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EFFECTS OF CINNAMON (CINNAMOMUM VERUM BLUME) BARK EXTRACT ON INSECT PESTS OF SMOKE-DRIED AFRICAN CATFISH (*CLARIAS GARIEPINUS*, BURCHELL, 1822)

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Abstract
The effects of Cinnamon (*Cinnamomum verum* Blume) bark extract on insect pests of smoke-dried African catfish (*Clarias gariepinus*) was carried out. The aim was to investigate *Cinnamomum verum* as a protectant of smoke-dried African catfish to increase its shelf life. A total of one hundred (100) live *Clarias gariepinus* were purchased from Gamboru fish market and transported to the Department of Fisheries, University of Maiduguri. They were slaughered gutted and washed thoroughly and *Cinnamomum verum* bark extract was applied to each of the treatments excluding the control. The fish were randomly assigned to five (5) different concentration of 0gram (control), 15g, 25g, 35g and 45g respectively soaked in one (1) litre of water. Each treatment was replicated thrice and soaked into the aqueous solution of the *Cinnamomum verum* bark extract. The fish was drained under shade and the whole fish treatment were arranged randomly in the smoking kiln and smoke-dried, after which they were stored. The smoked fish were then divided into three (3) batches. Batch A was used for sensory evaluation, batch B, for proximate composition analysis and batch C was for insect inoculation and kept for the period of 56 days. Data obtained were subjected to analysis of variance and the differences between the means were separated using least significant difference (LSD). The effect of *Cinnamonum verum* bark extract on *D. maculatus* infestation in smoke-dried *C. gariepinus* showed that *C. verum* was most effective at 45g concentration. Number of larvae, pupa and adult of *D. maculatus* recorded were 8.67±3.01, 3.67±2.08 and 1.33±1.53 respectively. Likewise, for *Necrobia rufipes,* larva, pupa and adult were recorded to be 9.67 ± 2.08, 13.00 ± 4.00 and 6.00 ± 1.0 respectively. The crude protein recorded highest at fish treated with 35g with 71.92%, and ash was recorded highest in the control with 7.00% and lowest at 25g and 35g with 1.00% respectively. The fish weight losses were recorded in all the treatments after smoking and infestation. Therefore, effective concentrations to control insect infestation *D. maculatus* and *N. rufipes* and improve the crude protein content were at 45g and 35g. Dry Matter (DM) and

Nitrogen free extract (NFE) with value of 84.20% and 36.54% respectively were recorded highest in 45g *C. verum*. The organoleptic properties of *C. gariepinus* revealed that the catfish soaked in 45g was Extremely Liked in relation to taste and texture. C. verum bark extract reduce the pest damages and spoilage caused by the two insects pest *D. maculatus* and *N. rufipes* of smoke-dried African Cat fish (*C. gariepinus*). It also preserved the nutritional compositions of the fish and maintained the sensory properties of the fish. Therefore, the use of *C. verum* bark extract should be incorporated into fish post-harvest management.

Keywords: Insects, Desmestes *maculatus, Nerobia, rufipes, Clarias gariepinus, Cinnamonum verum*

Introduction

Fish is a very rich source of protein, which needs to be guarded against pathogens, decay and loss of taste or flavour. It is one of the most important sources of food and income to many people in developing countries (Osarenren and Ojor, 2014). It is also a good source of other elements for the maintenance of healthy body, compared to other human dietary items such as meat, eggs and cereals is an excellent source of digestible essential nutrients considering its amino acid, vitamins and minerals (Marimuthu *et al.*, 2012).

In Nigeria, fish production has been increasing as a result of the expansion of the aquaculture industries brought about by various developmental programs of the government to encourage private sector participation, thereby making fish protein available to the teaming populace. With increase in fish production, there will be the need to process excess to prevent post-harvest losses (Adeniji *et al*., 2015).

Shelf life is defined as the period of time a product is fit for consumption, the limit of the shelf-life which can be determined based on sensory, chemical and microbial criteria is affected by the rate of enzymatic reactions and the number and species of microorganisms affecting the products storability (Salaudeen and Osibona, 2018).

