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ORGANOLEPTIC EFFECT OF USING DIFFERENT PLANT MATERIALS ON SMOKING OF MARINE AND FRESHWATER CATFISH

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ABSTRACT

Freshwater catfish (*Clarias gariepinus*) and marine catfish (*Galeichthys feliceps*) were smoked using *Acacia raddiana* (Moriela), *Prosopis julifora* ("Mathenge"), *Azadirachta indica* (Neem) and *Cocos nucifera* (Coconut husks) in view to assess and compare the organoleptic scores- taste, appearance and overall acceptability of the smoked fish. Insect and mould attack was also monitored during storage. The scores for taste for marine catfish were better than that for freshwater catfish irrespective of the plant materials used. Taste for freshwater catfish and marine catfish smoked with *Acacia* was significantly different ($p<0.05$). Appearance and overall acceptability for freshwater catfish smoked with *Acacia, Prosopis* (Mathenge), Neem, and Coconut husks was better than marine catfish though not significantly different ($p<0.05$). The scores for taste, appearance and overall acceptability for marine catfish smoked with *Acacia*, *Prosopis*, Neem and Coconut husks were not significantly different ($p<0.05$). *Acacia* had better taste, appearance and overall acceptability scores. For freshwater catfish smoked with *Acacia, Prosopis*, Neem and Coconut husks, scores for taste, appearance and overall acceptability were not significantly different ($p<0.05$). Insects were first detected in the marine catfish smoked by *Acacia* and *Prosopis* on day 35, 48 and 56 recording score 1, 2 and 3 respectively. For Coconut husk and Neem smoked marine catfish, insects appeared on day 48 and 56 with scores of 1 and 2 respectively. In the freshwater catfish smoked by *Prosopis*, insects were first noticed on day 35 and 48 with scores of 2 and 3. For those smoked with *Acacia* and Coconut husks the first insect attack was on day 48 with a score of 1 and scores of 2 and 3 respectively on day 56. The first insect attack on Neem smoked catfish was day 56. Mould was first detected in the marine catfish smoked with *Prosopis* and Coconut husks on day 35 and on *Acacia* and Neem on day 48 of storage. In the freshwater catfish, mould was first detected in the fish smoked by *Acacia*, *Prosopis* and Coconut husks on day 14 of storage and on fish smoked with Neem on day 56. The Neem tree delays insect and mould attack in smoked fish during storage. The percentage moisture recorded on day 0, 14, 21, 28, 35, 48 till 56 correspond to days when mould was noticed on the fish during storage and it increased with storage time. The 4 trees can be used in marine and freshwater catfish smoking for human consumption.

Key words: Organoleptic, Smoking, Catfish, Storage, Infestation

Abbreviations: KMFRI: Kenya Marine and Fisheries Research Institute

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INTRODUCTION

Fish and fish products are readily available sources of animal protein in the coastal region of Kenya. The Tana River area is known for freshwater catfish (*Clarias gariepinus*) landings which are smoked by artisanal fishermen to prevent spoilage [1]. Rarely is marine fish smoked in Kenya except cold smoking of sailfish for up-market hotels. In the West African countries on the contrary, marine fish smoking is common [2]. Attempts to smoke marine fish with community participation have been carried out by [3]. Some of the species that have been smoked on trial basis include the popular fish species like *Caranx, Siganids, Pomadysis* and *Barracudas, Lethrinidae, Lutjanidae* among others with good response from the communities who have shown great preference in taste and acceptability [3]. Introduction of newer fish candidates for smoking in Kenya like the marine catfish (*Galeichthys feliceps*) provides a chance of enhancing protein in human diet. The marine catfish closely resembles the freshwater catfish (*C. gariepinus*) in appearance (Plate 1a and 1b). It is landed in the north coast and at times finds its way near freshwater catfish landing areas.

Plate 1a: Marine catfish

Plate 1b: Freshwater catfish

The marine catfish is however treated as a low value fish by prawn trawlers in Kipini and Ungwana bay areas, discarded by locals or dried and sold at throw away prices [4]. Smoking improves flavor and appearance of fish [5,6]. Marine catfish currently

valued lowly, can be smoked to provide a new product with enhanced organoleptic properties to be utilized alongside the African catfish. Smoking involves use of wood fuel which in turn affects product quality [7]. Variations in the quality of the fish products produced due to the type of wood fuel used for smoking have however not been monitored closely. This can present a chance of improving product quality as well as introducing newer wood fuel products hitherto unutilized for fish smoking. In Kenya, reports on the wood quality of various species of trees as fuel energy source for smoking fish are limited.

