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Full Length Research Paper

Effect of gamma irradiation on the microbiological quality and shelf life of *Engraulis encrasicolus* in GhanaStella Agyemang Duah^{1*}, Geoffrey Emi-Reynolds², Patrick Kumah³ and Daniel Agyarko Larbi¹¹Radiation Technology Centre, Ghana Atomic Energy Commission, Accra, Ghana.²Radiation Protection Institute, Ghana Atomic Energy Commission, Accra, Ghana.³Department of Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

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The effect of irradiation on microbial load and shelf-life of anchovies (*Engraulis encrasicolus*) was assessed in this study. Irradiation doses used in the study were 2.5, 5.0, 7.5 and 10 kGy. The assessment was carried out at 3 weeks intervals for the period of 9 weeks. Samples were analyzed for microbial load (total viable count, total coliform count and *Staphylococcus aureus*). Smoked samples were more contaminated as compared to sun-dried samples from both locations. A dose dependent effect was observed in all the samples obtained from both Chorkor and Keta ($p < 0.05$). Samples from Keta were less contaminated for both smoked and sundried samples as compared to the samples from Chorkor whether sun dried or smoked ($p < 0.05$). At 2.5 kGy, microbial load levels (CFU/g) for total viable count, total coliform count and *S. aureus* were below the standard (CFU/g of microbial load) set by the Ghana Standards Authority for microbial load in fish. This dose is the most appropriate dose for the decontamination and shelf extension of anchovy from Ghana.

Key words: Microbial load, processing methods, irradiation dose, shelf-life.

INTRODUCTION

Fishing is an extremely important economic activity in Ghana. It has been estimated that the fish resources in Ghana's water bodies support the livelihoods of a total of about 2 million people which includes fishermen, fish processors (including fish canneries and cold stores), traders and boat builders. These people, together with their dependents, account for about 10% of the Ghanaian population (Onumah et al., 2010).

The FAO indicated that annually, there are about 10 to 12 million tons postharvest losses of fish caused by spoilage. It is also estimated that about 20 million tons of

fish in a year become wasted at sea which could possibly lead to further losses (FAO, 2010). It has been estimated that in high temperatures of the tropics of which Ghana is a part, fish deteriorate within 12-20 h after being caught, depending on the kind and size of fish. In order to reduce fish deterioration in the tropics, a considerable proportion of the landed catch is processed to preserve most of their catch by artisanal methods (FAO, 2001) in order to reduce losses. Fish deterioration and storage may be due to autolysis, rancidity, mechanical damages due to handling methods and the presence of spoilage

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organisms (Huss, 1994).

The major challenge worldwide including Ghana, is the unhygienic environmental conditions in which fish finds itself before and after capture and before it comes to the table for consumption (Debrah et al., 2011).

Fish without any preservative or processing measures is exposed to a number of physiological and microbial deterioration and thereby degrading the fish (Davies and Davies, 2009). The common traditional preservative methods used in Ghana are depuration, freezing, smoking, sun-drying and salting (Obodai et al., 2011).

Traditionally, harvested anchovies are sun-dried on the roadside or at the sea shore and sometimes on raised racks by artisanal fishermen. Sun drying (also known as open air drying) is one of the methods of preserving anchovies in Ghana; however, the duration of drying depends on the weather vagaries. Apart from sun drying, anchovies are exposed to smoke from fire wood for the purpose of preservation (Abolagba and Uwagbai, 2011).

Gamma irradiation does not only ensure food safety due to its ability to decontaminate food by inactivating pathogenic organisms but also extends the shelf life of the commodity that has been exposed to it (Mahapatra et al., 2005).

Arvanitoyannis and Stratakos (2010) reported that irradiation doses of 2 to 7 kGy can reduce important food pathogens or microbes such as *Salmonella*, *Listeria* and *Vibrio* spp., as well as many fish specific spoilers such as *Pseudomonaceae* and *Enterobacteriaceae*. Ionizing radiation treatment of food is an effective means of slowing down growth of pathogenic bacteria such as *Escherichia coli* and *Salmonella* (Olson, 1998; Thayer, 1994).

This study aimed to determine the effect of gamma irradiation on the microbial quality and the shelf life of anchovies harvested in two main anchovies fishing communities in Ghana.

MATERIALS AND METHODS

Experimental designs

The experimental design for the study on processed anchovies was a 2 × 2 × 2 × 5 factorial in completely randomized design (CRD) (two locations: Chorkor and Keta; source: processors and marketers; processing methods: smoked and sun-dried; and irradiation doses: control, 2.5, 5.0, 7.5 and 10 kGy).

Sampling procedure

A total of 1600 g of anchovies were collected from both locations (Chorkor and Keta). Two hundred grams (200 g) of sun-dried and 200 g smoked anchovies were collected randomly from processors (400 g) and marketers (400 g) from both locations.

Gamma irradiation

Packaged samples in polyethylene zip lock bags were

irradiated at doses of 2.5, 5.0, 7.5 and 10.0 kGy at a dose rate of 1.43 kGy/h using the category IV cobalt 60 (⁶⁰Co) wet storage gamma irradiation source at the Ghana Atomic Energy Commission. Non-irradiated samples were used as control.

Microbial load analysis

The microbiological analysis was performed at the Food Microbiology Laboratory, Biotechnology and Nuclear Agriculture Research Institute (BNARI) according to the standard procedure of APHA (2000) using methods of serial dilution and pour plate to determine total viable count, total coliform count and *Staphylococcus aureus*.

Enumeration of total viable count (TVC)

Ten (10) grams of anchovies sample was aseptically weighed into sterile Petri dish, macerated in a stomacher and transferred into a sterile 90 ml peptone water in a 250 ml conical flask to make a 1:10 dilution of the anchovy sample. Each dilution bottle was agitated to re-suspend material that may have settled out during preparation and serially diluted to 10⁶. 1 ml of each diluent was aseptically transferred into sterile well-labeled Petri dishes and pour-plated on plate count agar (PCA) in duplicates and aerobically incubated in inverted positions at 37°C (APHA, 2000).

Enumeration of total coliform count (TCC)

About 10 g of anchovies sample was aseptically weighed into sterile Petri dish, macerated in a stomacher and transferred into a sterile 90 ml peptone water in a 250 ml conical flask to make a 1:10 dilution of the anchovy sample. Each dilution bottle was agitated to re-suspend material that may have settled out during preparation and serially diluted to 10⁶. 1 ml of each diluent was aseptically transferred into sterile well-labeled Petri dishes and pour-plated using eosin methylene blue agar (EMBA) in duplicates and aerobically incubated at ±37°C (APHA, 2000).

Enumeration of *Staphylococcus aureus*

About 10 g of anchovies sample was aseptically weighed into sterile Petri dish, macerated in a stomacher and transferred into a sterile 90 ml peptone water in a 250 ml conical flask to make a 1:10 dilution of the anchovy sample. Each dilution bottle was agitated to re-suspend material that may have settled out during preparation and serially diluted to 10⁶. 1 ml of each diluent was aseptically transferred into sterile well-labeled Petri dishes and pour-plated using bird parker agar (BP) in duplicated and aerobically incubated at 37°C. Colonies were counted promptly after the incubation period using the Stuart colony counter-SC6+. Plates with 30-300 colonies or nearest to the 30-300 range were counted (including pinpoint colonies). Colonies were counted as colony forming units per gram of fish sample (CFU/g) (APHA, 2000).

Shelf-life (storage) studies

Packaged samples of both unirradiated and irradiated sun-dried and smoked anchovies were stored and visually assessed every three weeks for nine weeks. This was done to determine the effect of the irradiation doses (2.5, 5.0, 7.5 and 10 kGy) on the anchovy samples. The samples were stored in an enclosed

mesh shelf under ambient conditions (average temperature of 22°C and RH of 50%).

