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Full Length Research paper

Assessing the Impact of Plant-Based Insecticides on the Nutritional Quality of Smoked Clarias gariepinus

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The biochemical composition of smoked African mud catfish, *Clarias gariepinus* Burchell treated with four tropical plant materials, *Dennettia tripetala*, *Eugenia aromatica*, *Piper guineense* and *Monodora myristica* for the control of *Dermestes maculatus* was determined. 10 g of plant powders and 5 ml of 10% concentration of extracts were separately applied onto 1000 g disinfested smoked fish, exposed to ten insect larvae of the pest and stored for 30 days. Treated fish was analyzed for proximate and mineral compositions using standard procedures. The percentage protein (60.10 ± 0.00 - 62.05 ± 0.00), moisture (5.64 ± 0.12 - 8.98 ± 0.28), ash (17.06 ± 0.55 - 19.47 ± 0.21), lipid (10.98 ± 0.00 - 14.45 ± 0.00) and carbohydrate (0.28 ± 0.00 - 1.48 ± 0.00) compositions were obtained in fish treated with plant powders. Meanwhile extract-treated fish had protein (59.84 ± 0.00 - 61.35 ± 0.00), moisture (10.74 ± 0.18 - 12.11 ± 0.16), ash (13.31 ± 0.20 - 16.98 ± 0.26), lipid (10.60 ± 0.00 - 11.38 ± 0.00) and carbohydrate (0.45 ± 0.00 - 1.08 ± 0.00) components. Potassium, iron and sodium were present in high amounts while there were traces of calcium, zinc and magnesium. Selenium, lead and cadmium were not detected. The proximate values recorded in the treated fish significantly differed ($p < 0.05$) from the control but all values were within the range normally recorded in freshwater fish. The results obtained showed the nutritive acceptance of the admixtures and thus enhancing the use of the plant products as protectants of stored products in the tropics.

Key words: Proximate, insecticides, biochemical, catfish, hide-beetle.

INTRODUCTION

Dried fish is one of the highly digestible and respectable sources of proteins and essential minerals in the tropics but it is highly susceptible to insect pest infestation (Odeyemi et al., 2000). The major pests on smoked catfish, *Clarias gariepinus* include *Dermestes maculatus* (hide beetle) and *Necrobia rufipes* (copra beetle) (Osuji, 1974; Awoyemi, 1989) which could be controlled by synthesized chemicals (Boeke et al., 2001). However, in recent years, there have been increasing and concerted efforts directed at developing natural pest management control agents that are relatively cheap, safe, biodegradable and environment friendly as alternatives to synthesized insecticides (Boeke et al., 2001; Akinwumi et al., 2007).

Although many of the natural protectants are regarded as safe because they are also commonly used traditionally as spices and herbal medicines, studies have shown that some of such plants contain noxious compounds which may render them unsafe for man's consumption. For example, the toxicity of *Piper guineense* to the nymph and adult of grasshopper, *Zonocerus variegatus* (L.) and rat, respectively, have been reported (Ivbijaro and Agbaje, 1986; Raji et al., 2003) . Okon (2002) also reported the sub-lethality of the same plant on *Oreochromis niloticus*. The latter author observed the destructive property of *P. guineense* as an ichthyotoxic plant, causing vacuolation, liver cord disarray/necrosis and distortion of the organized cellular pattern. Similarly, Akinbulumo (2005) reported the acute toxicity of the roots of *Derris elliptica* to *C. gariepinus* fingerlings.

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Table 1. Percentage proximate composition of fish sample treated with plant powders.

Plant powder	Protein	Moisture	Ash	Lipid	Carbohydrate
D. tripetala	62.05 ± 0.00^{e}	6.08 ± 0.16^{c}	17.06 ± 0.55^{a}	13.21 ± 0.00^{d}	1.48 ± 0.00^{e}
E. aromatica	60.10 ± 0.00^{b}	8.23 ± 0.22^{d}	19.47 ± 0.21^{d}	10.98 ± 0.00^{a}	0.28 ± 0.00^{b}
P. guineense	61.15 ± 0.00^{d}	8.98 ± 0.28^{e}	17.22 ± 0.48^{b}	11.60 ± 0.00^{b}	0.30 ± 0.00^{c}
M. myristica	60.43 ± 0.00^{c}	5.64 ± 0.12^{b}	18.64 ± 0.10^{c}	14.45 ± 0.00^{e}	0.75 ± 0.00^{d}
Control	60.07 ± 0.00^{a}	5.38 ± 0.00^{a}	20.53 ± 0.49^{e}	13.78 ± 0.00^{c}	0.07 ± 0.00^{a}

Values are means of triplicate samples followed by the standard error of means. Means in the same vertical column with different superscripts are significantly different ($p < 0.05$) by Tukey's test.

