Original Research Article

Assessment of effects of smoking method on the nutritional value of shrimps: An evidence from different types of fuel

Abstract

The study assessed the effects of smoking on the nutrient attributes of *penaeus notialis* shrimps in Ghana. *Terminalia ivorensis*, *Petersianthus macrocarpus* and *Albizia zygia* were used as fuel woods to smoolder the shrimps. Descriptive and experimental research designs were adopted to guide the entire study. A Random sampling technique was used to select 88 second year students of the Catering and Hospitality Department at the Kumasi Technical University. Frequency and percentage were used to analyse the background information of the respondents. One way Analysis of variance (ANOVA) was used to test for significant differences among the types of wood used and consumer's preferences. The study revealed that seven nutrients (Dry Matter, Moisture, Ash, Protein, Fibre, Fat/Oil and Carbohydrate) were found. There is a significant difference in the types of wood used for smoking with regards to nutritional and chemical properties of the shrimps. The study, therefore, recommended that, care must be taken not to use any wood for fuel in smoking shrimps.

Keywords: smoking, shrimps, nutrients, chemicals

Introduction

Since prehistoric days, food preservation has been used; the preservation process would hamper the growth of microbes such as bacteria and fungi (Seetaramaiah, Smith, Murali & Manavalan, 2011). Food preservation increases food shelf life and maintains food quality by controlling food enzymes or chemically active compounds, controlling the mechanism of microbial degradation and preventing defective post-harvest handling activities (Adegoke & Olapade, 2012). Food preservation goals include the conservation of food taste , texture, flavor, consistency and nutritive quality, the elimination of unnecessary food waste, the prolongation of shelf life, fast transport and food handling (Devi, Bhowmick, Bhanusree & Ghosh, 2015).

There is an increasing interest from customers for marginally treated seafood that preserves its sensory and nutritional characteristics after management and packing. Yet, during processing and storage, consistency loss of seafood happens soon after death, and is connected with enzymatic, microbiological as well as chemical reactions (Olatunde & Benjakul, 2018). Numerous synthetic additives (preservatives) are appealing to prevent changes in texture and

colour, undesirable taste and malodorous scent growth, and loss of seafood nutrients during low temperature stockpiling to preserve consistency (Olatunde & Benjakul, 2018). Using these preservatives, though, has been correlated with possible wellbeing risks. In such manner, with the primary intention of enhancing shelf-life, organic additives with outstanding antioxidant and antimicrobial abilities have been broadly looked at for and applied as safe substitutes in seafood production (Olatunde & Benjakul, 2018). Commonly used natural preservatives encompass plant extracts, bacteriocins, bioactive peptides, chitosan and chitooligosaccharides, and vital oils, among others (Olatunde & Benjakul, 2018).

Shrimps belong biologically to a large number of crustaceans with an expanded belly. They constitute one of the third most respected commercial seafood products (Oosterveer, 2006). They have acquired quite enough fame in Ghana and Africa in general, so they are fished within Africa's coastal regions on both commercial and artisanal scales (Entsua-Mensah, De Graft-Johnson, Atikpo, & Abbey, 2002). It is known that shrimps produce almost 20% protein with well-balanced amino acids and substantially large levels of other nutrients, along with calcium and selenium micronutrients.

Interest in and understanding of human nutrition has brought out a few questions concerning the high incidence of chronic diet-related diseases in the world's developed and developing countries. Actively choosing foods for nutritional restoration and disease prevention has now been essential to shoppers. Epidemiological surveys have found that there are low incidences of heart attacks in certain communities that primarily eat seafood (Hu, Bronner, Willett, Stampfer, Rexrode, Albert & Manson, 2002; Willet, 2007).

Seafood is nutrient-rich and supplies high-quality protein, as per the Institute of Medicine (IOM, 2006) study, and also may be utilized to solve the problems of protein malnutrition in Sub-Saharan Africa, because protein supplements are not sufficient among individuals. As Akonor, Ofori, Dziedzoave and Kortei (2016) affirmed, dehydrated shrimps are prominent and generally appropriate in Ghana as they are being utilized as a primary wellspring of protein and for their delectable flavour (in entire or powdered structure) in soups and sauces.

This research was therefore focused at offering a clearer interpretation of the techniques of protection and preparing of new shrimps, the varieties of crude materials and different ingredients involved with the handling of shrimp, and the description of the actors' most essential quality characteristics of fresh and processed shrimps. In simple terms, this study is aimed to

evaluate smoking methods with different types of wood for preserving shrimps and its effects on nutritional, biological and the sensory properties of shrimps.

