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Impact of Varying Salt Concentrations and Storage Containers on the Shelf life and Fungal Growth Associated with Hot Smoked *Micromesistius poutassou*

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ABSTRACT

This study investigates the impact of varying salt concentrations and storage containers on the shelf life and fungal growth associated with hot smoked *Micromesistius poutassou*. Fresh *M. poutassou* samples were treated with salt concentrations of 0 g/L (control), 5 g/L, 10 g/L, 20 g/L, and 30 g/L before smoking using the NIOMR smoking kiln. The smoked samples were then stored for 28 days in paper cartons and bamboo baskets. Weekly analysis included isolation and identification of stored fungi, as well as proximate composition assessment of the smoked fish samples. Results revealed the presence of *Aspergillus*, *Penicillium*, *Botrytis*, *Rhizopus stolonifer*, *Fusarium*, *Mucor*, *and Macrophemina* fungi species. Additionally, protein, moisture, and fat content decreased significantly, while ash content increased across all salt concentrations in both cartons and bamboo baskets over the storage period. This study concludes that the nutritional quality of smoked *M. poutassou* declines with prolonged storage time.

Key words:
shelf life, storage containers, salting, Proximate composition, Salting

Introduction

Proximate composition of fish flesh is regarded as a reliable predictor of the fish's quality and nutritional value and aids in understanding its better processing and preservation (Ahmed *et al*., 2022). Proximate composition of foods includes moisture, ash, lipid, protein and carbohydrate contents. According to Begum *et al.* (2012), 96 %−98 % of the body composition of fish is constituted by moisture, protein, fat and ash. The evaluation of these components is known as the 'proximate composition' of fish (Rani *et al*., 2016). Smoking is a method that utilizes smoke to introduce flavour, taste, and preservative ingredients such as phenolics, acetiand carbonyls, into fish. It is one of the oldest methods used to process and preserve food and helps slow fish deterioration, thereby giving the commodity a longer shelf-life (Mahmud *et al*., 2018). Cold and hot smoking are the two main categories of smoking processes. Cold-smoked fish are done below 30 °C to prevent undesired changes in the muscle texture. During hot smoking, the temperature of smoke ranges from 60 ^{0}C – 80 ^{0}C (Cyprian *et a*l., 2015). Salting is one of the oldest and commonly used processing techniques for fish preservation all over the world because of the simplicity of the process and low production cost. Salting increases the shelf life of fish

and provides desirable sensory changes, it reduces water activity and inhibits the growth of microorganisms and enzymatic spoilage (Faralizadeh *et al*., 2016). The commonly used packaging materials for smoked fish include baskets, sacks, wooden rackets and paper cartons. The purpose of packaging is to prevent rehydration and also to protect the product from physical, chemical and biological damage (Oyedokun, 2020). The aim of this study is to determine the impact of varying salt concentrations and storage containers on the shelf life and fungal growth associated with hot smoked *Micromesistius poutassou*.

Materials and Methods

Sample collection

Twenty-five kilogram (25 kg) of *M. poutassou* was purchased and weighed using the TCS-L Electronic platform scale. Fish (*M. poutassou*) were gutted, washed and placed in clean plastic basin.

Sample Processing

The fish (*M. poutassou*) was divided into five portions of 5 kg each and five treatment of brine solution; Control (T1), T2 (5 g/L) T3 (10 g/L), T4 (20 g/L) and T5 (30 g/L) were prepared. One portion of 5 kg of *M. poutassou* was subjected to salt treatment respectively for 30 minutes.

Smoking Process

Fish were smoked with NIOMR smoking kiln for 7 hours between 60 ^{0}C – 80 ^{0}C with temperature monitored by gun thermometer and cooled at room temperature after smoking.

Shelf life determination

After smoking, each treatment was divided into two parts and packed into 2 different containers; paper carton and basket at temperature (26 ^{0}C - 28 ^{0}C) for 4 weeks.