In view of these findings, there is a need to assess the effect of plant- derived insecticides on the keeping quality of treated smoked fish. In this study, the effect of four commonly eaten spices on the nutritive values of smoked fish, C. *gariepinus* is presented. The results obtained from the present study will enrich current national and global efforts to develop a database on the use of natural plant materials in post-harvest fish management.

MATERIALS AND METHODS

Preparation of plant products and fish samples

The powders and extracts of dry fruits of pepper (*Dennettia tripetala*), black pepper seed (*P. guineense*), African nut-meg (*Monodora myristica*) and the dry buds of clove (*Eugenia aromatica*) obtained from Erekesan Market in Akure, Nigeria were investigated for the control of hide beetle, *D. maculatus* on smoked African mud catfish, *C. gariepinus*. To obtain the plant powders, each of the plant materials was washed with clean tap water, oven-dried at 40°C for 8 h, ground thoroughly in an electric 5.0 HP grinder, and sieved through a 40 holes/mm^2 mesh screen. Each of the plant powders was kept in a plastic container with a tightly-fitted lid before use. To obtain the plant extracts, 100 ml of absolute ethanol was added to 10 g of each plant powder in a round-bottomed flask and soaked for 24 h. The mixture was boiled at 60°C for 30 min in UNISCOPE SM801A laboratory water bath. The solution was filtered with Whatman No. 1 filter paper and the resulting filtrate was kept in a tightly covered dark brown bottle prior to use.

Samples of 100 g smoked fish used for the experiments were obtained from Erekesan Market in Akure, Ondo State, Nigeria and disinfested by treatments in the Gallenkamp oven at 60°C for 1 h and allowed to cool at room temperature before use (Adedire and Lajide, 2000). The initial source of culture of *D. maculatus* was obtained from naturally infested smoked *C. gariepinus*.

Effects of plant materials on the nutritive value of smoked fish

10 g of each of the plant powders and 5 ml of 10% concentration of extracts were separately rubbed onto the body of a 100 g disinfested smoked fish. The treated fish was placed in a plastic jar, ten insect larvae starved for 48 h were introduced and the perforated lid was covered with muslin cloth and the jar was left on the shelf for 30 days. The protected fish and the untreated fish (control) were ground separately in the electric grinder and analyzed for proximate compositions using AOAC (2005) procedures. The minerals were analysed after dry-ashing of samples at 550°C in a Muffle furnace and deionized water to standard volume. Standard curves were plotted using 0, 5, 10, 15 and 20 ppm of sodium and potassium. The absorbencies were determined by the flame photometer model PFP 7 (Jenway). The concentrations of calcium, magnesium, iron, copper, manganese and zinc were determined according to Vogel (1985) using atomic adsorption spectrophotometer model 210 (bulk scientific).

Statistical analysis

The design was completely randomized. Proximate composition analysis was replicated three times (n = 3). Results presented are mean values of each determination ± standard error of mean (SEM). Analysis of variance was performed by one-way ANOVA procedures (SPSS 11.0 for Windows). Differences between the mean values of the treatments were determined by the Tukey's test and the significance was defined at $p < 0.05$.

RESULTS AND DISCUSSION

The proximate contents of smoked *C. gariepinus* treated with selected plant powders are shown in Table 1. Table 2 shows the data obtained from treatments with plant extracts. The data in the Tables 1 and 2 indicated that there were statistical differences ($p < 0.05$) in proximate composition of the smoked fish treated with the different plant products in comparison to the control. In general, the value obtained for each of the parameters was similar to the value obtained for the control.

In this work, none of the fish samples treated with a particular plant material demonstrated an overall best nutritive value because the proximate values obtained in fish protected with plant powders and extracts were similar. However, the values for protein, lipid and carbohydrate in treated fish samples are similar to those earlier recorded for freshwater smoked clariid fish (Adewoye and Omotosho, 1990; Ashamo and Ajayi, 2003; Fasakin, 2003). Fawole et al. (2007) reported the percentage mean proximate values of 44.28, 4.00 and 6.60 for crude protein, ash and moisture contents respectively in *C. gariepinus.* Similarly, Chukwu and Shaba (2009) reported the proximate values of 67.21 ± 0.16, 15.62 ± 0.03, 29.60 ± 0.14, 3.62 ± 0.03 and 3.84 ± 0.06 (%) for protein, moisture, lipids, ash and carbohydrate, respectively, in electric-dried *C. gariepinus*.