An alien tree species considered a nuisance that has encroached the Tana delta area is *Prosopis julifora* ("Mathenge") [8,9]. *P. julifora* has potential as a wood fuel though it has not been tried to smoke fish [10]. It also has edible components [8]. It can ease pressure off *Acacia raddiana*, the current tree of choice for fish smoking in the area [1]. Coconut (*Cocos nucifera*) plantations provide numerous products such as coconut meat, milk and husks. Coconut husks can be used for cooking, heating and as the heating base for smoking meat and fish. The use of coconut husks for fish smoking was tried by [7], If found to be effective, the use of husks may ease pressure on local trees like mangroves. Little work has also been done to assess post processing and general quality deterioration of smoked fish in Tana Delta area during storage. In West African countries the traditionally smoke-dried fish are stored in round smoking ovens and covered in polyethylene and jute sacks. Occasional re-smoking is undertaken to maintain dryness and drive off insect pests and control mould attack. Storage under such conditions is still unsatisfactory due to frequent insect infestation, microbial decomposition and rodent attack [11, 12]. Insect infestation can cause a loss of 30 to 50 percent of fish meat [13,14,15]. In Kenya, exact statistics of storage losses of smoked fish are not available but observations reveal that post processing losses of the smoked fish do occur during storage. Insect infestation especially by beetles is common. Efforts to reduce high losses are needed if the beneficial effects of improved processing techniques are to be derived. Any reduction in processing and post processing loss by simple modifications of existing methods will benefit the fishing villages in the Tana Delta area. The main interest in using Neem (*Azadirachta indica*) in fish smoking is because of activity of its components as a deterrent for both insect activity and mould. It has multiple pesticidal and medicinal properties: smoke from its leaves are used as insect repellant, about 135 different compounds are found in every part of the tree and it has antimicrobial effects [16,17,18,19]. In Kenya, interest started being shown in the Neem tree for commercial and industrial potential in 1980's and has been sustained [20]. No work has been reported for the use of Neem tree in Kenya in fish smoking and for control of insect infestation during storage of smoked fish.

The purpose of this study was to evaluate some organoleptic characteristics of the African catfish (*C. gariepinus*) and marine catfish (*G. feliceps*) smoked by *A. raddiana, P. julifora,* Neem (*A. indica*) and Coconut husks (*C. nicifera*)

Study area
Moa is in the Tana delta area and lies 40.4^{0}E, 2.39 ^{0}S and 4 km off the Garsen-Witu road on the way to Lamu. The fishing grounds which are ox-bow lakes along Tana River are shared by both Lamu and Tana Delta Districts. It is an area made up of fishing villages within which are several mini fishing villages in homestead clusters based on common cultural backgrounds.

MATERIALS AND METHODS

Construction of smoking ovens

4 clay-walled improved double door fish smoking ovens were constructed according to [1,21] in Moa village and used in the study.

Sample collection
A total of 500 pieces of marine and freshwater catfish were purchased fresh during the months of August and September 2008 in Kipini and Tana River areas respectively. It was not possible to get all fish of the same size as they land different sizes in different seasons. The marine catfish were generally smaller in size compared to the freshwater catfish.

Preparation of samples for processing
The fish were gutted and washed thoroughly. The tails were then slit by making a small cut in them, then coiled and by squeezing the gill region between the thumb and forefinger to open the mouth, the tail was fixed in the mouth and with pressure released, the tail stuck inside the mouth. [1].

Fish distribution
The mesh of the fish smoking trays was oiled prior to the distribution of fish using liquid food vegetable oil so that fish did not stick during smoking. 60 pieces of each species of fish were randomly placed on each of the 4 fish smoking trays. Each tray therefore contained 120 pieces of fish on either side with marine or freshwater catfish. The trays with the fish were transferred under shade and at an angle to let the fish drip dry for 2 hours.

