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Proximate Analysis and Sensory Evaluation of Some Molluscan Shellfish Preserved with Different Drying Methods

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Abstract

The proximate composition of foods or food components is of interest in the food industry for product development, quality control or regulatory purposes. Some shellfish - *Thais califera* (whelk), *Tympanotonus fuscatus* (periwinkle) and *Crassostrea gasar* (oyster) preserved with different drying methods were investigated to predict the most effective method of drying on the basis of proximate composition, sensory attributes and affective testing using standard techniques. Proximate results obtained showed that percentage moisture in *T. callifera*, *T. fuscatus* and *C. gasar* were 65.2%, 63.1% and 66.9% respectively; Crude Protein for *T. callfera*, *T. fuscatus* and *C. gasar* were 19.9%, 18.5% and 21.2%. Percentage fat was 0.74%, 3.1%, and 0.8%. Crude fiber was 0.15%, 0.50% and 0.11%; Ash was 2.9%, 1.0% and 1.8% and percentage carbohydrate was 11.0%, 13.21% and 9.09% respectively. With the exception of crude fiber, there were significant differences ($p \leq 0.05$) in proximate composition with drying methods. Sensory and affective evaluation to determine the degree of acceptability of the dried shellfish products showed that 1.7% dislike extremely and 11.7% like extremely for whelk, 0% dislike extremely and 0% like extremely for periwinkle and 3.3% dislike extremely and 0% like extremely for oyster. The result of the proximate composition, sensory and affective attributes revealed that with the exception of sun drying, preservation of shell fish with different drying methods used in this study was effective in enhancing the flavor and acceptability of the products. However, drying methods without health risk is advocated.

Keywords: Proximate, proximate analysis, Molluscan Shellfish, nutrition, foods, contamination

Introduction

Proximate analysis refers to the determination of the major constituents of feed and it is used to assess if a feed is within its normal compositional parameters or somehow been adulterated. The proximate composition of foods or food components (moisture, protein, fat, fiber and ash) are commonly referred to as Proximates since their sum totals approximately 100% of many feed stuffs. Missing from this approximation are several carbohydrates and other minor components (Nielsen, 2006; FDA, 2013). Products should be tested by nutritional panels regulated by the appropriate authorities and must undergo rigorous testing to ensure the exact and precise content of nutrients in order to prevent a food processor from making unfounded claims to the public (FDA, 2013). Although proximate do not give the entire nutritional assay, they are an inexpensive way to track deviations from the quality of foods. Proximate analysis has been useful for many years; it is cheap, rapid and easily understood. Although it could be inaccurate in quantification of nutritional entities, it does not account for fecal, urine and gaseous losses and ignores palatability, digestibility, toxicity, e.t.c. Volatile fatty acids, ammonia and alcohols are lost during oven drying (Dahlke and Doran, 2016). The ash assay excludes volatile minerals such as iodine, selenium, chlorine and zinc. It may include sand and other inorganic elements of organic origin such as phosphorus and sulphur from proteins and the method does not identify individual minerals (Dahlke and Doran, 2016).

However, the proximate composition of foods or food components is of interest in the food industry for product development, quality control (QC), or regulatory purposes (Nielsen, 2006).

The enjoyment of products is closely related to the senses, and in the case of food - mainly sight, taste, aroma and texture. Sensory evaluation is a dynamic field concentrating on the utilization of humans for the measurement of sensory perceptions and/or their effect on food and taste acceptance (Stone and Sidel, 2004; Meilgaard *et al*., 2007). By applying statistical techniques to the results it is possible to make inferences and insights about the products under test. Most large consumer goods companies have departments dedicated to sensory analysis (ASTM, 1992).

Seafood is any sea animal or plant that is served as food and is eaten by humans. Seafood includes fish and shellfish including mollusks and crustaceans (Archibong *et al*., 2014). *Thais callifera* (Whelk), *Tymponotonus fuscatus* (Perewinkle) and *Crassostrea gasar* (Oyster) are among the molluscan shellfish of the world. They are the most dominant shellfish in the mangroves of the Niger Delta and other estuaries in West Africa (Deekae and Idoniboye 1995).

