Weight yield factor, chemical composition and energy value in three imported shellfish species in Nigeria

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Abstract

Shellfish is a major component of our global aquatic food supply, which includes the molluscs, crustaceans and echinoderms. The aim of this study was to evaluate the weight yield factor, chemical composition and energy value in three imported shellfish species (*Palinurus regius*, *Sepia officinalis* and *Farfantepenaeus notialis*) in Nigeria. The physical and chemical determinations were in accordance with the official methods. The results showed that all the shellfish species had weight yield factor less than 1, and the weights obtained for the samples showed no statistically significant differences before and after boiling. In raw samples, *S. officinalis* had significant ($p < 0.05$) higher protein and crude fat values of 20.41 ± 0.63 g/100 g and 2.67 ± 0.68 g/100 g respectively. In boiled samples, high protein levels (15.21-19.22 g/100 g) with no significant difference characterized the overall proximate profile of shellfish species studied herein. In terms of minerals, all investigated elements (calcium, magnesium, potassium, phosphorus and sodium) were generally found at lower levels in boiled samples when compared with the mineral contents of the raw shellfish samples. *S. officinalis* had the higher total energy value in both raw (344.94 kJ 100/g) and boiled samples (373.96 kJ 100/g). All the species can be considered as food items with interesting dietetic properties due to high contents of proteins, minerals and useful energy values.

Keywords: Cuttlefish, lobster, minerals, proximate, shrimp

Le Facteur de rendement, composition chimique et valeur énergétique de trois espèces de mollusques et crustacés importés au Nigéria

Résumé

Les mollusques et crustacés sont une composante importante de notre approvisionnement alimentaire aquatique mondial, qui comprend les mollusques, les crustacés et les échinodermes. L'objectif de cette étude était d'évaluer le facteur de rendement pondération, la composition chimique et la valeur énergétique de trois espèces importées de mollusques et crustacés (*Palinurus regius*, *Sepia officinalis* et *Farfantepenaeus notialis*) au Nigéria. Les déterminations physiques et chimiques étaient conformes aux méthodes officielles. Les résultats ont montré que toutes les espèces de mollusques et crustacés avaient un facteur de rendement de poids inférieur à 1, et les poids obtenus pour les échantillons n'ont montré aucune différence statistiquement significative avant et après l'ébullition. Dans les échantillons crus, *S. officinalis* avait des valeurs significatives ($p < 0,05$) de protéines et de matières grasses brutes de $20,41 \pm 0,63$ g/100 g et $2,67 \pm 0,68$ g/100 g respectivement. Dans les échantillons bouillis, des niveaux élevés de protéines (15,21-19,22 g/100 g) sans différence significative ont caractérisé le profil proximate global des espèces de mollusques et crustacés étudiées dans le présente. En ce qui concerne les minéraux, tous les éléments étudiés (calcium, magnésium, potassium, phosphore et sodium) ont généralement été trouvés

à des niveaux inférieurs dans les échantillons bouillis par rapport au contenu minéral des échantillons de mollusques et crustacés crus. *S. officinalis* avait la valeur énergétique totale la plus élevée dans les échantillons bruts (344,94 kJ 100/g) et bouillis (373,96 kJ 100/g). Toutes les espèces peuvent être considérées comme des aliments aux propriétés diététiques intéressantes en raison de la teneur élevée en protéines, minéraux et valeurs énergétiques utiles.

Mots-clés: Seiche, homard, minéraux, proximate, crevettes

Introduction

Nigeria is the fourth largest importer of fish in the world, where the country's top suppliers are the United States and Chile, but fish is also sourced from Europe, Asia, and a few African countries, including Mauritania, Algeria, and Mauritius (Daniels *et al.*, 2016). Meanwhile, the shellfish industry offers great potential to the country in terms of food provision, increasing the income of small-scale fishermen faced with dwindling catches, as well as providing livelihood for people in coastal areas (Norhana *et al.*, 2011; Moruf, 2020). It is a valuable sub-sector of the fisheries sector, with potentials for local production and export of shellfish products. Shellfish is a major component of our global aquatic food supply, which includes the molluscs, crustaceans and echinoderms (Moruf and Adekoya, 2018). Worldwide shellfish imports have increased steadily over the past 20 years, with over 300,000 tons of products in 2013 (Dima *et al.*, 2016). However, despite the high acceptability of shellfish products, the exploitation of this resource in Nigeria is still lagging behind due to lack of scientific and technical information for optimum industrial processing. Economically important shellfish such as shrimp, prawn, crayfish, lobster and crab constitute one of the major sources of nutritious food for human, providing an important amount of dietary protein and lipid diet in many countries (Lawal-Are *et al.*, 2018a). Several products related and individual factors can define the quality of a shellfish. Reported commonly