The fish smoking process
Small logs of wood from *Acacia raddiana, Prosopis julifora* and *Azadirachtin indica* were cut into chunks using a power saw HUSQVARNA 61-268 272XP. Smaller pieces were cut using hand saws from the chunks to smaller pieces with a length of 50 cm and a fairly uniform thickness of 4.0 to 7.0 cm. The coconut husks were utilized the way they normally are in nature when dry. The fire was lit 30 minutes before smoking started using grass and let to burn till the flames died off and only smouldering wood remaining. The fish were transferred to the smoking chambers already pre-prepared according to [1]. Each set of trays with 60 pieces each of freshwater and marine catfish on either side were smoked using the 4 tree types in each of the 4 double door ovens. The labels for fish used were MCA, MCP, MCN,

MCC for marine catfish and FCA, FCP, FCN, FCC for freshwater catfish smoked with *Acacia, Prosopis,* Neem and Coconut husks, respectively.

The fire from coconut husks was controlled by closing the stoke holes more often during smoking to allow less air. To control the excessive temperature in the ovens, the intensity of the fire was reduced by intermittent withdrawal of some of the logs from the fire point. At intervals the positioning of the fish was interchanged to effect uniform penetration. At the end of the 3 day smoking period, the fish were removed from the kilns and exposed to air to cool for 2 to 3 hours [22].

The fish were packed in labeled plastic open sided milk crates and transported for storage in the open on benches in KMFRI lab Mombasa 350 km away, for moisture, organoleptic analysis, insects and mould observations. The fish for organoleptic and insect monitoring were each kept and treated separately from the ones for moisture and mould during storage.

Moisture analysis
Moisture content was determined by the air oven method using 6 fish samples [23].

Sensory evaluation
This involved semi-trained panelists drawn from KMFRI staff. The organoleptic parameters that were evaluated included appearance, taste and with provision for a score on overall acceptability. A 5 point hedonic scale was used with a score of 5 indicating "extremely acceptable" 4- "very acceptable"; 3 "acceptable"; 2 "fairly acceptable; 1 " not acceptable". The tests carried out were in three sets. The first one was MCA vs. FCA, MCP vs. FCP, MCN vs. FCN and MCC vs. FCC. The second set was MCA vs MCP, MCA vs MCN and MCA vs MCC. The third set was FCA vs FCP, FCA vs FCN and FCA vs FCC. Set one was to establish sensory scores between freshwater catfish and marine catfish, set two for sensory scores due to marine catfish smoked with *Acacia* against *Prosopis,* Neem and Coconut husks and set three for sensory scores due to freshwater catfish smoked with *Acacia* against *Prosopis,* Neem and Coconut husks. A score below 2 was considered not acceptable. The fish samples were coded with numbers of 2 digits indicating no information about the samples to avoid bias in preferred treatments. Samples for taste (cooked flavor) were heated in a microwave oven LG INTELLOWAVE without any additives e.g. salt before tasting. Normal consumption temperature for food was used. 10 panelists who were neither hungry nor satiated were used at each sampling time. The panelists were advised not to smoke or eat 1 hour before the sensory evaluation, to avoid perfumes or aftershave and avoid being in the panel if sick or suffering from cold. Each panelist was served as similar a part of the fish as possible i.e. a sample from the loin parts. The quantities of samples were at least 2-3 bites for each panelist. The panelists received each sample separately. Rinsing the mouth between samples was done using plain unsalted crackers then water.

Storage trials

Insect and mould attack was monitored during the storage period. Attacks by insects or moulds were determined with modifications according to [13]. Insect and mould attacks were evaluated by giving scores on a hedonic scale of 0-3. A numerical score of 0 meant there was no sign of infestation or damage, 1 occasional infestation, 2 noticeable consistent infestations and 3 heavy insect/mould infestations covering the whole fish. For insect infestation, a score of 3 and above led to rejection of the fish and a score above 0 was the limit of acceptability for mould.

Data analysis

Each data set had N=40 (10 panelists evaluating 2 sample groups in duplicate for each attribute) and ANOVA was chosen as it put all the data into one number (F) and gave us one P for the null hypothesis. The ANOVA was carried out on the sensory data in the statistical program NCSS 2000 (NCSS, Utah USA). The program calculates multiple comparisons using Duncan's test to determine if sample groups are different. Significant difference was defined at the 5% level.

RESULTS

Sensory evaluation

A comparison of organoleptic scores for freshwater and marine catfish was made using the different trees as shown in Table 1.

