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EFFECT OF *MORINGA OLEIFERA* MARINADE ON PROXIMATE COMPOSITION AND SENSORY CHARACTERISTICS OF SMOKE-DRIED AFRICAN CATFISH (*CLARIAS GARIEPINUS*)

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ABSTRACT

The study assessed the effect of *Moringa oleifera* marinade on chemical composition and organoleptic properties of smoke-dried catfish in a 6x8 factorial experiment. The experimental treatments are the control, 1, 2 and 3% (w/v) *Moringa oleifera* Marinade (MOM), 5% brine and 0.2% Butylated Hydroxyl Anisole (BHA) (w/v) solutions. Ninety fishes of average weight of 230±8 g were gutted, washed and randomly assigned to the treatments. Thereafter, the fishes were soaked in the treatments for 2 hours and later hot smoked for 12 hours. After smoking, the fishes were stored in air-free netted boxes and placed on laboratory shelves at room temperature (37±2 °C) for 8 weeks. Samples were taken every seven days for chemical and sensory analysis. The proximate analysis showed that *Moringa oleifera* marinade (MOM) reduced the moisture content of smoke-dried fish samples throughout the storage period. The dehydrating property of MOM was concentration dependent with 3% MOM samples having the lowest moisture content, which was significantly different from other treatments. There was no significant difference in the dehydrating properties of 1% MOM, 2% MOM and salt treated samples. All levels of MOM enhanced and maintained the protein, ash and fat content of smoke-dried fish samples. Sensory scores showed no significant difference among the treatments in terms of color, flavor, juiciness and overall acceptability of fish samples. *Moringa oleifera* marinade could be used to maintain the quality attributes of smoke-dried African catfish stored for 2 months.

INTRODUCTION

Fish received increased attention as a potential source of animal protein and essential nutrients for human diets (Ekpenyong and Ibok, 2012). In addition to its nutritional value, fish play important role in providing incomes and poverty alleviation in both rural and urban areas of many developing countries. Due to the susceptibility of fish to chemical, microbial and physical deterioration, various preservation techniques are put in place to check spoilage (Eyo, 1992). Fish spoilage is a metabolic process that causes fish to be undesirable for human consumption due to changes in sensory and nutritional characteristics. Thus, processing and preservation of fresh fish were of utmost importance to maintain product quality, reduce wastage and prevent economic losses (Olley et al., 2000). Methods of fish preservation include freezing, smoking, canning, sun-drying etc. (Eyo, 1992). Smoking is the oldest and most common method of fish preservation in many developing countries (Kumolu-Johnson et al., 2010). Smoke-dried fish is a traditional part of the diet of a large section of the world's population and it is relished for its appetizing flavor and taste (Kiin-Kabiri et al., 2011). In spite of numerous benefits derived from fish smoking, smoke-dried fish is still susceptible to oxidative and microbial spoilage. Traditionally prepared hot smoke-dried fish products suffer heavy insect infestation, high moisture content, bacteria and fungal attack, which cause reduced shelf life (Tobor, 1984). Hot smoke dried fish is liable to protein degradation due to Millard browning (Gilbert and Knoule, 1975). In addition, smoke deposited on fish during smoking is composed of carboxyl and some poly-nuclear aromatic hydrocarbons, which have been implicated in degenerative diseases such as cancer (Eyo, 2001). In view of the aforementioned problems, it is necessary to enhance the quality attributes and shelf life of smoke-dried fish as well as reduce the hazardous effect of smoke on consumers, hence the use of *Moringa oleifera* marinade. All parts of *Moringa oleifera* possess nutritional and medicinal values (Paliwal et al., 2011a). The leaves contain essential amino acids, vitamins and minerals (Fahey, 2005; Grubben and Denton, 2004). *Moringa oleifera* exhibits potent pharmacological activities, low toxicity and economic viability when compared with synthetic drugs (Paliwal et al., 2011a) and could serve as a functional food (Paliwal et al., 2011b). Myriad phytochemicals present in Moringa are responsible for its pharmacological properties. An examination of the phytochemicals of moringa species affords the opportunity to examine a range of unique compounds (Fahey et al., 2001; Bennett et al., 2003). Various compounds have been isolated from moringa preparations and are reported to have hypotensive, anticancer and antibacterial properties (Daxenbichler et al., 1991; Bennett et al., 2003; Mekonnen and Dräger, 2003). The objective of this study was to determine the effect of *Moringa oleifera* marinade on chemical composition and sensory characteristics of smoke-dried African catfish (*Clarias gariepinus*) stored for two months.

