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Microbial Evaluation of Selected Post Harvest Processing Techniques for Quality Fish Product at Bahir Dar Town, Ethiopia

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Abstract

The objective of this study was to evaluate the quality of fish processed by open air rack, solar tent and smoking methods. African catfish (*Clarias gariepinus*) was filleted, washed, sliced, brine salted and processed by the selected methods, packed in plastic bags and stored at room temperature. Abalo (*Brucea antidysenterica*) and Olic tree (*Olea europaea*) were used as smoking wood. For moisture content test, 25 g of processed fish was put in an oven at 105°C and weight change of the samples was measured until the change become constant. It was calculated as the difference between the initial and final weight. Twenty-five gram of processed fish was taken aseptically and standard procedures of dilution and spread plating were done based on the type of microorganism to be identified. Then, the number of colonies were counted and changed into log 10 cfu/g. Solar tent reduced the moisture content to 20% and 23% for Nile tilapia and African catfish, respectively. Microbial load of solar tent dried fish samples was below the standard norm than open air rack and smoking methods. There was statistical difference between treatments (p=0.05). Solar tent drier produced better quality of fish product.

Keywords: *Clarias gariepinus*; Solar tent; Microbial count; Moisture content; Quality

Introduction

Fish is a highly nutritious food for providing high quality protein and income to many people in the developing world [1]. In Africa, 5% of the population (35 million people) depends on the fisheries sector for their livelihood [2]. However, fish is one of the most perishable of all the foods because it is a suitable medium for growth of microorganisms after death [1]. In the tropics at ambient temperature fish will spoil within 12-20 hrs depending on species and method of capture [3].

Lake Tana, the largest lake in Ethiopia, creates job opportunity for 3,514 fishers [4]. Most communities engaged in fisheries of *L. Tana* have been experiencing significant loss. Fish postharvest loss in Lake Tana is more than 30%, excluding low value fish parts [5]. Losses occur as a result of flaws in the handling, storage, distribution, processing and marketing techniques. Traditional fish processing and preservation method is the only method used to dry fish in the study area where the price of the such fish is very low due to quality problems affecting the fishers' livelihood and nutrient loss for the consumers. Hence, it is important to identify appropriate improved fish processing methods to reduce postharvest fish loss, increase quality, and market value and their income. This could be by upgrading the traditional fish processing technology and adoption of solar dryer [6]. Therefore, the main purpose of this study was to evaluate the quality of fish processed by solar tent, open air rack and smoking methods.

Materials and Methods

Description of the study area

The study was conducted in Bahir Dar town, capital of Amhara National Regional State. It is located 565 km North-Western from the capital city of Ethiopia, Addis Ababa, at 11° 4'N and 37° 3'E. The altitude is 1800 masl. The minimum and maximum temperature is 9°C and 34°C, respectively, with annual rainfall of 1300 mm (National Meteorology Agency Bahir Dar Branch, 2011).

Sample preparation and processing

Sample of African Catfish (Clarias gariepinus) was used. For the drying method, the sample was gutted, filleted and sliced using knife and washed thoroughly; 3 kg of fillet was used for each treatment. Then it was soaked in 16% brine solution for 30 minutes, drained and arranged on rack. For smoking method, the fish was only gutted and washed thoroughly. Then it was soaked in 16% brine solution until the colour of the eye become white. Immediately after the completion of fish sample preparation, it was processed by using open air rack, solar tent and smoking methods. After the processing was completed, the sample was packed in plastic bags and stored at ambient temperature with no preservative.

Open air rack drying

For open air drying, rack was used. The rack, bed like rectangular structure, was made up of wood frames and plastic ropes to avoid rusting of wire mesh (Figure 1). The fish was arranged on the rack and placed on the open air to be dried by the direct sunlight and the flow of air.

Figure 1: Open air/sun drying rack.

