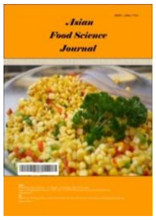

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Effect of Drying on the Rehydration Properties of Some Selected Shellfish

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Authors' contributions

This work was carried out in collaboration between both authors. Author DBKK is a lecturer and project supervisor to the second author. Author DBKK designed the study, wrote the protocol and the first draft of the manuscript. Author NO is a B.Sc student. Author NO managed the literature searches and performed the statistical analysis. Both authors managed other analyses of the study, read and approved the final manuscript.

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ABSTRACT

This study was conducted to evaluate the effect of oven drying on the proximate composition and rehydration characteristics of shellfish. Shellfish studied included rough and smooth periwinkle, oyster and whelk. Proximate composition of the fresh samples were determined. Then dried in the oven to a moisture content of 10% and further rehydrated with distill water in sample water ratio of 1:40 and allowed to equilibrate. Proximate composition of the fresh shellfish showed that moisture content ranged from 82.38 to 69.24% with fresh smooth periwinkle having the highest moisture value while whelk had the lowest. The results also showed that whelk had the highest values for ash (2.92%), crude protein (18.83%) and crude fibre (3.71%) when compared to other samples. On rehydration, a moisture loss of 11.75%, 13.28%, 19.24% and 22.04% were observed for rough periwinkle, smooth periwinkle, oyster and whelk, respectively. The results for rehydration indices revealed that dehydration ratio was significantly ($p<0.05$) high for whelk (1.44), followed by oyster (1.29), rough periwinkle (1.23) and lastly, smooth periwinkle 1.20. Rehydration ratio of whelk (1.47) was equally significantly higher, followed by oyster (1.33) and the least were rough and smooth

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periwinkle (1.17). For coefficient of reconstitution, oyster recorded the highest value of 1.03, followed by whelk 1.02, rough periwinkle 0.95 and smooth periwinkle 0.98. Rate of water imbibition revealed a sharp increase in the water content of smooth periwinkle up to 240 min and thereafter, it slowed down until equilibrium was reached. In terms of rough periwinkle, oyster and whelk; water imbibition took place with rehydration time up to 300 min, 210 min and 270 min, respectively, thereafter they slowed down. The results have demonstrated that the rate in which oven drying affect the physical and nutritional qualities of shellfish differs.

Keywords: Shellfish; drying; rehydration; dehydration.

1. INTRODUCTION

Shellfish such as periwinkles (rough and smooth specie), oyster and whelk are highly nutritional balanced food which provides high quality protein [1]. They are considered as a low fat, low saturated fat, high protein food that can be included in a low fat diet [2]. Shellfish is regarded as a ‘super food’, owing to their high nutritive value including high levels of polyunsaturated fatty acids (PUFAs), especially omega-3 fatty acids. Most shellfish eat a diet composed of phytoplankton and zooplankton. They also feed on marine microalgae that contain high levels of PUFAs [3]. Shellfish are rich in several nutrients that are needed in the body. The high moisture content of shellfish together with its high protein content predisposes them to rapid deterioration. Shellfish are highly perishable due to their biological composition. Under normal refrigerated storage conditions, the shelf life of shellfish is limited by enzymatic and microbiological spoilage. They begin to go bad shortly after capture unless they are subjected to processing [4].

Dehydration process provides a long term preservation and marketability of shellfish. Drying remains one of the best options of processing of sea foods especially shellfish. It is one of the oldest means of food preservation and is applicable to a wide range of food product including shellfish. The principle behind drying is primarily reduction of moisture levels low enough to prevent microbial growth and also slow down enzymatic and other biological reactions that may contribute to food spoilage. Dried fish are popular and widely acceptable. Several drying techniques have been applied to process shellfish. Some of these methods are freeze drying, oven drying and smoke drying. The changes in quality that can occur in any product during drying are those in its optical properties (colour, appearance), sensory properties (odour, taste, flavour) and structural properties such density, porosity, specific volume and textural properties [5].

