Afropolitan Journals

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ISSN: 3027-2637 www.afropolitanjournals.com

Effect of Sodium Chloride Curing on the Microbial Quality of Fresh Water and Marine Periwinkle Species in Nigeria

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DOI: *https://doi.org/10.62154/ajasfr.2025.020.01014*

Abstract

Studies on the effect of sodium chloride curing on the microbial quality of fresh water and marine species of African periwinkles (*Pachymelania aurita* and *Tympanotonus fuscatus)* from Itu market, Itu Local Government Area, Akwa Ibom State, Nigeria was conducted. A standard solution of sodium chloride was prepared in the ratio; 1:10 w/v. The cleaned periwinkles species were sorted manually and cured at different concentrations (0%, 5%, 10%, 15%, and 20%). Data collected were analyzed and tested at ($P<0.05$) level of significance, using analysis of variance (ANOVA). The Total Heterotrophic Bacterial Load (THBC) ranged from ($0.8x10^2$ – $2.1x10^3$ CFU/g) for fresh water periwinkle and ($0.9x10^2$ – $1.5x10^3$ CFU/g) for marine periwinkle. In both species, the uncured samples recorded the highest THBC. The fresh water periwinkle recorded higher THBC than marine periwinkle. The *Staphylococcus* count recorded was ($1.1x10^3$ CFU/g) for uncured fresh water periwinkle, and ($1.0x10^2$ CFU/g) for uncured marine periwinkle. The fecal count ranged from ($1x10^2$ – $3x10^2$ CFU/g) and ($1x10^2$ – $2x10^2$ CFU/g) for fresh water and marine periwinkle respectively. The results of the microbial analysis showed that the uncured fresh periwinkles had higher microbial load than the cured periwinkles. However, the microbial load observed in the study was not higher than ($1x10^5$ CFU/g) recommended by USFDA as maximum safety limit. The viable cell count at 600 nm ($x10^6$) detected by spectrophotometer revealed a significant reduction with increased concentration of sodium chloride from (0.682, 0.954) to (0.007, 0.006) nm ($x10^6$) for fresh water and marine periwinkle respectively. The study showed that preservation of periwinkles by curing could be an effective approach to curbing microbial spoilage, enhancing shelf life and nutritional quality.

Keywords: Sodium Chloride, Curing, Microbial Quality, Fresh Water, Marine, Periwinkle.

Introduction

Fish is one of the essential commodities in Africa that enhances nourishment and economic vitality (Chan *et al.*, 2019). In Nigeria and most part of Africa where food insecurity and malnutrition is prevalence, shellfish is a primary source of animal food that (Desiere *et al.*, 2018). Periwinkles are soft body tiny snails that are found in estuary. They are highly nutritious and mostly consumed in Southern geo-political zone, especially in the Niger Delta. Two common types of periwinkles consumed include the fresh water and salt water periwinkle (*Tympanotonus fuscatus* and *Pachymelania aurita*) respectively. In the Niger Delta, periwinkle is basic ingredient and primary animal-food diet rich in protein, and are

used to prepare special native delicacies (*Adebayo et al*., 2006). Periwinkle harvesting also provide job opportunities to many individuals ranging from harvesters to sellers, transporters, distributors and exporters who export them to other countries (Martin *et al*., 2020).

These bio-feeders are found in brackish water, feeding on algae or biofilms covering mud surfaces. Periwinkles tends to harbor high microorganisms due to their feeding nature and environment, causing major outbreak of food borne disease (Adebayo and Tayo 2008). Shellfish, including periwinkles can be contaminated by the release of industrial effluence, human waste and contaminants from the surrounding environment, including microbial pathogens, pesticides and heavy metals from oil spill. (FEPA, 2023). Human activities such as bathing, washing and waste deposit may also increase contamination of these shellfishes. According to Otitoju and Otitoju (2013), the common practice of eating periwinkle, using the mouth to extract the unshelled periwinkle meat may be associated with ingesting contaminants and sediments from the digestive system of these organisms compared to shelled periwinkle due to potential higher level of pollution and microbial proliferation in the aquatic habitat. However, they are mostly consumed by high population because of their nutritional benefits, especially for low cholesterol and high protein. Periwinkles contain Omega 6 fatty acids which helps in body and mental development (Adebayo *et al*., 2006).