Proximate analysis

Proximate analysis was carried out on random sample from each storage container weekly in triplicates using AOAC, (2012).

Isolation and identification of isolated fungi

Potato Dextrose Agar (PDA) prepared according to manufacturer's instruction was used for isolation of fungi from each storage container. Using the pour plate method of Pitt and Hockings, (2009), a part of the storage fish (*M. poutassou*) was plated directly on freshly prepared PDA plates in triplicates. These were incubated at 30 ^{0}C for 3 – 5 days. Fungal morphological features were observed and noted. With the aid of a compound microscope attached to a digital camera (Miotic Mccamera 2.0 megapixel), the microscopy characteristics of the isolated fungi were recorded.

Molecular identification of isolated fungi

DNA Extraction and polymerase chain reaction (PCR)

Fungal isolates were used for DNA extraction using Zymo research kit Quick DNA™.

PCR amplification was carried out by universal primers, TS1 (5' TCC GTA GGT GAA CCT GCG G 3') and ITS4 (5'TCC TCC GCT TAT TGA TAT GC 3'). PCR reaction was performed with 30µl reaction volume containing 7.5 µl nuclease-free water, 4.5 µl genomic DNA (5-10 ng), 15 µl of master

mix (5X FIREPol, Solis Biodyn) and 1.5 µl of ITS-1 and ITS-4. Thermal cycler (model GTC96S, cleaver scientific, UK) was employed for PCR amplification.

Sequencing

PCR amplicons of isolates were purified and sequenced by Inqaba Biotec (South Africa). Raw sequences were trimmed and edited using Sequencher 5.4.6. Build 46289 and BioEdit Sequence Alignment Editor. Sequence homology and sequence alignment was done using NCBI-BLASTn tool and ClustalW in MEGA 7 respectively.

Statistical Analysis.

Proximate composition of hot smoked *M. poutassou* are presented as mean ± standard deviation (SD) of three replicates and subjected to one-way ANOVA followed by Duncan multiple range test (DMRT) using SPSS version 25.0 software. Level of significance was set at $P<0.05$ T-Test to compare significant difference in basket and paper carton storage containers.

Results

Storage fungi from smoked *M. poutassou* were observed in both storage containers. Table 5 shows i**so**lated fungi from *M. poutassou* in storage container A (paper carton). First, second and third week of storage, no fungi growth was observed in all the treatments (T1, T2, T3, T4 and T5) in both containers. In the fourth week patches of mould were observed in T1 T2 and T3 while T4 and T5 had no fungal growth. *A. niger, A. flavus, Penicillium species, Fusarium, Rhizopus stolonifer, mucor and Botrytis* were found to be associated with smoked *M. poutassou*) stored in paper cartoon. Table 6 shows i**so**lated fungi from *M. poutassou* in storage container B (bamboo basket). First and second week of storage recorded no fungal growth. In the third week, patches of mould were observed in T1 and T2. In the fourth week, treatments T1 and T2 were completely covered with mould while patches of mould were observed in treatments T3 and T4, no fungal growth was observed in treatment T5. *A. niger, A. flavus, A. fumigatus, Penicillium species, Rhizopus stolonifer, mucor and macrophemena* were found to be associated with smoked *M. poutassou* stored in basket.

The mean percentages of Moisture contents in smoked *M. poutassou* across different concentrations stored in carton and basket are presented in Tables 1a and 1b. The mean moisture content of smoked *M. poutassou* ranged between 12.33 ± 0.03 % and 17.82 ± 0.10 % and 12.36 ± 0.12 % and 21.37 ± 0.12 % stored in carton and basket at day 0 and 28 respectively. There was significant differences ($p<0.05$) in the Moisture contents of smoked *M. poutassou* across the preserved salt concentrations stored in carton and basket. T-Test revealed significant differences ($p<0.05$) between carton and basket storage.