There are various traditional methods employed to preserve and process fish for consumption and storage in an attempt to extend its shelf life. These include smoking, drying, salting, frying, fermentation and combination of these. In Nigeria, fish smoke-drying is the most widely practised method. Practically, all species of fish available in the country can be smoked. It has been estimated that 70 - 80 % of domestic marine and freshwater catch is consumed in smoked form. The advantages of smoking fish are manifold, fish smoke-drying prolongs shelf life, enhances flavour and increases utilization in soups and sauces (Salaudeen and Osibona. 2018). It reduces wastages in time of bumper catches and/or harvest and allows storage for the lean season. It also increases protein availability to people throughout the year and makes fish easier to handle (pack, transport and market).

Objectives of the study

The objectives of the study are to determine the effects of *C. verum* extracts on the insects' infestation of smoke-dried *C. gariepinus*, evaluate the proximate composition of the smoke-dried *Clarias gariepinus* after treatment with C. verum extract at different levels of concentration, and evaluate the organoleptic characteristics of smoke-dried *Clarias gariepinus* after treatment with *C. verum* extract.

Justification

There was no information on the use of V. verum extracts to preserve smoke-dried fish in Northern part of Nigeria. So this study was designed to provide information on the use of V. verum to preserve smoke-dried fish

Materials and Methods

Study Area

The experiment was conducted in Fish Post Harvest laboratory for smoking, insect inoculation and storage, Animal Science Laboratory for proximate analysis, and Veterinary Medicine Laboratory all in University of Maiduguri, Borno State where microbial analysis was carried out with latitude 11^0 5′ N and longitude 13^0 15′E with a mean monthly temperature of (40.2^0C) prior to the onset of rain in June and the lowest (31.3^0C) during the peak of the rainy period of August (Haruna *et al*., 2021).

Experimental Fish and Preparation

A total number of 100 freshly caught catfish (*C. gariepinus*) were purchased from Gamboru Fish Market in Maiduguri, Borno State and transported in a sterilized cooler to Fish Post-Harvest laboratory in University of Maiduguri for preparation and smoking. The fish were killed by striking the spinal cord, gutted using sterilized sharp knife by cutting laterally from the end of the gill cover through the belly portion to the anus and was thoroughly washed and rinsed. The tail was slit by making a small cut, then coiled by squeezing the gill region between the thumb and the fore-finger to open the mouth. The tail was then fixed inside the mouth with pressure. The fish were then dried using disposable towel paper and then measured using weighing balance.

Preparation of *C. verum* Bark Extract

Three hundred grams (300g) of fresh air-dried Cinnamon bark were purchased from Maiduguri Monday Market, Borno state. The *C. verum* bark were grounded into powdered form, a solution was prepared by adding separately specific quantity (15g, 25g, 35g, and 45g) of the Cinnamon bark powder extracts to one (1) litre of distilled water to 15g, 25g, 35g and 45g respectively and allowed to stay for 1 hour. No additives were added to the control treatment (Haruna *et al*., 2021, Bello *et al*., 2021) and divided into five (5) treatments including the control. The Extracts collected were introduced to the experimental fish.

Collection of Insects

Two different insect species *Dermestes maculatus* and *Necrobia rufipes* were acquired from heavily infested dried fish *Clarias gariepinus* purchased from fish sellers at Baga Road fish Market, Maiduguri, Borno State, Nigeria. The two insect pests were identified with the following features; the size range from 5.5 to 10.0 mm, each side of the thorax has a band of white hairs and the underside of the abdomen is primarily white with black spots at the sides, with a large black spots at the sides and a large black patch on the last segment. The elytra are dark brown or black with hair for adult *Dermestes maculatus* and upper surface of body (head, thorax, elytra) entirely shining metallic bluish-green. Underside of abdomen entirely dark blue with legs bright reddish-brown or orange and the antennae mainly reddish-brown but with a dark brown club at the tip. The adult stage of these pests were carefully disengaged from the tissues and placed in a clean reagent bottles (500ml) with perforated covers. In the laboratory, the pests were placed in another set of reagents bottles whose open ends were covered with mosquito mesh nets to prevent the insects from escaping and allow aeration (Babarinde *et al*., 2016).