In addition, the moisture contents of powdered smoked

Table 2. Percentage proximate composition of fish sample treated with plant extracts.

Plant extracts	Protein	Moisture	Ash	Lipid	Carbohydrate
D. tripetala	62.05 ± 0.00^{c}	12.11 ± 0.16^{c}	15.31 ± 0.31^{b}	10.96 ± 0.00^{c}	1.08 ± 0.00^{c}
E. aromatica	61.35 ± 0.00^{e}	10.74 ± 0.18^{b}	16.24 ± 0.10^{c}	18.18 ± 0.00^{a}	1.08 ± 0.00^{c}
P. guineense	60.73 ± 0.00^{d}	11.33 ± 0.64^{cd}	13.31 ± 0.20^{a}	11.38 ± 0.00^{d}	0.45 ± 0.00^{a}
M. myristica	59.84 ± 0.00^{a}	11.84 ± 0.62^{cd}	16.98 ± 0.26^{d}	10.60 ± 0.00^{b}	0.74 ± 0.00^{b}
Control	60.42 ± 0.00^{b}	11.60 ± 0.00^{a}	16.26 ± 0.12^{e}	11.83 ± 0.00^{e}	1.30 ± 0.00^{d}

Values are means of triplicate samples followed by the standard error of means. Means in the same vertical column with different superscripts are significantly different ($p < 0.05$) by Tukey's test.

Table 3. Mineral composition (ppm) in smoked fish treated with plant powders.

Metal	Plant Powder				
	D. tripetala	***E. aromatica***	***P. guineense***	***M. myristica***	**Control**
Se	ND	ND	ND	ND	ND
Cu	0.81 ± 0.01^{c}	0.41 ± 0.01^{a}	1.32 ± 0.00^{c}	1.33 ± 0.00^{c}	0.414 ± 0.01^{a}
Zn	123.27 ± 0.15^{a}	123.40 ± 0.06^{b}	120.23 ± 0.07^{a}	120.29 ± 0.03^{a}	120.30 ± 0.00^{a}
Mn	0.07 ± 0.00^{b}	0.61 ± 0.01^{a}	ND	ND	ND
Mg	142.13 ± 0.07^{b}	133.47 ± 0.73^{a}	153.70 ± 0.10^{a}	137.50 ± 0.06^{a}	157.40 ± 0.00^{b}
Fe	419.60 ± 0.06^{b}	429.60 ± 0.06^{c}	444.73 ± 0.45^{d}	419.57 ± 0.03^{b}	413.57 ± 0.03^{a}
Pb	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND
Ca	160.73 ± 0.19^{a}	161.20 ± 0.21^{a}	171.20 ± 0.21^{c}	167.87 ± 0.03^{b}	171.53 ± 0.03^{a}
Na	390.23 ± 0.20^{a}	304.33 ± 0.30^{c}	323.17 ± 0.15^{d}	303.33 ± 0.07^{b}	300.47 ± 0.32^{a}
K	592.27 ± 0.33^{c}	529.33 ± 0.27^{c}	469.17 ± 0.23^{b}	629.50 ± 0.21^{d}	464.50 ± 0.21^{a}

ND: Not detected.
Values are means of triplicate samples followed by the standard error of means.
^{abcde} Means on the same row with different superscripts differ significantly ($p < 0.05$) by Tukey's test.

fish (5.64 - 8.98%) and of extract- protected fish (10.74 - 12.11%) obtained in this study are similar to the moisture content values of 10 - 12% reported by Omafuvbe and Kolawole (2004) in samples treated with *P. guineense.*

The protein and fat contents of Indonesian traditional smoked catfish, *Macrones nemurus* were 32.25 and 32.06%, respectively and they were 38.81 and 8.02%, respectively for *Cryptopterus micronema* (Huda et al., 2010). Similarly, Omojowo et al. (2009) demonstrated the use of potassium sorbate on the proximate values of smoked *C. gariepinus* and reported 40 - 45 and 15 - 17% for protein and moisture contents respectively. The relatively high ash contents obtained in this study probably reflected the impact of smoke on the fish sample and the drying process of the botanicals.