The scores for taste for MCA, MCP, MCN and MCC were better than for FCA, FCP, FCN and FCC. Only taste for FCA and MCA was significantly different ($p<0.05$).
The scores for appearance for FCA, FCP, FCN and FCC were better than for MCA, MCP, MCN and MCC though not significant ($p<0.05$). The overall acceptability score for FCA, FCN and FCC were better than for MCA, MCN and MCC though not significant ($p<0.05$) and the overall acceptability score for MCP was better than for FCP but not significant ($p <0.05$). Organoleptic scores for marine catfish smoked using the 4 tree species were also compared (Table 2). The scores for taste, appearance and overall acceptability for MCA were better than for MCP, MCN and MCC but not significant ($p<0.05$). Organoleptic results for freshwater catfish smoked with all treatments are shown in Table 3. The score for taste for FCA was better than FCP and FCC. FCN however had a better score than FCA. All differences in scores were however not significant ($p<0.05$). FCA had better appearance scores than FCP, FCN and FCC though not significant ($p<0.05$). Overall acceptability scores for FCA were better than FCP and FCC. FCN had a better score than FCA. All the differences in scores were not significant ($p<0.05$).

Insect attack during storage

Insects were first detected in the marine catfish smoked by *A. raddiana* and *P.julifora* on day 35 (Table 4). On day 48, the insect score increased to 2 then 3 the rejection limit by day 56. Insects appeared on both coconut husk and Neem smoked marine catfish on day 48 and 56 with scores of 1 and 2 respectively. The insect scores for marine smoked coconut and Neem fell within acceptable levels with scores of 2 and

below. In the freshwater catfish smoked by *P.julifora*, insects were first noticed on day 35 with a score of 2 and attained a score of 3 by day 48 and were discarded. Freshwater catfish smoked with *A.raddiana* and coconut husks had first insect presence on day 48 with a score of 1 and scores of 2 and 3 respectively on day 56. The freshwater smoked catfish using coconut crossed the threshold value of acceptance. The first time of insect attack was noticed in the Neem on day 56.

Temperature and Humidity

The mean humidity during the entire 56 day storage period was 81.2% ±1.27 with a high frequency between 80-81% while temperature was 26.33^{0}C ±1.73 with a frequency of 26 to 27.5 (Figures 1 and 2).