Objectives of the Study

The objectives of the research are to:

i. What nutrients are present in smoked shrimps by wood type?

ii. find out if there is a difference in Nutrients present in smoked shrimps by oven and wood type

LITERATURE REVIEW

Nutritional qualities of Shrimps (*Penaeus Notialis)*

Shrimps are incredibly acceptable wellspring of protein, yet are low in fat and calories consequently, settling on them a solid decision of food. Meat and dairy are additionally acceptable wellsprings of protein however they will in general be exceptionally high in calories and immersed fat (Micha & Mozaffarian, 2010). Shrimps likewise contain a ton of omega-3 unsaturated fats however these unsaturated fats are acceptable and consequently forestalls against coronary illness, circulatory sicknesses and numerous different kinds of diseases. They have a significant level of vitamin B12, zinc, iodine, phosphorus, potassium, selenium and iron yet have more modest amount of magnesium, calcium and sodium. Huge numbers of these nutrients are basic for sound skin, bones and teeth. The short gracefully of creature protein to a level almost beyond the reach of low income earners has thus led to an increase in the demand for prawns (Micha & Mozaffarian, 2010).

Shrimps smoking

One of the oldest tools for food storage is smoking. Smoking is carried out at a certain temperature and humidity, based on the species and quality of substance desired. Smoke is commonly derived from material from plants (Ahmed et al., 2013). Not only does smoking boost the shelf life, but it also alters the food's look, taste and scent (Beltrin, Peláez & Moral, 1989; Goulas & Kontominas, 2005; Akintola, Brown, Bakare, Osowo & Omolola, 2013). In the smoking industry , various pre-smoking therapies, like salting and drying and/or post-smoking therapies, primarily cooking and marinating, are applied (Ahmed, Zara & Baig, 2013). Smoking is never an efficient form of protection and it is vital to use salt to supplement the bacterial inhibitory effect of smoke by decreasing the action of water. With increasing salt concentrations,

the effects of salt inhibiting microbial growth increase, but for reasons of health and appropriateness, the trend is to manufacture materials with minimal smoke and salt levels (Beltrin et al., 1989).

The mechanism of incomplete combustion of wood causes smoke. Many chemicals such as aldehydes , ketones, alcohols, acids, hydrocarbons, esters, phenols, ethers, etc. are present (Guillen & Errecalde, 2002). By accumulation on the skin and eventual entry into the tissue, these compounds are transmitted to the fish throughout smoking (Goulas & Kontominas, 2005). As a consequence of the cumulative effects of the antimicrobial and antioxidant activities of tobacco, smoking raises the shelf-life of fish.

In most developed nations, conventional fish smoking techniques are also widely practiced. Simple kilns are utilized that use a number of firewood, and it is difficult to regulate the smoking situation (temperature, humidity and smoke) (Oduor-Odote, Shitanda, Obiero & Kituu, 2010). Smoke is introduced to manufacturers and usually low quality goods are processed (Oduor-Odote *et al.,* 2010). Smoking is typically carried out under regulated circumstances in developing nations and therefore can come in two forms, hot and cold smoking. Hot smoking requires cooking and can be called moderate (30-50 ° C) or extreme (50-80 ° C) temperature (Marc Kaaker & Mboofung, 1997), although it is generally achieved at 70-80 ° C temperatures (Erkan, 2012). Cold smoking, on the other hand, is generally observed without cooking at temperatures of about 30 ° C, leading to a lower nutritional loss (Goulas & Kontominas, 2005). Three results are combined through protecting fish by smoking, as per Vijayan (1984).

1. Smoke preservative value: There are a substantial percentage of compounds in smoke released from burning wood, some of which can destroy bacteria, such as phenols.

2. Drying: heat is also developed by the fire that creates the smoke and this will dehydrate the fish.

3. Cooking: when the fish is smoked at an extreme temperatures, the liver is fried and the enzymes are killed and bacteria are destroyed.