MATERIALS AND METHODS

Preparation of Marinade

Fresh moringa leaves were obtained from the University of Ilorin, Ilorin, Nigeria. The leaves were air dried for 4 days at ambient temperature (37±2 °C) and ground into powder using a food blender (Starlite, Model No:SL-999 CHINA). *Moringa oleifera* marinade (MOM) was prepared by adding separately specific quantity (10 g, 20 g or 30 g) of *Moringa oleifera* leaf powder to 1000 ml of water to form 1, 2 or 3% MOM respectively. 50 g of salt or 2 g of BHA was added separately to 1000 ml of water to form 5% brine or 0.2% BHA solution. No additive was added to the control treatment.

Fish preparation

Ninety catfish samples were purchased from Osagbemi Farms in Ilorin metropolis. The processing and smoking of the fishes were carried out at Godbet Homestead Fish Farm, Basin road, Ilorin, Nigeria. The average weight of the fishes was 230±8 g while the total weight was 20 kg. The fishes were gutted using a sharp knife by cutting laterally from the end of the gill cover through the belly portion to the anus. Thereafter, they were thoroughly washed and rinsed. The total weight of the fish after gutting was 18.5 kg with the average weight of 220±6 g. The fishes were randomly assigned to six experimental treatments: Control, 1% MOM, 2% MOM, 3% MOM, 5% salt and 0.2% BHA. Each treatment was replicated thrice with 5 fishes/replicate. The fishes were soaked in the marinade for 2 hours. Thereafter, the fishes were set in the smoking kiln consisting of five-twin tiers and subjected to hot smoking for 12 hours with charcoal as the heat source. The tiers were interchanged every 3 hours to ensure uniform heat distribution and drying. The smoke-dried fishes were placed in air-free netted boxes to prevent flies infestation and stored at room temperature (37±2 °C) for 8 weeks.

Determination of proximate composition

Proximate compositions of samples were determined in accordance to the method of the Association of Official Analytical Chemists (AOAC, 1994). The proximate component determined are moisture content, crude protein, crude fat (ether extract) and ash. Moisture content was measured by weighing the differences before and after drying the fish and this was done at 100-105 °C for 16 h. Protein content (% N x 65) was determined by the Kjeldahl method. Ash content was determined using dry ashing procedures. Fat content was measured by drying the samples at 100 °C in an oven and then extracting the crude fat with petroleum ether in a Soxhlet extractor for 4 hours.

Sensory analysis

A sixty-member panel conducted the sensory analysis. The taste panelists (assessors) were drawn from staff and students of the Faculty of Agriculture, University of Ilorin. They were instructed on the parameters to adjudge using a 9-point hedonic scale. The hedonic scale is delineated as follows: 9=Like extremely, 8=Like very much, 7=Like moderately, 6=Like Slightly, 5=Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much, 1=Dislike extremely. Water was provided for the panelists to rinse their mouth after each bite to eliminate the taste of the previous fish sample.

Statistical analysis

The experiment followed a 6x8 factorial arrangement in a completely randomized design. The data obtained were analyzed using analysis of the variance (ANOVA) model suitable for the design with the aid of a Genstat discovery program package (fourth edition). The ANOVA model is as follows:

$Y_{ij} = \mu + \alpha_{i+}\beta_j + (\alpha i \times \beta j) + e_{ij}$.

Where Y_{ij} denotes the ij^{th} observation arising from level i of additive and level j of storage time