Curing is a method of preservation that enhances the quality of food or meat. It involves the use of salt, sugar or nitrate to prevent spoilage by reducing the water activity and inhibiting the growth of bacteria which may cause food spoilage. Curing also result in flavor enhancement and color retention. This paper aims to determine the effect of sodium chloride curing on the microbial quality of fresh water and marine periwinkle mostly consumed in the Niger Delta. The study seeks to investigate and utilize sodium chloride curing as a conventional technique in curbing microbial load to enhance the shelf life of African periwinkle. It also seeks to determine what specie of African periwinkle is considered microbiologically safe for international trade.

Materials and Method

Processing of Periwinkle

The freshly harvested periwinkles were processed using the procedure described by Inyang *et al*. (2018) with slight modification. Potable water was used to thoroughly wash the whole body of the periwinkles in order to remove mud and other adhered materials. A standard concentration of sodium chloride was prepared in the ratio, (1:10) w/v. The two species of the cleaned periwinkles were sorted manually and cured at different concentrations (0%, 5%, 10%, 15%, and 20%) for 24 hrs. The samples were coded and labeled; CF-0, CF-5, CF-10, CF-15, CF-20, CS-0, CS-5, CS-10, CS-15, and CS-20. After curing, the samples were poured into hot water (100 ^{o}C) and allowed to boil for about 10 mins. After boiling, it was cooled to room temperature (28$\pm$2^{o}C). The edible portion (meat) of the periwinkle was extracted from shell, processed and stored for further analysis.

Formulation of Samples

A total of ten (10) samples were formulated from two species of African periwinkles to compare and contrast the effect of curing on both species. Five samples were obtained from each specie. The control sample was processed without treatment with sodium chloride to monitor the variation in the attributes of the treated samples. The salt concentrations used were 0%, 5%, 10%, 15% and 20% respectively.

Table I: Formulation of Samples for curing

Samples	Concentration of Sodium Chloride
CF-0	0%
CF-5	5%
CF-10	10%
CF-15	15%
CF-20	20%
CS-0	0%
CS-5	5%
CS-10	10%
CS-15	15%
CS-20	20%

Estimation of Microbial Load in the Samples

Standard microbiological techniques described by Prescott (2004) were employed for the microbiological analysis of the processed samples. The Total heterotrophic bacterial count (THBC), Total Coliform counts, (TCC) *Salmonella Shigella* count (SSC), Total Vibrio count (TVC), Total faecal coliform count (TFC), *Staphylococcal* count (SC), Re-enforced Clostridial Count (RCC), *Lactobacilli* counts (LAB) and fungal count (FC) were estimated by the Pour plates methods except fungal count that used the spread plates method. These procedures used Nutrient agar (NA), MacConkey agar (MCA), Salmonella Shigella agar (SSA), Thiosulphate Citrate bile-salt Agar (TCBS), Eosine Methylene Blue Agar (EMBA), Mannitol Salt Agar (MSA), Re-enforced Clostridial Medium (MRS) Agar and Sabouraud Dextrose agar (SDA) as analytical media respectively.

Characterization and Identification of Microbial isolates

Bacterial isolates were characterized and identified presumptively based on their morphological, cultural and physiological characteristics, confirmatory identification was based on Biochemical reactions. The following Biochemical test were carried out. Gram staining, motility test, coagulase test, catalase test, spore staining test, oxidase test, urease test, citrate test, starch hydrolysis test, methyl red-Voges Proskaures (MR-VP) test and sugar fermentation test (lactose, glucose, mannitol, maltose, galactose, fructose and sucrose).