The Experimental Design

The fish were randomly assigned to five experimental treatments. These are the treatments, 0g, 15g, 25g, 35g, and 45g respectively of Cinnamon bark extract solution. Each treatment was replicated with 300-450g weight fish/treatments. The fish were soaked into the solution for one (1) hour; furthermore, the fish were placed on wire frame and allowed to drain under shade. Then the fish were arranged randomly and replicated in improved steel drum smoking kiln consisting of three trays and subject to hot smoking for 15hours using firewood as source of fuel. After smoking, the fish were allowed to cool and packed in different containers based on their treatments. For uniform smoking, the experimental fish were turned over at thirty (30) minutes intervals. The process was repeated until the samples are completely dried and ready for use or storage. The smoked fish were then divided into four (4) batches. Batch A was used for sensory evaluation, batch B, for microbial analysis, batch C, for proximate composition analysis and batch D was for insect inoculation and kept for the period of 56 days away from contamination in the laboratory shelves for storage.

Infestation of *C. verum* Smoked *Clarias gariepinus* with Insect Pests

Fish were infested manually with two different insect pests *Dermetes maculatus* and *Necrobia rufipes* separately in transparent plastic containers. Adult stages of the insects were introduced in the bottles containing *Cinnamomum verum* bark extract smoked fish (A, B, C, D and E). Group A representing the control with no *C. verum* while groups B, C, D and E representing the treated fish at different concentration and replicated thrice. Each group of bottles with infested smoked fish samples was appropriately labelled according to treatments and left for the examination. Fish samples from each bottle

were disengaged from the insect pests after the storage duration period (56 days), data was collected on adult number of insect, number of pupa, number of larva, and weight loss due to infestation and physical damages (fragmentation).
The *C. verum* bark extracts smoked fish were packaged in a carton with insects inoculated. Then further sealed to prevent dust, flies and contaminants from entering the experimental fish, and stored at room temperature 25-27^0 C/ 76-80^0 F (Babarinde *et al*., 2018).

Proximate analysis
The proximate composition of the *C. verum* bark extract smoked fish which includes moisture, fat, protein, and ash content of dried products were assayed as describe by AOAC (2006). All samples of the raw materials and finished products (smoked fish samples) were stored for analysis in sealed containers, prior to analysis; samples were grounded and allowed to pass through a 1mm screen. Moisture determination was carried out on the material before and after grinding.

Organoleptic (Sensory) Assessment
The organoleptic evaluation of the preserved *Cinnamomum verm* bark extract fish was subjected to sensory evaluation to obtain data. The test utilized parameters such as taste, flavour, texture, colour, aroma and general acceptability for quality assessment of *C. gariepinus* smoked with cinnamon bark extract. Questionnaires were used. The questionnaires were prepared using a 9 point hedonic scale (Chibuko *et al.*, 2019). The points are outlined below: extremely like -9, liked very much -8, liked moderately -7, liked slightly -6, neither liked nor disliked -5, disliked slightly -4, disliked moderately -3, disliked very much -2, extremely disliked -1. A taste panel of 100 untrained persons made up of 50 males and 50 females were randomly selected.


Plate 1: Fish Samples


Plate II: Fresh coiled fish


Plate III: Fish smoking


Plate IV: *D. maculatus*


Plate V: *N. rufipes*

PlateVI: Exptal. Design

Plate VII: Smoke-dried *C. gariepinus* using 0g *C. verum* extract after 56 days innoculation

Plate VII: Smoke-dried *C. gariep.* using 45g of *C. verum* after 56 days of insects' infestation

Data Analysis

Data collected was analysed using one-way analysis of variance (ANOVA) and the differences between the means values were determined using Fisher Least Significant. Differences (LSD) and using 5% confidence level (P≤0.05) with the aid of Statistix 13.0 version software packages.