The samples were assessed visually for color change, moldiness, insects and pest attacks. This monitoring was done every three (3) weeks before samples were taken to the laboratory for microbial analysis. Shelf life was taken as the number of days or period for a sample to be contaminated or infested. The shelf-life of a product is a critical factor in both quality and profitability, and is influenced by several factors, such as light, heat, gases intrinsic to the product and stresses on the material.

Statistical analysis

Sample analyses were conducted in triplicates for the study. Results were expressed as mean values and the differences among means of both unirradiated and irradiated samples of smoked and sun-dried Anchovies (*Engraulis encrasicolus*) obtained from Chorkor and Keta were calculated using analysis of variance (ANOVA) and statistically significant differences were reported at $p < 0.05$. The least significant difference (LSD) was conducted for independent sample t-test as required between two treatments. Data analyses were done with the use of GenStat software version 18.0.

RESULTS AND DISCUSSION

Microbial load analysis

All anchovy samples collected from both processors and marketers in Chorkor and Keta recorded total viable count, total coliform count and counts of *S. aureus*. Table 1 shows the results of analysis of microbial load in unirradiated smoked and sun-dried anchovies obtained from both Chorkor and Keta. Total viable count (5.660 CFU/g) of the samples were significantly ($p < 0.05$) higher than total coliform count (3.621 CFU/g). *S. aureus* had least contamination (2.911 CFU/g) at week 0. Sun-dried samples obtained from Chorkor at week 0, had significantly ($p < 0.05$) higher total viable count (5.633 CFU/g) as compared to sun-dried samples from Keta anchovies (4.490 CFU/g); as well as smoked samples from Chorkor (6.175 CFU/g) and Keta (6.042 CFU/g). There were no significant ($p > 0.05$) differences in total coliform count between sun-dried (3.487 CFU/g) and smoked samples (3.645 CFU/g) obtained from Chorkor as compared to sun-dried (3.272 CFU/g) and smoked samples (3.487 CFU/g) from Keta at week 0 and also at 9th week. *S. aureus* had least contamination in sun-dried (2.575 CFU/g) and smoked anchovy samples (3.318 CFU/g) from Chorkor; and sun-dried (2.972 CFU/g) and smoked samples (2.778 CFU/g) from Keta respectively. There was a general decrease in microbial load with time. At the 9th week, the level of contamination had generally decreased in sun-dried samples obtained from Keta generally when compared when sun-dried samples obtained from Chorkor. Both locations had no significant ($p > 0.05$) difference when anchovy samples were smoked even though some amount of contamination was recorded in the period of study (week

0, 3, 6 and 9). The quality and freshness of fish are known to rapidly deteriorate through microbial and biochemical mechanism and therefore, with thorough drying, microbes will reduce (Al-Jasser and Al-Jasass, 2014). In this study, samples that were sun dried had lower microbial contamination as compared to the smoked ones, which might be due to the effect of solar radiation on the microbes in the samples that were sun dried from both towns. The general decrease of TVC, TCC and *S. aureus* in unirradiated samples when stored may be attributed to the effective packaging of the anchovies which created an environment that was not conducive for the microbes to grow or multiply. The absence of oxygen would generally decrease multiplication of microbes even though initial oxidation may lead to rancid taste and off flavor and development of many different compounds from which some have even adverse effects on human health. After storing the unirradiated smoked fish for five (5) weeks, attack by insects was evidenced which is similar to the observation of Bari et al. (2000).

Effect of irradiation on microbial load of processed anchovies from Chorkor and Keta

Table 2 shows the effect of gamma irradiation on the microbial load of smoked and sun-dried anchovies obtained from both locations, respectively. There was a dose dependent effect on the microbial load as there was a general reduction in TVC, TCC and *S. aureus* in all the samples irradiated at 2.5, 5.0, 7.5 and 10.0 kGy as compared to the unirradiated samples (whether sun dried or smoked).

Total viable count was high in smoked samples (4.502 CFU/g) as compared to sun-dried samples (3.393 CFU/g) at 0 kGy and least in smoked samples (1.158 CFU/g) and in sun-dried samples (1.607 CFU/g) at 5.0 kGy respectively.

Microorganisms in samples irradiated at 7.5 and 10 kGy were below the detection limit for both processing methods. There was high CFU/g of TVC as compared to *S. aureus*. There was significant ($p < 0.05$) difference between the microbial loads of irradiated samples from control to 10 kGy.

Lower microbial load was recorded in sun-dried samples as compared to smoked samples. Lower CFU/g of *S. aureus* were recorded in sun-dried samples (1.308 CFU/g) and smoked samples (1.453 CFU/g) at 2.5; at 5.0 kGy, 0.263 and 0.554 CFU/g in sun dried and smoked samples, respectively. There was significant ($p < 0.05$) difference (in the contamination levels) in the processing methods used for the treatment and preservation of *E. encrasicolus*.

Microbial load of smoked anchovies reduced from 4.502 (control) to 1.158 CFU/g for TVC in the lower doses of at 5 kGy while the same trend was observed for the sun-dried samples which reduced from 3.393 to

Table 1. Microbial load of unirradiated sun-dried and smoked anchovies obtained from Keta and Chorkor.

Microbial load (CFU/g)	Processing Methods	Locations	Storage period (weeks)				
			0	3	6	9	Mean
Total viable count	Sun dried	Keta	4.490*	3.542	2.94	2.602	3.394
		Chorkor	5.633	5.597	3.668	2.428	4.332
	Smoked	Keta	6.042	5.117	4.285	2.265	4.430
		Chorkor	6.175	6.082	3.023	2.562	4.500
		Mean	5.66	5.085	3.479	2.464	
Total coliform count	Sun dried	Keta	3.272	2.62	2.59	2.047	2.632
		Chorkor	3.487	3.412	2.938	2.202	3.001
	Smoked	Keta	4.08	3.432	2.972	2.002	3.122
		Chorkor	3.645	3.645	3.212	2.163	3.166
		Mean	3.621	3.277	2.928	2.104	
<i>Staphylococcus aureus</i>	Sun dried	Keta	2.972	2.31	2.547	1.605	2.359
		Chorkor	2.575	1.985	1.767	1.62	1.987
	Smoked	Keta	2.778	2.243	2.313	1.873	2.302
		Chorkor	3.318	2.917	2.32	1.692	2.562
		Mean	2.911	2.364	2.237	1.698	

LSD (5%); Microbial load = 0.1939; processing methods = 0.1583; storage = 0.2239; microbial load x processing methods x storage = 0.2743; * = log₁₀

Table 2. Effect of gamma irradiation on microbial load on smoked and sun-dried anchovy.

Doses (kGy)	Microbial Load (CFU/g)	Processing method	
		Smoked	Sun dried
Control	Total viable count	4.502*	3.393
	Total coliform count	3.121	2.632
	<i>Staphylococcus aureus</i>	2.302	2.358
2.5	Total viable count	2.333	2.305
	Total coliform count	1.902	1.794
	<i>Staphylococcus aureus</i>	1.453	1.308
5.0	Total viable count	1.158	1.607
	Total coliform count	1.017	0.271
	<i>Staphylococcus aureus</i>	0.554	0.263
7.5	Total viable count	ND	ND
	Total coliform count	ND	ND
	<i>Staphylococcus aureus</i>	ND	ND
10	Total viable count	ND	ND
	Total coliform count	ND	ND
	<i>Staphylococcus aureus</i>	ND	ND

LSD (5%): Dose = 0.184; microbial load = 0.184; processing methods = 0.150; dose x microbial load x processing methods = 0.319; *log₁₀; ND = no detection.

1.607 CFU/g when a dose of 5.0 kGy was applied. CFU/g of the organisms investigated in this study, were below detection limits when doses greater than 5 kGy was

applied to the samples in general.

During the present study, the results showed that contamination levels of samples that were irradiated at

Table 3. Effect of gamma irradiation on the shelf life of smoked and sun dried anchovy obtained from Chorkor and Keta.