Molluscan shellfish is tasty and constitutes a major source of proteins, vitamins and minerals. *Thais callifera*, *Tympanotonus fuscatus* and *Crassostrea gasar* are important edible sea foods essential to life. They are delicacies in African and Asian countries and are of great economic importance in the Niger Delta (Akwari *et al*., 2015). Studies have showed that the protein content and chemical composition of these molluscs are comparable to those of chicken whole eggs, domestic livestock and fish (FAOSTAT, 2015; Bruyn *et al*., 2016). Seafood is a high-protein food that is low in calories, total fat, and saturated fat. High in vitamins and minerals, seafood has been shown to have numerous health benefits. For example, recent studies have shown that eating seafood can decrease the risk of heart attack, stroke, obesity, and hypertension. Seafood also provides essential nutrients for developing infants and children (National Sea Grant, 2017). Doctors can recommend them to add to the diet of patients with endemic goiter because of its iodine contents and to pregnant women because of iron content. Effective utilization of these protein rich aquatic resources is recommended to improve the protein intake of rural population who are usually affected by protein deficiency syndrome (FAO/WHO, 2005).

Shellfish are commercially harvested aquatic organisms of the brackish water zone of the Niger Delta of Nigeria. After harvesting, the shellfish are sorted by size, washed and packed in bags or piled on top of each other. The shellfish may be sold live to the consumer or may be processed (shucked) raw or by use of heat. The heat applied during this processing is only enough to facilitate shucking by causing the animal to relax the abductor muscle, and has no effect on the microbial contamination of the animal. The sucked meat is packed in basin of water and sold fresh along the street of the water-side market or may be transported to other inland markets and sold in the same way. Some are also partially processed by drying using gauze placed over fire.

Freshly shucked shellfish is soft and easily damaged; therefore, rough handling may result in contamination of shellfish. Their short shelf life poses serious practical problems of their storage and distribution (Frazier and Westhoff, 2000). Whelk, periwinkle and Oysters will become unfit for human consumption within about one day after being shucked, unless it is subjected to some form of processing or preservation by drying. This will reduce or destroy the contaminating microbial load and in turn destroy intrinsic enzymatic activities in them. Traditional curing methods such as sun-drying and smoking are used in preserving shellfish that cannot be sold by fishermen (National Institute of Industrial Research, 2003).

Considering the massive consumption/demand and enormous nutritional and industrial importance of Mollusca shellfish in the Niger Delta region, the fishing industry cannot continue to remain neglected in terms of sourcing for reliable preservation methods.

This work was undertaken to evaluate the effect of different drying methods on the proximate composition and sensory and affective characteristics of *Thais callifera*, *Tymponotonus fuscatus* and *Crassostrea gasar*. Seafood preservation will remarkably lead to reduced wastage and improve eating quality of shellfish (National Institute of Industrial Research, 2003). Improved preservation technologies will help to ensure that not only plentiful and large variety of shellfish are available throughout the year, but desirable quality of shellfish in terms of flavor, odor, taste, texture and appearance can be obtained Acceptable and safe technologies should be adopted in Nigeria to avoid huge economic and financial losses in the fishing industry and public health risks.

Materials and Methods

Sampling location

The sampling location was Creek Road Market in "Town Area" of Port Harcourt, Nigeria. Freshly shucked *Thais callifera* (whelk) *Tympanotonus fuscatus* (periwinkle) and *Crassostrea gasar* (oyster) samples purchased were transported to the laboratory in a clean container within 2 hours of purchase for analysis.

Type of seafood samples used for analysis

Fresh seafood samples [*Thais callifera* (Whelk), *Tymponotonus fuscatus* (Perewinkle) and *Crassostrea gasar* (Oyster)] were purchased from seafood vendors in Creek Road Market in Port Harcourt. Samples were aseptically collected and transported to the laboratory immediately for processing and analysis.

The fresh shellfish samples were subjected to different drying methods which included drying using dryer manufactured by (NSPRI); electric oven; sun drying; and wood smoke drying. Freshly shucked samples were used as control.

Methods of drying of shellfish samples

Sun Drying: The heat from the Sun was used in drying the shellfish samples during the day. Average temperature attained was 29^{o}C. The samples were turned after every 4 hours until drying was completed.

Oven drying: An oven dryer, electrically powered, was set to operate at 50^{o}C. The come –up time was one hour, after which the metal trays loaded with the shellfish samples were introduced into it. To ensure uniformity in drying, the shellfish samples were turned hourly with the positions of the trays being swapped-top trays brought lower and lower ones sent up. The temperature of the tray was maintained between 50^{o} C and 55^{o}C.

Multipurpose dryer drying: The dryer was built by Nigerian Stored Product and Research Institute (NSPRI). It has two parts: the stove and cabinet compartments. The stove portion is made of aluminum and the cabinet compartment mounted on it. The cabinet portion is an enclosed wooden chamber containing layers of trays (wooden frames with wire mesh beneath). The enclosed cabinet has a small vent at the top and sides for smoke and moisture expulsion. The stove compartment was heated with a kerosene stove and the temperature was maintained between 50 and 55^{o}C.