Results and Discussion

Effect of *Cinnamomum verum* Bark Extract on *D. maculatus* Infestation in Smoke-dried *Clarias gariepinus*

The effects of *Cinnamomum verum* bark extract on insect infestation *D*. *maculatus* in smoke-dried *C*. *gariepinus* revealed that the mortality values of the insect larva were 70 ±15.89, 50 ±25.0, 30±3.0, 21.00±7.0 and 8.67 ±3.01 for 0g, 15g, 25g, 35g and 45g of *C. verum* extract treated fish, respectively (Table 1). The treated fish at a concentration of 45g of the extract at one (1) litre had the highest mortality of the insect larvae at the larval stage of the insects and the lowest mortality value at 0g concentration. There was significant difference in respect to number of larvae. But with a decrease in the infestation as the concentration of the *Cinnamomum verum* bark extract increases, as expected. The experiments demonstrated that the mortality of the insect larvae was due to the presence of cinnamaldehyde and other critical enzymes in the cinnamon bark extracts. The results of this study are similar with the results obtained by Bello *et al*. (2021), who reported that high larvae mortality was recorded in fish treated with 80g/200 ml with 28.67 of Sodom apple leave and lowest mortality in 0g with 26.79 after 24 days. Also the high number of larvae, in the untreated fish was similar to the results found by Nta *et al*. (2019), who reported that development of *D. maculatus* larvae and pupae were inhibited in all treated smoked fish compared to the control with *C. gariepinus* treated with plants extracts. Similarly, to Kayode (2021) observed a significant difference between the toxicity effect of *V. amygdalina*, *T. diversifolia* powders and the control, with *Tithonia diversifolia* powder which caused 100% mortality to hide beetle larvae at concentration 9g/100g of the smoked catfish after 96h of treatment compared to the control.

Table 1: Effect of *Cinnamomum verum* Bark Extract on insect infestation *D. maculatus* in Smoke-dried *C. gariepinus*

Parameters	*Cinnamomum verum* 0	*Dosage* 15	*g/Liter of Water* 25	35	*SEM (<0.05)* 45	
IFW (g)	250 ± 5.0^{c}	300± 50.0^{a}	250 ± 5.0^{c}	350±10.0^{a}	260±5.0^{bc}	*18.89**
GFW(g)	245± 5.0^{d}	293± 3.00^{b}	246 ± 6.0^{d}	320± 5.00^{a}	257± 2.6^{c}	*3.63**
FFW (g)	147±2.0^{d}	190.45±5.0^{a}	135.30±3.0^{d}	192± 2.00^{a}	154± 2.0^{b}	*2.48**
IWS (g)	145 ± 2.0^{c}	188.10±0.9^{a}	132.0 ± 2.0^{d}	190± 2.00^{a}	152± 2.0^{b}	*1.50**
FWS (g)	125 ± 1.0^{c}	167.20±3.0^{a}	112.0 ± 5.0^{d}	170.13±1.31^{a}	132± 2.0^{b}	*2.33**
NL	70±15.89^{a}	50 ± 25.0^{ab}	30 ± 3.0^{bc}	21.00 ± 7.0^{c}	8.67±3.01^{c}	*11.22**
NP	50 ± 5.0^{a}	25.0 ± 2.0^{b}	8.33 ± 6.11^{c}	5.0 ± 3.6^{c}	3.67±2.08^{c}	*3.34**
FNAI	11.33±5.13^{a}	5.33± 2.52^{b}	5.33± 3.79^{b}	3.0 ± 2.0^{b}	1.33±1.53^{b}	*2.67**
ML (%)	70.6± 2.0^{a}	57.85±2.52^{c}	66.0 ± 2.0^{b}	70.0 ± 2.0^{a}	68.0 ± 2.0^{b}	*1.73**

*Means along the same row having the same superscript are not significantly different ($p<0.05$)

SEM = Standard Error of Means

- = Significant ($P\leq 0.05$)

Key: IFW $_{(g)}$ = Initial Fish Weight, GFW $_{(g)}$ = Gutted Fish Weight, FFW $_{(g)}$ = Final Fish Weight, IWS $_{(g)}$ = Initial Weight of Storage, FWS $_{(g)}$ = Final Weight of Storage, NL = No. of Larvae, NP = No. of Pupae, FNAI = Final Number of Adult Insects, ML $_{(\%)}$ = Moisture loss.

