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Full Length Research Paper

Quality improvement and value addition of processed fish (*Clarias gariepinus*) using phenolic compounds in coffee pulp smoke

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Abstract

The antioxidative and antimicrobial effects of coffee pulp were investigated against rancidity (lipid oxidation) and microbial growth on smoked fish samples. About thirty kilogram's (wet weight) of catfish (C*larias gariepinus*) were killed, gutted and immersed in 15% brine for a period of 4 minutes before smoking. The fishes were divided into three batches and exposed to three smoking sources (Electric cooker (Control), Dry coffee pulp smoke and firewood smoke) for about five hours at temperature range of 80 – 90^{0}C. The three smoked fish samples were then kept differently in high densed polythene bag and kept for twenty-one days. Significantly lower values than the control were obtained for Trimethylamine, Thiobabituric acid and Peroxide values in both Coffee and charcoal smoked fish samples. During the second week, a well pronounced antioxidative effect of coffee pulp was noticed both control and firewood smoked samples. Higher preference (Physical) was shown for coffee smoked sample, as coffee aroma characterized the sample when exposed to air. Mould growth was most delayed in the coffee smoked sample till about fifteen days of storage. Fillet cut from the Coffee and firewood smoked samples were still appreciable when tasted. No repulsive odour was detected in coffee smoked sample. Coffee pulp therefore has potential antioxidative effect on rancidity in smoked fish and could also be used to flavor smoked fish products.

Keywords: Coffee pulp, Rancidity, Fillet, Antioxidative, Antimicrobial.

INTRODUCTION

Phenolic compounds in most firewood which are commonly used in traditional smoking techniques have been emphasized as a way of imparting preservative and organoleptic value on smoked products (Kjeilstand and Petersson, 2001). Scientists have not only proved phenols and its compounds as food preservative (Ogali, 1994), it has also been established that relative concentration of these compounds also varies with wood types (Guillen and Iibargotra, 1998). However, literatures that evaluate and appropriate the use of agro-industrial by-products that are rich in phenolic compounds are very scanty. Fish, as widely reported, is an extremely perishable food item. Fish spoils few hours after death (Ames *et al., 1991*). Global concern is presently on to source for natural preservatives (antioxidants) which could be harnessed to combat spoilage due to rancidity. Food scientists are passionately deemphasizing the use of synthetic antioxidants in tackling spoilage because of their deleterious effects on enzymes of the lung (Inatani *et al., 1982*). It has again been established that phenolic compounds are not only present in trees alone, but are as well present in other three components like: leaf, roots and fruits (Opeke, 2005). In many agro-based industries and farms all over the world, crop by-products are wasting away in million tones, For instance, about 800,000 tons of Cocoa-pod husk (CPH) is annually wasting away (Opeke, 2005, Hamzat, 2006). Cocoa bean shell (CBS) is equally wasting away in about half the quantity of CPH. Kola-pod husk (KPH) is also produced annually in tones but is also been underutilized. Another agricultural by-product which has not receives attention in the area of value addition is coffee pulp (CP). Coffee is

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the second most valuable traded good in the world. After oil, coffee is the second largest import in the United States, with U.S. consumers drinking one-fifth of the world's coffee, making them the largest consumers of coffee in the world, and this country alone imports more than 2.5 billion pounds of coffee each year (Package facts, 2003). Coffee byproducts represent about 50% (dry matter) of the world coffee bean production, and coffee husks, peel and pulp, comprises nearly 45% of the cherry (P. Esquivel and V. M. Jiménez, 2012). Coffee pulp is rich is carbohydrates, amino acids, minerals and various chemical compounds (mainly polyphenols) T. Sera *et al*, (2000). About 2.8 million tons of coffee pulp is globally produced between 1989 to 1990 (Perraud- Gaime, 1995). On a dry matter basis coffee pulp consists of 1.3 % caffeine and 4.5 % tannin. According to Hamzat *et al*, (2011), coffee pulp usually constitute a major material causing pollution in Lakes and rivers around coffee processing sites (Farms and Industries). Coffee pulp found a limited utilization as animal feedstuff, due to the presence of antinutritional chemical compounds like caffeine, tannins and polyphenols. The presence of these antinutritional factors coupled with rather low crude protein militates against it use as feedstuff. Coffee pulp contains 23.3 % of dry matter which include 3.4% fiber, 2.1 % protein, 1.5 % ash, non-protein and organic components like tannins, sugars, caffeine, chlorogenic acid and caffeic acid (Mazzafera, 2000). Further investigation however revealed that coffee pulp is a rich source of caffeine which could be said to be the known active ingredient in coffee and coffee byproducts. Caffeine is known to find its most useful application as a preservative. Hence, this present study aims at investigating the preservative effects of coffee pulp on smoked fish.