Solar tent drying

Solar tent was made up of wood frame and transparent polythene sheet which was 1.70 m length, width and height (Figure 2A and 2B) with constructed ventilation located at the top of the tent made up of wire mesh which was vermin proof. Black plastic sheet was put on the ground inside the tent to increase heat trapping capacity of the tent. Fish sample was arranged on the rack and put inside the drying tent.

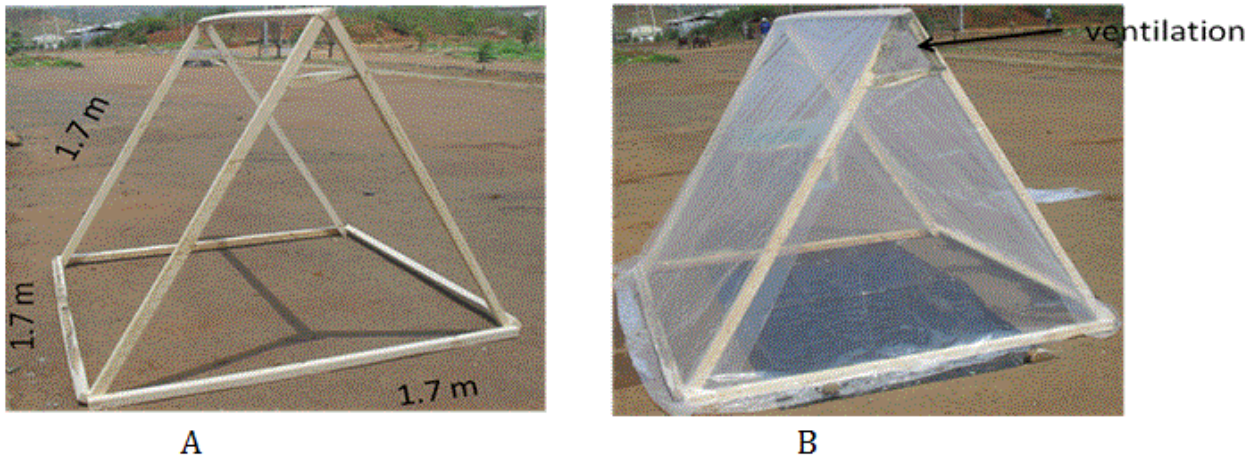

Figure 2: Solar tent frame (a) and solar tent covered with polythene sheet (b).

Smoking

Smoking was done by using rectangular iron sheet having container like structure (Figure 3). It had two doors; lower opening to supply and control the fire for smoke and the upper for inserting and checking of fish samples.

Figure 3: Smoking unit.

The sample was hanged over by metal rods arranged on top of the smoking unit. It had also three small opening at the top to escape the smoke. Abalo (*Brucea antidysenterica*) and Olic tree (*Olea europaea*) woods were used to produce smoke. The fish was turned at intervals and smoked for 8 hrs and cooled. The smoking process followed surface drying, smoking and cooling procedures. Surface drying is the removal of surface moisture leaving a protein coating (pellicle) on each piece of fish so that it accepts an even smoke deposit and the smoked product will not be fragile soon [7].

Data Collection Methods

Moisture content test

A sample of 25 g of processed fish from each treatment was taken and put in an oven at 105°C. The weight change of the samples was measured until the change becomes constant. The moisture content was calculated as the difference between the initial and final weight.

Microbiological test

Twenty-five gram of each processed fish was taken aseptically and individually transferred to sterile plastic bags. The sample was placed in a sterile standard stomacher bag containing distilled water and peptone water with a dilution ratio of 1:100 and was blended and homogenized for 1 to 2 minutes in a stomacher. Samples were, then, serially diluted (1:10) and spread plated onto various media depending on the type of microorganism to be tested. The microorganisms isolated, media used, incubation and indicator of its presence is shown by Table 1. Then, the number of colonies were counted and changed into log10 cfu/g of sample.