Morphological and Biochemical Characterization of the Bacterial Isolates

Standard characterization tests were performed. The pure culture was identified on the basis of its cultural, morphological and physiological features and compared with those in Bergeys Manual of Determinative Bacteriology (Cowan, 1974; Buchanan and Gibbons, 1974).

Statistical Analysis

Data was expressed as mean ± standard deviation of triplicate determination. One Way analysis of variance with interaction was used to determine the effect of the curing treatment. Where the effect of a factor was significant, the results were compared using multiple comparison by Duncan's test in order to determine the differences between two means, and ANOVA was used to determine statistical significance ($p< 0.05$).

Results

Viable Cell Count of Cured *Pachymelania aurita and Tympanotonus fuscatus*

The result of the viable cell count is presented in Table 1. The viable cell count for fresh water periwinkle ranged from (0.007-0.950) nm ($x10^6$), and (0.006-0.682) nm ($x10^6$) for marine periwinkle. The highest viable cell count was observed in CS-0 (*Tympanotonus fuscatus),* fresh water not treated with sodium chloride. The least viable cell count was observed in *T. fuscatus* treated with 20% sodium chloride.

Table 1: **Viable Cell Count of Cured *Pachymelania aurita and Tympanotonus fuscatus***

Samples	Viable Cell Counts at 600 nm ($x10^6$) cells
CF-0	0.682
CF-5	0.580
CF-10	0.420
CF-15	0.398
CF-20	0.007
CS-0	0.950
CS-5	0.860
CS-10	0.705
CS-15	0.290
CS-20	0.006

***Key**; CF-0 = P. aurita treated with 0% Sodium chloride, CF-5 = P. aurita treated with 5% Sodium chloride, CF-10 = P. aurita treated with 10% Sodium chloride, CF-15 = P. aurita treated with 15% Sodium chloride, CF-20 = P. aurita treated with 20% Sodium chloride, CS-0 = T. fuscatus treated with 0% Sodium chloride, CS-5 = T. fuscatus treated with 5% Sodium chloride, CS-10 = T. fuscatus treated with 10% Sodium chloride, CS-15 = T. fuscatus treated with 15% Sodium chloride and CS-20= T. fuscatus treated with 20% Sodium chloride.*

Microbial Load of Cured Fresh Water and Marine Periwinkle

The result of the microbial load of cured African periwinkle is presented in Table 2. The total heterotrophic bacterial count observed in the study ranged from $0.8x10^2$ CFU/g to $2.1x10^3$ CFU/g for fresh water periwinkle. Fresh water periwinkle recorded higher heterotrophic bacteria count than marine periwinkle. *Tympanotonus fuscatuss* processed without treatment with sodium chloride recorded $1.5x10^3$ CFU/g while sample treated with 5% and 10% recorded $1.4x10^3$ and $1.3x10^3$ CFU/g respectively. At 15% sodium chloride, marine periwinkle recorded $1.1x10^3$ CFU/g heterotrophic bacterial count while $0.9x10^2$ CFU/g was observed in sample treated with 20% sodium chloride. There was no presence of total coliform observed in either of the species. Fecal coliform was completely not detected in either of the specie. *Salmonella* and *Shigella* count was not observed in *P. aurita* and *T. fuscatus*. $1.1x10^3$ CFU/g of *Staphylococcus* count was observed in fresh water periwinkle not cured with sodium chloride. Uncured marine periwinkle recorded $1.0x10^2$ *Staphylococcus* count. Vibrio count was not detected in the two species. Re-enforced clostridial count (RCC) was not observed in either of the species (*P. aurita and T. fuscatus*). Lactic acid bacteria was not present in *P.aurita* and *T. fuscatus*. Fecal count observed in the study ranged from $1.0x10^2$ CFU/g to $3.0x10^2$ CFU/g. Fecal count ranged from ($1x10^2 – 3x10^2$ CFU/g).