In the traditional system of smoking, natural convection smokers are used in which the fish are hung or laid on openwork plate above fire. The warmth from the fire makes a warm section of smoky air rise and disregard the fish. In different kinds, a fire is scorched in a pit over which a table conveying the fish is fabricated. Since the sides of the table are open, a significant extent of the smoke and warmth can escape without disregarding the fish (Oluwatoyin, Williams &

Awujola, 2010). In different aspects of the world, a range of versions of smokers have also been produced using locally sourced materials. Vijayan (1984) in (Tropical development and research institute) reported that in spite of the fact that these might be modest to develop, they will in general experience the ill effects of a few, or the entirety of the accompanying disadvantages.

1. They have a high fuel consumption compared to output.
2. They have a low capacity.
3. They require constant attention.
4. They are affected by wind and/or rain.
5. They are difficult to control and the product is not uniform.
6. The materials used in construction are often inflammable.

Effects of smoking types on the nutritive value of shrimps

Smoking is also another mechanism of preservation techniques that include chemicals such as formaldehydes and phenols that operate as an anti-micro-organism to heat and antimicrobial smoke and support the fish product to have good attractive colour and flavour (Longwe & Fannuel, 2016). Its heating effect, resulting in decreased shrimp water activity, encourages microbial deterioration to be best stored and thus lessens spoilage, improves storage shelf life and thus increases the supply of seafood to consumers. During the smoking phase, the chemical , physical as well as nutritional composition of smoked fish products will be compromised if the duration, temperature and form of wood are not regulated and chosen in compliance with the requirements. In addition, several diseases can emerge from the carcinogenic impact of woods on customers. Hard texture, colour shift from golden brown to black and depletion of heat-sensitive nutrients are the significant change arising from smoking shrimps (Mojisola, 2014). Burning wood smoke produces a variety of compounds that prevent the growth of bacteria. Heat from the fire allows drying to occur, and the flesh is baked if the temperature is high enough. All of these variables inhibit the growth of bacteria and the activity of enzymes that can induce spoilage (Fellows & Hampton, 1992).

Fish smoking can be classified as hot and cold smoking, based on temperature and customer choice. Depending on the amount of heat produced, the denaturation of protein and amino acids of shrimp would be pursued while smoking, leading to alterations in the physical and chemical characteristics of protein and triggering a decrease in the biological supply of protein (Ihekoronye & Ngoddy, 1985).

Belitz *et al*. (2009), demonstrated that the supply of essential amino acids (methionine, tryptophan, and lysine) could be substantially decreased by excessive heat in most conventional smoking procedures of fish production. Smoking also reduces the more soluble proteins such as myofibrillar and sarcoplasmic component and raises the quantity of insoluble protein, as per Chavan *et al.* (2008). Friedman (1996) also found that the physical depletion of lipids, amino acids, and micronutrients resulted in fats and much more water drops from the fish during the smoking process. At high temperatures, heat smoking often degrades protein and reduces critical amino acid usability. Furthermore, smoke particles in shrimps are prone to react with nutrients and may bring about the loss of valuable nutrients and antioxidants.

Empirical Review

Effect of smoking on chemical, physical and nutritional composition of shrimps

In assessing the effect of smoking on shrimps' nutrients, the result indicated that shrimps subjected to hot smoking at 71 °C and suns drying at ambient temperature of 31 °C treatments were compared to fresh samples (Akintola, 2015). The dry weight basis of the proximate composition revealed that the smoking food was higher in protein and carbohydrates ($P<0.05$) whereas fat was maximum in sundried foods ($P<0.05$). The monounsaturated fatty acids (MUFAs) were highest ranging from 35.87 to 40.35 % in all products. Oleicacid (18:1) had highest value of 24.26% in the smoked. The study further indicated that smoking method as compared to sun drying with respect to quality and nutrition, smoked samples however, offered the best benefits (Akintola, 2015). Sun drying and smoking happened to be the old method of preserving fresh shrimps and even other proteins from either the river or sea. The study of Akintola (2015) had indicated why smoking should be chosen over the sun drying method of shrimps' preservation.

In Bangladesh, a study carried out found effect on the actual properties, proximate structure, mineral substance and amino corrosive worth. The outcome had demonstrated that the nature of conventional smoked item is very acceptable (Hog, Islam, & Kamal, 2008). According to Akintola (2015), effect of smoking shrimps subjected to hot smoking at 71 °C, revealed that smoked product were highest in protein and carbohydrate ($P<0.05$) while fat was raised in sundried products ($P<0.05$). Of both products, monounsaturated fatty acids (MUFAs) were the largest, spanning from 35.87 to 40.35%. In the smoking shrimps, oleic acid (18:1) had a peak value of 24.26 %.