Wood Smoke drying: Fire wood was used in drying the shellfish samples; this was done by putting the firewood under a metal drum and placing wire gauze on top. Temperature control was achieved by withdrawing or adding firewood.

The dried shellfish samples from the different drying methods were packaged in clean polythene bags, sealed and stored for 28 days.

Determination of Proximate composition

The recommended methods of the association of Official Analytical Chemist (AOAC 1999) were used for the proximate analysis. Moisture was determined using a thermostatically controlled forced air oven (Gallenkamp, England) operating at 105^{O}C for 3h. The difference in weight before and after drying was used to calculate the per cent moisture content.

Calculation: $$\text{Moisture (\%)} = \frac{\text{Loss in weight on drying (g)}}{\text{Initial sample weight (g)}} \times 100$$

Crude fat determination was done using the Soxhlet extraction apparatus to thoroughly extract crude fat from 4 g of sample using petroleum ether (boiling point 40 to 60^{o}C), in the soxhlet method of fat determination.

The weight of fat divided by weight of sample was used to compute for the percent crude fat content.
Calculation: Extractable fat (%)
= Weight (g) of flask with fat – Weight (g) of flask without fat x 100

Crude protein (%N × 6.25) was determined by Kjeldahl method. 0.1g sample was weighed to the nearest mg each into 250 ml Pyrex conical flask containing the digestive catalyst. The product was digested with concentrated sulphuric acid, using copper sulphate as a catalyst, to convert organic nitrogen to ammonium ions. Alkali was added and the liberated ammonia distilled into an excess of boric acid. The distillate was titrated with hydrochloric acid to determine the ammonia absorbed in the boric acid.

Calculation: $N (\%) = \frac{\text{Titre value} \times 1.4 \times 100 \times 100}{1000 \times 20 \times \text{sample weight}}$

Ash was determined by incinerating 5.0 g of sample at 550^{O}C overnight in a muffle furnace (Gallenkamp, England) and the weight before and after ashing used in calculating the per cent ash content.

Calculation: $\text{Ash} (\%) = \frac{\text{Ash weight (g)} \times 100}{\text{Oven dry weight (g)}}$

Total carbohydrates were obtained by using dried homogenized sample (0.1g) of each type of shellfish samples, weighing to the nearest mg into a flat bottom flask. The material was digested with perchloric acid. Hydrolysed starches together with soluble sugars were determined colorimetrically (Filter photo colorimeter, Electra system, model 321, Sn: 0208052) by the Anthrone method and expressed as glucose.
Calculation: Total available carbohydrates (as % glucose)

$$= \frac{25 \times \text{absorbance of dilute sample}}{\text{Absorbance of dilute standard} \times \text{weight of sample}}$$

Sensory and Affective Evaluation

Fresh and dried shellfish samples from the different drying methods were separately used to prepare soup using equal quantities of ingredients. Twelve panelists, who regularly eat seafood were randomly selected and trained for sensory evaluation. The degree of liking for color, texture, odour, taste and overall acceptability was determined using the 9 point hedonic scale.

Statistical Analysis

The data obtained from the microbiological analysis and proximate composition and sensory evaluation were subjected to statistical analysis using one-way analysis of variance (ANOVA) to test significant differences ($p < 0.05$) among mean values obtained. Where significant differences existed, Duncan's least significance difference (LSD) test was applied to indicate where the differences occurred. The statistical packaged used was SPSS 17.0 (SPSS Inc. Chicago, IL, USA).

Results

The result of the physical examination of the processed dried shellfish samples after one month of storage is shown in Table 1 below.

Table 1: Physical examination of dried shellfish samples after one month of storage

Shell fish sample	Appearance	Odor	Texture	Flavor
SDW	change in color, no insect infestation	Stale odor	Loss of texture	unpleasant flavor
ODW	No color change	Fresh odor	Tight texture is slightly loosen but breakage is not evident	Pleasant flavor
MDW	No colour change	Fresh odor	Texture is tight	Pleasant flavor
MSDW	No color change	Fresh odor	Texture is tight	pleasant flavor
SDP	change of colour	Fresh odor	Tight texture	Pleasant flavor
ODP	No change in colour	Odour is fresh	Texture is tight	pleasant flavor
MDP	Change of colour	Fresh odor is lost	Texture is tight	Pleasant flavor
MSDP	Change of colour	Stale	Loss of texture	Flavor is evidently spoilt, bitter taste not to be eaten
SDO	Colour is dark with much breakage	Production of off odours	Loss of texture and started breaking	Spoilt
ODO	No colour change	Odor is fresh	Texture is tight	Pleasant flavor
MDO	No colour change	Odor is fresh	Texture is tight	Pleasant flavor
MSDO	No colour change	Odour is fresh	Texture is tight	Slightly spoilt flavor

Key: SDO- Sun dried oyster, ODO- Oven dried oyster, MDO- Multipurpose dried oyster, MSDO- Market smoked dried oyster.