Table 2: Microbial Load of Cured Fresh Water and Marine Periwinkle (*Pachymelania aurita and Tympanotonus fuscatus)*

Sample	THBC (CFU/g)	TCC (CFU/g)	FC (CFU/g)	SSC (CFU/g)	SC (CFU/g)	VC (CFU/g)	CC (CFU/g)	LAB (CFU/g)	FC (CFU/g)
CF-0	$2.1x10^3$	NG	NG	NG	$1.1X10^3$	NG	NG	NG	$3.0X10^2$
CF-5	$1.7x10^3$	NG	NG	NG	NG	NG	NG	NG	$2.0X10^2$
CF-10	$1.4x10^3$	NG	NG	NG	NG	NG	NG	NG	$1.0X10^2$
CF-15	$1.2x10^3$	NG	NG	NG	NG	NG	NG	NG	NG
CF-20	$0.8x10^2$	NG	NG	NG	NG	NG	NG	NG	NG
CS-0	$1.5x10^3$	NG	NG	NG	NG	NG	NG	NG	$2.0X10^2$
CS-5	$1.4x10^3$	NG	NG	NG	$1.0X10^2$	NG	NG	NG	$1.0X10^2$
CS-10	$1.3x10^3$	NG	NG	NG	$1.0X10^2$	NG	NG	NG	$1.0X10^2$
CS-15	$1.1x10^3$	NG	NG	NG	NG	NG	NG	NG	NG
CS-20	$0.9x10^2$	NG	NG	NG	NG	NG	NG	NG	NG

***Key**; THBC:Total heterotrophic bacterial count, TCC: Total coliform count, FC: Fecal count, SSC: Salmonella and Shigella count, Staphylococcus count, VC: Vibrio count, RCC; Re-enforced clostridial count, LAB: Lactic acid bacteria count, FC: Fungal count, NG: No growth. Mg = Magnesium, Ca = Calcium, K = Potassium, P = Phosphorus, Na = Sodium chloride, CF-0 = P. aurita treated with 0% Sodium chloride, CF-5 = P. aurita treated with 5% Sodium chloride, CF-10 = P. aurita treated with 10% Sodium chloride, CF-15 = P. aurita treated with 15% Sodium chloride, CF-20 = P. aurita treated with 20% Sodium chloride, CS-0 = T. fuscatus treated with 0% Sodium chloride, CS-5 = T. fuscatus treated with 5% Sodium chloride, CS-10 = T. fuscatus treated with 10% Sodium chloride, CS-15 = T. fuscatus treated with 15% Sodium chloride and CS-20= T. fuscatus treated with 20% Sodium chloride.*

Biochemical Characterization and Identification of Bacterial Isolated from Cured Fresh Water and Marine Periwinkle (*Pachymelania aurita and Tympanotonus fuscatus)*

The result of the biochemical characterization and identification of bacterial isolated from African periwinkle cured with sodium chloride is presented in Table 3. The Gram reactions observed in the study was positive. The bacterial shapes observed consisted of rod, cocci in pairs and cocci in clusters. The Catalase was positive while Coagulase test was negative. Motility was positive in rods but not in cocci in pairs and clusters. The Starch hydrolysis test was positive in rods, cocci in pairs and cocci in clusters. Citrate test was negative in rods but positive in cocci. Urease test was negative in rod shaped bacteria, positive in cocci pairs and cocci clusters. MR test was negative in rod and cocci while VP was positive in rod and cocci in clusters. Spore formation was positive in rod while negative in cocci pairs and clusters. H_2S was negative. Oxidase was only positive in cocci pairs. Indole was negative. Glucose was observed in rod, cocci pairs and clusters. Xylose was positive only in cocci pairs while Lactose was negative. Fructose was positive in both rods and cocci while sucrose was positive in rods and cocci clusters but negative in cocci. Manitol was negative in rod but positive in cocci. The probable bacterial species present in the sample were *Bacillus subtilis*, *Micrococcus sp, Staphylococcus albus* and *Staphylococcus aureus.*