MATERIALS AND METHODS

Collection of Pulp

Coffee berry was collected during in season of coffee. This berry pulp was dry processed and the bean extracted through the conventional dry processing methods. Pulp obtained from the operation was tagged Dry Pulp according to the method of extraction. This pulp was then dried at room temperature. This was packed into polythene sack and kept for use.

Fish Sample

About 30 adult live Catfish was purchased at a sea shore and slaughtered immediately by breaking the head with wooden hammer. These fishes were then carefully gutted by cutting the ventral side removing all the visceral. The fish was rinsed and salted by immersing the fillets in brine solution for 3 minutes after which it then set on the gauze for smoking. Before smoking, these processed fishes were grouped into three batches and each batch was differently exposed to Hot-plate electric cooker, coffee pulp smoke and firewood smoke for about three hours.

Shelf life Evaluation of Fish sample

Samples of the three smoked fishes were put into high densed polythene bags after cooling to room temperature (27^0C) and then kept at ambient temperature for three weeks. Insect infestation was prevented by tightening the mouth of the bags.

Smoking kiln

The smoking kiln that was used for this work is the metal drum barrel with wire gauze suspended at the middle of the drum. The opened upper end allowed the processed fish to be set on the gauze. A coal-pot with burning charcoal was placed at the bottom of the kiln to supply heat. A galvanized sheet with fine hole was hung at 10cm distance away from the burning coal upon where a weighed quantity of coffee pulp was placed for pyrolysis. A well skillfully processed fish fillets were arranged on top of the upper chamber gauze and the metal kiln cover replaced to allow kiln efficiency. The control batch was placed over a wire mesh on hot plate electric cooker with temperature regulated to 65^oC for three hours.

Microbiological analyses

Parameters used to assess the microbial load of the fish samples include: Trimethylamine (TMA) which was carried out according to the standard procedure of AOAC (1984), thiobarbituric acid value (TBA) done according to Schmedes and Holmer (1989) and the peroxide value (POV) which was determined according to AOAC Standard method (1999).

Antioxidative and Antifungal effects of Coffee pulp

Samples of these smoked fishes were packed into a high-dense polythene bags and taking to a standard laboratory where each samples was periodically evaluated by chemical means for both antioxidative and antifungal effect of Coffee pulp.

Statistical Analysis

Results obtained in this study were subjected to analysis of variance (ANOVA) using SAS software (SAS Institute,

Table 1. Proximate Composition of *Clarias gariepinus* smoked with Coffee pulp and Charcoal as Smoking sources

Parameter	Control	Coffee pulp	Charcoal
Moisture (%)	69.43	53.91	57.78
Crude lipid	0.78	0.96	0.84
Ash	4.82	4.48	3.62
Crude protein	18.31	17.62	16.28
Total nitrogen (%)	2.93	2.82	2.60

Table 2. Biochemical Analysis of *Clarias gariepinus* smoked with Coffee pulp and Charcoal as Smoking sources

Parameter (Mean of values)	Control	Coffee pulp	Charcoal
TMA (mg/kg)	1.86		
Wk 1	8.64	8.79	11.61
Wk 2	11.16^{a}	6.62^{a}	10.12^{b}
Wk 3	23.56^{b}	4.12^{a}	9.45^{c}
PV(mg/kg)	8.32		
Wk .1	12.15	7.03	7.41
Wk .2	18.21^{a}	6.44^{b}	10.15^{c}
Wk. 3	27.85^{b}	5.12^{a}	12.72^{c}
TBA(mg/kg)	0.16		
Wk. 1	0.32	0.35	0.30
Wk. 2	0.58	0.18	0.22^{b}
Wk. 3	0.65^{c}	0.21^{a}	0.48^{a}

Means that do not have the same superscript within a column or row, are significantly different (P > 0.05)

1990). Differences between means were determined by the least significant difference test, and significance was defined at $P<0.05$.