Results of the effect of drying methods on the proximate values of whelk, periwinkle and oyster are shown on Figures 1, 2, and 3 respectively.

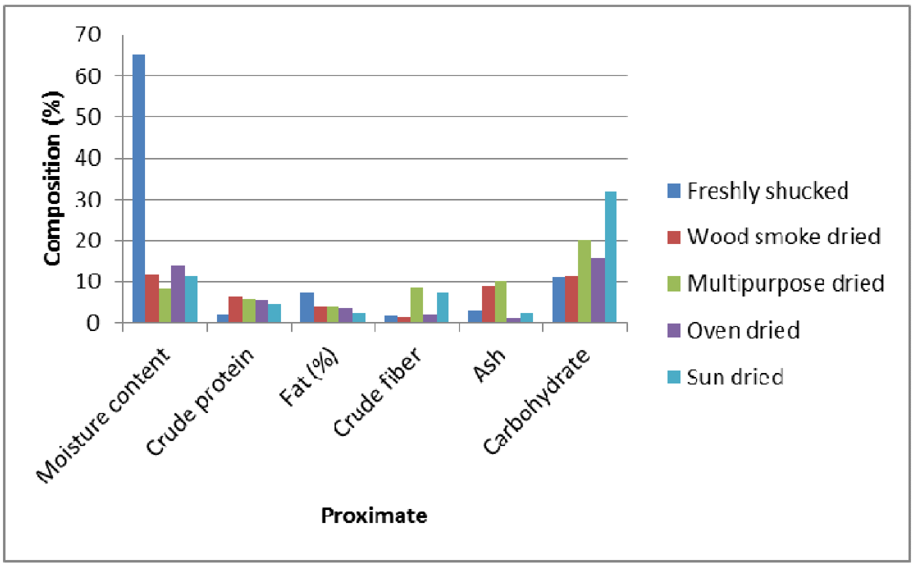

Fig. 1: Effect of different drying methods on proximate analysis of Thais callifera

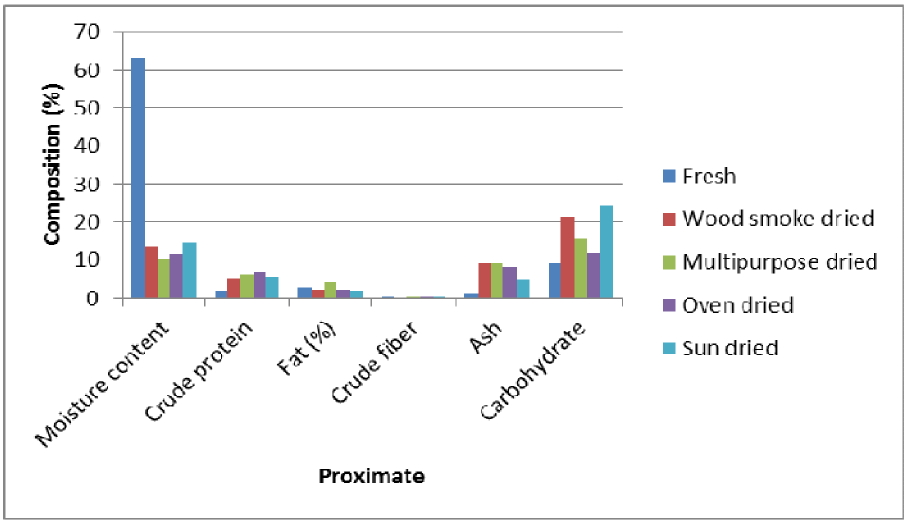

Fig. 2: Effect of different drying methods on proximate analysis of Tympanotonus fuscatus