Table 3: Biochemical Characterization and Identification of Bacterial Isolates from Cured Fresh Water and Marine Periwinkle (*Pachymelania aurita and Tympanotonus fuscatus)*

Gram reaction	+ve	+ve	+ve	+ve
Shape	rod	cocci in pairs	cocci in cluster	cocci in cluster
Catalase	+	+	+	+
Coagulase	-	-	-	+
Motility	+	-	-	-
Starch hydrolysis	+	+	-	-
Citrate	-	+	+	+
Urease	-	+	-	-
MR	-	+	-	-
VP	+	-	+	+
Spore formation	+	-	-	-
H_2S	-	-	-	-
Oxidase	-	+	-	-
Indole	-	-	-	-
Glucose	AG	-	-	AG
Maltose	A	A	A	A
Xylose	-	A	-	AG
Lactose	-	-	-	-
Fructose	A	A	A	A

Sucrose	A	-	A	A
Manitol	-	A	AG	AG
Galactose	A	A	A	A
Probable organism	Bacillus subtilis	Micrococcus sp	Staphylococcus albus	Staphylococcus aureaus

Key; (+) = Positive, (-) = Negative, A = Acid, G = Gas

3.4 Macroscopic and Microscopic Characteristics of Fungal Isolated from Cured *Pachymelania aurita and Tympanotonus fuscatus*

The result of the macroscopic and microscopic characteristics of fungal isolates from cured African periwinkle is presented in Table 4. The colony color observed consisted of brownish colony which became dark with age, white colony which turned greyish brown and creamy white moist colony. The types of soma observed were filamentous and pseudohyphae. The types of hyphae detected were septate, coenocytic and pseudohyphae. The vegetative structures observed consisted of foot cell, stolo-rhizoids and anamorphs. Sexual spores included *Globose conidia*, *Ovoid sporangiospores* and *Blastoconidia chlomydospores*. Special reproductive structures observed were short conidiophore, tall *sporangiophores* in groups, black-brown sporangia and budding cells. The conical head was also indicated as long columnar and radiate. Vesicle shapes identified were hemispherical and dome shape. The probable fungal species were *Aspergillus terreus, Rhizopus stolonifer and Saccharomyces sp.*

Table 4: Macroscopic and Microscopic Characteristics of Fungal Isolated from Cured Fresh Water and Marine Periwinkle (*Pachymelania aurita and Tympanotonus fuscatus)*

Occurrence and Distribution of Diverse Species of Bacteria and Fungi Isolated from Cured Fresh Water and Marine Periwinkle (*Pachymelania aurita and Tympanotonus fuscatus)*

Colony colour	Types of soma	Nature of hyphae	Vegetation structure	Asexual spore	Special Reproductive Structure	Conical head	Vesicle Shape	Probable organism
Brownish colony becoming dark with age	Filamentous	Septate	Footcell	Globose conidia	short conidiophores	Long columnar	Hemispherical	*Aspergillus terreus*
White becoming greyish	Filamentous	Coenocytic	Stolon rhizoids	Ovoid sporangiospores	Tall sporangiophores in groups			*Rhizopus stolonifer*
Brownish col					Black-brown sporangia			
Creamy white moist colony	pseudohyphae	pseudohyphae	Anamorphs	Blastoconidia chlomydospores	Budding cells	Radiate	Dome shape	*Saccharomyces sp*