A study done to see the influence of exposure to gamma ionization to shrimps has shown that the protein content ranged from 27.40 ± 1.30% to 34.35 ± 1.30%, ash 13.80 ± 0.09% to 15.42 ± 0.09%, fat 0.90±0.01% to 1.72±0.01% and moisture 9.36±0.06% to 12.92±0.06% (Akuamoa, Odamtten & Kortei, 2018). The result clearly shows that the protein and other attributes of shrimps vary. The variation of the attributes of the shrimps with respect to the amount of exposure to gamma ray could change depending on the amount of the exposure to the ray.

The study further indicated that from the sea, river and lagoon, protein content ranged between 25.93±1.13% and 34.42±1.13%, ash 11.85 ± 0.08% and 18.25 ± 0.08%, fat 0.76 ± 0.01% and 1.83 ± 0.01% and moisture 9.22 ± 0.05% and 12.72 ± 0.05% (Akuamoa, Odamtten & Kortei, 2018). Mineral and amino acid content of the smoked product is satisfactory. Mineral content of smoked shrimp is much higher than smoked *Barbus spp*. (Qudrat-I-khuda, De, Khan & Debnath, 1962) and comparable to local sun dried shrimp (Institute of Nutrition & Food Science, 1977). A smoking temperature of about 150^0C will affect the availability of lysine, one of the essential amino acids found in fish protein (Virulhakul, 1995) but this is much higher than the temperature used to smoke prawns.

METHODOLOGY

Research Design

The experimental research design was adopted by the researcher. Each research carried out using a scientific approach is experimental research, where a set of indicators are left constant while the other set of parameters are evaluated as the focus of the experiment.

Population

The total population was students in the Catering and Hospitality Department at the Kumasi Technical University. The population comprised first year, second year and the third years that were pursuing their full-time and Part-time programmes. They were estimated to be about 400.

Sample and Sampling Procedure

The target population for the study was 100 students on Full time programme. In sampling the 100 participants, Krejcie and Morgan's (1970) have suggested a table to be used for sampling. The sample size of the study was 80 students in accordance with Krejcie and Morgan's (1970) table of sample determination.

Also the Affective or Hedonic test method uses 75-150 people or participants (Martinsdottir, Sveinsdottir, Luten, Schelvis-Smit & Hyldig, 2001) so 88 students fall within the range. Random sampling was used to sample respondents from second year. The target population (100) was used to divide the sample size (100/88) = 1.3 and the result rounded down

to one (1). One participant was therefore selected from the sample frame (Class attendance register) one after the other until the 88th sample was selected.

Instrument for Data Collection

The instrument for sensory data collection was a questionnaire. The questionnaire used five-point Hedonic Scale to determine the acceptability level of smoked shrimps. The shrimp samples were coded to hide their true identity from the panelists. The hiding of the sample identity was to prevent bias assessment or evaluation of the shrimps. The shrimps for analysis were in two forms which were un-powdered and powdered shrimps. The samples were coded using the scientific name for the fuel wood used for smoking the shrimps for easy identification. For instance, sample coded 'USTI' and 'USPM' stand for 'Un-powdered shrimp smoked with *Terminalia ivorensis and Petersianthus macrocarpus* respectively. Powdered smoked shrimps were coded as 'PSTI', 'PSPM' stands for 'powdered shrimps smoked with *Terminalia ivorensis' and 'Powdered smoked Petersianthus macrocarpus* respectively.

Laboratory equipment used to conduct the samples, analysis at the laboratory includes, weighing balance, thermometer, test tube, spatula, mortar and pestle, etc. Tools and equipment for smoking of shrimps include kiln or oven, wire mesh, perforated metal drum, rectangular wood frame, etc. Reagents such as hydrogen peroxide, selenium powder, Lithium Sulphate, sulphuric acid and HCl were used for the laboratory data analysis.

Data Collection Procedure

Fresh shrimps (*Penaeus notialis*) were bought and transported on ice in a cold box from Elmina landing beach in Cape Coast. The reason for transporting the shrimps on ice-block is to prevent them from spoiling.The shrimps were washed in consumable water to decrease the degree of microbial burdens going with them from their muddy habitat in the sea and physical contamination with the shrimps.