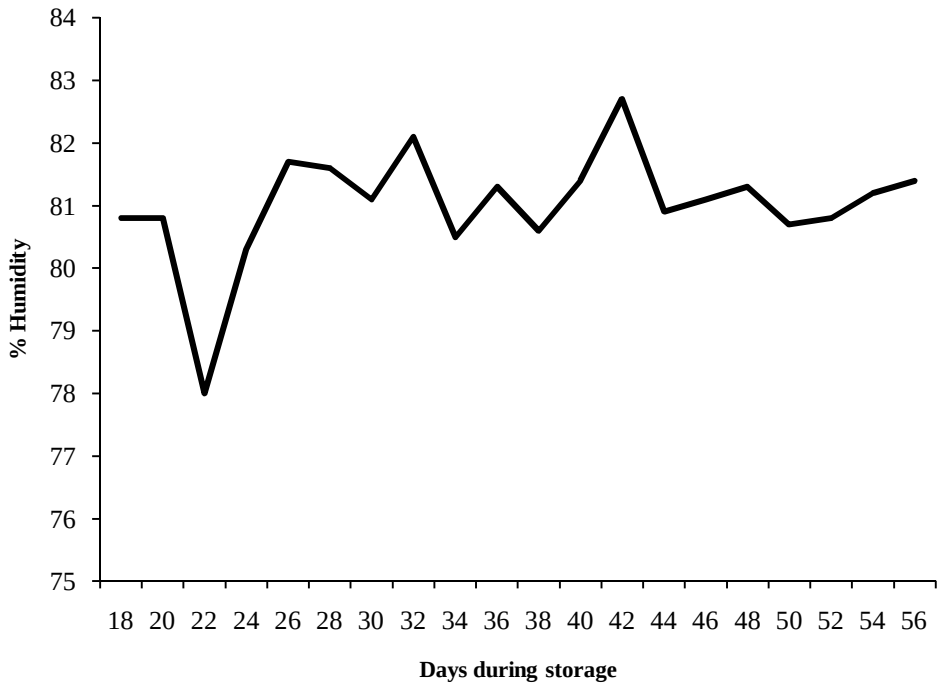

Figure 1: Humidity during storage of fish

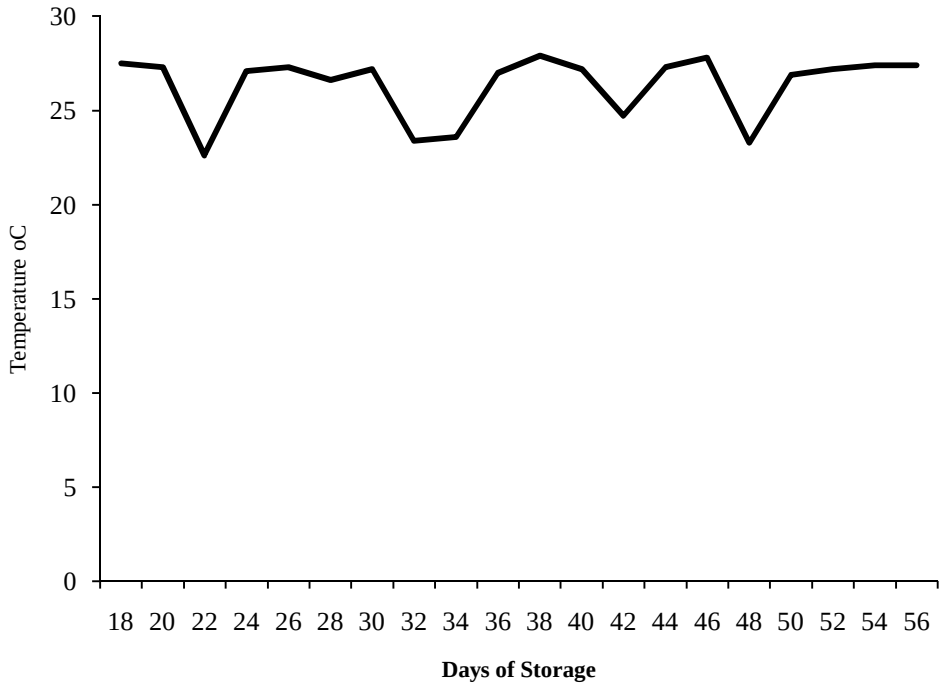

Figure 2: Temperature during storage of fish

Mould attack during storage

Mould was first detected in the marine catfish smoked with *P.julifora* and coconut husks on day 35 and on *A.raddiana* and Neem on day 48 of storage (Table 5). In the freshwater catfish, mould was first detected in the fish smoked by *A.raddiana*, *P.julifora* and Coconut husks on day 14 of storage and on fish smoked by Neem on day 56. For serious marketing purposes any fish with mould on them should be rejected though at community level marketing they would be scraped, re-smoked and sold.

Moisture during storage

Fish muscle absorbed moisture during storage. The percentage moisture in this study was recorded on day 0, 14, 21, 28, 35, 48 till 56 corresponding to days when mould was noticed on the fish during storage (Table 6). The moisture content in MCA was 16.1%, 16.6%, 16.4%, 16.3% and 16.4 % on day 0, 14, 21, 35 and 48; MCP 16.1%, 18.9%, 16.6% and 21.7% on day 0, 14, 21 and 35; MCN 16.0%, 18.8%, 15.9%, 20.5% and 19.0% on day 0, 14, 21, 35 and 48; MCC 15.8%, 17.4%, 16.2% and 17.9% on day 0, 14, 21 and 35 when mould was first detected.

The moisture content in FCA was 13.3% and 16.3% on day 0 and 14; FCP 16.8% and 18.9% on day 0 and 14; FCN 16.0%, 15.6%, 16.0%, 18.3%, 17.7% and 17.5% on day 0, 14, 21, 35, 48 and 56; FCC 15.3% and 16.6%, on day 0 and 14 when mould was detected.

DISCUSSION

Sensory evaluation

The smoked fish that is preferred in the Tana Delta area is freshwater catfish and the tree of choice is *A. raddiana*. In this study, there were cases in which the marine catfish gave better organoleptic scores than freshwater catfish (Tables 1-3). The newer trees used also gave scores above 2 which was the limit of acceptability and competed well with *A.raddiana* (Tables 1-3). Coconuts husks used to smoke catfish fillets in a separate study gave acceptable attribute ratings comparable to what is found in this work [7]. In another study involving fish smoking trials with *Acacia* tree species as fuel wood, good appearance and taste were recorded [24].