used product related factors are: product safety, the nutritional content, freshness and the physical attributes of the fish product (Grunert *et al.*, 2012; Moruf *et al.*, 2020). According to Grunert *et al.* (2012), quality is a factor strongly related to the raw material itself but also individual factors such as the perceived image and trust in the end product, which influences food choice in general. Nigerians have started using imported marine lobster (*Palinurus regius*), cuttlefish (*Sepia officinalis*) and shrimp species (*Farfantepenaeus notialis*) as commercial meats, though the utilization is yet limited with a little scientific information about the nutritional status of these shellfish species. Thus, the aim of this study was to evaluate the weight yield, chemical composition, and energy value before and after the cooking of these three imported shellfish species (*P. regius*, *S. officinalis* and *F. notialis*), in order to provide useful nutritional information to seafood consumers in Nigeria.

Sample collection

Samples of three different imported shellfish species (*P. regius*, *S. officinalis* and *F. notialis*) were obtained from Ajeloro Fish Market, a popular ice fish sales point in Lagos. Nine samples of each organism were placed in small sterile polyethylene plastic bags in an icebox and transported to the laboratory. The soft tissues were extracted from the shellfish and thoroughly washed with distilled water. The samples were then separated into two parts, one part was analyzed raw and the second part was boiled in water for 20 minutes until the pieces were cooked and tender. The

processing method followed the procedures described by Lawal-Are *et al.* (2018b) in the preparation of molluscs for table consumption in Nigeria.

Analytical procedures

The weight yields were determined in a single experiment. The mass (g) before and 1 hour after cooking was determined with a semi-analytical balance. The weight yield factor was calculated dividing the weight of the freshly cooked sample at room temperature by its weight before cooking sample (de Carvalho *et al.*, 2018).

Samples were ground in an analytical micro-mill, and sieved in 20 mesh sieves. Then, the samples were characterized regarding the contents of moisture, lipids, proteins, and ashes according to AOAC (2006).

Total carbohydrates were calculated by difference, i.e., $100 - (\text{moisture \%} + \text{ash \%} + \text{lipids \%} + \text{proteins \%} + \text{fibers \%})$. The energy value of the samples was calculated by using the specific Atwater energy factors to obtain kcal/100 g. The energy values in kilojoules were calculated directly from kilocalories by using the conversion factor $4.184 \text{ kJ} \times \text{kcal}$ (Merrill and Watt, 1955). For the mineral determination, the samples were digested in HNO_3/HCl , while some metal parameters namely calcium, magnesium, potassium, phosphorus and sodium were measured by a Varian Spectra

Atomic absorption spectrophotometer (AAS), Buck Scientific 210 GVP model following the procedure reported by Santoso *et al.* (2006).

Statistical analysis

Mean and standard error were derived from data obtained and subjected to analysis of variance (ANOVA) using Microsoft Excel and STAT 7.0 statistical package. Duncan Multiple Range Test (DMRT) was used to sort out the differences in the means at significance level of 95%.

Results and discussion

Weight yield of the soft tissue of imported shellfish species

The results obtained for the weight yields of the sampled shellfish species are shown in Table 1. The weights obtained for the samples (*P. regius*, *S. officinalis* and *F. notialis*) showed no statistically significant differences before and after boiling. However, they generally have a low weight yield factor (< 1). The results obtained were comparable to the values of 0.83 ± 0.02 observed for silver carp fish (Ojagh *et al.*, 2013) and 0.80 ± 0.01 for Chicken Nuggets (de Carvalho *et al.*, 2018). According to Biantolino *et al.* (2018), the percent meat yield of a shellfish is a good commercial quality indicator varies seasonally and geographically, depending on food availability and the timing of the gametogenic cycle.