The mean percentages of Protein contents in smoked *M. poutassou* across different concentrations stored in carton and basket are presented in Tables 2a and 2b. Protein content value of hot smoked *M. poutassou* ranged between 36.50 ± 1.09% to 56.45 ± 0.59% and 31.00% ± 1.15 to 56.45 ± 0.59% for carton and basket storage at day 28 and 0 respectively. Significant differences ($p<0.05$) was observed in Protein contents of smoked *M. poutassou* across all preserved salt concentrations stored in baskets and carton and also between paper carton and basket storage.

The mean percentages of Ash contents in smoked *M. poutassou* across different concentrations preserved in carton and basket are presented in Tables 3a and 3b.The Ash content of smoked *M. poutassou* recorded highest and lowest mean percentage of 19.66 ± 0.11% to 3.57% ± 0.01 and 17.99 ± 0.01% to 3.57 ± 0.01% in carton and basket at day 28 and 0 respectively. There was significant differences ($p<0.05$) in the Ash contents of smoked *M. poutassou* across the treated concentrations stored in cartons and baskets. No significant differences ($p>0.05$) between carton and baskets storage.

The mean percentages of Fat contents in smoked *Micromesistius poutassou* across different concentrations and stored in carton and basket are presented in Tables 4a and 4b. The Fat content of smoked *M. poutassou* stored in paper carton and basket ranged between 25.48 % ± 0.27 - 12.33 % ± 0.15 and 25.48 % ± 0.27 - 12.60 % ± 0.36 at day 0 28 respectively. There were significant differences ($p<0.05$) in the Fat contents of smoked *M. poutassou* across the preserved concentrations stored in cartons and baskets. No significant differences ($p>0.05$) between paper carton and baskets containers.

Table 1a: Mean percentage variations of Moisture contents of salt treated hot smoked *Micromesistius poutassou* stored in carton
Salt Concentration g/L

DAYS	Moisture_0	Moisture_5	Moisture_10	Moisture_20	Moisture_30
DAY 0	15.66 ± 0.01^{a}	15.22 ± 0.02^{a}	14.46 ± 0.07^{a}	14.25 ± 0.17^{a}	12.33 ± 0.09^{a}
DAY 7	15.92 ± 0.01^{b}	15.44 ± 0.07^{a}	15.66 ± 0.07^{b}	15.16 ± 0.11^{b}	13.36 ± 0.03^{b}
DAY 14	16.68 ± 0.09^{c}	16.84 ± 0.08^{b}	16.32 ± 0.03^{c}	16.73 ± 0.13^{c}	14.10 ± 0.04^{c}
DAY 21	17.22 ± 0.10^{d}	17.38 ± 0.01^{c}	17.03 ± 0.06^{d}	16.92 ± 0.08^{cd}	15.70 ± 0.09^{d}
DAY 28	17.82 ± 0.07^{e}	17.66 ± 0.14^{d}	17.30 ± 0.02^{e}	17.24 ± 0.11^{d}	16.08 ± 0.01^{e}

Alphabets with similar superscript ‘a’ indicates no significant difference ($p>0.05$)

Table 1b: Mean percentage variations of Moisture contents of salt treated hot smoked *Micromesistius poutassou* stored in basket
Salt Concentration g/L

DAYS	Moisture_0	Moisture_5	Moisture_10	Moisture_20	Moisture_30
DAY 0	15.66 ± 0.01^{a}	15.09 ± 0.06^{a}	14.46 ± 0.07^{a}	14.25 ± 0.17^{a}	12.36 ± 0.12^{a}
DAY 7	16.32 ± 0.11^{b}	16.16 ± 0.02^{b}	15.08 ± 0.04^{b}	14.83 ± 0.04^{b}	13.42 ± 0.10^{b}
DAY 14	18.93 ± 0.05^{c}	16.54 ± 0.14^{c}	17.23 ± 0.01^{c}	16.42 ± 0.16^{c}	15.46 ± 0.00^{c}
DAY 21	19.59 ± 0.10^{d}	17.41 ± 0.02^{d}	17.88 ± 0.04^{d}	16.87 ± 0.03^{d}	16.59 ± 0.10^{d}
DAY 28	21.37 ± 0.12^{e}	18.84 ± 0.06^{e}	18.17 ± 0.04^{e}	17.39 ± 0.12^{e}	17.22 ± 0.07^{e}