Many factors influence the quality of smoked fish products including the properties of fish flesh, maturity, age, sex, seasonal variations and factors involved in the smoking procedure such as wood type, composition of smoke, temperature, humidity, velocity and density of the smoke [6]. Phenolic and carbonyl compounds contribute towards taste in smoked fish [25,26]. Specific volatile compounds in particular phenolic compounds have been related to the different smoking techniques which directly influence the sensory characteristics of smoked fish [5,27]. Some of the phenolic compounds are guaiacol and syringol which are very characteristic in smoked fish [27]. Organoleptic properties of smoked foods are decisively influenced by composition of the smoke and nature of wood involved. There is no agreement about which wood or mixture of woods imparts the preferred sensorial properties to smoked woods [28]. The fact that there is no significant difference in sensory attributes between freshwater catfish and marine catfish during smoking in this study indicates that smoked marine fish can be used as a fish product in the market just like the freshwater catfish. There could just be a psychological feeling of inferiority towards marine catfish. This could basically be due to the influence in culinary habits and customs of each region on food acceptability [28]. The marine catfish therefore is a protein source being ignored and more work needs to be done towards optimization of processing like making fillets.

Neem, *P.julifora* and Coconut husks have potential for use in fish smoking and can be analyzed further for intrinsic properties like smoke components. The difference in taste observed between fresh and marine catfish smoked with *A.radiana* could be due to the different compounds in *A.raddiana* smoke interacting differently with body components of the marine and freshwater catfish. Different wood sources give wood smokes that have distinctly different sensory properties. It is assumed that reactions between the carbonyl compounds and proteins are mainly responsible for colour formation on smoked surfaces whilst the absorbed phenolic compounds are related to flavor and aroma of the smoked product [29,30]. Fish also differ in flavour owing to a variety of volatile compounds [31]. The organoleptic responses observed were a combination of any of these factors. Further investigations to isolate individual parameters responsible for the organoleptic properties can be carried out.

Insect attack during storage

Insects and mites are often found infesting cured fish during and after processing. In this study, no identification was made on beetles or mites and all were lumped as "insects". Insect development during storage of cured fish in the open is influenced by temperature, relative humidity and moisture content [32,33]. Optimal temperatures for insect development in such cured fish are between 25 to 35^0C [32]. In this study, both humidity (Figure 1) and storage temperature which was between 25 and 26 ^{0}C (Figure 2) favoured development of insects during storage. The Neem tree in this study is a better insect deterrent during storage in both fresh and marine catfish owing to the limited insect attacks observed during storage (Table 4). Several Neem compounds that prevent insect infestation have been identified in the Neem tree [16,18,19,34]. It can be postulated that the Neem smoke still contains bioactive ingredients which when deposited on fish muscle during smoking prevents insect infestation.

Mould attack during storage

Reports on the role of moulds in the spoilage of smoked foods and their mycotoxigenecity are scanty [35]. The marine catfish and freshwater catfish were attacked by moulds on different days over a period of 56 days (Table 5). The differences in mould attack could be due to differences in active microbial components in the respective smoke sources [28]. Carboxylic acids and phenols have been reported to show the highest antimicrobial activity with carboxylic acids lowering the pH while phenols inhibit microorganisms [7,28]. Moulds grow on smoked fish whenever there is enough moisture. Moulds also like humid and damp conditions. Under normal circumstances when moulds occur, they are relatively easy to remove if caught early enough as they attack surface of the fish first and do not immediately penetrate the fish [2]. This however is unacceptable and proper standards must be met as it is not easy to establish extent of toxin penetration. Among the 33 moulds isolated from 20 samples of wood smoked *Chlamydoselachus anguincus* (shark-fish), 20 isolates were capable of producing toxic metabolites [35].