Microorganism	Media used	Incubation		Indicator
		Temperature (°C)	Time (Days)	
Staphylococcus species	Mannitol Salt Agar	37	01-Feb	round white colonies
Enterobacteriaceae	Violet Red Bile Dextrose Agar	37	01-Feb	blue to red-blue colonies
Aerobic mesophilic count	Plate Count Agar	35	01-Feb	
Yeasts and moulds	Potato Dextrose Agar	35	01-Feb	development of black and white colonies

Table 1: Microbiological isolation and identification.

Data analysis

Descriptive statistical analysis was used to analyse the mean and standard deviations of microbial load of samples with respect to the processing methods. One-way ANOVA was used to determine statistical significant difference among fish processing methods. Statistical significance was done at the p=0.05 value. Statistical package SPSS version 18.0 software was used for the analysis.

Results

Drying duration

Fish samples dried with solar tent took shorter period of time, 2.5 days. However, rack drying took 4 days. This can be attributed by the capacity of trapping heat by the tent. Solar tent drier had higher internal temperature, 56°C, than atmospheric temperature which was 27°C.

Moisture content

The moisture content of fish samples processed by solar tent was lower than those processed by open-air rack drying and smoking methods (Table 2). Solar tent reduced the moisture content to 23%. Solar tent reduced the moisture content to below 25% where the growth of bacteria and moulds is suppressed.

Treatment	Moisture content (%)
Solar tent dried	23
Open air rack dried	31
Smoked	41

Table 2: Moisture content of African catfish sample treated by different processing technologies.

Microbial count analysis

High yeast and mould, total plate count (TPC), *S. aureus* and *Enterobacteriaceae* count was found in open air dried catfish samples (Table 3). This high load may come from higher load from raw materials and environmental contamination since it is exposed to open atmosphere. Lower yeast and mould, total plate count (TPC), *S. aureus* and *Enterobacteriaceae* counts were found at the fish sample processed by solar tent drying (Table 3). Smoked fish samples had lowest yeast and mould counts, but, it was only for 15 days of storage that the sample had low yeast and mould count (Table 3). There was significant difference (p=0.05) between treatments.

Storage time (days)	Yeast and mould			Total plate count			*Staphylococcus* species			*Enterobacteriaceae*		
	Solar dried	Rack dried	Smoked	Solar dried	Rack dried	Smoked	Solar dried	Rack dried	Smoked	Solar dried	Rack dried	Smoked
0	3.54 ± 0.01^{d}	8.39 ± 0.02^{e}	3.24 ± 0.00	3.69 ± 0.06^{e}	7.69 ± 0.04^{d}	3.72 ± 0.02	3.16 ± 0.04^{f}	7.55 ± 0.02^{c}	ND	ND	5.81 ± 0.03^{f}	ND
15	4.55 ± 0.03^{a}	8.63 ± 0.04^{d}	5.26 ± 0.11	3.90 ± 0.00^{d}	7.93 ± 0.02^{c}	6.16 ± 0.00	3.45 ± 0.07^{e}	8.08 ± 0.05^{b}	4.14 ± 0.08	1.30 ± 1.84^{b}	5.90 ± 0.00^{e}	2.60 ± 0.00
30	3.56 ± 0.03^{d}	7.15 ± 0.17^{f}		4.35 ± 0.06^{c}	8.37 ± 0.06^{b}		3.63 ± 0.04^{d}	7.93 ± 0.01^{b}		3.46 ± 0.085^{a}	5.57 ± 0.04^{g}	
45	4.00 ± 0.00^{c}	9.72 ± 0.03^{a}		4.80 ± 0.03^{a}	8.48 ± 0.04^{b}		3.58 ± 0.06^{d}	8.07 ± 0.04^{b}		3.32 ± 0.02^{a}	6.90 ± 0.00^{d}	
60	4.27 ± 0.10^{b}	9.24 ± 0.09^{b}		4.60 ± 0.02^{b}	8.45 ± 0.05^{b}		4.33 ± 0.04^{c}	8.93 ± 0.00^{a}		3.45 ± 0.06^{a}	7.81 ± 0.01^{c}	
75	4.48 ± 0.04^{a}	8.87 ± 0.01^{c}		4.79 ± 0.02^{a}	9.18 ± 0.12^{a}		3.71 ± 0.01^{a}	8.82 ± 0.22^{a}		3.64 ± 0.04^{a}	8.76 ± 0.01^{b}	