Dose (kGy)	Chorkor		Keta		Mean
	Smoked	Sun dried	Smoked	Sun dried	
Control	3	5	5	7	5
2.5	9	9	9	9	9
5	9	9	9	9	9
7.5	9	9	9	9	9
10	9	9	9	9	9
Means	9.75	10.25	10.25	10.75	

2.5 kGy was found to be below the guidelines set by the Ghana Standard Authority: (Total heterotrophic bacteria count: 1×10^6 CFU/g; Total coliform count: 1×10^4 CFU/g; *Bacillus cereus* count: 1×10^4 CFU/g), which implies that irradiation to a dose of 2.5 kGy is enough to decontaminate the processed anchovies to meet standards set by the GSA. Mahin et al. (2011) stated that high radiation doses of 2.5 and 5.0 kGy reduced TVC by 3 logarithmic cycles for mola (*Amblypharyngodon mola*) at -20°C for 6 months.

Effect of gamma irradiation on the shelf-life of processed Anchovies

Table 3 shows the shelf-life of irradiated smoked and sun-dried anchovies obtained from both locations when stored for a period of 9 weeks at a 3-week interval studies. Smoked but unirradiated samples obtained from Chorkor showed signs of pest destruction at the 3rd week as well as sun-dried samples in week 5. Samples obtained from Keta at the 5th and 7th week for smoked and sun-dried samples respectively, had signs of insect pest damage. Samples exposed to doses of 2.5, 5.0, 7.5 and 10 kGy had no records of insect destruction within the 9 weeks of storage.

Microbial load in all the samples (both sun dried and smoked samples) reduced as the doses of gamma irradiation increased (apart from unirradiated samples that had higher microbial load). It was observed that samples obtained from Keta stored better than those from Chorkor. Unirradiated, sun-dried samples remained for up to a period of 7 weeks without pest damage. Irradiation doses of 2.5, 5.0, 7.5 and 10 kGy when stored for 9 weeks showed no sign of pest infestation. This indicated that, even at a dose of 2.5 kGy, the samples could be stored at a period of 9 weeks and even beyond without insects or pest damage. Both irradiated smoked and sun-dried samples could possibly be stored beyond the 9 weeks duration. It could also be concluded that, 2.5 kGy dose applied on smoked and sun-dried anchovies is enough to eliminate microbes and extend the shelf-life of the product. From the study, generally, both smoked and sun-dried anchovies obtained from processors and marketers in Keta are more hygienic than

samples from Chorkor. This confirms the assertion of Kombat et al. (2013) that unhygienic environment in which fish are caught and processed have influence on the contamination level in the fish. Thus, the differences observed in the contamination levels of the samples from Keta and Chorkor might be due to the differences in the contamination of the environment in which the fishes were obtained from.

Conclusion

Unirradiated *E. encrasicolus* from both locations had some level of contamination which was above the threshold of the Ghana Standards Authority and therefore not wholesome for human consumption. The application of gamma irradiation reduced the level of contamination in the anchovies thus, making it safe for consumption and also could be preserved for a longer period of time for future use. At a dose rate of 2.5 kGy, effectiveness of the irradiation was able to eliminate harmful microbes in the fish. The use of irradiation was also able to keep the fish samples for the duration of study. After the 9 weeks of storage period of *E. encrasicolus*, sun-dried samples were less contaminated than smoked samples. Irradiation is a safe and effective method of food preservation used in many countries all over the world.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Consumers' preference and perception of smoke-dried white shrimp (*Nematopalaemon hastatus*) in coastal areas of Ondo State, Nigeria

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The study assessed consumers' preference and perception of smoke-dried white shrimps in Igbokoda, a coastal area of Ondo State, Nigeria. The community was purposively chosen because the town is a major cluster for natives from coastal communities in Ilaje and Ese-Odo LGAs of Ondo State, Nigeria. Forty shrimp consumers (20 males and 20 females) were randomly selected for this study. They assessed the sensory properties of smoke-dried shrimps collected from processing units in Ayetoro and Bijimi. The two communities were purposively chosen for the predominance of white shrimp processing using smoking method. Five smoke-dried samples (A1-A5 and B1-B5) were collected from Ayetoro and Bijimi respectively. Panelists assessed the sensory attributes of white shrimps using a 9-point hedonic scale. Results indicated that there were significant differences ($p \leq 0.05$) in the organoleptic properties of the white shrimps. Samples A3, B2 and B3 had low acceptability while samples A1 and B5 were more accepted than the other samples. Taste of the samples was the highest significant factor that influenced general acceptability among assessors as indicated by the magnitude of its t-Stat. All the sensory attributes were positively correlated ($R = 0.71$) with general acceptability and 50% ($R^2 = 0.50$) dependent on these sensory attributes. Majority of the respondents said they consumed white shrimps with no allergic reactions in dried form. Consumers were highly satisfied with smoked white shrimps in market places; however, off flavour, inadequate taste, odd appearance and the quantity of by-catches were the perceived reasons that determined consumers' satisfaction with shrimps in the market outlets. Hence, more emphasis should be laid on reducing off flavour, odd appearance, by-catches and increased utilization of white shrimp in food products. This would further increase consumers' satisfaction, patronage in market places, boost coastal economy and contribute to healthy living of consumers in Nigeria.

Key words: Consumers, preference, sensory attributes, perception, white shrimp, coastal areas.

INTRODUCTION

Crustaceans have attracted considerable attention as an important source of nutritional benefits in human diet

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(Shehu et al., 2013). Apart from their delicacy, they contain amino-acids, peptides, protein and other useful nutrients such as calcium and vitamins (Bello, 2013). Seafood in its different forms contributes substantially to the diet of Nigerians (Ajala and Oyategbe, 2013). White shrimp (*Nematopalaemon hastatus*) (Aurivillius, 1898) also known as estuarine prawn is one of the most important animal sources of food for a healthy diet. Its consumption represents 28% of the total consumption of animal protein content of the average Nigerian diet (Food and Agricultural Organization, 2012). They are abundant and shrimped in the over 180 km coastline in coastal areas of Ondo State, Nigeria with an estimated 75% frequency of occurrence in shrimp catches (Olawusi and Ajibare, 2014). Thus, the species is of utmost importance in the diets of coastal inhabitants and beyond while activities in the shrimp value chain serves as source of employment and raw materials for food processing and allied industries (Bello, 2013). White shrimps are mostly sold in dried form in Nigeria; they are milled and used in flavoring different types of food. In other climes, most especially European countries, they are generally consumed fresh (FAO, 2012). Its consumption in Nigeria varies between the coastal and inland regions; they are marketed within and outside the study area with consumers geographically distributed across the country; most especially in the Southern States (Bello, 2013).

Despite the nutritional benefit of this aqua food, age, education, marital status, income, family size, residing area, occupation, religion, food attribute (sanitation, nutrition, package, quality, price and sensory properties, etc.) and awareness on nutritional properties are some of the few factors that affect its consumption (Balfour et al., 2014). Pieniak et al. (2011) stated that shrimp consumption, frequency of consumption, and preferences are affected by consumers' geographic, social and cultural characteristics. Food preferences are also affected by a number of sensory (taste, smell, texture etc) and non-sensory factors (behaviour, beliefs, personal characteristics, risk perception, etc) (Honkanen et al., 2006).

Generally, toxic substances, handling and processing methods are some of the factors that can affect these attributes. Therefore, an estimate of freshness of this product can be obtained by defining criteria related to changes in sensory attributes such as appearance, odour, colour and texture that can be measured or quantified by sensory or instrumental methods (Olafsdottir et al., 2004). Huidobro et al. (2002) reported that the market value of shrimp is predominately based on the visual appearance of their body colour; thus appearance and the resulting quality implications play a significant role in maintaining a high consumer acceptance and perception. Consumers' perception of seafoods provides information on specific experiences (e.g., familiarity with shrimp preparation, eating frequency) which may influence subjective knowledge about shrimp

(Jodice et al., 2006). Other factors such as seasonality, consumer's income, storage, distance between the consumers and markets, product attributes, processing method, quantity of bycatches and awareness affect the perception of an aqua product. The advantage of product awareness cannot be overemphasized, assisting various sectors (processing, marketing, and economic) to improve the knowledge of consumers towards the nutritional benefits of *N. hastatus* (Huidobro et al., 2002).