In this study, mould was seen to infest the fish during storage at different times depending on the tree species used during smoking. The development of mould as a measure of spoilage rate was less pronounced in the fish smoked with Neem whether fresh or marine water catfish. Marine catfish generally stored for a longer time before mould attack than freshwater catfish. When moisture is reduced to 25 % wet basis, contaminating agents cannot survive and autolytic activity is greatly reduced [36]. To prevent mould growth during storage, moisture must be reduced to below 15% [36]. For smoked fish to survive mould attack during storage after a few days, moisture should be below 12%. [33]. Other factors however like different arrangements of fish muscles vis-à-vis free/bound waters, and the fat content of fish species could be important factors to storage [33]. In this study, after 14 days of storage, moisture was above 15% creating an environment for mould growth. The Neem smoke could have bioactive compounds that prevent mould growth. Antifungal activity due to Neem extracts have been reported by [17]. The Neem smoke probably contains these active antifungal ingredients that are deposited on the fish muscle during storage and subsequently reduces attack by mould.

Moisture during storage

In this study, the final moisture content of the marine and freshwater catfish was between 13 to 16% on day 0 (Table 6). This increased variously during storage. Similar increases of moisture during storage of smoked fish have been reported by [33,37].

Increase in moisture content could be attributed to the difference in the moisture of the smoked fish relative to the surroundings.

Humidity

Humidity also influences moisture content [33]. When the relative humidity is greater than 75 percent, rehydration of dried fish occurs if product is not wrapped in polythene or any cover. In an atmosphere with more than 60% humidity, the fish will tend to pick up moisture with consequent risk of spoilage [7, 13, 38,]. The humidity in this study was 80 to 81 percent (Figure 1) which could be ideal for moisture absorption. This is because fish muscle is normally hygroscopic. The hygroscopic nature of dried fish muscle and the high humidity played a part in increasing moisture thus creating an environment for mould attack.

CONCLUSIONS

Whereas *A.raddiana* is the tree commonly used for smoking fish in the Tana Delta region, the performance of *P. julifora,* Neem and Coconut husks is commendable especially in terms of organoleptic properties like appearance and taste. There was no difference in overall acceptability of the fish smoked using the different trees. The difference in taste between marine and freshwater catfish during smoking using *A. raddiana* showed that marine catfish was preferred to freshwater catfish. The Neem tree smoked marine and freshwater catfish stayed for a longer time before mould or insect infestation suggesting presence of antifungal and insect infestation deterrent factors in the Neem smoke.

RECOMMENDATIONS

It would be prudent to start using other tree species apart from *A. raddiana* for fish smoking in Tana Delta area and other regions at the coast of Kenya. The use of Neem tree in fish smoking as a possible deterrent to insect and mould infestation during storage can be investigated further.

The use of *Prosopis* should be encouraged as it will ease pressure off *A. raddiana* as a tree of choice in fish smoking. Tree products currently treated as waste like coconut husks can be utilized in fish smoking to reduce cost of wood fuel and can ease pressure off mangroves as source of wood fuel.

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Table 1: Mean sensory scores of taste, appearance and overall acceptability for freshwater catfish smoked with *A. raddiana, P. julifora,* Neem and coconut husks (FCA vs MCA, FCPvs MCP, FCN vs MCN and FCC vs MCC)

Groups	FCA	MCA
Taste	$3.7^{a}\pm1.3$	$4.3^{b}\pm0.7$
Appearance	$4.6^{a}\pm0.48$	$3.8^{a}\pm0.88$
Overall acceptability	$4.0^{a}\pm0.6$	$3.9^{a}\pm0.54$
	FCP	**MCP**
Taste	$3.3^{a}\pm1.1$	$4.2^{a}\pm0.92$
Appearance	$3.5^{a}\pm1.27$	$2.9^{a}\pm1.12$
Overall acceptability	$3.6^{a}\pm0.97$	$3.8^{a}\pm0.92$
	FCN	**MCN**
Taste	$4.2^{a}\pm0.8$	$4.2^{a}\pm0.48$
Appearance	$3.5^{a}\pm1.5$	$2.2^{a}\pm0.88$
Overall acceptability	$4.4^{a}\pm0.48$	$2.6^{a}\pm0.72$
	FCC	**MCC**
Taste	$3.6^{a}\pm1$	$4.1^{a}\pm1.08$
Appearance	$3.5^{a}\pm0.8$	$3.0^{a}\pm1$
Overall acceptability	$3.3^{a}\pm0.84$	$2.7^{a}\pm0.7$

Data within the same row for each attribute with different letters (superscript) are significantly ($p<0.05$) different

Table 2: Mean sensory scores of taste, appearance and overall acceptability attributes of Marine catfish smoked with *A. raddiana* compared with marine catfish smoked with *P. julifora,* Neem tree and coconut husks.