Table 1: Weight yield of three imported shellfish species in Nigeria

Species	Weight before cooking (g)	Weight after cooking (g)	Weight yield factor
<i>Palinurus regius</i>	97.80 ± 0.05^a	89.98 ± 0.05^a	0.92 ± 0.01
<i>Sepia officinalis</i>	1228.50 ± 0.31^a	1089.92 ± 0.11^a	0.89 ± 0.05
<i>Farfantepenaeus notialis</i>	21.33 ± 0.12^a	19.25 ± 0.08^a	0.90 ± 0.01

Key: Mean $\pm$ standard deviation ($n = 27$). Means followed by different letters in the same column differ significantly ($p < 0.05$).

Proximate composition of the soft tissue of imported shellfish species

The proximate compositions of raw and boiled imported shellfish species are shown in Tables 1 and 2, respectively. As expected,

the main component of all studied species is the moisture, whose content indicates flesh freshness. In raw samples, *S. officinalis* had significant ($p < 0.05$) highest protein and crude fat values of $20.41 \pm 0.63 \text{ g/100 g}$ and

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2.67±0.68 g/100 g respectively. Generally, all the species under study represent a good source of protein considering the WHO Daily Value (DV) recommendation of 0.80g/kg/day (Biandolino *et al.*, 2019). Crude fiber with the mean value of 6.31±0.86 was found in *P. regius* while below detection level in both *S. officinalis* and *F. notialis*. The highest ash content, which indicates the amount of inorganic compounds in the tissues of shellfish, was found significant in *P. regius* (6.31±0.86 g/100 g). Non-significantly highest ($p<0.05$) carbohydrate content was noted in *F. notialis* (6.24±1.27 g/100 g). Protein contents in the imported shellfish samples were comparable to that found in two edible crabs of Lagos coast (Moruf and Lawal-Are, 2019). In boiled samples, high protein levels (15.21-19.22 g/100 g) with no significant differences characterized the overall proximate profile of shellfish species studied herein. However, the total lipid

amount, exhibited differences among the species, with the highest value determined in *S. officinalis* (2.75±0.01 g/100 g), significantly different from the similar crude fat values of *P. regius* (0.74±0.06 g/100 g) and *F. notialis* (0.68±0.12 g/100 g). According to Zhukova (2014), lipids exert important biological functions as energy storage compounds, structural components of the cell membranes and as signalling molecules. Lipid contents in species studied herein were lower than the value of 4.09±1.42 g/100 g reported for boiled cuttlefish (Lawal-Are *et al.*, 2018b), but agreed well with those reported for *Callinectes amnicola* flesh from Badagry Lagoon (2.12±0.94 g/100 g), Lagos Lagoon (1.78±0.43 g/100 g) and Epe Lagoon (2.05±0.44 g/100 g) (Moruf *et al.*, 2019). Under this present study, crude fibre of the boiled samples were below detection level while total ash and carbohydrate contents displayed non-significant differences among the imported shellfish species.

Table 2: Proximate composition of raw flesh of three imported shellfish species in Nigeria

Parameters (g/100 g)	<i>Sepia officinalis</i>	<i>Palinurus regius</i>	<i>Farfantepenaeus notialis</i>
Moisture	71.14±1.1 ^a (69.21-73.01)	72.45±0.56 ^a (71.40-73.33)	73.94±1.66 ^a (70.80-76.47)
Protein	20.41±0.63 ^a (19.15-21.11)	14.45±0.51 ^b (13.62-15.38)	14.93±1.35 ^b (12.52-17.2)
Crude Fat	2.67±0.68 ^a (1.31-3.4)	0.85±0.12 ^b (0.73-1.08)	1.98±0.06 ^c (1.87-2.08)
Crude Fibre	BDL	2.20±0.21 (1.80-2.50)	BDL
Total Ash	1.79±0.34 ^a (1.11-2.15)	6.31±0.86 ^b (4.72-7.68)	2.91±0.06 ^c (2.80-3.01)
Carbohydrate	3.99±0.34 ^a (3.31-4.38)	3.74±0.55 ^a (2.84-4.74)	6.24±1.27 ^a (3.78-8.03)