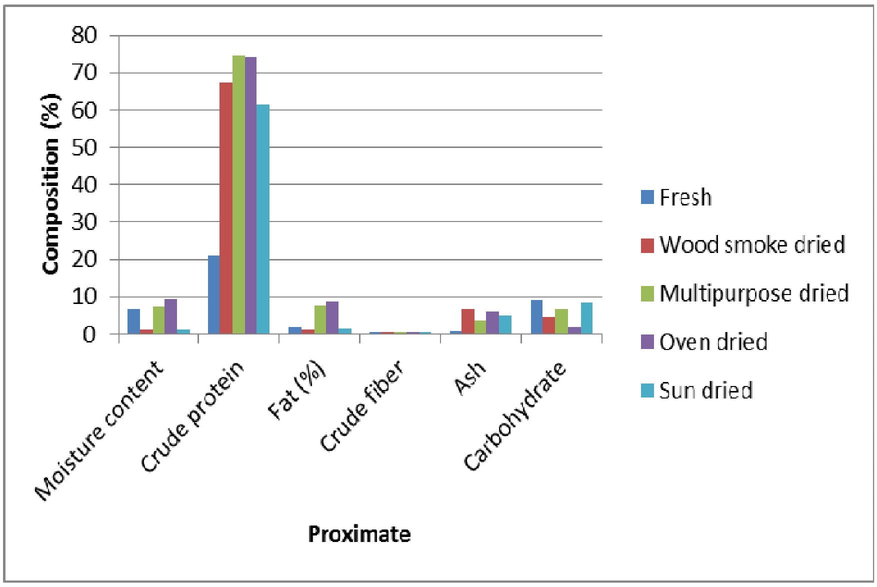

Fig. 3: Effect of different drying methods on proximate analysis of Crassostrea gasar

The results of the effect of different drying methods on the sensory evaluation of whelk, periwinkle and oyster are shown on Figures 4, 5, and 6 respectively.

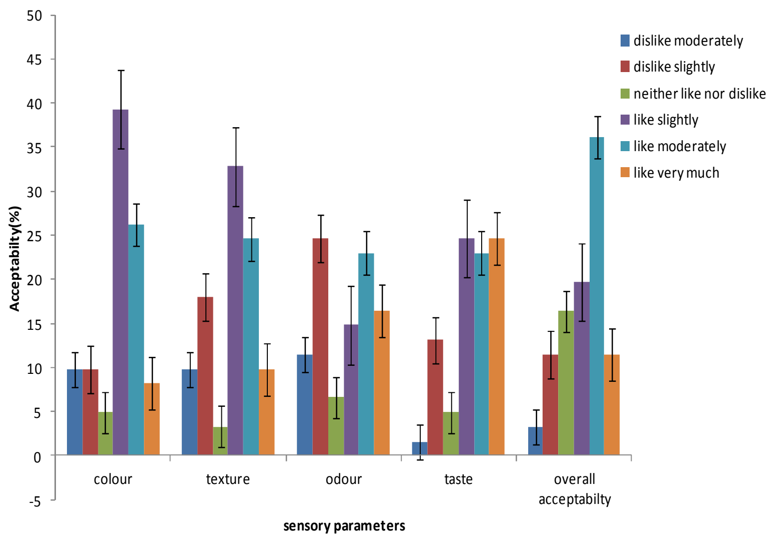

Fig. 4: Sensory evaluation of Thais callifera (whelk)

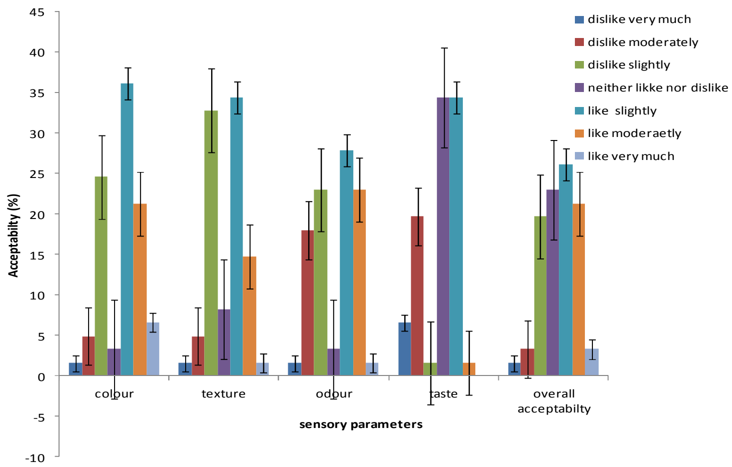

Fig. 5: Sensory evaluation of Tymponotonus fuscatus (periwinkle)