Alphabets with similar superscript ‘a’ indicates no significant difference ($p>0.05$)

Table 2a: Mean percentage variations of Protein contents of salt treated hot smoked *Micromesistius poutassou* stored in carton
Salt Concentration g/L

DAYS	Protein_0	Protein_5	Protein_10	Protein_20	Protein_30
DAY 0	56.45 ± 0.59^{c}	43.51 ± 1.14^{c}	42.88 ± 1.70^{a}	41.52 ± 1.35^{a}	40.37 ± 1.18^{b}
DAY 7	55.48 ± 0.83^{bc}	42.50 ± 1.04^{bc}	42.21 ± 1.71^{a}	40.41 ± 1.60^{a}	39.03 ± 1.37^{b}
DAY 14	54.38 ± 0.85^{abc}	41.63 ± 0.87^{abc}	41.12 ± 1.66^{a}	39.85 ± 1.13^{a}	38.62 ± 0.90^{ab}
DAY 21	53.21 ± 0.7^{ab}	40.10 ± 0.87^{ab}	40.05 ± 1.82^{a}	38.71 ± 1.26^{a}	37.28 ± 0.85^{ab}
DAY 28	52.45 ± 0.63^{d}	40.46 ± 0.78^{c}	37.44 ± 1.72^{b}	36.50 ± 1.09^{b}	35.45 ± 1.01^{a}

Alphabets with similar superscript 'a' indicates no significant difference ($p>0.05$)

Table 2b: Mean percentage variations of Protein contents of salt treated hot smoked *Micromesistius poutassou* stored in basket
Salt concentration g/L

DAYS	Protein_0	Protein_5	Protein_10	Protein_20	Protein_30
DAY 0	56.45 ± 0.59^{d}	43.51 ± 1.14^{c}	42.88 ± 1.70^{c}	40.52 ± 1.35^{c}	40.37 ± 1.18^{c}
DAY 7	55.79 ± 0.31^{d}	42.79 ± 0.67^{bc}	39.89 ± 0.62^{b}	39.05 ± 1.54^{bc}	38.08 ± 1.17^{c}
DAY 14	54.62 ± 0.04^{c}	41.19 ± 0.67^{bc}	37.27 ± 0.69^{ab}	37.91 ± 1.31^{bc}	35.35 ± 1.83^{bc}
DAY 21	52.90 ± 0.26^{b}	40.54 ± 0.26^{ab}	35.98 ± 0.49^{a}	35.03 ± 1.48^{ab}	33.84 ± 1.65^{ab}
DAY 28	51.15 ± 0.29^{a}	38.51 ± 0.77^{a}	34.75 ± 0.02^{a}	32.35 ± 1.15^{a}	31.00 ± 1.21^{a}

Alphabets with similar superscript 'a' indicates no significant difference ($p>0.05$)

Table 3a: Mean percentage variations of Ash contents of salt treated hot smoked *Micromesistius poutassou* stored in carton
Salt concentration g/L

DAYS	ASH_0	ASH_5	ASH_10	ASH_20	ASH_30
DAY 0	3.57 ± 0.01^{a}	4.06 ± 0.02^{a}	4.57 ± 0.11^{a}	5.81 ± 0.08^{a}	6.69 ± 0.07^{a}
DAY 7	9.88 ± 0.03^{b}	10.26 ± 0.03^{b}	10.92 ± 0.02^{b}	11.26 ± 0.03^{b}	11.89 ± 0.03^{b}
DAY 14	10.37 ± 0.08^{c}	10.87 ± 0.07^{c}	11.95 ± 0.03^{c}	12.44 ± 0.06^{c}	13.54 ± 0.11^{c}
DAY 21	11.82 ± 0.06^{d}	12.15 ± 0.06^{d}	12.82 ± 0.05^{d}	13.53 ± 0.13^{d}	14.91 ± 0.05^{d}
DAY 28	17.25 ± 0.04^{e}	17.84 ± 0.05^{e}	18.32 ± 0.13^{e}	18.83 ± 0.11^{e}	19.66 ± 0.11^{e}