The rehydration properties, rehydration rate and rehydration capacity are important characteristics of many products related to their later preparation for consumption [6]. Products with a high rehydration capacity are tastier and retain their fresh appearance. Rehydration is a complex process aimed at restoration of raw material properties when dried material is in contact with water. During rehydration, absorption of water into the tissue and leaching of the product solute (sugar, acids, minerals, vitamins) into the medium both occur concurrently [7]. Dried materials subjected to rehydration undergoes many chemical and physical changes owing to the property of water imbibition and solute loss. Imbibition of water by dry material is dependent on the porosity of the material which is related to drying and pre-drying processes involved. Other factors of interest during rehydration include: temperature, chemical composition of product, drying techniques and condition, composition of rehydration medium. Hence, the objective of the study was to process selected shellfish samples using oven drying technique. Then, evaluate the effect of drying and rehydration on the proximate compositions, rehydration indices and percentage of water imbibition time on the selected shellfish samples.

2. MATERIALS AND METHODS

2.1 Materials

Freshly harvested periwinkle species (*Tympanotonus var fuscatus and Tympanotonus var radula*), Oyster (*Crassostreagrasar*) and Whelk (*Buccinumundatum*) used in this study were collected from Nembe waterside in Port Harcourt, Rivers State and transported to the Department of Food Science and Technology Laboratory, Rivers State University, Port Harcourt, Nigeria. All chemicals and reagents used were obtained from the same department and of analytical grade.

2.2 Methods

2.2.1 Preparation of samples

The samples (with their shell on) were properly washed in running tape water to remove mud and other dirt and then boiled in a stainless steel pot at 100ºC for 5 min. The boiled samples were poured into a perforated basket to drain off water and allowed to cool at room temperature. The edible portion (meat) was extracted from the shell with the aid of a sterile pin in the case of the periwinkle and a sharp knife in the case of oyster. They were stored at -20ºC until required for analysis.

2.2.2 Drying experiments

Drying experiments were conducted using an air-oven. Shellfish meat, weighing 100 g (in triplicates) were spread in a single layer on a wire mesh and loaded into the convective hot air-oven. The samples were dried at 55ºC for 17 hrs as illustrated by Akonor et al. [8] as shown in Fig. 1.

2.2.3 Proximate analysis

Moisture, ash, fat, protein, crude fibre and carbohydrate contents of both fresh and rehydrated shellfish samples were determined using AOAC [9] standard methods.

2.2.4 Rehydration properties

Dried shellfish meat was rehydrated according to the method described by Doymaz and Smail [10]. Five grams (5 g) of dried shellfish meat were rehydrated in distilled water at room temperature using a sample to water ratio of 1:40. At 30 min interval, shellfish meat was removed and carefully blotted with tissue paper, weighed on an electronic balance and immediately returned into the same soaking water. Dried shellfish was rehydrated over a period of 5 hrs when the weight of rehydrated samples had stabilized.

2.2.5 Rehydration Indices

The rehydration parameters were determined according to Van Arsdel et al. [11] method measuring the rehydration ratio and coefficient of rehydration as shown in equations below:

$$Dehydration\ ratio = \frac{Weight\ of\ prepared\ material\ before\ drying}{Weight\ of\ dried\ material}$$

$$Rehydration\ ratio = \frac{Weight\ of\ rehydrated\ material}{Weight\ of\ dehydrated\ material}$$

$$Co-efficient\ of\ reconstitution = \frac{Rehydration\ ratio}{Dehydration\ ratio}$$