Effect of *Cinnamomum verum* Bark Extract on insect infestation *Necrobia rufipes* in Smoke-dried *Clarias gariepinus*

Table 2 showed the effects of *Cinnamonum verum* bark extract on *Necrobia rufipes* infestation in smoked fish. Initial weight of fish was recorded highest in fish smoked with 25g *Cinnamonum verum* bark extract with (400 ± 25.00) followed by 35g, 0g, 15g and 45g with (300 ± 10.00), (300 ± 5.0), (290 ± 10.0) and (250 ± 5.0) respectively. There was significant difference shown among the treatment ($P < 0.05$) in respect to initial weight. Gutted fish weight was recorded in fish smoked with 25g *Cinnamonum verum* extract, which recorded the highest value of (397.00 ± 6.00). Followed by treatment with 35g, 0g, 15g and 45g with (294 ± 2.0), (294.00 ± 2.0), (286.0 ± 2.0) and (246 ± 1.0) respectively. Number of pupa with highest value was recorded in fish with 0g (63.33 ± 13.32) and followed by 15g, 25g, 35g and 45g with mean values of (40.33 ± 16.01), (16.67 ± 10.97), (23.0 ± 9.53) and with (13.00 ± 4.00) respectively and there was significant difference shown among the treatment ($P < 0.05$) in respect to number of pupa. This results shows that *C.verum* extract has effect on the pupae stage of *Necrobia rufipes* which was similar to the result obtained by Nta *et al*. (2019). They reported similar scenario when they used plant oil extracts as surface protectant against leather beetle in smoked fish of *Clarias gariepinus* due to the strong pungent odour produced by these plants and was effective in killing of all the insects (Adults, pupae, and eggs).

Table 2: Effect of *Cinnamomum verum* Bark Extract on *Necrobia rufipes* Infestation in Smoke-dried *C. gariepinus*

Parameters	*Cinnamomum verum* 0	*Dosage* 15	*g/Liter of Water* 25	35	*SEM (<0.05)* 45	
IFW (g)	300.00± 5.0^{b}	290 ± 10.0^{b}	400± 25.00^{a}	300 ± 10.00^{b}	250 ± 5.0^{c}	*10.80**
GFW(g)	294.00± 2.0^{b}	286.0 ± 2.0^{c}	397.00 ± 6.00^{a}	295 ± 2.0^{b}	246 ± 1.0^{d}	*2.56**
FFW (g)	197.00 ± 3.0^{a}	144± 2.0^{b}	198.50±4.00^{a}	147.50± 2.0^{b}	123 ± 9.0^{c}	*3.90**
IWS (g)	195.00±5.00^{a}	141±2.0^{b}	196.50±3.0^{a}	142.50±3.0^{b}	118±4.0^{c}	*3.06**
FWS (g)	193.00±2.00^{a}	138 ± 2.0^{b}	193.50 ± 3.0^{a}	140.50± 3.0^{b}	116 ± 2.0^{c}	*2.00**
NL	77.33±21.603^{a}	55 ± 5.29^{b}	33.67 ± 4.51^{c}	34.0 ± 7.0^{c}	9.67±2.08^{d}	*8.70**
NP	63.33± 13.32^{a}	40.33±16.01^{b}	16.67±10.97^{c}	23.0± 9.53^{bc}	13.00±4.00^{c}	*9.39**
FNAI	39.00 ± 15.13^{a}	32.33 ± 7.51^{a}	25.33±6.11^{ab}	13.0± 3.61^{bc}	6.00 ± 1.0^{c}	*6.70**
ML (%)	60.00 ± 5.0^{a}	70.69± 1.53^{a}	62.0 ± 26.06^{a}	57.0 ± 8.89^{a}	62.0 ± 2.0^{a}	*10.29**

*Means along the same row having the same superscript are not significantly different ($p<0.05$)

SEM = Standard Error of Means

- = Significant ($P\leq 0.05$)

Key: IFW $_{(g)}$ = Initial Fish Weight, GFW $_{(g)}$ = Gutted Fish Weight, FFW $_{(g)}$ = Final Fish Weight, IWS $_{(g)}$= Initial Weight of Storage, FWS $_{(g)}$ = Final Weight of Storage, NL = No. of Larvae, NP = No. of Pupae, FNAI = Final Number of Adult Insects, ML $_{(\%)}$ = Moisture loss.