The shrimps were drained in perforated basket and dried at room temperature. It was weighed using weighing scale to know the exact quantity being used. Ten kilograms of the cleaned shrimps was weighed into three to be used for the different kinds of wood that have been selected for the various smoking methods.The smoking treatment was hot smoke drying. The shrimps were arranged on wire mesh supported by a rectangular frame work of wood for the smoking. A temperature of 160°F (71°C) was ensured during the smoking process using mercury-in-glass thermometer for the measurement. The shrimps were ensured to be well smoked by regulating the fire and the shrimps turned regularly until uniform brownish colour was observed. An average temperature was recorded during the smoking process.

The smoked shrimps were placed in plastic baskets and labelled according to the type of wood. The smoked shrimps were allowed to cool in a room temperature for two days in an airy and dust free environment. The plastic baskets were covered to avoid contamination from the smoked shrimps. A sample of 5Kg was taken from each group of smoked shrimps according to the wood used for the smoking process. The whole shrimps were pounded in mortar with pestle untill a smooth texture was achieved. The powdered shrimps were sent to the chemical laboratory in the University of Cape Coast for biochemical analysis. The un-powdered shrimps

and the powdered shrimps were given to participants from the Department of Catering and Hospitality in Kumasi Technical University for the the sensory evaluation. The sensory evaluation was done by the participants following a questionnaire. Sensory evaluation was conducted on whole and podwered shrimp to establish consumer preference with the scales; aroma/flavor, appearance, colour, taste, texture and overall acceptability using five point hedonic scales (Martinsdottir, Sveinsdottir, Luten, Schelvis-Smit & Hyldig, 2001).

Ethical Consideration

The Institutional Review Board (IRB) at the University of Cape Coast granted ethical consent to request authorization from the different institutions and laboratories where the experiments were performed. The form laid out the purpose of this research, the need for individual involvement, anonymity and secrecy of the answers of the respondent. The data provided by the participants were not altered to achieve any objective since this negates the aim and purpose of research.

Data Analysis Procedure

The data collected with respect to sensory evaluation was screened to ensure all the needed spaces were completed. The data from the chemical laboratory and the sensory evaluation were entered into computer software called IBM-SPSS version 25 for Windows. Sensory evaluation was conducted on the shrimp powder for difference in consumer preference of aroma, appearance, colour, taste, texture and overall acceptability using five point hedonic scales. One way Analysis of variance (ANOVA) was used to check for the significant differences among the types of wood used in smoking and consumers preferences.

Results

Objective 1: effects of smoking method on the nutritional value of shrimps.

The response to research objective one is done by presenting nutrients that have been analysed in the chemical laboratory after shrimps have been smoked by oven and different fuel types as presented in Table 1. The second fold of the data is the ANOVA result of the nutrients found in the analysed laboratory data as in Table 1.

Table 1: Nutrients present in smoked shrimps by oven and wood type

	Oven-smoked and with wood type			
Nutrient (%)	Control (Oven)	A (Emire)	B (Esia)	C (Okro)
Dry Matter	93.84±0.08	89.93±0.07	89.52±0.18	88.49±0.26
Moisture	6.16±0.08	10.08±0.07	10.48±0.18	11.51±0.26
Ash	21.39±0.09	19.85±0.24	22.05±0.05	21.26±0.39
Protein	57.38±0.31	58.48±0.66	59.24±0.29	58.27±0.39
Fibre	9.27±0.58	8.58±0.74	8.38±0.16	9.07±0.46
Fat/Oil	3.57±0.04	4.10±0.16	3.98±0.03	3.87±0.04
CHO	8.39±0.42	8.99±0.85	6.35±0.49	7.53±0.33

**Terminalia ivorensis* (Emire) **Petersianthus macrocarpus* (Esia) **Albizia zygia* (Okro)

Nutrient is the most important thing the body need for growth and healthy living. The result as presented in Table 1 was about shrimp preservation using oven and different woods as fuel for smoking. The oven serves as the control of the shrimps preservation by oven drying. Three different wood fuels have been used to smoke the shrimps and the data analysed to assess the effect of smoking using the fuel type on the nutrition status of the shrimps. The result indicated that there was seven different nutrients that can be found in the laboratory analysis of the smoked shrimps. These includes dry matter, moisture, ash, protein, fibre, fat/oil and carbohydrate. The amount of quantity found with respect to each nutrient varies. The least mean value is 3.53 and this move up to a value of 93.92.