The proximate values of the mineral composition of smoked fish treated with plant powders (Table 3) and fish protected with plant extracts (Table 4) also evoked significant differences ($p < 0.05$). However, in this study, no fish sample protected with a particular plant product demonstrated superior mineral composition because the values obtained were generally similar. Chukwu and Shaba (2009) recorded 0.00048 ± 0.00001 and 0.00040 ± 0.00003% for potassium and phosphorus respectively in dried *C. gariepinus* while Fawole et al. (2007) reported the mean mineral compositions (%) of 0.34 (P), 0.33 (Ca), 0.36 (K), 0.30 (Mg), 0.12 (Fe), 0.80 (Na) and 0.02 (Cu) in the same fish species.

Studies on the biochemical composition of spices showed that *D. tripetala* contains crude protein (15.31%), total carbohydrate (62%), crude fibre (9.84%), crude lipids (3.6%) and moisture (8%) (Okwu and Morah, 2004). The authors also reported mineral components of calcium (1.8%), phosphorous (0.33%), potassium (2.5%), magnesium (0.42%) and the detection of iron, copper, zinc and cadmium. Similarly, Essien et al. (1995) reported total lipid contents (g/kg dry weight) of 31.8 - 68.9 for both *P. guineense* and *D. tripetala.*

Variability in the biochemical constituents of fish has been attributed to the fish species, age, sex and processing (Balogun and Fasakin, 1996; Azam et al., 2004). Similarly, Marr and Creasser (1983) and Adeyeye (1994) linked variation in nutrient composition in fish to such factors as habitat, feeding habits, human activities and industrial processes. Fruits and vegetables differ greatly in the length of time for which they can be

Table 4. Mineral composition (ppm) in smoked fish treated with plant extracts.

Metal	Plant extract				
	D. tripetala	***E. aromatica***	***P. guineense***	***M. myristica***	**Control**
Se	ND	ND	ND	ND	ND
Cu	ND	0.41 ± 0.02^{a}	0.41 ± 0.02^{a}	0.83 ± 0.01^{c}	0.61 ± 0.01^{b}
Zn	120.37 ± 0.19^{a}	119.30 ± 0.68^{a}	119.63 ± 0.49^{a}	119.83 ± 0.27^{a}	120.40 ± 0.06^{a}
Mn	ND	0.15 ± 0.00^{b}	0.06 ± 0.02^{a}	ND	0.08 ± 0.00^{a}
Mg	157.37 ± 0.19^{c}	148.65 ± 0.26^{a}	158.67 ± 0.24^{d}	153.33 ± 0.24^{b}	161.13 ± 0.07^{e}
Fe	432.43 ± 0.34^{d}	409.27 ± 0.12^{a}	424.93 ± 0.22^{c}	421.43 ± 0.18^{b}	433.43 ± 0.55^{d}
Pb	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND
Ca	171.77 ± 0.13^{c}	173.29 ± 0.16^{d}	164.97 ± 0.75^{a}	170.13 ± 0.03^{b}	190.30 ± 0.15^{e}
Na	311.07 ± 0.12^{b}	307.57 ± 0.20^{a}	315.90 ± 0.75^{c}	317.23 ± 0.38^{c}	320.23 ± 0.52^{d}
K	644.37 ± 0.19^{e}	605.63 ± 0.03^{b}	621.60 ± 0.58^{c}	573.27 ± 0.33^{a}	634.27 ± 1.20^{d}

ND: Not detected.
Values are means of triplicate samples followed by the standard error of means.
^{abcde} Means on the same row with different superscripts differ significantly ($p < 0.05$) by Tukey's test.

maintained in a wholesome condition before deterioration in the quality of the product begins (Aboaba and Sobande, 1994), therefore, the need for adequate pre-treatments of both the fish and spices (Andress et al., 2001). Omafuvbe and Kolawole (2004) reported that oven-drying generally achieved the required moisture content earlier and more uniformly than sun-drying.

Fish have the ability to concentrate heavy metals in their muscles (Varshney, 1991); therefore plant products need to be carefully screened to ensure that additional high levels of toxic metals are not being transferred to man through plant-protected fish. However, lead and cadmium which are potentially harmful to animals (Adeyeye, 1994) were not detected in this study. According to Waldron and Stofen (1974) lead inhibits protein synthesis while cadmium, if ingested, accumulates in the kidney (Crosby, 1977).

The results obtained in this work portray the admixtures as stable in nutritive values hence the plant products could be acceptable as control agents of pests on stored food.

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