The proximate composition of the smoke-dried *Clarias gariepinus* after treatment with *C. verum* extract.

The proximate contents of smoked *C. gariepinus* treated with *C. verum*. Bark extract are shown in table 3. The data from the table indicated that there were statistical differences ($p<0.05$) in proximate composition of the smoked fish treated with the different levels of the bark extract in comparison to the control. The changes in the proximate composition of fresh, control and *C. verum* treated samples at different levels of concentration reveals that there were significant variations ($p< 0.05$) among the samples. The moisture content of the samples significantly decreased but the content of crude protein, ether extract, and ash were significantly increased. The value obtained for each of the parameters was different to the value obtained for the control. *Cinnamomum verum* treated samples demonstrated best nutritive value compared to

the control which is similar to Aremu *et al*. (2013) who reported that smoking as a means of preservation has a significant effect on the proximate composition of fish.

Table3: Proximate Composition of *C. gariepinus* Smoke-dried using *Cinnamomum verum* Bark Extract

Components	0	15	25	35	45	F	SEM
DM	80.20^{c}	81.60^{b}	76.70^{d}	77.20^{d}	84.20^{a}	28.12^{e}	0.35*
CP	62.89^{c}	41.21^{e}	66.60^{b}	71.92^{a}	43.46^{d}	38.21^{f}	0.48*
EE	11.67^{ab}	16.00^{a}	7.00^{bc}	7.00^{bc}	2.00^{c}	14.33^{ab}	3.95*
CF	11.67^{d}	22.00^{a}	15.00^{c}	16.00^{bc}	17.00^{b}	21.00^{a}	0.77*
ASH	7.00^{a}	4.67^{ab}	1.00^{c}	2.00^{ab}	1.00^{c}	2.00^{bc}	1.60*
NFE	7.00^{a}	16.12^{bc}	10.40^{cd}	3.08^{d}	36.54^{a}	24.53^{b}	4.31*

*Means along the same row having different superscripts are significantly different (P≥0.05) SEM = Standard Error of Means

- = Significant (P≤ 0.05)

Keys: DM= Dry matter content, CP= Crude protein, CF= Crude fibre, EE= Ether extract, Ash= Ash content, NFE= Nitrogen free extract, F= Fresh fish.

The highest crude protein was recorded in 35g *C. verum* bark extract with a crude protein value of 71.92 as compared to the fresh and other levels of concentrations used, the lowest crude protein value of 38.21 was obtained from fresh fish. This result indicated that fresh fish sample has the lowest protein content, these findings was strong evidence of high moisture content. The protein contents of both the treated and the untreated smoke-dried fish were higher than that of fresh sample. Therefore, the increase in the protein content in the treated samples increased dry matter per unit of weight. The findings in the present study was similar with the findings of Bello *et al*. (2021) who reported that smoking results in an increased concentration of nutrients due to low residual moisture content and also the increase in the proximate composition of the control, and *C. verum* treated samples could be due to smoking of the fish that bring about the concentration of crude proteins and decreased in moisture content which is in accordance with the findings of Salihu *et al*. (2013) who observed the percentage of total protein, ash, and fats were significantly higher in smoked treated fish than in fresh fish which resulted in the high concentration of nutrients like proteins and fat after smoking. While 66.60, 62.89, 43.46 and 41.21 were analysed in 25g, 0g, 45g and 15g *C. verum* respectively.

The highest Ash value was recorded in control treatment (0g), then 4.67 in 15g treatment, while the value of 2.00 each were recorded for Fresh fish and 35g respectively. Also, 1.00 each was also recorded for treatment 25g and 45g. There was

variation in the ash content of both fresh and *C. verum* treated samples with smoked catfish having the highest ash content at 0% (control) with 7.00 and lowest at 25g and 45g. The high ash content obtained was probably due to the impact of smoke on the treated fish samples, the bark extract used and the drying process.