The result of the occurrence and distribution of diverse species of bacteria and fungi isolated from cured African periwinkle is presented in Table 5. The result of the study

showed that *P. aurita* not treated with sodium chloride had *Bacillus subtilis*, *Staphylococcus albus*, *Staphylococcus aureaus*, *Rhizopus stolonifer and Saccharomyces species*. The bacteria and fungi present in *P. aurita* treated with 5% sodium chloride were *Bacillus subtilis*, *Micrococcus sp*, *Rhizopus stolonifer* and *Saccharomyces sp*. *P. aurita* treated with 10% sodium chloride harbored *Baccilus subtilis*, *Micrococcus sp*, *Aspergillus cerreus* and *Saccharomyces sp*. *Micrococcus sp* was the only organism observed in *P. aurita* treated with 15% and 20% sodium chloride. *Tympanotonus fuscatus* processed without treatment with sodium chloride was found to harbor *Bacillus subtilis*, *Staphylococcus albus*, *Staphylococcus aureus*, *Aspergillus terreus* and *Saccharomyces sp. T. fuscatus* treated with 5% sodium chloride harbored *Micrococcus sp*, *Staphylococcus albus*, *Aspergillus cerreus* and *Saccharomyces sp. Bacillus subtilis*, *Micrococcus sp and Staphylococcus aureus* was found in *T. fuscatus* treated with 10% Sodium chloride while *Bacillus subtilis* was the only organism observed in *T. fuscatus* treated with 20% sodium chloride.

Table 5: Occurrence and Distribution of Diverse Species of Bacteria and Fungi Isolated from Cured *Pachymelania aurita* and *Tympanotonus fuscatus*

***Key**: Mg = Magnesium, Ca = Calcium, K = Potassium, P = Phosphorus, Na = Sodium chloride, CF-0 = P. aurita treated with 0% Sodium chloride, CF-5 = P. aurita treated with 5% Sodium chloride, CF-10 = P. aurita treated with 10% Sodium chloride, CF-15 = P. aurita treated with 15% Sodium chloride, CF-20 = P. aurita treated with 20% Sodium chloride, CS-0 = T. fuscatus treated with 0% Sodium chloride, CS-5 = T. fuscatus treated with 5% Sodium chloride, CS-10 = T. fuscatus treated with 10% Sodium chloride, CS-15 = T. fuscatus treated with 15% Sodium chloride and CS-20= T. fuscatus treated with 20% Sodium chloride.*

Isolates/ Samples	*Bacillus subtilis*	*Micrococcus sp*	*Staphylococcus albus*	*Staphylococcus aureaus*	*Aspergillus terreus*	*Rhizopus stolonifer*	*Saccharomyces sp*
CF-0	+	-	+	+	-	+	+
CF-5	+	+	-	-	-	+	+
CF-10	+	+	-	-	+	-	+
CF-15	-	+	-	-	-	-	-
CF-20	-	+	-	-	-	-	-
CS-0	+	-	+	+	+	-	+
CS-5	-	+	+	-	+	+	+
CS-10	+	+	-	+	-	-	-
CS-15	+	-	-	-	-	-	-
CS-20	+	-	-	-	-	-	-

Discussion

Viable cell count of cured African Periwinkle (*Pachymelania aurita* and *Tympanotonus fuscatus)*

The viable cell counts represent the number of cells capable of surviving under favorable conditions. The results showed that the number of viable cells decreased in the two species

of the cured periwinkle meat. The number of viable cells decreased with increased concentration of sodium chloride. The high value of viable cells observed in uncured *Pachymelania aurita* reduced drastically as the concentration of sodium chloride for curing increased. Similar trend of viable cells reduction was observed in *T. fuscatus*. The viable cell count of fresh and marine periwinkles observed in the study was lower than the value reported by Nnenna and Blessing, (2022). The high viable cell count observed in the uncured periwinkles could be due to high ingestion of sediment, organic matter or microorganisms (Crandall, 2016). Adebayo *et al.*, (2016) reported a high level of microbial count in periwinkle, stating that microbial count in shellfish depends on the level of pollution of the waters.