Keys: BDL; Below detection level, Mean±SE (Range), Means followed by different letters in the same column differ significantly ($p < 0.05$)

Table 3: Proximate composition of boiled flesh of three imported shellfish species in Nigeria

Parameters (g/100 g)	<i>Sepia officinalis</i>	<i>Palinurus regius</i>	<i>Farfantepenaeus notialis</i>
Moisture	67.98±0.67 ^a (66.89-69.19)	71.87±1.31 ^a (69.58-74.13)	72.87±1.76 ^a (71.06-76.38)
Protein	17.61±0.34 ^a (17.25-18.30)	17.59±1.22 ^a (15.21-19.22)	17.35±0.9 ^a (16.18-19.11)
Crude Fat	2.75±0.01 ^a (2.73-2.78)	0.74±0.06 ^b (0.63-0.84)	0.68±0.12 ^b (0.56-0.91)
Crude Fiber	BDL	BDL	BDL
Total Ash	2.86±0.34 ^a (2.18-3.21)	3.24±0.39 ^a (2.47-3.67)	2.53±0.39 ^a (1.78-3.12)
Carbohydrate	8.8±0.66 ^a (7.61-9.88)	6.55±0.83 ^a (5.24-8.10)	6.58±1.63 ^a (3.41-8.83)

Keys: BDL; Below detection level, Mean±SE (Range), Means followed by different letters in the same column differ significantly ($p < 0.05$)

Mineral content in the soft tissue of imported shellfish species

The contents of minerals (calcium, magnesium, potassium, phosphorus and sodium) in raw and boiled soft tissue of the imported shellfish species are shown in Table 3 and Table 4 respectively. In raw samples, significant differences ($p < 0.05$) were found in the distribution of the minerals among the species analyzed; though with the exception of sodium, non-significant difference was observed between the content of *P. regius* and *F. notialis*. Calcium and magnesium were predominant in *S. officinalis* with respective mean values of 334.2 ± 3.99 and 363.84 ± 4.22 mg/100 g; potassium and sodium were predominant in *P. regius* with respective mean values of 305.43 ± 27.97 and 482.15 ± 2.93 mg/100 g; phosphorus and sodium were predominant in *F. notialis* with respective mean values of 375.44 ± 0.01 and 398.38 ± 0.61 mg/100 g. Both sodium and potassium contents in the present study were higher than those: 55.53 ± 20.97 mg/100g of sodium and 33.33 ± 1.76 mg/100g of potassium, reported for *Tympanotonus fuscatus* var *radula* from Abule-Eledu Creek (Moruf and Akinjogunla, 2018). Sodium and potassium are essential in the regulation of pH, osmotic pressure, acid- base

equilibrium, muscle and nerve irritability, control glucose absorption, and active transport of glucose/amino acids. In the boiled shellfish samples, investigated minerals were generally found at lower levels when compared with the raw mineral contents. As regards the maximum contents, the highest values of calcium (323.26 ± 2.85 mg/100 g), magnesium (304.28 ± 1.92 mg/100 g) and potassium (86.94 ± 3.18 mg/100 g) were found in *S. officinalis*, while the highest level of phosphorus (227.97 ± 3.55 mg/100 g) and sodium (135.92 ± 0.61 mg/100 g) were found in *P. regius* and *F. notialis* respectively. The high content of calcium in *S. officinalis* suggests that its consumption can increase the calcium in the body better than the consumption of *P. regius* and *F. notialis*. However, considering their WHO Daily Value recommendation, these shellfish species are good sources of minerals. In the work of Lawal-Are *et al.* (2018b), raw sample of the cuttlefish recorded the highest values for all the measured minerals while boiled sample recorded the lowest with the exception of calcium which lowest value was observed in fried sample. Differences found in the shellfish mineral levels could be due to the different physiological state, abiotic factors, biotic factors and processing methods.