μ = overall mean

α_i = effect of level i of additive

β_j = effect of level j of storage time

($\alpha_i \times \beta_j$) = interaction effect of additive and storage time

e_{ij} = random error term

RESULTS AND DISCUSSION

There were significant differences ($P<0.01$) in the moisture content of the treatments at various weeks of storage (Table 1). There was a general decrease in moisture content from the first to eight week of storage. This could be attributed to prevailing ambient temperature and relative humidity around the fish samples. Fish samples treated with 3% *Moringa oleifera* marinade (MOM) had the lowest moisture content which was significantly different from that of other treatments throughout the storage period. This was closely followed by 2% MOM, 1% MOM and salt treated samples in that order. There was no significant difference ($P>0.01$) among fish samples treated with salt, 1% and 2% MOM. The control samples had the highest moisture content, which was followed by BHA treated samples. At the end of the eight week, the moisture content of the control and BHA treated samples exceeded the benchmark of 10% (Daramola et al., 2007) and 12% (Sveinsdottir, 1998) when microbial spoilage might occur. The ability of *Moringa oleifera* marinade to decrease the moisture content of the fish sample could result from myriad chemical compounds (that have high dehydrating properties) e.g. calcium salts (Grubben and Denton, 2004), present in *Moringa oleifera* leaves from which the marinade was prepared. Dehydrating properties of salt are well known. Salt decreases the water activity of foods; this mechanism involves transporting salt into food structures and is achieved by various physical and chemical factors such as diffusion, osmosis and a series of complicated chemical and biochemical processes (Turan et al., 2007). Salting is a cheap, popular and effective means of fish preservation (Ayub et al., 2011). A high dehydrating property exhibited by *Moringa oleifera* and salt is beneficial in that microbial deterioration is inhibited thus enhancing the shelf life of smoke-dried fish. In addition, both are cheap and readily available. The moisture content of all *Moringa oleifera* treated samples in the eight week was significantly lower than what was observed in the first week of storage. The moisture content of BHA and control samples followed the same trend. Although, BHA is a potent antioxidant (Adeyemi et al., 2011), it imparted negatively on the moisture content of smoke-dried fish samples.

Moringa oleifera marinade enhanced and stabilized the protein content of smoke-dried fish samples. The crude protein content of all *Moringa oleifera* samples was significantly higher ($P<0.01$) than that of other treatments. The increase in the crude protein content of *Moringa oleifera* samples could be due to the increase in dry matter of processed fish samples as more moisture and volatile compounds are evaporated from the fishes during storage. Except in week 4 and 6, 3% MOM had the highest crude protein content. The control samples had lowest crude protein values that were significantly

different from other treatments in all storage weeks except in the second and third week of storage when BHA samples had the least. The crude protein content of salt treated samples was higher than control and BHA samples but lower than 1, 2 and 3% MOM samples in the second and third week of storage. The protein content of salt treated samples increased from the first to fifth week and decreased afterwards. A similar trend was observed for the control samples. The results observed for *Moringa oleifera* samples corroborate the report of Grubben and Denton (2004) that *Moringa oleifera* leaves contain 9.4 g crude protein/100 g of wet leaves. The extracted and unextracted Moringa leaves gave crude protein values of 43.5 and 25.1% respectively (Makker and Becker, 1997).

There were significant differences in the crude fat content of all treatments in all storage weeks (Table 1). A decrease in the crude fat content of control, salt and BHA treated samples was observed in the eight week of storage. These values were significantly different from those observed in the first week of storage. All Moringa treated samples maintained the crude fat content of the fish samples from the inception of storage until the eight week. The crude fat content of the control samples experienced significant fluctuations.

The salt treated samples had the highest ash content which was significantly different (P<0.01) from other treatments throughout the storage period (Table 1). The observation was in line with the report given by Andrés et al. 2005 who asserted that in addition to product preservation, salt is used to promote nutritional properties and important sensorial changes that make the final product appealing to consumers. *Moringa oleifera* also increased the ash content of fish samples. However, there were remarkable fluctuations in ash content of the

Table 1: Effect of additives and storage time on proximate composition of smoke-dried catfish