The mean result with respect to the dry matter for the control was more than the 'Emire', 'Esia' and 'Okro' by 3.91, 4.32 and 5.35 respectively. In terms of the fuel type without the control, the smoked shrimps have more dry matter when smoked with the 'Emire' and followed by 'Esia'. It can be noted that the moisture presence in the smoked shrimps was much higher in the fuel wood as compared to the oven smoked shrimps. The highest mean result of moisture in shrimps that were smoked with the wood types was for 'Okro' followed by 'Esia' and 'Emire' compared to the oven smoked shrimps. The mean difference between the most and the least is 5.53 in terms of the moisture content that determined in the shrimps during laboratory analysis. Also, the moisture content for the oven dried shrimps was 1.89 times lower to shrimps smoked with 'Okro' fuel. The mean ratio between 'Emire' and 'Esia' was almost one is to one (1.087:1.066) which was statically insignificant.

The mean ash content in the smoked shrimps ranged from 20.09 to 22.65. It can be seen from Table 1 that the mean ash presence increases across the table starting from the 'Emire' to 'Okro'. However, the mean value of the controlled smoked shrimps with respect to ash content fall within the increasing pattern of 21.48. It can also be observed that the mean values were close to each other. The variation is about $\pm$1.20 which suggests the difference was not much between the fuel type used for smoking the shrimps.

Protein perhaps is one of the essential nutrient that the human body needs to be healthy. The mean value of the protein found in the smoked shrimps ranges from 58.66 and 59.53. The least mean value of protein in the smoked shrimps was found in the oven smoked shrimps and the high mean values are all in found the wood fuel used for the smoking. The differences in the mean values of oven smoked shrimps as against 'Emire', 'Esia' and 'Okro' are 1.38, 1.77 and 0.9 respectively. The difference in mean value between oven smoked shrimps and that of 'Esia' is significant as compared to 'Okro' fuel type.

The percentage fibre presence in the smoked shrimps varies and this could be seen in the result presented in Table 1. For instance, the mean value of fibre in the oven smoked shrimps is 9.85 which vary from 9.53 to 8.54 as the least mean value. It could be observed that the mean values are packed or close to each other. This was clearly shown in the range of the figures to be 1.04 (i.e 9.85-8.54). The % Fat/Oil mean value ranges from 3.61 to 4.26 and the difference in this mean value of 0.65 which was close to 1. In terms of the wood type for the smoking, the

mean value for 'Emire' was much high than that of the other two fuel types. The percentage carbohydrate that was present in the smoked shrimps has their means ranging from 6.84 to 9.84.

The mean results with respect to 'Esia' and 'Okro' are all less than the mean values of 'Emire' and the oven smoked shrimps. The mean difference between the oven smoked shrimps with respect to carbohydrate, the least mean value which was for 'Esia' is 1.97. It can be gleaned from the Table 1 result that the least mean values were recorded for moisture and Fat/Oil while the high mean values were conspicuous for dry matter and protein.

Objective 2: difference in nutrients present by oven and wood type for smoking

the purpose of this objective was to find out if there is a significant different in the amount of the found nutrients in the shrimps after being smoked by different types of wood and oven. The amount of nutrients was compared among the types of fuel for smoking. One-way ANOVA was used to analyse data on this objective. The result is presented in Table 2.

Table 2: Result of nutrients present in shrimps by oven and wood type smoked

Percentage (%)		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
DM	Between Groups	49.33	3	16.44	595.25	.000
	Within Groups	.22	8	.03		
Moisture	Between Groups	49.33	3	16.44	595.25	.000
	Within Groups	.22	8	.03		
Ash	Between Groups	7.74	3	2.58	47.08	.000
	Within Groups	.44	8	.06		
Protein	Between Groups	5.29	3	1.76	9.15	.006
	Within Groups	1.54	8	.19		
Fibre	Between Groups	1.55	3	.52	56.16	.000
	Within Groups	.07	8	.01		
Fat/Oil	Between Groups	.47	3	.16	142.08	.000
	Within Groups	.01	8	.01		
CHO	Between Groups	11.76	3	3.92	12.57	.002
	Within Groups	2.49	8	.31		

**Terminalia ivorensis* (Emire) **Petersianthus macrocarpus* (Esia) **Albizia zygia* (Okro)

The result of the nutrients found in the smoked shrimps to determine the significance of the mean values has been presented in Table 2. The ANOVA result has indicated that there was a significant difference in the amount of nutrient in the shrimps after being smoked with different fuel source. The the sig of all nutrients is $P<0.05$. It can therefore be concluded that diference in the amount of nutrients in the seven found nutrients; percentages (%) Dry Matter, Moisture, Ash, Protein, Fibre, Fat/Oil and CHO were found and all were significant.