Various researchers have reported different findings on shrimps in Nigeria. These findings include researches on smoke-curing of shrimp (Adeparusi et al., 2003); biology (Animoro and Meye, 2007); species richness, abundance, condition factor and length-weight relationship (Olawusi and Ajibare, 2014); Olawusi-Peters et al. 2014) and indigenous knowledge of the species (Okayi et al., 2013). In all these studies, there is relatively little/no information on the preference and perception of smoke-dried white shrimp particularly among consumers in coastal areas of Ondo State, Nigeria. Therefore, the objectives of the present paper include (i) obtaining information on the sensory properties of smoke-dried shrimps (ii) evaluating the relationship between the sensory attributes and general acceptability of the shrimps (iii) evaluating shrimp consumption level and frequency (iv) assessing consumers perception of the white shrimps in the study area. By analysing this information, it is possible to prepare a strategic plan which can influence processing and marketing decisions and ascertain long term goals of the shrimp fishery as well as contribute to nutrition policies at both regional and national scales.

MATERIALS AND METHODS

Study area

The study was carried out in the coastal area of Ondo State, Nigeria. The study area is at the extreme southern part of Ondo State. The coastal areas of Ondo State consist of over five hundred settlements spreading over 3,000 km². The area has over 180 km long shoreline thereby making it the longest coastline in Nigeria (Bayode et al., 2011). The study area falls within Latitude 6° 21' 00" N and Longitude 4° 48' 00" East of the Greenwich Meridian (Figure 1). The area is positioned within the equatorial evergreen swamp forest. It shares boundaries with Okitipupa Local Government Area in the North; the Atlantic Ocean in the South; Ijebu Waterside Local Government Area (Ogun State) in the West and Delta State in the East.

Sampling methods

White shrimp consumers were identified in Igbokoda. The community was purposively chosen for this study because the town is a major cluster for natives from coastal communities in Ilaje and Ese-Odo LGAs that makes up the coastal areas of the State. Forty (40) shrimp consumers comprising of 20 males and 20 females were randomly selected for this study. The selected consumers equally assessed the sensory properties of smoke-dried shrimp

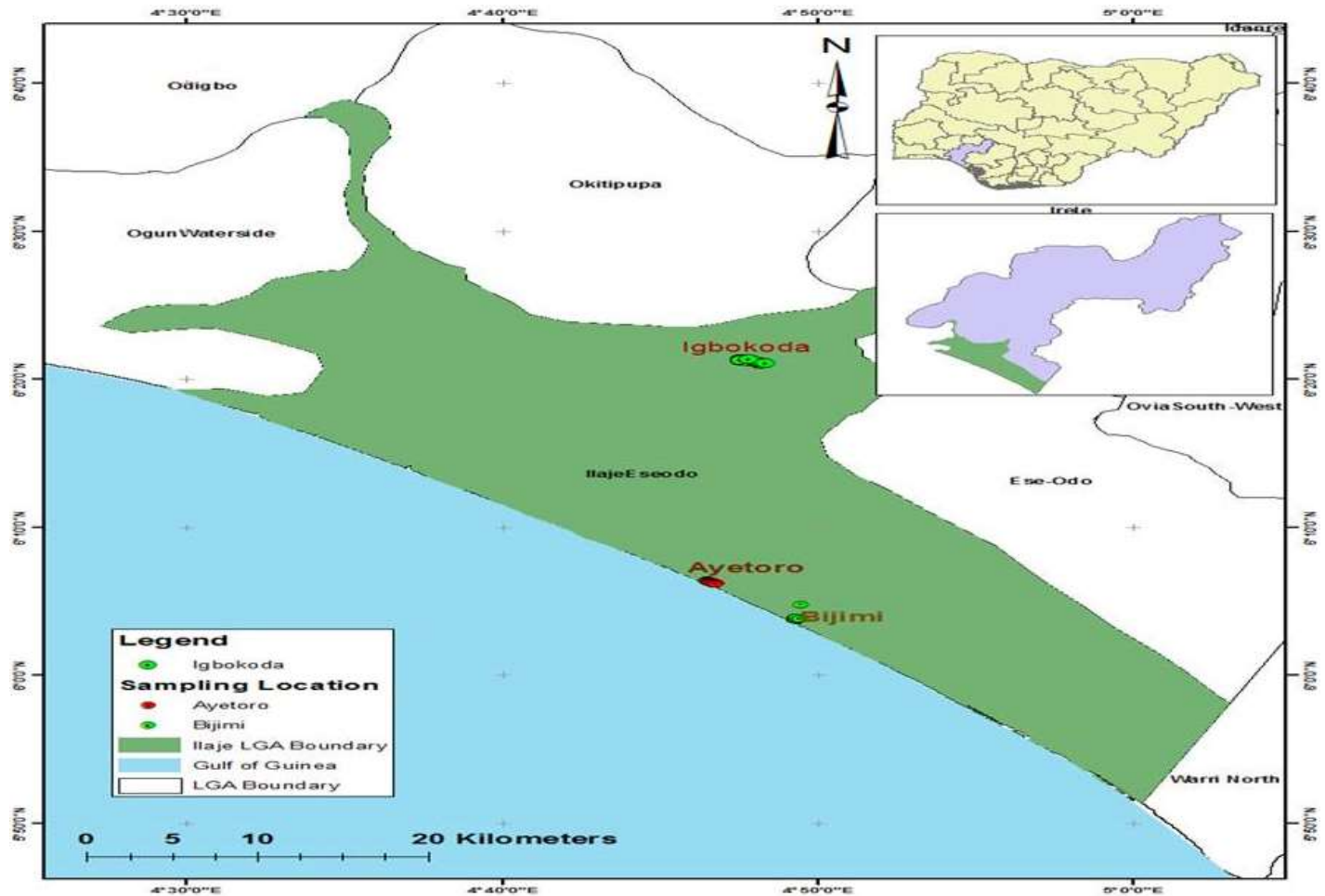


Figure 1. Map of the study area.

samples collected from Ayetoro and Bijimi; chosen for the predominance of white shrimp processing using smoking method. Five (5) samples (A1-A5 and B1-B5) were collected from processors in the two communities respectively. Samples were produced by sorting out by-catches and spreading measured quantity on a mat; then smoke-dried between 5 and 7 h depending on heat intensity and dryness of the wood (*Rhizophora racemosa*) commonly used (Centre for Environment Human Right and Development, 2007; Alhaji et al., 2015). Panelists assessed the sensory attributes of the samples using a 9-point hedonic scale: (extremely (9), very much (8), like moderately (7), like slightly (6), neither like nor dislike (5), dislike slightly (4), dislike moderately (3), dislike very much (2), and dislike extremely (1). Sensory attributes rated in the samples were colour, taste, flavour, crispness, appearance and overall acceptability. Structured questionnaire was used to assess consumers' information on preference and perception of white shrimps in the study area between December, 2016 and January, 2017.

Statistical analysis

Descriptive statistical tools such as tables, charts and percentages were used to describe consumers' information. Sensory attributes of smoke-dried white shrimps were subjected to one way analysis

of variance using the Statistical Package for Social Science (SPSS) Version 20.0. Means were separated where significant difference occurs at $p \leq 0.05$ using the Duncan's New Multiple Range Test (DNMRT). Multiple regression analysis was used to evaluate the effects of sensory attributes on the acceptability of white shrimps in the study area.