Proximate Component	Additives	Storage time (week)								SED	P²
		1	2	3	4	5	6	7	8		
Moisture content (%)	Control	20.07_{z}^{c}	13.4_{z}^{a}	14.5_{z}^{a}	13.97_{z}^{a}	15.66_{z}^{b}	21.14_{z}^{d}	16.23_{y}^{b}	14.33_{y}^{a}		*
	1%MOM	7.67_{x}^{b}	7.83_{x}^{b}	8.96_{x}^{b}	7.83_{y}^{b}	12.13_{y}^{c}	5.7_{w}^{a}	10.25_{x}^{c}	5.36_{v}^{a}		*
	2%MOM	7.86_{x}^{b}	6.65_{x}^{a}	8.81_{x}^{b}	8.13_{y}^{b}	12.47_{y}^{d}	6.25_{w}^{a}	10_{x}^{c}	6.82_{w}^{a}		*
	3%MOM	2.48_{w}^{a}	2.62_{w}^{a}	5.36_{w}^{c}	4.33_{w}^{b}	6.77_{w}^{c}	3.5_{v}^{b}	3.78_{v}^{b}	3.01_{u}^{a}	0.39	*
	5%Brine	8.44_{x}^{b}	5.66_{x}^{a}	6.15_{w}^{a}	6.04_{x}^{a}	9.73_{x}^{b}	6.93_{x}^{a}	6.48_{w}^{a}	9.25_{x}^{b}		*
	0.2%BHA	16.15_{y}^{c}	11.74_{y}^{a}	12.92_{y}^{a}	13.16_{z}^{a}	15.54_{z}^{b}	14.64_{y}^{b}	15.04_{y}^{b}	16.45_{z}^{c}		*
	P²	*	*	*	*	*	*	*	*		
Crude Protein (%)	Control	48.92_{x}^{b}	49.01_{x}^{b}	49.06_{x}^{b}	51.83_{w}^{c}	53.59_{w}^{d}	54.02_{w}^{d}	54.2_{w}^{d}	43_{v}^{a}		
	1%MOM	53.60_{y}^{b}	58.28_{z}^{d}	56.57_{y}^{c}	56.85_{y}^{c}	57.75_{y}^{d}	50.67_{v}^{a}	57.18_{y}^{c}	53.87_{x}^{b}		*
	2%MOM	55.26_{y}^{b}	57.99_{z}^{c}	55.79_{y}^{b}	58.38_{z}^{c}	60.1_{z}^{d}	58.71_{z}^{c}	53.39_{w}^{a}	56.02_{y}^{b}	0.39	*
	3%MOM	56.37_{z}^{b}	58.13_{z}^{c}	57.43_{z}^{c}	55.13_{x}^{a}	59.5_{z}^{d}	55.85_{x}^{a}	58.17_{Z}^{d}	60_{z}^{d}		*
	5%Brine	54.59_{y}^{a}	55.54_{y}^{b}	55.52_{y}^{b}	59.05_{z}^{e}	60_{z}^{f}	57.65_{y}^{d}	56_{x}^{c}	54_{x}^{a}		*
	0.2%BHA	49.52_{x}^{b}	45.01_{w}^{a}	45.01_{w}^{a}	54.79_{x}^{d}	56.66_{x}^{e}	59.5_{z}^{f}	57.06_{y}^{e}	47.99_{w}^{b}		*
	P²	*	*	*	*	*	*	*	*		
Crude Fat (%)	Control	32.69_{y}^{d}	29.18_{y}^{b}	31.73_{y}^{c}	31.42_{w}^{c}	30.19_{y}^{c}	30.06_{x}^{c}	32.89_{x}^{d}	24.83_{x}^{a}		*
	1%MOM	32.3_{y}^{c}	29.66_{y}^{b}	27.67_{x}^{a}	35.69_{z}^{e}	29.03_{x}^{a}	29.11_{x}^{a}	33.42_{x}^{d}	30.95_{y}^{b}		*
	2%MOM	32.43_{y}^{b}	25.44_{x}^{a}	32.99_{y}^{b}	34.31_{x}^{c}	38.34_{z}^{d}	33.37_{y}^{c}	34.08_{y}^{c}	32.38_{y}^{b}	0.33	*
	3%MOM	30.88_{x}^{c}	25.88_{x}^{a}	31.53_{y}^{c}	32.90_{w}^{d}	28.22_{w}^{b}	29.07_{x}^{b}	34.78_{y}^{e}	31.76_{y}^{c}		*
	5%Brine	31.59_{x}^{e}	24.67_{w}^{a}	28.13_{x}^{d}	31.71_{w}^{f}	30.67_{y}^{e}	29.99_{x}^{e}	26.13_{w}^{c}	23.3_{w}^{a}		*
	0.2%BHA	30_{x}^{c}	31.54_{y}^{d}	31.77_{y}^{d}	31.58_{w}^{d}	29.81_{x}^{c}	29.88_{x}^{c}	27.58_{w}^{b}	22.22_{w}^{a}		*
	P²	*	*	*	*	*	*	*	*		
sh (%)	Control	18.59_{x}^{e}	20.88_{v}^{f}	17.5_{x}^{c}	11.88_{v}^{a}	14_{x}^{b}	13.99_{w}^{b}	12.96_{x}^{b}	16.41_{v}^{c}		*
	1%MOM	19.71_{y}^{c}	21.51_{w}^{d}	19.23_{y}^{c}	13.58_{x}^{a}	14.75_{x}^{b}	14.69_{w}^{b}	12.46_{x}^{a}	22.23_{y}^{e}		*
	2%MOM	17.67_{w}^{c}	23.41_{x}^{e}	16.89_{w}^{c}	12.93_{w}^{a}	14.61_{x}^{b}	14.67_{w}^{b}	12.99_{x}^{a}	19.02_{w}^{d}		*
	3%MOM	17.67_{w}^{d}	22.24_{x}^{e}	15.83_{v}^{c}	12.26_{w}^{a}	14.3_{x}^{b}	14_{w}^{b}	17_{y}^{d}	20_{x}^{e}	0.25	*
	5%Brine	28.67_{z}^{e}	28.68_{z}^{e}	25.3_{z}^{d}	15.52_{z}^{a}	23.49_{z}^{c}	23.49_{y}^{c}	18.72_{z}^{b}	24.71_{z}^{c}		*
	0.2%BHA	16.7_{v}^{c}	24.37_{y}^{f}	19.91_{y}^{e}	14.67_{y}^{b}	17.68_{y}^{d}	17.71_{x}^{d}	11.55_{w}^{a}	20.2_{x}^{e}		*
	P²	*	*	*	*	*	*	*	*		