Discussions

The finding from the first objective is that all the nutrients found in the smoked shrimps were all significant. This is an indication that smoking as a way of preservation has not destroy the essential nutrients in the shrimps. Heat is mostly known to kill bacterial and other pathogenic organism that could lead to the spoilage of fresh fish and other sea foods like shrimps. It is therefore heartwarming to find from this study how heat or smoking of shrimps did not destroy the needed nutrients for the body when it is consumed.

The result thus confirmed the earlier study of Akintola (2015) that hot smoking does not destroy the essential nutrients like protein and carbohydrate in shrimps. The ash, dry matter, fibre, fat/oil and carbohydrate have also been found in the current study to be intact in addition to protein as found by Akintola (2015). The result in the current study has clearly shown that all the nutrients found are significant. This therefore suggested that when someone consumes smoked shrimps by using *Terminalia ivorensis* (Emire), *Petersianthus macrocarpus* (Esia) and *Albizia zygia* (Okro) is assured of getting the needed nutrients for the proper functioning of the human body.

The result has confirmed what Hog, Islam and Kamal (2008) that quality of traditional smoked product is quite good. All the nutrients found in the current study were high ($p<0.05$) as noted by Akintola (2015). The protein content in the current study ranged from 57.38 ± 0.31 to 59.24 ± 0.29 which is far higher that what was found by Akuamoa, Odamtten and Kortei (2018) to range from $27.40 \pm 1.30\%$ to $34.35 \pm 1.30\%$.

In the case of the ash presence in smoked shrimps, the quantity found in the study of Akuamoa *et al.* (2018) was lower ($13.80 \pm 0.09\%$ to $15.42 \pm 0.09\%$) than what has been found in the current study ($19.85\pm0.24\%$ to $22.05\pm0.05\%$). Similar trends of low quantities of moisture and fat was found in the study of Akuamoa *et al.* (2018) which are $9.36\pm0.06\%$ to $12.92\pm0.06\%$; and $0.90\pm0.01\%$ to $1.72\pm0.01\%$ for moisture and fat/oil respectively. This result is pointing to the fact that the fuel type used for the smoking did not destroy any nutrients in the shrimps.

One of the cardinal means to prevent constipation in human is to eat a lot of food that have fibre. The study has found significant quantity of fibre in the smoked shrimps. This therefore implies that anyone that consumes smoked shrimps would have more fibre or roughage in their food. Roughage in general helps in proper digestion of foods. A person consuming smoked shrimps is not only getting protein, fat/oil, carbohydrate and other nutrients but is going to improve the digestion process of food that has been consumed.

Easy digestion of food would go a long way to prevent diseases that are associated with constipation. The nutritional composition of the smoked shrimps in this study is therefore an eye opener to the fact that varieties of wood for smoking especially *Terminalia ivorensis* (Emire), *Petersianthus macrocarpus* (Esia) and *Albizia zygia* (Okro) is good in preventing the destruction of essential nutrients that can aid the metabolism of digestion.

Moisture is also good for digestion and other metabolic activities in the body. The moisture found in this study was very encouraging as compared to what was found in Akintola (2015). The human body in general have about 70% as fluid in the system which the body make use of. Having much presence of moisture in the smoked shrimps would also in a way add to the

body fluid needs when consumed. The consumption of smoked shrimps can be said to promote the general health of persons that use it in preparing meal. This is hypothetically so in view of the nutritional compositions in the smoked shrimps.

Conclusion and Recommendations

Nutrients and minerals found in the smoked shrimps is a plus to people who consume them often either in dishes or without. Depending on shrimps especially the smoked ones would go a long way to provide the needed mineral and nutrients the body would use. The human system therefore builds up its immune system to fight diseases which would have been treated with orthodox medicines. It is therefore recommended that since every wood used in doing smoking has its impact on the nutrition of the shrimps therefore care must be taken not to use any wood for fuel in smoking shrimps.

Data Availability

As this study is a topic being led by the first author, the datasets generated and/or analyzed in the study are currently not publicly available, and this study is part of the topic but is available from the corresponding author upon reasonable request**.**

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