90	4.28 ± 0.03^{b}	9.59 ± 0.03^{a}		4.68 ± 0.01^{b}	9.10 ± 0.06^{a}		4.59 ± 0.04^{b}	9.00 ± 0.01^{a}		3.62 ± 0.02^{a}	8.87 ± 0.01^{a}	

Table 3: Microbial load of African catfish (*C. gariepinus*) processed by solar tent, open air rack and smoking methods (log10 of cfu/g). All values are means of duplicate ± standard deviation. Means with the same superscript letters within a column are not significantly different (p=0.05).

Discussion

Drying duration

The drying duration of solar tent was shorter than open air rack drying method. Hot air might be trapped by a black plastic sheet put on the floor inside the tent. The opening designed by a wire mesh would reduce the humidity inside the tent. These conditions caused the sample to be dried faster than rack open air/sun drying methods. The result agreed with the studies conducted by different authors. Assefa et al. [8,9] reported that the time taken to dry tilapia with solar tent was one and half days and African Catfish was dried one day later.

Moisture content

Moisture loss rate of solar tent dryer was higher than open air rack dryer and smoking methods. The black plastic sheet put on the ground inside solar tent trapped heat and the tent maintained high heat inside the tent resulting higher temperature, hence, increased moisture loss rate and reduced moisture content. This result is agreed with [8,9] in which solar drying resulted in lower moisture content than rack drying and rock drying. Solar tent reduced moisture content of tilapia (*O. nilaticus*) to 18.51% [10]. If the moisture content of fish is reduced to 25%, spoilage bacteria can't survive as lower moisture content inhibits growth of bacteria and moulds [11]. The result obtained from this study showed that the final moisture content of solar tent dried fish samples was below the specified critical value (25%). This can be explained by the capacity of the solar tent to maintain high internal heat, which had reached up to 56°C.

Microbial count

Yeast and mould count: High yeast and mould count was found in open air dried tilapia and catfish samples (Table 3). Open air dried fish samples were significantly different (p=0.05) and highest yeast and mould count from other treatments 7.82 ± 0.47 and 8.80 ± 0.84 for tilapia and catfish, respectively. This highest yeast and mould count might come from high yeast and mould load from raw materials and environmental contamination since it is exposed to open atmosphere. Fungi generally prefer substrate with low water activity and usually very high on dry fish samples [12]. The water activity in dried products is low and in favor moulds which spore are spread by air since fish samples are exposed to the ambient atmosphere.

Lower yeast and mould count was found on fish samples dried by solar tent (Tables 3). The reason for this may go to the processing condition (Table 4). It was dried under relatively higher temperature (560°C) with constructed ventilation and protected from environmental contamination by the tent. The higher internal temperature enabled the sample to have relatively higher moisture loss rate. Dehydration preserves fish by destroying enzymes and removing the moisture necessary for bacterial and mold growth [7].

Smoked fish samples had lowest yeast and mould counts, but, it was only for 15 days of storage that the sample had low yeast and mould count. Smoked fish are preserved primarily by control of salt and moisture content. However, smoke deposition is effective only in controlling surface spoilage [13].

Total plate count: Total plate count (TPC) indicates the level of microorganisms in a product [14]. Higher TPC was found on open air rack dried fish samples (Tables 3 and 4). The TPC of open air dried fish samples was significantly different (p=0.05). Rahman et al. [7] reported that the drying temperature of 50°C or below has no lethal effect on the microflora. Therefore, relatively lower atmospheric temperature during drying, exposure towards the open atmosphere, post-processing contamination during packaging and/or higher microbial load of raw material contributed to higher TPC for open air dried tilapia and catfish samples. The logic behind this mainly focused on the exposure of the fish samples to the open environment. This reason is because fish products treated at the open environment with low level of temperature in which microorganisms are found anywhere is expected to have high microbial load specifically aerobic plate count.