RESULTS

Demographic characteristics of selected white shrimp consumers in the study area

Figure 2 provides information on the distribution of white shrimp consumers by demographic characteristics. It reveals that 22.5% of the respondents were below 20 years of age; 25% were between ages 20 and 29; 30% fell between 30 and 39 years old, 12.5% were between 40 and 49 years while 10% of the selected white shrimp consumers were above 49 years. Results further indicated that 7.5, 10, 12.5, 20, 17, 5 and 12.5% were natives of Arogbo, Awoye, Ayetoro, Igbokoda, Mese and

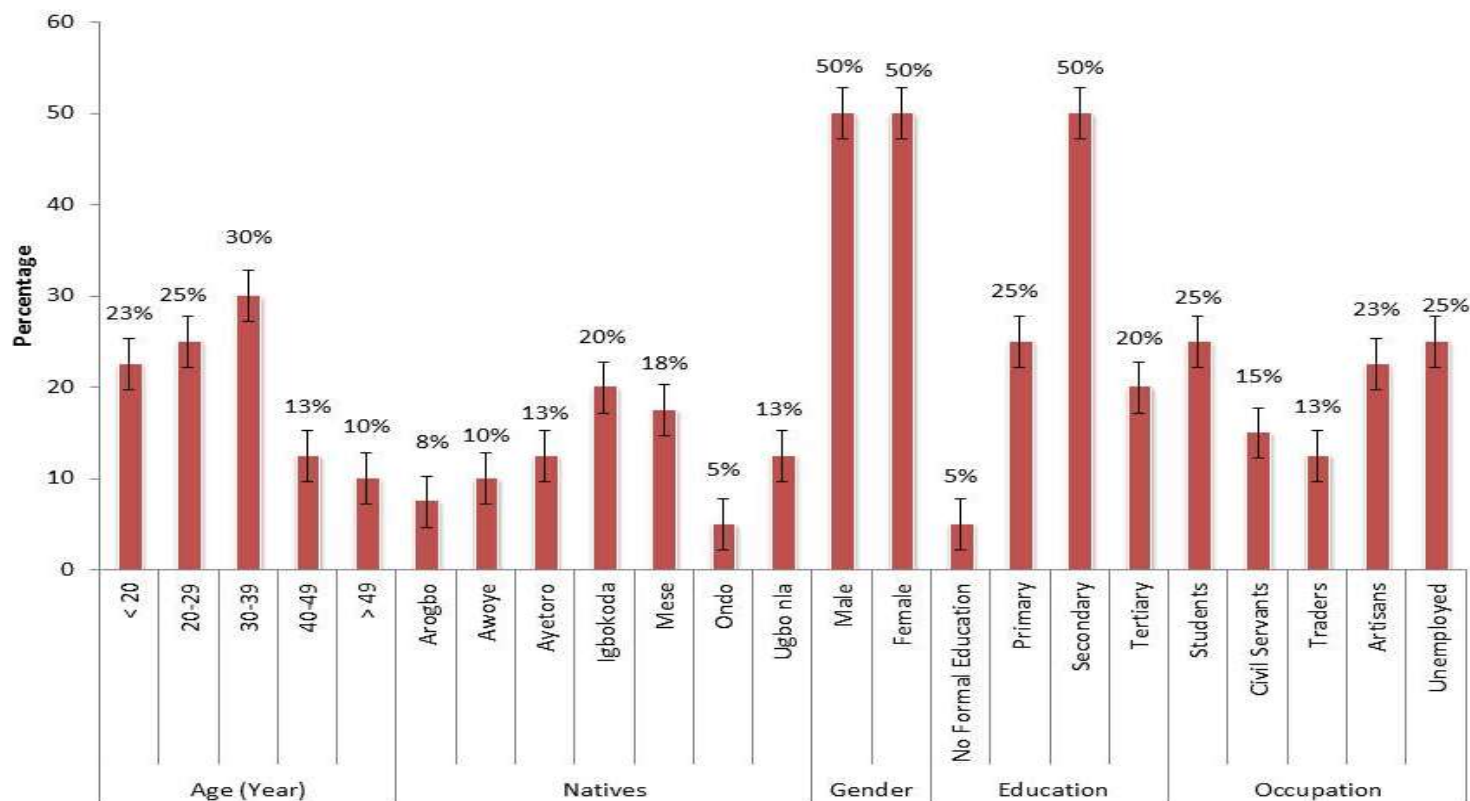


Figure 2. Demographic characteristics of selected shrimp consumers. Source: Computed from Field Survey (2017).

Table 1. Sensory characteristics of smoke-dried *N. hastatus*.

Sample	Colour	Flavour	Taste	Crispness	Appearance	Acceptability
A1	6.85 ± 0.33 ^d	7.05 ± 0.28 ^b	7.38 ± 0.29 ^d	6.63 ± 0.35 ^c	7.23 ± 0.28 ^e	7.53 ± 0.19 ^{de}
A2	6.75 ± 0.24 ^d	6.93 ± 0.24 ^b	7.05 ± 0.22 ^{cd}	6.70 ± 0.29 ^c	7.10 ± 0.24 ^e	6.95 ± 0.25 ^{de}
A3	5.85 ± 0.32 ^c	6.08 ± 0.29 ^b	5.90 ± 0.27 ^{ab}	5.23 ± 0.31 ^{ab}	5.80 ± 0.27 ^c	5.55 ± 0.26 ^c
A4	4.60 ± 0.36 ^b	5.08 ± 0.31 ^a	5.40 ± 0.31 ^a	5.43 ± 0.32 ^{ab}	4.68 ± 0.33 ^b	5.45 ± 0.32 ^b
A5	7.30 ± 0.21 ^d	6.15 ± 0.28 ^b	6.43 ± 0.27 ^{bc}	5.50 ± 0.29 ^{ab}	6.00 ± 0.26 ^{cd}	6.75 ± 0.20 ^{de}
B1	7.03 ± 0.22 ^d	6.43 ± 0.27 ^b	6.38 ± 0.26 ^{bc}	5.73 ± 0.28 ^b	5.98 ± 0.28 ^{cd}	6.33 ± 0.26 ^d
B2	3.75 ± 0.33 ^a	4.50 ± 0.37 ^a	5.28 ± 0.33 ^a	4.55 ± 0.33 ^a	3.55 ± 0.31 ^a	4.58 ± 0.29 ^a
B3	3.45 ± 0.32 ^a	4.50 ± 0.32 ^a	5.13 ± 0.31 ^a	4.70 ± 0.32 ^a	4.33 ± 0.35 ^{ab}	4.78 ± 0.31 ^{ab}
B4	6.68 ± 0.33 ^{cd}	6.53 ± 0.36 ^b	7.15 ± 0.28 ^{cd}	6.88 ± 0.26 ^c	6.78 ± 0.24 ^{de}	6.93 ± 0.25 ^{de}
B5	7.38 ± 0.27 ^d	6.93 ± 0.33 ^b	7.38 ± 0.29 ^d	6.98 ± 0.34 ^c	7.13 ± 0.29 ^e	7.55 ± 0.25 ^e

Mean ± S.E with different superscripts along rows are significantly different ($p \leq 0.05$). A1-A5 and B1-B5: Samples collected from Ayetoro and Bijimi respectively.

Source: Computed from Sensory Evaluation (2017).

Ondo respectively. Fifty percent (each) of the consumers were male and female respectively. Only five percent of the consumers had no formal education, 25% had primary education, 50% had secondary while 20% had tertiary education. Equally, 25% of the consumers were students, 15% were civil servants, 13% were traders, and 23% were artisans while 25% were unemployed.

Sensory analysis of smoke-dried white shrimp

Results of the differences in the sensory attributes of dried white shrimps collected from Ayetoro and Bijimi is presented in Table 1 while the effect of the sensory attributes on the general acceptability of smoke-dried shrimps is presented in table 2. Colour of smoked *N.*

Table 2. Effects of sensory properties on acceptability of smoke-dried shrimp.