Table 4: Mineral content in raw flesh of three imported shellfish species in Nigeria

Parameters (mg/100 g)	<i>Sepia officinalis</i>	<i>Palinurus regius</i>	<i>Farfantepenaeus notialis</i>
Calcium	334.2 ± 3.99^a (329.82-342.16)	106.18 ± 0.01^b (106.17-106.19)	111.08 ± 2.69^b (107.07-116.19)
Magnesium	363.84 ± 4.22^a (355.46-368.81)	103.32 ± 0.01^b (103.31-103.33)	106.37 ± 2.24^b (103.16-110.69)
Potassium	122.62 ± 0.93^a (121.32-124.42)	305.43 ± 27.97^b (249.51-334.65)	321.86 ± 0.12^b (321.74-322.09)
Phosphorus	105.67 ± 5.74^a (95.75-115.63)	257.37 ± 29.69^b (201.60-302.92)	375.44 ± 0.01^c (375.43-375.46)
Sodium	211.70 ± 19.79^a (175.33-243.41)	482.15 ± 2.93^b (476.53-486.37)	398.38 ± 0.61^c (397.38-399.48)

Keys: Mean $\pm$ SE (Range), Means followed by different letters in the same column differ significantly ($p < 0.05$)

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Table 5: Mineral content in boiled flesh of three imported shellfish species in Nigeria

Parameters (mg/100 g)	<i>Sepia officinalis</i>	<i>Palinurus regius</i>	<i>Farfantepenaeus notialis</i>
Calcium	323.26±2.85 ^a (319.82-328.91)	62.66±53.86 ^b (51.89-69.21)	14.17±2.69 ^c (10.16-19.28)
Magnesium	304.28±1.92 ^a (300.50-306.74)	46.9±1.60 ^b (43.77-49.02)	62.47±2.24 ^c (59.26-66.79)
Potassium	86.94±3.18 ^a (82.15-92.95)	50.35±1.06 ^b (48.24-51.45)	46.83±0.12 ^c (46.71-47.06)
Phosphorus	88.11±3.00 ^a (85.11-94.11)	227.97±3.55 ^b (221.25-233.29)	188.02±0.01 ^c (188.01-188.04)
Sodium	77.17±12.31 ^a (54.73-97.14)	90.56±27.97 ^{ab} (34.64-119.78)	135.92±0.61 ^b (134.92-137.02)

Keys: Mean±SE (Range), Means followed by different letters in the same column differ significantly (p < 0.05)

Energy values of the edible part of imported shellfish species

The total energy (TE) as contributed by the proportion of total energy due to protein (PEP), proportion of total energy due to carbohydrate (PEC) and proportion of total energy due to fat (PEF) in raw and boiled imported shellfish species are shown in Figure 1 and Figure 2 respectively. In raw samples, *S. officinalis* had the highest TE (344.94 kJ 100/g) as contributed by PEP (216.81 kJ 100/g) > PEF (76.96 kJ 100/g) > PEC (51.17 kJ 100/g). Same trend follows in the proportion of energy contribution in *P. regius* and *F. notialis*. This shows that the protein concentration in the flesh of these imported shellfish species in terms of energy would be more than enough to

prevent protein energy malnutrition in children and adults fed solely on the shellfish as main sources of protein. In boiled shellfish species, the trend of energy contributions follows decreasing order of PEP > PEF > PEC with the highest energy value in *S. officinalis* (373.96 kJ 100/g), followed by *P. regius* (341.85 kJ 100/g) while the lowest in *F. notialis* (340.97 kJ 100/g). These values did not differ statistically among the shellfish species (p<0.05). As reported by Adeyeye and Olaleye (2016), an increase in calories from carbohydrate causes hydration; whereas an increase in calories from proteins causes dehydration. Hence, the energy values found in these imported shellfish species were better than those noted for beef jerky meat (1,659 kJ 100/g) (Adeyeye *et al.*, 2020).

Figure 1: Energy values in raw flesh of three imported shellfish species in Nigeria

Figure 2: Energy values in boiled flesh of three imported shellfish species in Nigeria

Conclusion

Despite the differences found for the weight values before as well as after cooking, all the studied imported shellfish species showed weight yield factor less than 1, which is a good commercial quality indicator for edibility. All the species (especially *Sepia officinalis*) can be considered as food items with interesting dietetic properties due to high contents of proteins, minerals and useful energy values.

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