Fish samples processed by solar tent drying method had lower TPC (Tables 3 and 4). This is because of simultaneous reaction of brining, relatively higher temperature and protection of the samples from environmental contamination. According to Hardy [15] salting converts fresh fish into shelf-stable products by reducing the moisture content and acting as a preservative. Moreover, the bacterial load of dried fish decreased due to removal of water level below that needed for microbial growth and enzyme activity [16]. Drying process remove enough moisture from fish to a limit that greatly decreases these destructive effect [17]. This microbial load is even lower than the study conducted by Ahmed [17] where the total number of bacterial count for dried African catfish (*Clarias gariepinus*) was 5.75 ± 5.5 (log10 cfu/g).

The TPC of smoked fish samples was initially low because of brining, relatively high temperature treatment and anti-microbial effect of smoke, however, the lower total count was only for 15 days of storage. This can be attributed by the higher moisture content (Catfish (44%) and Tilapia (35%) of smoked fish. The level of growth of microorganisms on the smoked fish depends on the amount of water which has been expelled from them [18] and smoke deposition is effective only in controlling surface spoilage [13]. This result is agreed with Getachew [19] in which the microbial load of smoked tilapia samples stored at room temperature reached maximum level after 15 days of storage.

Staphylococcus aureus count: Higher S. aureus count was found on open air rack dried fish samples; 7.56 ± 0.31 and 8.34 ± 0.55 for tilapia and catfish, respectively (Tables 3 and 4). Relatively lower temperature during processing, exposure to the open atmosphere, post-processing contamination during packaging and/or higher microbial load of raw material contributed to higher staphylococcus count for open air dried tilapia and catfish samples (Tables 3 and 4). The staphylococcus load of open air dried fish samples was significantly different (p=0.05). The reason behind might be the exposure of the fish samples to the open environment. Samples processed by sun drying appeared to be of poor

microbiological quality since *E. coli, S. aureus* and moulds were detected at concentrations above recommended norms [12] sun drying reduces microbial loads but did not eliminate completely contaminant in most samples.

Lower *S. aureus* count was scored for fish samples processed by solar tent drying method (Tables 3 and 4). In smoke dried fish samples *E. coli*, *S. aureus* and enterococci were totally absent [12]. Since the processing temperature was relatively higher the vegetative microbes will be destroyed.

Enterobacteriaceae count: *Enterobacteriaceae* is a large family of bacteria including many of the more familiar pathogens, such as *Salmonella, Escherichia coli, Shigella* species etc. Usually, its occurrence in a final product is due to contamination during processing by an infected asymptomatic carrier with poor personal hygiene [20].

Enterobacteriaceae count in Nile tilapia and African catfish processed by smoking and solar tent drying was not detected until 15 days of storage for Nile tilapia and at zero-time for African catfish. But very low count was found after the later days (Tables 3 and 4). This was because mainly smoking process was gone for high temperature for longer time duration (8 hours).

After the treatment, if there is no post contamination due to poor hygiene of the processors the smoked fish (especially hot smoked) is free from pathogenic micro-organisms. *Enterobacteriaceae* load was high and significantly different (p=0.05) from other processing techniques for fish samples processed by open air drying.

Open air rack drying	Solar tent drying
Not covered/protected	Covered/protected by polythene sheet
Environmental factor is very high	Environmental factor is low
Less temperature value	High temperature value
High environmental contamination	Low environmental condition
High incidence of flies	No incidence of flies
More responsive to changes in atmospheric condition	Less responsive to changes in atmospheric condition
Long time to dry	Short time to dry

Table 4: Comparison of open air rack and solar tent drying methods.

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