RESULTS AND DISCUSSION

Table 1 showed the proximate composition of the three smoked fish samples after five hours exposure to the smoke sources. Moisture contents of all the fish samples decreases significant, showing the effectiveness of the heat from the smoking sources. The lipid content of the two samples however increased a little above the initial value. This might be as a result of decrease in the percentage moisture content of the smoked samples.

The period of rancidity commencement was delayed for about10 days in the coffee pulp-smoked fish, as against the control wherein rancidity was observed earlier (about four days) Table 2. Plant phenols have strong antioxidant activity (Rice-Evans, C.A. *et al.* (1996). The initial mean levels of Trimethylamine (TMA), Thiobabituric acid (TBA) value and peroxide value (POV) were 1.86, 0.16 and 8.32 respectively. Values for TBA and POV were slightly higher than those obtained by Kh. I Sallam *et al.* (2004) when raw chicken sausage was treated with garlic powder. However after 21 days of storage, the average values of TMA, TBA and POV were 4.12, 0.21 and 5.12 respectively in pulp-smoked fish sample. All of these values were significantly ($p< 0.05$) lower than those of the control, but compare favorably well with those obtained when fresh Garlic spice was used to treat Chicken sausage Sallam *et al.* (2004) and Coriander extract (0.477) (A. Bali *et al.*, 2011). The values decreases inversely as the storage period increased. All samples showed increased TBA and peroxide values with time. The antioxidant and antimicrobial effects of coffee pulp smoke was demonstrated in its prolongation of period before rancidity onset. This thus lends further credence to the earlier findings of Pellegrini *et al.* (2003) and Vinson *et al.* (2005), that coffee berry contains chemical properties like caffeine, cafestol, kahweol and chlorogenic acids which are antioxidant in nature. Addition of coffee pulp to the smoke source significantly delayed lipid oxidation when compared with the control. The results of the microbiological analysis (Table 3) are in agreement with Ikeme, (1985) who reported that mackerel dipped in 15% brine and subsequently smoked were considered unacceptable by the 5th day of storage.

The observation of strands of mouldy mass of mycelium only on the control sample by the morning of

Table 3. Microbial Load of *Clarias gariepinus* smoked with Coffee pulp and Charcoal as Smoking sources

Sample	Total viable count	Total coli form count	*E. coli*	Total fungal count
Control	2.8×10^4	2.6×10^4	2.2×10^4	3.22×10^4
	3.6×10^4	3.1×10^4	2.6×10^4	3.25×10^4
	4.2×10^4	3.6×10^4	2.8×10^4	3.83×10^4
Coffee Pulp				
(Wk 1)	2.8×10^4	0.4×10^4	0.1×10^4	0.25×10^4
Wk 2	2.6×10^4	0.4×10^4	0.3×10^4	0.62×10^4
Wk 3	3.1×10^4	0.38×10^4	0.9×10^4	1.25×10^4
Charcoal				
Wk 1	3.6×10^4	0.3×10^4	-	$1.15x\ 10^4$
Wk 2	3.5×10^4	0.1×10^4	$0.26x\ 10^4$	$1.16x\ 10^4$
Wk 3	3.8×10^4	0.6×10^4	0.3×10^4	2.5×10^4

