Suresh, A., Siraramkrishna, B., Prebbavathi, B. and Radhadrishanaiab, K. (1992). Bio accumulation of nickel in the organs of the freshwater fish *Cyprinus carpio* and the water mussel *Lamethhodens marginals* under lethal and sub lethal nickel stress. *Chemosphere 24 (1): 29-39*

Suhenden, M., Diden, U. A. and Yasemin, S.T. (2008). Effect of different processing technologies on the chemical composition of sea foods. *Food Science and Technology Research.* 14: 467-4

Thakur, P. D., Morioka, K., Itoh, Y. and Obatake, A. (2003). Lipid composition and deposition of cultured yellowtail *Seriolaquinqueradiata*muscle at different anatomical locations in relation to meat texture. *Fisheries Science*, 69: 487 - 494.

Trang, S. T., (2012). Bioactive Compounds from By-products of Shrimp Processing Industry in Vietnam. Van-Heerden, S. M., Schonfeldt, H. C., Smith, M. F. & Van Rensburg, J. D. M. (2002). Nutrient Content of South African Chickens. *Journal of Food Composition and Analysis*. 15: 47- 64

Wood, J.D., Enser, M., Richardson, R. I., Whittington, F. M. (2008). Fatty acids in meat products. In: Chow CK (ed) Fatty acids in foods and their health implications. CRC Press/Taylor and Francis Group, Boca Raton, p 87–107.