a, b, c, d, e means having different superscript along the same row are significantly different (P<0.01).
v, w, x, y, z means having different subscript along the same column are significantly different (P<0.01).
* = P<0.01, NS=P>0.01, SED= standard error of difference of means

Table 2: Effect of additives and storage time on sensory properties of smoke-dried catfish

Sensory characteristics	Additives	Storage time (week) 1	2	3	4	5	6	7	8	SED	P²
Colour	Control	6.4±0.8	8.0±0.6	8.0±0.9	7.6±0.3	5.6±0.6	7.4±0.9	6.2±0.6	6.8±0.8		NS
	5%Brine	7.8±0.9	6.4±0.3	6.4±0.2	4.8±0.6	6.6±0.7	5.8±0.2	6.8±0.4	5.6±0.6		NS
	0.2%BHA	7.4±0.8	8.0±1.2	7.4±0.2	5.4±0.3	6.4±0.8	8.2±0.9	6.8±0.5	3.4±0.4	0.67	NS
	1%MOM	6.0±1.9	7.6±0.5	8.2±0.9	7.6±0.3	7.6±0.5	7.6±.2	7.0±1.5	6.6±0.8		NS
	2%MOM	6.4±1.9	7.2±0.5	6.0±1.2	6.6±0.8	7.2±0.7	7.2±1.3	7.0±0.7	6.8±1.3		NS
	3%MOM	6.4±1.3	6.8±0.7	7.4±0.1	8.0±1.5	6.6±0.4	8.2±0.8	7.6±0.9	6.2±1.3		NS
	P²	NS	NS	NS	NS	NS	NS	NS	NS		
Tenderness	Control	6.4_x±0.6	7.4±0.9	7±0.3	7.6_y±0.6	5.4_x±0.3	7.2±0.2	6.8±0.3	7.0_y±1.6		NS
	5%Brine	7.4_y±0.6	6.8±0.5	6.6±0.7	4.6_x±0.7	6_x±0.1	5.8±0.9	6.8±0.9	5.8_x±0.8		NS
	0.2%BHA	7.2_y^b±0.5	6.8^a±.7	7.2^b±0.4	4.6_x^a±.8	6_x^a±0.4	7.6^b±0.5	6.8^a±0.8	4.2_x^a±0.3		*
	1%MOM	4.8_x^a±0.6	6.4^a±.4	6.4^a±0.7	7.6_y^b±0.5	7_y^a±0.7	7.0^a±0.7	6.6^a±0.6	6.4_x^a±1.1	0.56	*
	2%MOM	6.2_x±0.3	6.8±.5	6.8±0.9	6_x±0.6	6.2_x±0.4	6.6±1.2	6.8±0.7	6.4_x±0.3		NS
	3%MOM	6.8_x±0.2	6.8±0.4	7.0±1.2	8.2_y±1.6	7.8_y±0.8	8±0.7	6.8±0.6	6.8_y±0.7		NS
	P²	*	NS	NS	*	*	NS	NS	*		
Flavour	Control	6.2^a±0.7	7.8^b±0.8	7.8^b0.5	7.6_y^b±0.7	5.0^a±0.3	6.8^a±0.6	7.4^b±0.2	7.2_y^a±.7		*
	5%Brine	7.0^a±2.0	7.2^b±1.2	6.0^a±0.7	4.8_x^a±0.9	6^a±1.1	5.8^a±0.5	6.8^a±0.3	5.6_x^a±.1		*
	0.2%BHA	7.6^b±0.5	7.4^b±1.2	7.6^b±0.6	5.4_x^a±0.1	5.4^a±0.9	8.0^c±0.5	7.2^b±0.6	3.4_x^a±.5		*
	1%MOM	5.2^a±0.1	7.4^b±0.9	7.0^b±0.2	8_y^b±0.8	7.4^b±0.3	7.2^b±1.2	7.2^b±0.4	6.6_y^a±.4	0.62	*