However, 22 and 21 Crude Fibre (CF) was recorded in 15g treatment and in Fresh Fish respectively. Moreover, 17.00, 16.00 and 15.00 CF were found in treatments 45g, 35g and 25g while the lowest crude fibre with 11.67 was recorded in control (0g). The high content of crude fibre in the smoked fish could be as a result of oxidation of poly unsaturated fatty acid (PUFA) present in the fish tissues into peroxides, aldehydes, ketones and free unsaturated fats thus bring about the high crude fat content as which is similar to Ajai *et al*. (2019).

The highest Dry Matter (DM) was recorded in 45g, followed by 81.60, 80.20, 77.20, and 76.70 in treatment 15g, 0g, 35g and 25g respectively. The lowest DM was recorded in Fresh fish (F) with a value of 28.12.

However, the highest amount (16.00) of Ether extract was recorded in 15g, 14.33 was recorded in Fresh Fish, and 11.67, 7.00 and 7.00 were recorded in treatment 0g, 25g, and 3.5% respectively. The lowest value of 2.00 was recorded in 45g.

The highest (36.54) Nitrogen Free Extract (NFE) was recorded in 45g treatment and 24.53 in Fresh Fish. 16.12, 10.40 and 6.78 were also recorded in 15g, 25g and 0g respectively. The least value was recorded in 3.5% with 3.08. The results obtained reveals that there was a significant variation ($P \leq 0.05$) along among the samples.

The increase in the proximate composition of the *Cinnamonum verum* bark extract smoke-dried *Clarias gariepinus* was in accordance with the finding of Salihu *et al*. (2013) who observed the percentages of total protein, ash and fats were significantly higher in smoked fish samples than fresh fish which result in the high concentration of nutrients like protein and fat after smoking.

Effect of *Cinnamonum verum* Bark Extracts on Organoleptic Properties of Smoke-dried *Clarias gariepinus*

Table 4 showed the organoleptic characteristics of smoked fish treated with bark extract which showed that all the variables considered were significantly different ($p < 0.05$) across treatments. The taste was recorded highest at 45g with 70% responses who extremely liked the treated fish and lowest at 15g with 51% responses. There was increase in the mean taste 61% obtained for extremely like (EL) of the smoked samples 70, 65, 63, 54, and 51% were recorded in 45g, 35g, 0g, 25g and 15g according to the concentration respectively.

However, many of the respondents with mean of 50 also showed Extremely Liked for the flavour. 39%, 47, 50, 53 and 60% were recorded in 0, 15, 25, 35 and 45g concentration respectively. The flavour was recorded highest at 45g with 60% responses and lowest at 0g with 39%.

Moreover, most of the respondents with mean of 45 also showed Extremely Liked towards the texture. The texture was recorded highest at 45g with 52% responses and lowest at 0g with 37% responses. This was in disagreement to the findings of Ekelemu *et al*. (2021) who stated that within the first 7 days, there was no significant difference in the texture of smoked *Clarias garipinus*.

Table 4: Organoleptic Properties of *C. gariepinus* Smoke-dried with *Cinnamomum verum* Bark Extract

Treatment	*Attribute*	*EL*	LVM	LM	LS	NLND	DS	DM	DVM	ED	TL
0gram	**Taste**	63	24	0	10	2	0	0	0	1	100
15grams		51	25	5	2	10	3	1	0	3	100
25grams		54	30	7	1	2	2	0	0	4	100
35grams		65	20	5	2	4	1	1	1	1	100
45grams		70	19	8	2	0	1	0	0	0	100
Mean		***61***	**24**	**5**	**3**	**4**	**1**	**0**	**0**	**2**	100
0gram	**Flavour**	39	18	7	6	5	3	1	0	0	100
15grams		47	30	10	2	5	0	0	0	0	100
25grams		50	19	6	3	10	0	14	4	5	100
35grams		53	30	15	4	2	0	0	2	0	100
45grams		60	20	0	3	6	2	10	0	9	100
Mean		**50**	**23**	**8**	**4**	**6**	**1**	**5**	**1**	**3**	100
0gram	**Texture**	37	31	0	5	6	0	8	0	3	100
15grams		47	27	19	5	0	4	0	0	8	100
25grams		41	33	4	10	2	0	0	5	5	100
35grams		48	18	8	3	12	6	0	4	1	100
45grams		52	10	13	0	9	5	4	0	7	100
Mean		**45**	**24**	**9**	**5**	**6**	**3**	**2**	**2**	**5**	100
0gram	**Colour**	80	12	2	0	0	0	2	2	2	100
15grams		70	15	0	7	5	0	0	1	2	100
25grams		78	9	5	1	3	1	0	1	2	100
35grams		9	8	5	5	30	12	5	2	24	100
45grams		7	2	0	2	45	2	4	0	38	100
Mean		**49**	**9**	**2**	**3**	**17**	**3**	**2**	**1**	**14**	100
0gram	**Aroma**	53	19	6	0	15	4	0	1	2	100
15grams		55	21	15	0	0	1	3	4	1	100
25grams		55	16	13	5	4	2	0	0	0	100
35grams		57	16	9	6	5	2	4	0	3	100
45grams		60	40	0	0	3	0	0	0	0	100
Mean		**56**	**22**	**9**	**2**	**5**	**2**	**1**	**1**	**1**	**100**