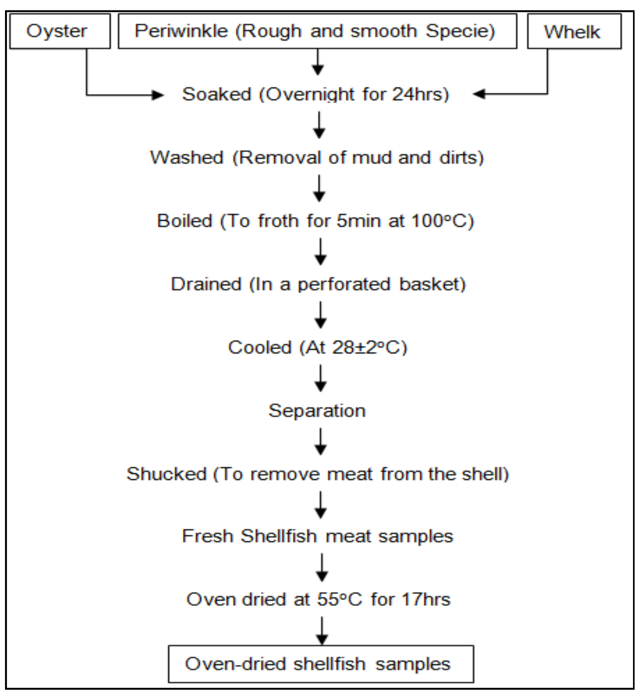

Fig. 1. Flow chart for the processing of oven-dried shellfish
Source: [8]

2.2.6 Percentage water in rehydrated samples

The percentage water in rehydrated samples were determined using the method of Ranganna [12] as presented below;

$$\% \, water \, in \, rehydrated \, samples = \frac{(Drained \, wt \, of \, rehydrated \, material) - (Dry \, matter \, content \, in \, sample \, for \, rehydration}{Drained \, weight \, of \, rehydrated \, material} \times \frac{100}{1}$$

2.2.7 Statistical analysis

All the analyses were carried out in duplicate. Data obtained were subjected to Analysis of Variance (ANOVA); differences between means were evaluated using Least Significant Difference (LSD) and significance accepted at P≤0.05 level. The Statistical Package for Social Science (SPSS) version 20.0 was used.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Selected Fresh Shellfish

From the result shown in Tables 1 and 2, moisture content was low for whelk and this was significantly (p<0.05) different from all other samples. This result compared favourably with 61-84% moisture content of shellfish previously reported by Kiin-Kabari et al. [13]. After the application of oven drying method on the samples, a reduction in moisture value to 10% was recorded. Reduced moisture content in the shellfish is encouraged to safeguard the product from microbial attack, enzymatic action and for better preservation. Protein content increased from 10.73-19.35%, 11.57-19.35%, 15.56-27.12% and 18.83-31.35% for rough periwinkle, smooth periwinkle, oyster and whelk, respectively after drying and rehydration. Shellfish meat from this study was slightly richer in protein compared to protein content of 19% reported by Venugopal and Shahidi [14]. The significant increase in protein levels in dried shellfish samples, when compared with the raw shellfish suggests that protein nitrogen was not lost during drying and this could be attributed to the extent of drying which concentrated proteins, in accordance with the findings of Puwastien et al. [15]; Gokoglu et al. [16] and Ogbonnaya and Ibrahim [17]. There was also a significant (p<0.05) increase in the fat content of shellfish from 0.28-0.92%, 0.18-1.00%, 1.93-4.22% and 1.65-2.60% for rough periwinkle, smooth periwinkle, oyster and whelk, respectively after drying and rehydration. In the present study, shellfish meat contained 1% fat (wb) but this increased to more than 2% after drying. This finding is similar to those of Ogbonnaya and Ibrahim [17] who reported increased fat content of oven dried catfish (*Clariasgariepinus*) from 14.28 to 29.60%.

There was significant (p<0.05) increase in the ash content from 1.55-2.49%, 1.32-2.28% and 2.92-5.53% for rough periwinkle, smooth periwinkle and whelk, respectively after rehydration. Ash represents the total mineral content in food and is essential in maintaining several bodily functions. These values compared well with 2% ash content of shellfish reported by Anthony et al. [18]. Carbohydrate content increased significantly (p<0.05) after rehydration from 3.72-4.39% rough periwinkle, 1.10-4.73% smooth periwinkle, 0.06-8.29% oyster and 3.24-3.46% for whelk. Whelk had the highest carbohydrate content after rehydration. Carbohydrate content in the fresh shellfish samples in this study was similar to 3% reported by USDA [19]. This finding is equally in agreement with that of Akintola et al. [20] who reported carbohydrate content of 3.24% in fresh giant tiger shrimp (*Penaeusmonodon*) and 4.35% after oven drying.