Parameter	Coefficient	t-Stat	P-value
Intercept	0.94	3.36	0
Colour	0.12	3.96	0
Flavour	0.19	4.33	0
Taste	0.28	6.11	0
Crispness	0.1	2.35	0
Appearance	0.18	4.47	0
Correlation Coefficient (R)	0.71		
Regression Coefficient (R ²)	0.5		

Source: Computed from Sensory Evaluation (2017).

Table 3. Consumption trend of white shrimp among selected consumers.

Variable	Frequency	%
Frequency of consumption		
Daily	9	22.50
Weekly	18	45.00
Monthly	2	5.00
Occasionally	9	22.50
Total	40	100.00
Product form		
Fresh	8	20.00
Dried	32	80.00
Total	40	100.00
Allergic to consumption		
Yes	6	15.00
No	34	85.00
Total	40	100.00

Source: Computed from Sensory Evaluation (2017).

hastatus was moderately rated high in B5 and moderately disliked in B3. There were significant similarities ($p > 0.05$) in the colour of A1, A2, A5 and B5 as well as B2 and B3 respectively. Similarities ($p > 0.05$) existed in the flavour of A1, A2, A3, A5, B1, B2, B3 and B5. Flavour of sample A1 was moderately liked while the lowest flavour was observed in B2 and B3 respectively. Shrimp samples A4, B2 and B3 were similar ($p > 0.05$) in taste. Also, panellists rated the taste of A2 and B4 a-like ($p > 0.05$). Assessors said A1 and A5 (7.38) were tastier than others while the taste (5.13) of A3 was neither liked nor disliked. Crispness was highest (6.98) in B5 and lowest (4.55) in B2 while same level ($p > 0.05$) of crispness was rated in A3, A4 and A5; and in A1, A2, B4 and B5 respectively. Appearance was rated differently ($p > 0.05$) in A1, A3, A4 and B5 while similar appearance ($p > 0.05$) were recorded in A5 and B1. Sample B5 was highly accepted

more than the others while sample A3 was the least accepted. Statistical significance was similar ($p > 0.05$) in A1, A2, A5 as well as in A3, A4 and B4 respectively. Results further indicated that all the sensory parameters had positive and significant ($p \leq 0.05$) influence on the general acceptability of the product going by their p-values, t-Stat and positive coefficients (Table 2). Taste of the shrimps was the highest significant factor that determined the general acceptability of panelists as indicated by the magnitude of its t-Stat. This was followed by appearance, flavour, colour and crispness. All the sensory attributes were positively correlated ($R = 0.71$) with general acceptability and 50% dependent on the attributes.

Consumption Trend among Selected Consumer

Table 3 provides information on the descriptive statistics of the consumption trend of white shrimps among selected consumers. It indicates that 22.5% of the respondents consumed shrimp daily, 45% consumed it weekly, 5% consumed it monthly while 22.5% took it occasionally. Twenty percent of the respondents consumed it in fresh form while the majority (80%) of them preferred it in dried form. Only 15% of the consumers said they were allergic to white shrimp consumption while 85% said they showed no allergy to it.

Accessibility and satisfaction

Consumers' information on accessibility and satisfaction of smoke-dried *N. hastatus* in the study area is presented in table 4. It reveals that 50% of the consumers purchased dried shrimps from retail outlets, 12.5% got it from wholesalers while 37.5% bought it from processors. The largest proportion (70%) of the consumers said that dried shrimps were readily available in marketing outlets, 25% said they were seasonally available while 5% said they were less available. Equally, 92.5% said seasonality affects the availability of the product in market outlets while 7.5% said availability was not affected by season. Seventy-five percent said white shrimps were more available in the raining season and 25% believed they are less available in the dry season.

Also, 45% of the respondents perceived smoke-dried *N. hastatus* as an expensive aqua product; 50% said they were less expensive while 5% said it was not expensive seafood. Results further indicated that over half (55%) of the consumers said they were highly satisfied with smoke-dried shrimps in different marketing outlets, 42.5% said they were less satisfied while only one respondent (2.5%) was not satisfied. Results further show that 22.5% and 52.5% said odd appearance and quantity of by-catch were the reasons for their non-satisfaction with shrimps in market places respectively. Majority (77.5%) of the consumers bought dried shrimp from marketing outlets

Table 4. Product accessibility and satisfaction.

Variable	Frequency	%
Marketing channel		
Retailer	20.00	50.00
Wholesaler	5.00	12.50
Processor	15.00	37.50
Total	40.00	100.00
Market availability		
Readily available	28	70.00
Seasonally Available	10	25.00
Less Available	2	5.00
Total	40	100.00
Seasonality affects availability		
Yes	37	92.5
No	3	7.50
Total	40	100.00
Seasonality of white shrimps		
More Available (Raining Season)	30	75.00
Less Available (Dry Season)	10	25.00
Total	40	100.00
Market cost		
Very Expensive	18	45.00
Less Expensive	20	50.00
Expensive	2	5.00
Total	40	100.00
Satisfaction		
Highly Satisfied	22	55.00
Less Satisfied	17	42.50
Not Satisfied	1	2.50
Total	40	100.00
Reasons for Non/Less Satisfaction		
Off Flavour	5	12.50
Not Tasty	5	12.50
Odd Appearance	9	22.50
By-Catch	21	52.50
Total	40	100.00
Market Distance (minutes)		
> 10	31	77.50
10-19	5	12.50
> 19	4	10.00
Total	40	100.00

Source: Computed from Field Survey (2017).

less than ten minutes walking distance, while 12.5 and

10% bought it from marketing outlets with a walking distance between 10 and 19 minutes and above 19 min respectively.

Information on medium of storage

Information on the distribution of shrimp consumers by medium of storage is presented in table 5. It indicates that 12.5% of the consumers' stored dried shrimp in nylon, half of them stored it in plastics; 7.5% stored in plate while 10% stored it in bowl. Equally, 7.5% of the consumers kept dried shrimp inside in refrigerators while 12.5% used cupboard. Results further indicated that 45% said dried white shrimp had a shelf life of less than 30 days, 47.5% said the shelf life was between 30 and 60 days while 7.5% said dried shrimp had storage length more than 60 days. Also, 85% of the consumers said dried *N. hastatus* do not grow mould in storage while 15% said it usually grow mould in storage.

Acceptability and types of food flavoured with dried *N. hastatus*

Consumers' acceptability and type of food flavoured with dried *N. hastatus* is presented in Figure 3. It indicates that 62.5% of the consumers highly accepted food flavoured with white shrimps; 12.5% said food flavoured with dried white shrimp were less acceptable while 32.5% said such food was moderately acceptable. Furthermore, 32.5% said they appreciate stew flavoured with dried shrimps, 27.5% liked it in soup, 15% in vegetables, 12.5% in beans cake (moi-moi) and 12.5% in all types of food.

Utilization and nutrition benefits of white shrimp

Consumers' information on the utilization and nutritional benefits of white shrimps is presented in table 6. All the respondents said they were aware of the utilization of white shrimps in weaning foods. Only 6 respondents representing 15% of the consumers admitted babies fed food supplemented with white shrimps do show allergic reactions; however, majority (85%) said babies were not allergic to weaning foods supplemented with white shrimps. Furthermore, 77.5% of the respondents were aware of the nutritional benefits of white shrimps while 22.5% were not aware. In addition, 7.5% said they were aware of the nutritional benefits of the shrimp through medical advice, 10% got informed through radio/tele media, 12.5% were through friends, 35% through literature/education, 10% through social media, while 25% said white shrimps was part of their native diet. Twenty percent of the consumers said the shellfish supplies vitamins to the body, 10% said it is proteinous, 37.5% said it aids strong and healthy bones while 25%

Table 5. Information on storage.