Key: EL = Extremely Liked, LVM = Liked Very Much, LM = Liked Moderately, LS = Liked Slightly, NLND = Neither Liked nor Disliked, DS = Disliked Slightly, DM = Disliked Moderately, DVM = Disliked Very Much, ED = Extremely Disliked, TL = Total.

Likewise, there are extremely liked to the colours of the smoked *Claria gariepinus* by most of the respondents with mean of 49. 80, 70, 78, 9, were recorded in 0, 15, 25, 35 and 45g concentration respectively. The colour was recorded highest at 0g with 80% responses and lowest at 45g with 9%.

Furthermore, majority of the respondents showed extremely liked for the Aroma of the treated smoked *Claria gariepinus* with mean of 56. 53, 55, 55, 57, and 60% were recorded in 0, 15, 35, 35 and 45g concentration respectively. The aroma was recorded highest at 45g with 60% responses and lowest at 0g with 53% responses.

According to the present study, the organoleptic properties of *C. gariepinus* smoked with *cinnamomum verum* was evaluated taste, flavour, texture, colour and aroma and this reveals that the catfish soaked in 45g was Extremely Liked in relation to the taste, texture, while treatment soaked in 0g were favoured in aspect of flavour, and colour. This correspond with Haruna *et al.* (2021) in their study to conduct sensory evaluation using 7-point hedonic scale. Their result reveals that the smoked catfish retained very good score for appearance, colour, flavour, texture and general acceptance after 28days of storage and the overall acceptability mean score in fish treated with 5g and 15g.

The smoke-dried fish with *Cinnamonum verum* extract gave better taste, texture, flavour and aroma. This is similar with the findings of Haruna *et al*. (2021) who observed that natural spices used in treating *Clarias gariepinus* enhanced the flavour and delayed the onset of deterioration of the products. This is also similar with the findings of Adibe *et al*. (2018) which stated that natural spices have preferred result on the organoleptic properties of smoked *C. gariepinus* in terms of taste, flavour, appearance and general acceptability.

Conclusion

Based on the results of the study, it was concluded that smoke-dried *Clarias gariepinus* with 45g *C. verum* bark extract reduced the level of *D. maculatus* and *N. rufipes* infestationeven when it is stored for some time. Also, the use of *Cinnamomum verum* in reducing damage done, progeny emergence, and overall control of *D. maculatus* and *N. rufipes* infestation in smoke-dried fish during storage was satisfactory and does not affects, flavour, texture, colour and even the proximation composition of the nutrient of the fish.

Recommendations

Based on the findings of this research, the following recommendations were made.

1. Cinnamon (*Cinnamomum verum*) bark extract is recommended as a protective coating for smoked-dried fish (*Clarias gariepinus*) against *D. maculatus*, *Necrobia rufipes* as a substitute for synthetic chemicals, which had been proved to be detrimental to the health.

2. Cinnamon bark extract is also recommended to be used to improve and preserve the nutritional compositions of smoked fish.
3. More study should be carried out to compare other spices with *C. verum* in controlling insect infestation and consumer acceptability of the smoke-dried fish.

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