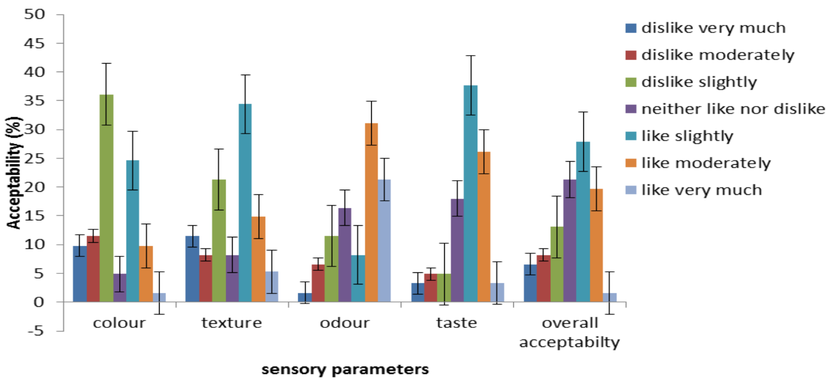

Fig. 6: Sensory evaluation of Crassostrea gasar (oyster)

The results of the effect of different drying methods on the Affective evaluation of whelk, periwinkle and oyster are shown on Figures 7, 8, and 9 respectively.

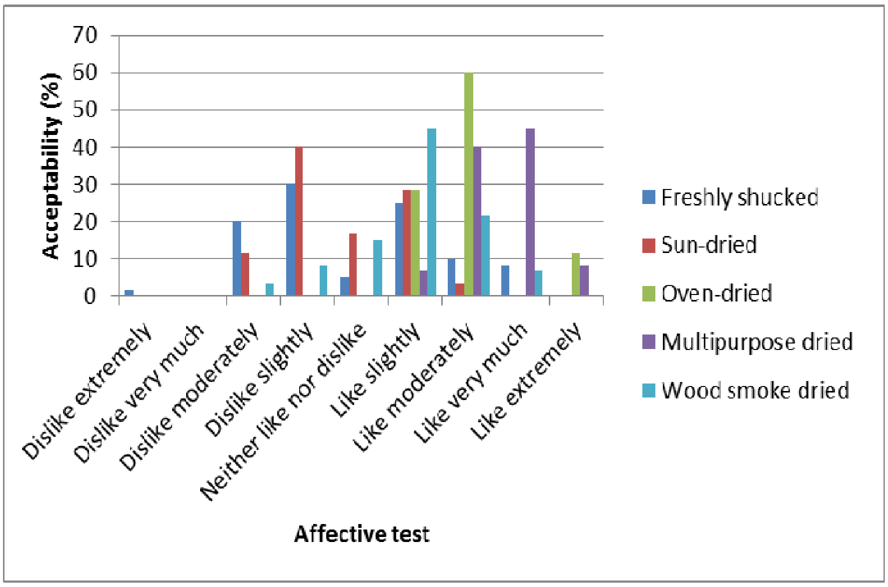

Fig. 7: Affective evaluation of Thais callifera (whelk)

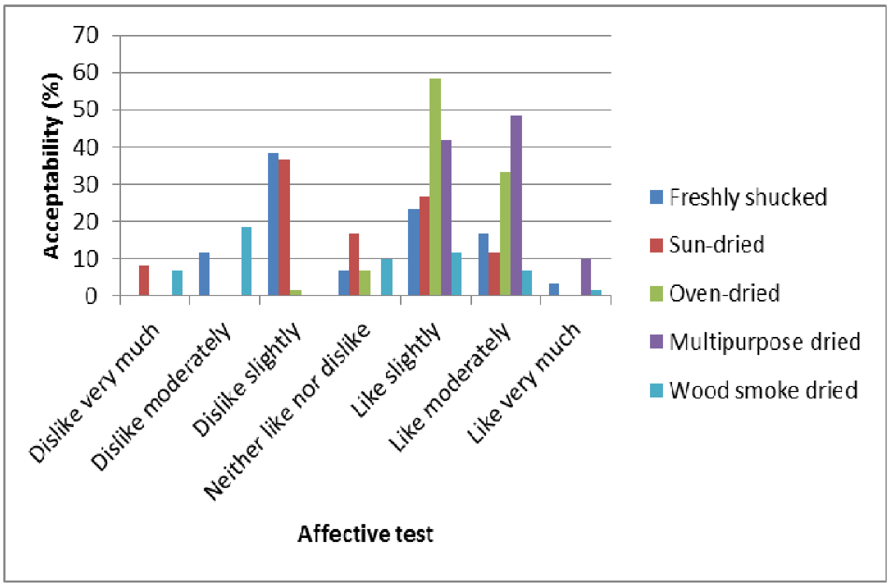

Fig. 8: Affective evaluation of Tymponotonus fuscatus (periwinkle)