Alphabets with similar superscript 'a' indicates no significant difference ($p>0.05$)

Table 3b: Mean percentage variations of Ash contents of salt treated smoked *Micromesistius poutassou* stored in baskets
Salt Concentration g/l

DAYS	ASH_0	ASH_5	ASH_10	ASH_20	ASH_30
DAY 0	3.57 ± 0.01^{a}	4.06 ± 0.02^{a}	4.57 ± 0.11^{a}	5.21 ± 0.13^{a}	6.69 ± 0.07^{a}
DAY 7	9.74 ± 0.00^{b}	10.03 ± 0.03^{b}	10.75 ± 0.03^{b}	11.62 ± 0.10^{b}	12.45 ± 0.07^{b}
DAY 14	11.09 ± 0.05^{c}	11.68 ± 0.06^{c}	11.78 ± 0.07^{c}	12.12 ± 0.07^{c}	12.51 ± 0.05^{b}
DAY 21	12.87 ± 0.02^{d}	12.98 ± 0.01^{d}	13.84 ± 0.08^{d}	14.54 ± 0.03^{d}	14.97 ± 0.01^{c}
DAY 28	16.43 ± 0.04^{e}	16.75 ± 0.04^{e}	17.06 ± 0.03^{e}	17.48 ± 0.07^{e}	17.99 ± 0.00^{d}

Alphabets with similar superscript ‘a’ indicates no significant difference (p>0.05)

Table 4a: Mean percentage variations of Fat contents of salt treated hot smoked *Micromesistius poutassou* stored in paper carton
Salt Concentration g/L

DAYS	Fat_0	Fat_5	Fat_10	Fat_20	Fat_30
DAY 0	23.67 ± 0.34^{d}	24.05 ± 0.35^{d}	24.77 ± 0.36^{d}	25.10 ± 0.38^{d}	25.48 ± 0.27^{c}
DAY 7	19.22 ± 0.51^{c}	18.50 ± 0.33^{c}	18.83 ± 0.00^{c}	18.42 ± 0.24^{bc}	19.84 ± 0.05^{b}
DAY 14	19.12 ± 0.45^{c}	16.62 ± 1.04^{bc}	17.46 ± 0.93^{c}	18.57 ± 0.83^{c}	20.43 ± 0.23^{b}
DAY 21	17.91 ± 0.08^{b}	15.46 ± 0.92^{ab}	15.44 ± 0.38^{b}	16.79 ± 0.52^{b}	18.50 ± 0.38^{b}
DAY 28	12.33 ± 0.15^{a}	13.88 ± 0.17^{a}	13.45 ± 0.76^{a}	13.36 ± 0.44^{a}	15.56 ± 1.49^{a}

Alphabets with similar superscript ‘a’ indicates no significant difference (p>0.05

Table 4b: Mean percentage variations of Fat contents of salt treated hot smoked *Micromesistius poutassou* stored in basket
Salt Concentration g/L