Variable	Frequency	%
Storage medium		
Nylon	5	12.50
Plastic	20	50.00
Plate	3	7.50
Bowl	4	10.00
Medium + Refrigerator	3	7.50
Medium + Cupboard	5	12.50
Total	40	100.00
Shelf life (Days)		
> 30	19	47.50
30 - 60	18	45.00
> 60	3	7.50
Total	40	100.00
Grow mould in storage		
Yes	6	15.00
No	34	85.00
Total	40	100.00

Source: Computed from Field Evaluation (2017).

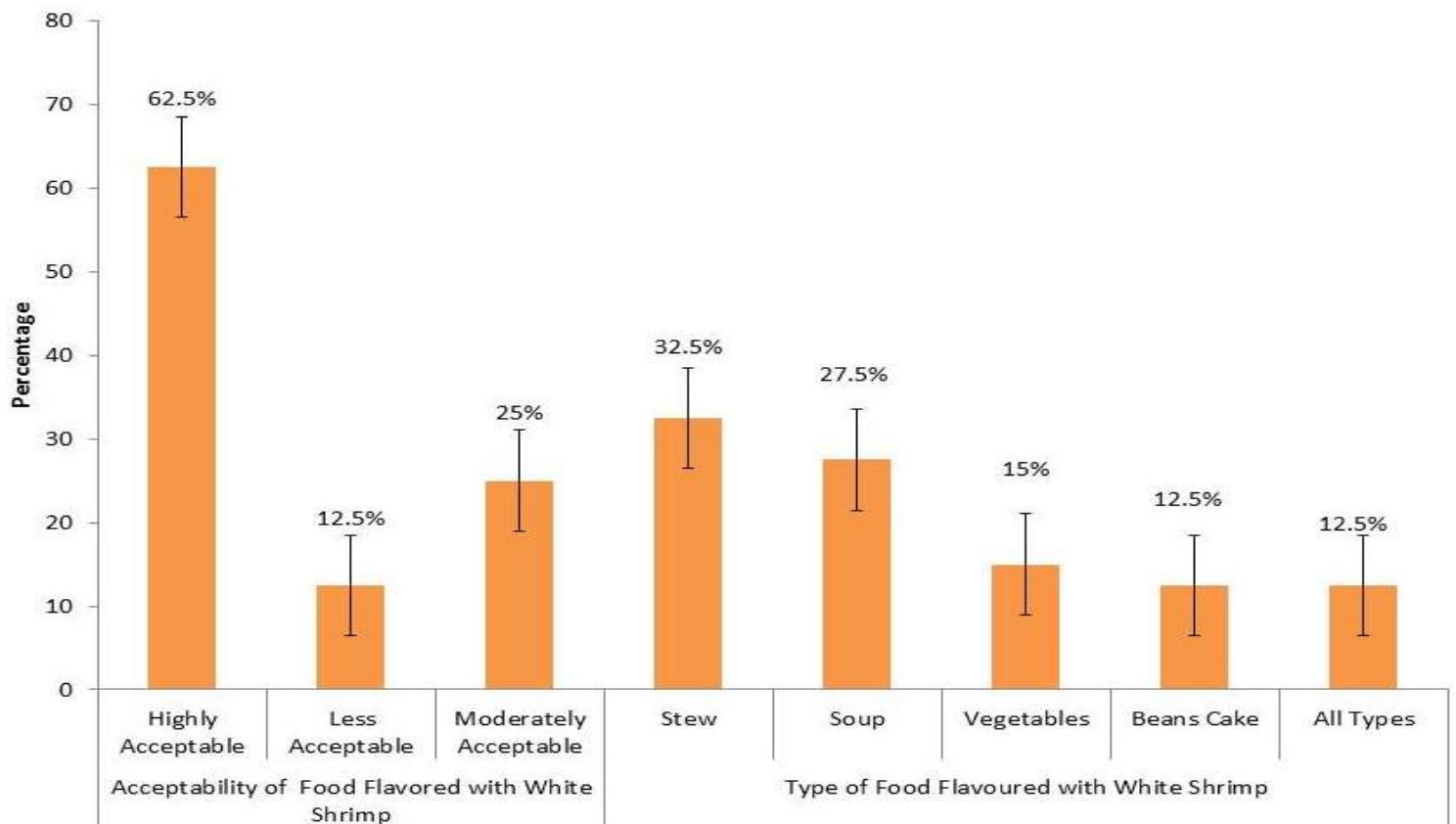


Figure 3. Acceptability and types of food flavoured with *N. hastatus*.
Source: Computed from Field Survey (2017).

Table 6. Utilization and nutrition benefits of white shrimp.

Variable	Frequency	%
Awareness of utilization in Weaning Food		
Yes	40	100.00
Total	40	100.00
Allergic reactions in babies		
Yes	6	15.00
No	34	85.00
Total	40	100.00
Awareness of nutritional benefits of white shrimp		
Yes	31	77.50
No	9	22.50
Total	40	100.00
Medium of awareness		
Medical advice	3	7.50
Radio/Tele-Media	4	10.00
Friend	5	12.50
Literature/Education	14	35.00
Social media	4	10.00
Native diet	10	25.00
Total	40	100.00
Nutritional benefits of white shrimp		
Vitamins supply	8	20.00
Proteinous	4	10.00
Healthy and enhance growth	15	37.50
Strong and health bones	3	7.50
I don't know	10	25.00
Total	40	100.00

Source: Computed from Field Survey (2017).

said they do not know the nutritional benefits of the shrimp species.

DISCUSSION

Sensory properties of smoke-dried *N. hastatus*

Results of the sensory evaluation of smoke-dried shrimps collected from processing units are of great importance to the acceptability of the product among consumers. The significant differences in the organoleptic properties of the species might be attributed to handling, heat intensity, hours of smoking and type of wood used. Guochen et al. (2008) and Yakubu and Nqueku (2015) documented that the physical and sensory properties of dried shrimp (*Pandalus borealis*) and fish samples were significantly affected by the handling conditions. These might be responsible for low acceptability of A3, B2 and B3; however, samples A1 and B5 were highly accepted than

the other samples. This might be credited to their colours, flavour, taste and appearance which were rated better. Processors in the study areas with dried shrimp with sensory properties less than 6 could still improve on their processing methods (by moderating the hours of smoking, heat intensity, type of wood used and pre-smoking handling) to increase their acceptability in the market place.

It could be inferred from the regression analysis that the taste of the shrimp was the highest significant factor that determined the acceptability of the species among assessors; followed by appearance. The significance of these factors implies that all the sensory attributes were important in determining general acceptability. This is in tandem with the assertion of Olaniyi et al. (2017) who posited that the overall acceptability or palatability rating of African catfish was a reflection or aggregation of the ratings for all cognitive and qualitative sensory attributes. Similar studies by Yakubu and Nqueku (2015) stated that flavour was the highest important factor that determined

general acceptability among consumers of smoke-dried fish collected from different markets in Lafia, Nigeria. Other studies by Barret et al. (2010) and Adeola et al. (2016) reported that the taste, flavour and appearance were the key three sensory factors determining the acceptability of processed shrimp and African catfish in market places; consumers evaluate the visual appearance and colour of food products first, followed by the taste, aroma, and texture. Hence, the high rating of these factors in most of the samples by majority of the assessors might have influenced their decision on the acceptability of white shrimps in the study area. Their decision may have been supported by the assertion of Barret et al. (2010) who opined that shrimp generally have bright natural colour, flavour and firmness (excellent elastic and rigid characteristics), presenting a very good overall quality.