Microbial Load of Cured Fresh Water and Marine African Periwinkle (*Pachymelania aurita* and *Tympanotonus fuscatus)*

Shellfish especially periwinkle plays an essential role in the diet of consumers as a cheap source of protein for a vast growing population. Although a cheap source of protein, seafood has been implicated as vehicles for food borne diseases as they, especially in their uncooked state are always associated with pathogenic microorganisms that are responsible for food borne infections (Eregoba, 2010). However, the microbial analysis of the cured periwinkle samples showed that the microbial load was below the acceptable limit stipulated by the International Commission on Microbiological Specifications for Food, which state that the maximum microbial count in shell fishes should not exceed the acceptable limit of $1x10^5$ CFU/g for the safety of consumers. The total heterotrophic bacterial count of the fresh *Pachymelania aurita* and *Tympanototnus fuscatus* was reduced when cured at different concentrations with sodium chloride. The results further revealed that the microbial load reduced significantly with increased concentration of the curing agent (Sodium chloride). The total bacteria count observed in the study was lower than the value ($4.23x10^4$) and ($4.05x10^4$) reported by Paul *et al.*, (2022), for *P. aurita* and *T. fuscatus* processed by cabinet drying and oven drying methods respectively.

Adebayo *et al.* (2021) reported a high level of microbial count in periwinkle from different creeks. According to Gokoglu *et al.,* (2004), periwinkles are filter feeders. Thus, there is a great tendency that they will accumulate several pathogenic organisms from water influenced by sewage pollution and biotoxins produced by planktons that they feed on. The presence of *Vibrio spp* in samples of raw shellfish suggest that food borne illness could arise if the seafood is consumed in the uncooked or poorly processed state. This may be due to human activities such as bathing, defecation by the local populace which are common phenomenon in the area. However, samples analyzed detected no presence of vibrio species. Salmonella species are typically found in animal and human intestine and are shed through feces. Humans serve as reservoir to the organism; *Salmonella spp.* causing disease called salmonellosis and humans become infected by consuming contaminated food and water (Ehuwa *et al.*, 2021). The detection of salmonella in raw samples could be due to

pollution of water bodies with feces from human and animals, whereas, contamination of processed samples could be linked to poor hand washing of the individuals processing the foods and generally poor hygiene.

Total salmonella and shigella count detected no growth. According to ICMSF standard and Microbiological Guidelines for Food (2014), total salmonella count should not exceed $1x10^2$ CFU/g for processed samples and $1x10^4$ for raw samples. However, samples analyzed in the study did not detect the growth of *salmonella spp.* and *shigella spp*. The result showed that the microbial loads in the two periwinkle meat samples were effectively reduced by curing with sodium chloride at different concentrations. The results generated from the study revealed that cured fresh water and marine periwinkles are microbiologically safe for healthy consumption. It also expounded the efficacy of sodium chloride curing in curbing microbial loads of unprocessed seafood.

Conclusion

The study revealed the effect of curing on the intrinsic parameters of African periwinkles. It unraveled the microbiological quality of African periwinkle processed without curing with sodium chloride while elaborating the variations in the cured samples. The study utilized curing as a cheap, conventional and safe approach in reducing microbial load and enhancing shelf life stability. The microbial species in the untreated samples were appreciably reduced. The viable cell count showed a significant reduction in the microbial population after treatment. The microbial parameters of importance such as TCC (Total Coliform Count), FC (Fecal Coliform), SSC (Salmonella and Shigella Count), LAB (Lactic Acid Bacteria Count), CC (Clostridial Count), and VC (Vibrio Count) indicated no growth. However, fecal count observed in control sample ($3.0x10^2$) and ($2.0x10^2$) for *Pachymelania aurita* and *Tympanotonus fuscatus* respectively was significantly reduced to NG (No Growth) with increased concentration of sodium chloride. The results of the microbial analysis revealed that the fresh periwinkles had higher microbial loads than the cured samples. The preservation of periwinkle by curing is an effective approach to curbing microbial loads, enhancing safety, wholesomeness and nutritional quality of the periwinkle types. The data generated from the study will help in the design and development of efficient treatment, processing, transportation and storage of periwinkle meat for safe consumption and exportation.

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