DAYS	Fat_0	Fat_5	Fat_10	Fat_20	Fat_30
DAY 0	23.67 ± 0.34^{c}	24.05 ± 0.35^{c}	24.77 ± 0.36^{d}	25.10 ± 0.38^{c}	25.48 ± 0.27^{c}
DAY 7	19.49 ± 0.33^{b}	19.26 ± 0.30^{b}	18.61 ± 1.20^{c}	$18.\ 57 \pm 0.14^{b}$	18.97 ± 0.02^{b}
DAY 14	18.05 ± 0.31^{ab}	18.71 ± 0.31^{b}	15.78 ± 0.33^{b}	17.67 ± 0.10^{b}	18.17 ± 0.66^{b}
DAY 21	17.83 ± 1.06^{ab}	18.32 ± 0.30^{b}	14.73 ± 0.45^{b}	15.05 ± 0.39^{a}	18.88 ± 0.01^{b}
DAY 28	16.15 ± 1.16^{ab}	15.44 ± 1.55^{a}	12.60 ± 0.36^{a}	15.14 ± 0.30^{a}	14.56 ± 0.73^{a}

Alphabets with similar superscript ‘a’ indicates no significant difference (p>0.05

Table 5: Occurrence of isolated fungi from *Micromesistius poutassou* in storage container A (paper carton)

Storage Period	Treatment (salt concentration)	*Aspergillus niger*	*Aspergillus fumigatus*	*Penicillum*	*Botrytis*	*Rhizopus stolonifer*	*Fusarium*	*Mucor*	*flavus*	*Macrophemina*
1st week	TI (0) control	-	-	-	-	-	-	-	-	-
	T2 (5 g/L)	-	-	-	-	-	-	-	-	-
	T3 (10 g/L)	-	-	-	-	-	-	-	-	-
	T4 (20 g/L)	-	-	-	-	-	-	-	-	-
	T5 (30 g/L)	-	-	-	-	-	-	-	-	-
2nd week	TI (0) control	-	-	-	-	-	-	-	-	-
	T2 (5 g/L)	-	-	-	-	-	-	-	-	-
	T3 (10 g/L)	-	-	-	-	-	-	-	-	-
	T4 (20 g/L)	-	-	-	-	-	-	-	-	-
	T5 (30 g/L)	-	-	-	-	-	-	-	-	-
3rd week	TI (0) control	-	-	-	-	-	-	-	-	-
	T2 (5 g/L)	-	-	-	-	-	-	-	-	-
	T3 (10 g/L)	-	-	-	-	-	-	-	-	-
	T4 (20 g/L)	-	-	-	-	-	-	-	-	-
	T5 (30 g/L)	-	-	-	-	-	-	-	-	-
4th week	TI (0) control	+	+	+	+	+	-	+	+	-
	T2 (5 g/L)	+	+	+	-	+	+	+	+	-
	T3 (10 g/L)	+	-	+	-	+	+	-	-	+
	T4 (20 g/L)									
	T5 (30 g/L)									

'+' Positive; '-' Negative; T: Treatment

Table 6: Occurrence of isolated fungi from *Micromesistius poutassou* in storage container B (Basket)

Storage Period	Treatment (salt concentration)	*Aspergillus niger*	*Aspergillus fumigatus*	*Penicillum*	*Botrytis*	*Rhizopus stolonifer*	*Fusarium*	*Mucor*	*flavus*	*Macrophemina*
1st week	TI (0) control	-	-	-	-	-	-	-	-	-
	T2 (5 g/L)	-	-	-	-	-	-	-	-	-
	T3 (10 g/L)	-	-	-	-	-	-	-	-	-
	T4 (20 g/L)	-	-	-	-	-	-	-	-	-
	T5 (30 g/L)	-	-	-	-	-	-	-	-	-
2nd week	TI (0) control	-	-	-	-	-	-	-	-	-
	T2 (5 g/L)	-	-	-	-	-	-	-	-	-
	T3 (10 g/L)	-	-	-	-	-	-	-	-	-
	T4 (20 g/L)	-	-	-	-	-	-	-	-	-
	T5 (30 g/L)	-	-	-	-	-	-	-	-	-
3rd week	TI (0) control	+	-	-	-	+	-	-	+	-
	T2 (5 g/L)	+	-	+	-	-	-	-	+	-
	T3 (10 g/L)	-	-	-	-	-	-	-	-	-
	T4 (20 g/L)	-	-	-	-	-	-	-	-	-
	T5 (30 g/L)	-	-	-	-	-	-	-	-	-
4th week	TI (0) control	+	+	+	+	+	-	+	+	-
	T2 (5 g/L)	+	+	+	-	+	-	+	+	-
	T3 (10 g/L)	+	+	+	-	-	-	-	+	+
	T4 (20 g/L)	+	-	+	-	-	-	-	-	-
	T5 (30 g/L)									