There was a decrease in the crude fibre content of smooth periwinkle from 3.03-2.94%, oyster 2.79-0.815 and whelk 3.71-3.46% while the fibre content of rough periwinkle were observed to increase from 2.42-3.31% after rehydration. This finding is similar to those of Akintola et al. [20] who reported fibre content in fresh giant tiger shrimp (*Penaeusmonodon*) to be 14.48% and the oven dried value as 12.06%. This decrease can be explained by the impact of heat generated by the oven drying method.

3.2 Rehydration Indices

Dehydration ratio of the shellfish ranged from 1.20-1.44, with whelk showing significantly higher value of 1.44 as shown in Table 3. Dehydration ratio of the shellfish samples were low compared with the result for solar dried bean seeds (4.59) as reported by Pervin et al. [21]. Rehydration ratio of the shellfish differed significantly (p<0.05) with whelk having a higher rehydration ratio of 1.47. Rehydration ratio of the shellfish samples were low as compared to 4.26 reported for sun dried pepper by Laura and Constance [22]. Higher rehydration ratio indicates better product because the pores of the shellfish allows water to reenter the cells [23]. Differences in rehydration ratio may be due to differences in the rate of moisture removal in the shellfish. Rehydration ratio of apple was found to decrease with rate of moisture removal as recorded by Lis and Lisowa [24]. Products with high rehydration capacity are tastier and retain their fresh appearance more than those with low rehydration capacity [6].

Coefficient of reconstitution of the shellfish samples was 0.95, 0.98, 1.03 and 1.02 for rough periwinkle, smooth periwinkle, oyster and whelk, respectively. The shellfish samples had higher coefficient of reconstitution when compared with results for solar dried bean seeds (0.54) as reported by Pervin et al. [21].

Water percentage in the rehydrated materials was 90.19, 93.49, 81.42 and 70.40% for rough periwinkle, smooth periwinkle, oyster and whelk, respectively. Percentage water in rehydrated material was higher as compared with that of solar dried bean seeds (47.6%) as reported by Pervin et al. [21].

3.3 Rate of Water Imbibition

As depicted in Fig. 2, there was an increase in the water content of the shellfish samples during the rehydration process. Smooth periwinkle revealed a sharp increase in the water content up to rehydration time of 240 min and thereafter it slowed down until the equilibrium was reached. For rough periwinkle, water imbibition took place with rehydration time up to 300 min while for oyster, water imbibition took place with rehydration time up to 210 min after which it slowed down. Water imbibition increased with rehydration time up to 270 min thereafter it slowed down for whelk.

Table 1. Proximate composition of selected fresh shellfish (%)

Samples	Moisture	Ash	Fat	Crude protein	Crude fibre	CHO
Per (Rough)	81.30 ± 0.39^{ab}	1.55 ± 0.10^{bc}	0.28 ± 0.05^{b}	10.73 ± 0.42^{c}	2.42 ± 0.43^{b}	3.72 ± 0.41^{a}
Per (Smooth)	82.81 ± 1.74^{a}	1.32 ± 0.00^{c}	0.18 ± 0.02^{b}	11.57 ± 0.38^{c}	3.03 ± 0.00^{ab}	1.10 ± 1.38^{b}
Oyster	77.40 ± 1.85^{b}	2.39 ± 0.16^{ab}	1.93 ± 0.18^{a}	15.56 ± 1.31^{b}	2.79 ± 0.00^{b}	0.06 ± 0.00^{b}
Whelk	69.24 ± 2.14^{c}	2.92 ± 0.70^{a}	1.65 ± 0.10^{a}	18.83 ± 1.04^{a}	3.71 ± 0.77^{a}	3.24 ± 0.11^{a}
LSD	4.24	0.94	2.36	0.29	0.88	1.82