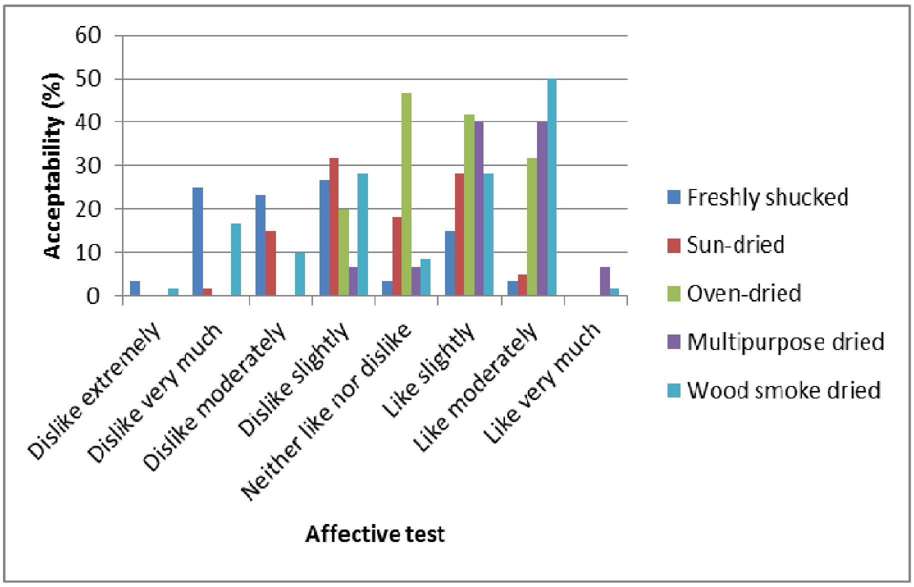

Fig. 9: Affective evaluation of Crassostrea gasar (oyster)

Discussion

This present study has revealed the proximate composition, sensory attributes and acceptability of some shellfish - *Thais califera* (whelk), *Tympanotonus fuscatus* (periwinkle) and *Crassostrea gasar* (oyster) preserved with different drying methods. Whelk, periwinkle and oysters used in this study are good source of protein and important commercial mollusks that are widely eaten from time immemorial especially by people of the coastal areas of the world.

Result of effect of drying methods on the proximate analysis and evaluation of proximate composition of *Thais callifera* showed that there was significant difference in the moisture content of the freshly shucked samples and samples dried with different drying methods. Oven dried samples had the highest moisture content for *Thais callifera* but least in *Crassostrea gasar.* However, there was no significant difference ($p< 0.05$) in all the other proximate analysed.

The wood smoke dried sample had the highest crude protein values followed by multipurpose dried, oven dried and sun dried samples in *Thais callifera*, while oven dried sample had the highest for crude protein followed by multipurpose dried, wood smoke dried and sun dried samples for *Tymponotonus fuscatus* and *Crassostrea gasar*. The relatively low protein value of the sun dried samples may be attributed to the putrefaction observed in the sun dried samples. Putrefaction leads to the production of ammonia and pyruvate (Engmann *et al*., 2012). The ammonia released and the conversion of amino acids to pyruvate led to loss of nitrogen, which is the element quantitatively determined in the Kjeldahl method of protein determination (Jaber *et al*., 2009). Thus a reduction in the nitrogen content invariably led to a reduction in the protein content of the sample. This accounted for the lower value recorded for the sun dried samples as compared to the samples of the other drying methods.

There were significant differences ($p<0.05$) in the mean values of crude fat between the freshly shucked samples and the dried samples. However multipurpose dried samples of *Thais callifera* and *Crassostrea gasar* recorded the highest fat values. There were significant differences ($p<0.05$) in the mean values of ash obtained for *Thais callifera* and *Crassostrea gasar* while there is no significant difference ($p>0.05$) in the samples of *Tymponotonus fuscatus*. Relatively the multipurpose dried samples had the highest ash value, for *Thais callifera* and *Tymponotunos fuscatus* while wood smoke dried samples had the highest for ash in *Crassostrea gasar*.

There were significant differences ($p<0.05$) in the mean values obtained for total carbohydrate. Sun dried samples had the highest carbohydrates in all the three samples. Browning, due to the Maillard reaction, may have accounted for the relatively low values of carbohydrate in the other drying methods as they underwent browning during drying. The reducing sugars that participate in the Maillard reaction could be transformed into various compounds and therefore were lost in the process (Martins *et al*., 2001; Engmann *et al*., 2012). Browning was extensive in the smoke dried samples than the oven dried and multipurpose dryer samples and that may explain why the multipurpose dryer samples had higher carbohydrate values than the oven dried samples. Browning did not take place in the sun dried samples, and thus the carbohydrate content may not have been affected, accounting for the high values that were recorded. Comparing the proximate composition of the shellfish after using the different drying methods, the shellfish samples of the multipurpose dryer retained the nutrients.