'+' Positive; '-' Negative; T: Treatment

Discussion

Proteins are made up of amino acids held together by a peptide bond (Khalili and Sampels, 2018). The decrease in protein content as salt concentration and storage days increased in both paper carton and basket storage containers in this study is in agreement with Ahmed *et al.* (2018) and Talab and Ghanem, (2021), who stated decrease in protein content of wet salted fermented product (fessiekh) and salted mullet fish with increase in storage time and salt concentrations respectively. This study is not in agreement with Ricketts and Oyero, (2021), who recorded an increase in protein content in *Gymnarchus niloticus* from 56±2.21% to 85.96±0.79% for a period of 28 days storage. The decrease in percentage protein content in this study could be attributed to gradual degradation of initial crude protein to more volatile products such as total volatile bases, hydrogen sulphide and ammonia (Daramola *et al*. (2021) and Rana and Chakraborty, (2016).

This study showed that moisture content increased with increased salt concentration and storage time in both cartoon and basket. This research work is in accordance with Ibrahim (2013) and Ayeloja *et al*. (2020), who reported increase in moisture content as salt concentrations and storage time increased in whole and gutted salted mullet fish and smoked *Oreochromis niloticus* respectively. This study is not in agreement with Talab and Ghanem, (2021), who stipulated that moisture content of salted grey mullet fish kept at ambient temperature decreased as storage days increased. The increase in moisture content in this study may be due to the absorption of moisture from the surrounding atmosphere (Daramola *et al*., 2007).
Ash content increased with increase in salt concentration as storage days increase in both paper carton and basket storage containers. The findings from this study is in accordance with El-Bassir *et al*. (2015) and Jahan *et al*. (2019), that reported an increase in percentage ash content of nutritive value of *Bagrus bayad* and sun-dried ribbon fish (*Trichiurus lepturus*). This study is not in accordance with Rana *et al*. (2019), who recorded decrease in ash content of salt-smoke-dried products kept at different storage condition.
Findings from this study indicated that fat content decreased as salt concentration and storage days increased in both carton and basket. This finding is similar to previous research works of Talab and Ghenem, (2021), that showed decrease in fat content in salted mullet fish with increased storage time and increased salt concentration. Jahan *et al*., (2019,) and Debnath *et al.* (2009) observed higher values of fat content as storage days and salt concentration increased. Decrease in fat content in this study might be due to the leaching of some substances during processing correlated with penetration of salt in muscle (Rana and Chakraborty, 2016).

The result from this study showed that paper carton is a better storage container than basket. This result is in agreement with Oyedokun, (2020), who showed that carton is a better storage container, and may be due to the absorption of oil by the carton, which accounts for low rate of fungi growth. The presence of mould at week 3 in basket container, in this study is similar to the work of other researchers (Abiala *et al.* (2020) and Osibona *et al*. (2018), who isolated *Aspergillus species, Penicillum, Fusarium* and *Rhizopus* and *Mucor* from stored fish.

Conclusion

Storage of smoke-dried *M. poutassou* at ambient temperature and different salt concentrations produced longer shelf life of products than the control (without salt). Although smoke-dried catfish still maintained good appearance till 3rd and 4th week in basket and paper cartoon storage respectively, the nutritional composition have reduced due to increase in moisture content and reduction in protein, ash and fat contents. The longer the smoked *Micromesistius poutassou* stays in storage at ambient temperature, the higher the mould infestation and consequently, the rate of deterioration.

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