	2%MOM	6.2±0.7	7.8±0.4	7.0±0.4	6.6_x±0.3	6.4±1.1	7.0±1.0	7.2±0.5	6.6_y±0.6		NS
	3%MOM	6.6±1.5	7.2±1.6	7.6±0.5	8_y±1.4	7.0±0.4	7.4±1.5	7.2±0.5	6.8_y±0.6		NS
	P²	NS	NS	NS	*	NS	NS	NS	*		
Juiciness	Control	6.0±0.7	7.6±0.3	7.8±0.5	7.4_y±0.9	5.6±0.5	7.4_x±0.4	7.0±0.7	6.8_y±0.5		NS
	5%Brine	6.4±0.3	7.2±0.7	6.0±0.8	5.0_x±0.7	5.8±.6	5.6_x±0.1	7.6±0.6	5.4_x±0.5		NS
	0.2%BHA	6.8^a±0.4	8.0^b±0.5	7.4^b±0.1	5.4_x^a±.6	5.4^a±0.9	8_y^b±1.2	7.2±0.9	3.6_x^a±.3	0.84	*
	1%MOM	5.0^a±1.0	7.8^b±0.6	7.6^b±0.5	7.8_y^b±.6	6.8^a±0.7	6.8_x^a±1	7.2^b±0.6	6.2_y^a±.4		*
	2%MOM	6.4±0.7	7.2±0.5	7.4±1.3	6.4_x±1.4	6.8±0.3	6.8_x±0.6	7.6±1	6.4_y±.4		NS
	3%MOM	6.8±0.7	7.0±0.6	7.2±0.7	8.2_y±1.4	7.6±0.4	7.6_x±1.2	7.4±1	6.8_y±1.9		NS
	P²	NS	NS	NS	*	NS	*	NS	*		
Overall acceptability	Control	7.0^a±1.4	8.2^b±0.4	7.8^b±0.7	7.8_y^b±0.8	5.2^a±0.3	7.2^a±0.2	7.0^a±1.3	7.0_y^a±0.6		*
	5%Brine	7.0^a±0.9	7.4^b±0.8	6.4^a±0.6	4.8_x^a±0.8	6.2^a±0.6	6.0^a±0.1	7.2^b±0.5	6.2_y^a±0.7		*
	0.2%BHA	7.4^b±0.9	7.8^b±0.7	7.8^b±0.7	5.2_x^a±0.6	5.6^a±0.5	7.6^b±0.5	7.0^b±1.0	3.6_x^a±0.7		*
	1%MOM	4.6^a±1.5	8^b±1.4	7.4^b±0.3	7.8_y^b±0.7	7.2^b±1.3	6.8^a±0.6	6.8^a±0.9	6.2_y^a±1.0	0.85	*
	2%MOM	6.4±1.3	7.8±1.2	7.4±0.4	6.2_x±1.1	6.4±1.6	6.4±0.4	7.2±0.5	6.6_y±1.2		NS
	3%MOM	6.4±0.9	7.6±1.0	7.0±1.1	8_y±1.4	7.4±1.0	8.2±1.5	7.0±0.8	7.0_y±1.6		NS
	P²	NS	NS	NS	*	NS	NS	NS	*		

Values are mean ± SD. a, b, c means having different superscript along the same row are significantly different (P<0.01). x, y, z means having different subscript along the same column are significantly different (P<0.05). *=P<0.01, NS=P>0.01, SED=Standard error of difference of means. SD=standard deviation

fish samples throughout the storage period. It has been reported that *Moringa oleifera* leaves contained substantial macro and micro minerals (Booth and Wickens, 1988).