Results of the evaluation of the sensory attributes and affective testing showed that the oven dried samples were the most preferred sample of the shellfish in terms of colour followed by the multipurpose dried, wood smoke dried and sun dried samples in that order. The wood smoke dried samples and multipurpose dryer samples were the most preferred in terms of taste this was closely followed by the oven dried samples and sun dried samples. The sun drying method did not really change the colour of the seafood and therefore there was no improvement in its colour. In smoke drying and oven drying procedure, the drying temperature was enough to cause maillard browning. However, smoke particles deposited on the wood smoke dried samples changed its colour as compared to the multipurpose dryer samples. This may have influenced panelist's decision to choose the oven dried samples over the smoke dried samples in terms of colour.

The smoke dried samples were preferred in terms of odour followed by the oven dried and multipurpose dried samples. Wood smoke generally enhances the flavor of foods. The presence of certain phenolic compounds such as guaiacol, 4-methylguaiacol, and syringol imparted by wood smoke play an important role in characteristic flavour of smoked product (Lin *et al*., 2008; Arvanitoyannis and Kotsanopoulos, 2014). The high acceptability of the wood smoked samples is attributed to the presence of these imparted chemicals from the wood smoke. Smoking kills certain bacteria and slows down the growth of others. It prevents fats from becoming rancid, and prevents mold from forming on foods. It extends shelf life of the product. The smell and flavor of smoked shellfish is more appealing.

However, statistical correlations exist that indicate that smoked foods may contain carcinogens. The smoking process contaminates food with polycyclic aromatic hydrocarbons (PAHs) (Lin *et al*., 2008; Drabova *et al*., 2013). Some experts believe that when smoked foods are consumed, it increases gastrointestinal cancer risks. Not everyone, however, agrees that the evidence is definitive.

The putrid odour of the sun dried sample, due to proteolysis, may have led to it being least in terms of taste. Another factor that helps with drying food is humidity. Since drying involves extracting the moisture from the food items and expelling it into the surrounding air, low humidity will help with the drying process. If the humidity is high, drying will be slower simply because the surrounding air would also be laden with moisture. By increasing the currents or flow of air, one can speed up the drying process.

The high humidity levels in the Niger Delta make sun drying difficult. Sun drying is a slow and time-consuming process since the unpredictable and uncontrollable weather is the drying agent. Moreover, it is this unpredictability that also makes sun drying a risky process. For instance, in the Niger Delta, sudden rains can ruin the entire process of drying. Not only that, having the ideal mix of temperature, humidity and air flow is often difficult to achieve and this prompts one to look for other methods of drying food.

The post-harvest technologies in seafood preservation have remarkably led to reduced wastage and improve eating quality of shellfish. Available preservation technologies had helped to ensure that not only plentiful and large variety of shellfish are available throughout the year, but desirable quality of shellfish in terms of flavor, odor, taste, texture and appearance can be obtained (National Institute of Industrial Research, 2003). These various technologies should be adopted in Nigeria to avoid huge economic and financial losses in the fishing industry.

Conclusion

The proximate, sensory and affective evaluation of molluscan shellfish samples preserved with different drying methods showed that this shellfish is nutritionally rich. The need for the preservation of whelk, periwinkle and oysters at the domestic level or in the trade channels cannot be ignored, particularly in the developing countries where little or no attention is paid to the hygienic status of food production, preparation and distribution. In addition, comparing the four drying methods in terms of proximate composition, multipurpose dryer samples were the best followed by oven dried, smoke dried and sun dried samples. Results obtained for sensory evaluation using the 9-point hedonic scale for *Thais callifera*, *Tymponotunus fuscatus* and *Crassostrea gasar* showed that oven dried and multipurpose dried samples had the highest percentage value followed by wood smoke dried and sun dried samples in different parameters used.

Recommendations

Preservation of food is extending its shelf life while ensuring its safety and quality. The microbial contents of the shellfish samples are related to the microbial quality of the water bodies from which seafood is harvested and other industrial and human activities taking place in the water. Therefore, attention should be paid to their safety through proper harvesting, processing, handling procedures, storage and packaging. Considering the massive consumption and demand of edible shellfishes, its commercial and industrial importance, preservation of molluscan shellfish by drying will increase the availability, durability, safety and wholesome supply of this protein rich food for the masses.

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