Consumption trend among selected consumers

Consumption trend among selected white shrimp consumers provides a better understanding of frequency of consumption, product form and allergic reactions in consumers. The weekly consumption of white shrimp in the study area would affect marketing, processing and extraction of the species. This is because the consumptive demands of consumers do affect resource extraction and other agent in sea food value chain. This assertion is supported by Ardjosoediro and Neven (2008) who reported that resource extraction of seafood is operated under economic incentive largely determined by agents in fish value chain. The preference for dried shrimp compared to other product forms could be attributed to the fact that *N. hastatus* is mostly available in dried form in the study area. The perishability of the species predisposes them to spoilage; hence they are usually smoke-dried to increase palatability and shelf life (Centre for Environment Human Right and Development, 2007). According to Akonor et al. (2016), shrimp may easily deteriorate after catch except they are kept in cold storage. However, this method is expensive in coastal communities owing to lack of public power supply, hence traditional methods such as sun drying and smoke-drying are used in producing dried shrimps for marketing and consumption. Though, majority of consumers said they showed no allergic reactions to white shrimp consumption; however, some said they do show allergic reactions such as vomiting/tingling of tongue and stomach. This could be the reason some respondents preferred consuming the shellfish in grounded form to reduce tingling in the mouth and stomach. The high acceptability of dried shrimps to fresh could be as a result of the greater nutritional yield of dried shrimps. This statement is supported by the findings of Hog et al. (2006) who posited that smoked shrimp from nutritional point of view can be considered as a product with good

nutritive value.

Consumers' accessibility and satisfaction

The presence of different marketing agent (retailer, wholesalers) connotes that the species could be sourced from different agents in the value chain. This result indicated that most of the consumers did not buy directly from processors. They usually buy from retail outlets and wholesalers markets that were less than 10 min walking distance from their homes. Though, majority of consumers said white shrimp was readily available in market outlets, they were less available and more expensive during the dry season. It thus implies that seasonality affects the supply demand and price of dried shrimps in market outlets. Therefore, consumer's price is expected to be high during the off peak months (November and May) compare with prices in the peak months (June and October). Several literatures have documented the effect of seasonality on the availability of shrimps in Nigeria. These include Ambrose (2004) who reported that the total quantity of shrimps and by-catch combined per landings was higher in wet season than dry season in the coastal artisanal shrimp beam trawl fisheries of Lagos State, Nigeria; Ofor and Kunzel (2009) estimated a peak catch per unit effort for *N. hastatus* between May and November in the coastal areas of Cross River State, Nigeria while Ambrose et al. (2016) reported that seasonal variation affects the catch composition of *Nematopalaemon* fishery. Generally, shrimp landing during the raining season is characterized by high catches compared with reduced volume and increased price; thus affecting the purchasing power of consumers most especially in rural areas and among low income earners (Akins and Winemiller, 2006; Christopher et al., 2017).

Satisfaction of consumers with white shrimps in market outlets could serve as a verdict on white shrimp processors. This might be attributed to acceptable sensory attributes of shrimp in market places which usually determines consumers' choice and price (Olaniyi et al., 2017; Adeola et al., 2016). However, consumers said they could be less/not satisfied with white shrimps in market places due to off flavour, inadequate taste, odd appearance or the amount of by-catch in the product which accounted for 55% of reasons for non/less satisfaction with smoke-dried products in market places.

Storage information

Mould growth is associated to the level of moisture in shrimps. Hence, majority of consumers could have bought dried shrimps with low level of moisture content that would discourage mould growth while those who said shrimps grew mould in storage could have bought

shrimps that had higher water activity which could be attributed to shorter processing hour or storage of the product in humid environment. Mould growth in food generally occurs when storage and/or drying conditions are not optimal. Casa-veneracion (2018) believes that dried shrimp are not exempted from storage spoilage but the degree of spoilage is dependent on the humidity of the environment and storage medium. The writer opined that mould might be the worst enemy of dried shrimps and once they get mouldy; there is no other choice but to throw them away. Eeckhout et al. (2013) equally submitted that mould growth and mycotoxin production in food is affected by moisture content, storage conditions, temperature, and humidity; hence, storage conditions should be well fine-tuned to avoid mould growth.

Storage information is important to consumers, producers and marketers. Though processors in the study area sold their product within the week of smoke/sun drying, retailers and consumers are participants in the value chain that usually stores white shrimps for longer period. The result of storage medium indicated that most of consumers stored white shrimps in cheap and available materials such as nylon, air-tight plastics, plates and bowl. The reduction in the numbers of consumers that stored the shrimp species in refrigerators could be as a result of inadequate electricity, or high cost of refrigerators which lowers its usage compared with 12.5% that used cupboard for this purpose which was less expensive. The length of dried shrimp in storage indicates that species could stay between 30 and 60 days in storage. However, the shelf life of the shellfish in storage could be affected by the medium of storage while the choice of storage medium is determined by cost. Studies by Asinghe et al. (2006) recommended Styrofoam as the best medium for storing processed whole and peeled dried shrimp while Casa-veneracion (2018) recommends storing dried shrimps in a jar with a screw-type cap and kept in the refrigerator as the best medium for increasing shelf life and maintaining product quality which was the form used by 7.5% of the consumers under study.

Acceptability and types of food flavoured with dried *N. hastatus*

High level of acceptability of food flavoured with *N. hastatus* among selected consumers is an indication that species was largely accepted in the diets of coastal inhabitants. The excellent sensory attributes (taste, flavour) could also be the reason why the product serves as source of seasoning in the diets of coastal inhabitants and beyond. Okayi et al. (2013) described white shrimps as a major and essential condiment which supplies nutrients to coastal inhabitants and beyond. Ajala and Oyategbe (2013) equally stated that shrimps in its different forms contribute substantially to the diet of

Nigerians because of its low price and easy availability; they are major source of animal protein to the low income earners because it is more acceptable than other forms of animal protein as there are no social, cultural or religious taboos associated with its consumption (Bello, 2013).

Utilization and nutrition benefits of white shrimps

Results from the study indicated that all the consumers were aware of the utilization of white shrimps as supplement in weaning foods. This shows that white shrimp was mostly used in the production of weaning food in coastal communities because of its easy accessibility (Bello, 2013). The relevance of this is to reduce malnutrition among the poor who cannot afford expensive supplementary weaning foods. Shehu et al. (2013) revealed that grounded white shrimps were increasingly being used in many developing countries as ingredients in the production of weaning/complementary foods. Most of consumers said babies fed with foods fortified with shrimp showed no allergic reaction while some of the consumers said some children do show allergy to food supplemented with white shrimps. Such allergic reactions include vomiting, tingling, abdominal pain and diarrhea.

Consumers' awareness of the nutritional benefits of white shrimps might be the reason for the high level of acceptance of the species in their diets. Awareness of the nutritional benefits of the species were gotten through different means which include medical advice, social media, television and radio medium, literature texts, friends while 25% of them said white shrimp was part of their native diet. The literacy level of consumers in the study area could have leveraged on their awareness of the nutritional qualities of white shrimps as 95% of them had between primary and tertiary education. The perception of consumers on the nutritional benefits of white shrimps is similar to the Dayal et al. (2011) and Shehu et al. (2013) who stated that dry matter of shrimps are loaded with protein, vitamin D, vitamin B3, iodine and zinc and carbohydrate-free food for anyone determined to shed off weight. Since white shrimps are excellent source of zinc and other micro nutrients; they could be used in supplementing Zn²⁺ deficient diets particularly for children (Shehu et al., 2013).

Conclusion

The study emphasized the importance of sensory evaluation and perception of consumers on the quality, acceptance and utilization of white shrimp in coastal areas of Ondo State, Nigeria. All the sensory properties were positively correlated with the general acceptability of smoked samples of the species. By-catches, off-flavour

and odd-appearance were the factors that determined consumers' satisfaction with shrimps in market places. Hence, shrimp processors should lay more emphasis on the type of wood, numbers of processing hours and heat intensity applied during processing. They should equally endeavour to thoroughly sort-out by-catches from fresh shrimp before processing. Equally, selective gears should be designed to reduce by-catches at landing; this would further increase consumers' satisfaction and patronage in market places.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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