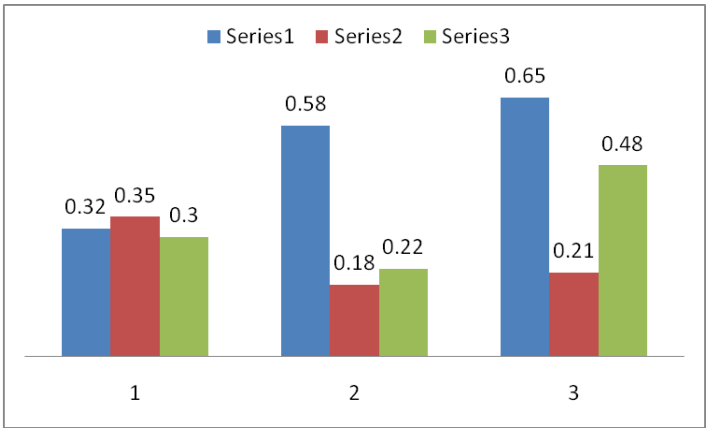

Figure 1. Antioxidant (TBA) activity chart showing effect of both Coffee husk pulp and Firewood smoke on smoked *Clarias gariepinus*
Key: Blue (Control), Red (Coffee Pulp), Red (Green)

Table 4. Means of Treatments and their corresponding standard error of taste panel rating for the smoked samples after 36 hours of storage

Treatment	Appearance	Juiciness	Saltiness	Rancidity	Flavour	General acceptability
Control	2.56(2.3-4.1)	3.02(2.0-3.4)	2.2(1.6-2.4)	3.21(2.1-2.6)	3.91(1.0-3.3)	2.62(1.6-2.2)
Coffee smoked	5.12 ± 0.04^{ab}	4.22 ± 0.11	4.30 ± 1.10^{b}	$.66\pm0.25^{ab}$	6.05 ± 1.80^{b}	8.60 ± 0.16^{ab}
	$(3.1\text{-}3.8)^{*}$	$(2.7\text{-}3.76)^{*}$	$(2.9\text{-}4.0)^{*}$	$(3.2\text{-}4.1)^{*}$	$(2.4\text{-}3.7)^{*}$	$(4.2\text{-}3.6)^{*}$
Wood smoked	4.20 ± 0.18^{ab}	3.73 ± 0.16	3.5 ± 0.11^{b}	4.13 ± 0.14^{ac}	3.30 ± 0.19^{d}	3.50 ± 0.17^{ac}
	$(3.14\text{-}3.4)^{*}$	$(2.0\text{-}3.1)^{*}$	$(2.2\text{-}3.0)^{*}$	$(3.4\text{-}3.6)^{*}$	$(3.0\text{-}3.1)^{*}$	$(3.0\text{-}2.9)^{*}$

Means that do not have the same superscript within a column, are significantly different (P > 0.05)

the 6th day of storage under ambient condition indicated the effectiveness of the pulp as anti-fungal agents and consequently the extension of shelf life of the coffee pulp-treated samples. Notable growth suppression (in mould count) was observed in the Coffee smoked fish sample till about two weeks of storage. This observation was in agreement with that of Oduor-Odote *et al.* (2010), when a freshwater catfish (Clarias gariepinus) was smoked with A.raddiana (a hard wood tree species in Kenya). Although mould count was as well affected in the charcoal smoked sample, this was not as pronounced as that in the charcoal smoked sample. This result was similar to that reported by Almeida *et al.* (2006), as cited by Baiq Rien Handayani, (2009), that coffee extracts and selected coffee chemical compounds such as caffeine, chlorogenic acid and protocatechuic exhibited antibacterial activity against Enterobacteria.

Organoleptic assessment of the coffee smoked samples showed that apart from the preservative effect of the pulp, the pulp also acted as a flavouring substance. The aroma from the coffee-pulp smoked sample was characteristically desirable (figure 1).

The mean hedonic scores for the three samples were shown on table 4. There was no significant difference in

the physical appearance of the two smoked samples (coffee and wood) after the third day of storage. Although the score for coffee smoked fish was slightly higher. However, there were significant differences in flavor, rancidity as well as general acceptability of both coffee and wood smoked samples, with higher scores for coffee smoked sample than both the control and firewood samples. Assessment via taste was not discussed, though both samples were slightly bitter. This might be as a result of direct contact with smoke.

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