Groups	MCA	MCP
Taste	$4.3^{a}\pm0.7$	$4.2^{a}\pm0.92$
Appearance	$3.8^{a}\pm0.88$	$2.9^{a}\pm1.12$
Overall acceptability	$3.9^{a}\pm0.54$	$3.8^{a}\pm0.92$
	MCA	MCN
Taste	$4.3^{a}\pm0.7$	$4.2^{a}\pm0.48$
Appearance	$3.8^{a}\pm0.88$	$2.2^{a}\pm0.88$
Overall acceptability	$3.9^{a}\pm0.54$	$2.6^{a}\pm0.72$
	MCA	MCC
Taste	$4.3^{a}\pm0.7$	$4.1^{a}\pm1.08$
Appearance	$3.8^{a}\pm0.88$	$3.0^{a}\pm1$
Overall acceptability	$3.9^{a}\pm0.54$	$2.7^{a}\pm0.7$

Data within the same row for each attribute with different letters (superscript) are significantly ($p<0.05$) different

Table 3: Mean sensory scores of taste, appearance and overall acceptability attributes of Fresh water catfish smoked with *A. raddiana, P. julifora,* Neem tree and coconut husks.

Groups	**FCA**	**FCP**
Taste	3.7^{a}±1.3	3.3^{a}±1.1
Appearance	4.6^{a}±0.48	3.5^{a}±1.27
Overall acceptability	4.0^{a}±0.6	3.6^{a}±0.97
	FCA	**FCN**
Taste	3.7^{a}±1.3	4.2^{a}±0.8
Appearance	4.6^{a}±0.48	3.5^{a}±1.5
Overall acceptability	4.0^{a}±0.6	4.4^{a}±0.48
	FCA	**FCC**
Taste	3.7a±1.3	3.6a±1
Appearance	4.6^{a}±0.48	3.5^{a}±0.8
Overall acceptability	4.0^{a}±0.6	3.3^{a}±0.84

Data within the same row for each attribute with different letters (superscript) are significantly ($p<0.05$) different

Table 4: Insect scores of marine and freshwater catfish smoked with *A. Raddiana, P. Julifora,* Neem and Coconut husks during storage in open air

	Day 0	Day 14	Day 21	Day 28	Day 35	Day 48	Day 56
	Insect score						
MCA	0	0	0	0	1	2	3
FCA	0	0	0	0	0	1	2
MCP	0	0	0	0	1	2	3
FCP	0	0	0	0	2	3	3
MCN	0	0	0	0	0	2	2
FCN	0	0	0	0	0	0	1
MCC	0	0	0	0	0	1	1
FCC	0	0	0	0	0	2	3

Table 5: Mould scores of marine and freshwater catfish smoked with *A. Raddiana, P. Julifora*, Neem and Coconut husks during storage in open air

	Day 0	Day 14	Day 21	Day 35	Day 48	Day 56
MCA	0	0	0	0	1	
FCA	0	1				
MCP	0	0	0	2		
FCP	0	1				
MCN	0	0	0	0	2	
FCN	0	0	0	0	0	1
MCC	0	0	0	1	0	
FCC	0	1				

Table 6: Percent Moisture of marine and freshwater catfish smoked with *A. Raddiana, P. Julifora*, Neem and Coconut husks during open air storage

	Day 0	Day 14	Day 21	Day 35	Day 48	Day 56
MCA	16.1±0.15	16.6±0.27	16.4±0.56	16.3±1.83	16.4±0.01	
FCA	13.3±0.41	16.3±0.28				
MCP	16.1±1.13	18.9±0.23	16.6±1.46	21.7±1.82		
FCP	16.8±0.31	18.2±0.83				
MCN	16.0±0.05	18.8±0.4	15.9±0.9	20.5±1.70	19.0±1.6	
FCN	16.6±0.57	15.6±0.02	16.0±1.28	18.3±1.58	17.7±0.94	17.5±1.33
MCC	15.8±0.08	17.4±0.44	16.2±0.35	17.9±0.08		
FCC	15.3±0.09	16.6±0.57				

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