Mean values bearing the same superscript within the same column do not differ significantly ($p \leq 0.05$)

Table 2. Proximate composition of rehydrated shellfish (%)

Samples	Moisture	Ash	Fat	Crude protein	Crude fibre	CHO
Per (Rough)	69.55 ± 1.93^{a}	2.49 ± 0.11^{b}	0.92 ± 0.35^{c}	19.35 ± 1.18^{c}	3.31 ± 0.48^{a}	4.39 ± 0.19^{b}
Per (Smooth)	69.53 ± 1.98^{a}	2.28 ± 0.19^{b}	1.00 ± 0.22^{c}	19.35 ± 1.27^{c}	2.94 ± 1.41^{a}	4.73 ± 1.11^{b}
Oyster	58.16 ± 1.20^{a}	1.42 ± 0.07^{c}	4.22 ± 0.11^{a}	27.12 ± 0.06^{b}	0.80 ± 0.21^{b}	8.29 ± 1.01^{a}
Whelk	47.20 ± 4.31^{b}	5.53 ± 0.41^{a}	2.60 ± 0.06^{b}	31.35 ± 2.56^{a}	3.46 ± 0.66^{a}	9.86 ± 0.74^{a}
LSD	7.13	0.63	0.30	4.20	2.01	2.18

Means bearing the same superscript within the same column do not differ significantly ($p \leq 0.05$)

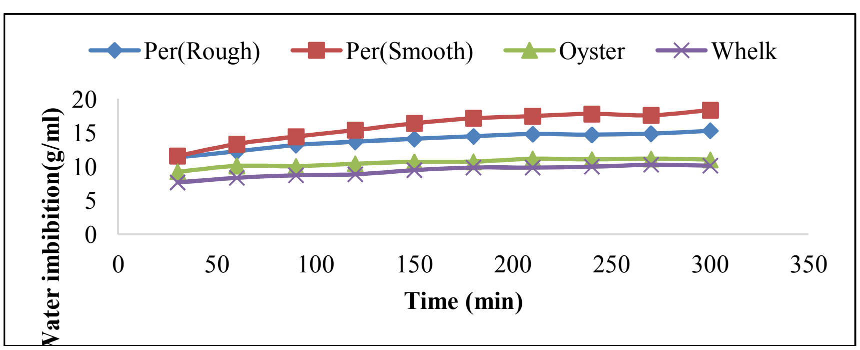

Fig. 2. Water content of shellfish

Table 3. Rehydration Indices for the rehydrated shellfish

Samples	Dehydration ratio	Rehydration ratio	Co-efficient of reconstitution	% Water in rehydrated shellfish
Per(Rough)	1.23±0.01[b]	1.17±0.04[c]	0.95±0.03[b]	90.91±0.18[a]
Per(Smooth)	1.20±0.01[b]	1.17±0.01[c]	0.98±0.02[b]	93.49±0.34[a]
Oyster	1.29±0.03[b]	1.33±0.00[b]	1.03±0.03[a]	81.42±1.53[b]
Whelk	1.44±0.04[a]	1.47±0.09[a]	1.02±0.03[a]	70.40±2.04[c]
LSD	0.06	0.10	0.06	2.71

Means bearing the same superscript within the same column do not differ significantly (p ≤0.05)

4. CONCLUSION

Increase in the proximate compositions of the rehydrated dried shellfish samples except for crude fibre was revealed. Whelk had more reduced moisture, increased ash, fat, protein and carbohydrate after rehydration while fat content increased more for oyster. Whelk equally had the highest moisture loss with regards to the rate of water imbibition. In respect to the rehydration indices, shellfish had low dehydration ratio and high rehydration ratio with whelk recording the highest indicating better product quality than other shellfish samples studied. Smooth periwinkle had a faster rehydration ability as it was able to absorb more water and increase in mass during rehydration than other shellfish samples on rehydration. Thus, results of the study demonstrated that the rate in which oven drying affect the physical and nutritional qualities of shellfish samples differs.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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