There was no significant difference (P>0.01) among the treatments with respect to color perceived by assessors (Table 2). All treatments were rated as having the same color throughout the storage period. A visual appraisal of the fishes showed that all samples had dark color. This dark color was probably due to smoke and ashes deposited on the fishes during smoke-drying process. *Moringa oleifera* treated samples had dark greenish patches on them. The intensity of the greenish patches was concentration dependent with 1% MOM having the least.

Flavor score for the control samples increased from the first to fourth week, decreased from the fifth to sixth week and increased afterwards (Table 2). There was a decrease in the scores assigned to salt and BHA treated samples. The flavor scores observed in the eight week for salt and BHA sam-

ples were lower and differed significantly from those observed in the first week of storage. There were fluctuations in the flavor scores observed for all treatments. Except in the fourth and eight week of storage, there were no significant differences in flavor among the treatments throughout the storage period. The scores for all Moringa treated samples in the eight week do not differ from that of the first week.

For tenderness, with the exception of BHA and 1% MOM, there was no significant difference (P>0.01) among the scores assigned to the treatments from the first to eight week of storage. There was a decrease in the scores for BHA samples. The scores for 1% MOM differ slightly throughout the storage weeks. In the first week of storage, 2% MOM had the highest score which was significantly different from other treatments. No significant difference (P>0.01) was observed in the second, third, sixth and seventh week among the treatments. In the fourth week, the control and 1% MOM had significantly higher scores than other treatments. 3% MOM had the highest score in the fifth week. The control and 3% MOM were rated higher than other treatments in the eight week. No significant difference was observed in the juiciness of all treatments except BHA and 0.1% MOM as storage progressed. The overall acceptability among the treatments did not differ (P>0.01) except in the fourth and eight week. There was no significant difference among Moringa treated samples and the control in the fourth and eight week. BHA samples had the least scores in these weeks.

The reduction in sensory scores as storage progressed could be attributed to the activity of spoilage agents. Quality loss during storage at both ambient temperature and chilling was revealed in the results of research on storage of Oyster (Llobreda et al., 1986) and Shrimps (Reilly and Dela-cruz, 1986). Although chemical quality indices of smoked-dried fish could predict their biological utilization by consumers (Trinidad and Estrada, 1986), physical assessment method is easily available to an intending fish buyer. While physical or subjective methods of analysis may suffer from the limitation of being subject to bias by the assessor and hence may not be reproducible, the chemical methods are reliable measures of freshness or state of deterioration of a product (Daramola et al., 2007). This major limitation of subjective method is evident in this study where assessors ranked 3% MOM with a moisture content of 2.48% and control with a moisture content of 20% in the first week as having the same tenderness.

CONCLUSION

All levels of *Moringa oleifera* marinade reduced the moisture content of smoke-dried African catfish. The dehydrating property of *Moringa oleifera* depends on concentration. 3% MOM samples had the least moisture content which was significantly different (P<0.01) from other additives. There was no significant difference (P>0.01) in the moisture content of samples treated with salt, 1% and 2% MOM. Control samples had the highest moisture content, which was closely followed by BHA samples. *Moringa oleifera* marinade improved and stabilized the crude protein and fat content of the fishes throughout the storage period. In this respect, 3% MOM was the most effective. Salt treated samples had the highest ash content throughout the storage period. This was significantly different from other additives. There was no significant difference in the ash content of *Moringa oleifera* treatments. There was no significant difference in the organoleptic properties of the additives during most of the storage period. *Moringa oleifera* marinade could be used to improve the chemical composition and shelf life of smoke-dried African catfish. Further studies should be carried out to determine the effect of mixing *Moringa oleifera* with salt on the chemical composition and sensory characteristics of smoke-dried African catfish for a longer period of storage.

Sažetak

UČINAK MARINADE *MORINGA OLEIFERA* NA NEPOSREDAN SASTAV I SENZORNA SVOJSTVA DIMLJENOG AFRIČKOG SOMA (*CLARIAS GARIEPINUS*)

Ovim istraživanjem izmjeren je učinak marinade *Moringa oleifera* na kemijski sastav i organoleptička svojstva dimljenog soma pomoću faktorskg eksperimenta 6x8. Eksperimentalna obrada uključivala je kontrolu, marinadu *Moringa oleifera* (MOM) od 1, 2 i 3% (w/v), otopine rasola od 5% i butil-hidroksil-anisola (BHA) od 0,2% (w/v). Izvađena je utroba devedeset riba prosječne težine 230±8 g, oprane su te im je nasumce određena vrsta tretmana. Nakon toga ribe su se dva sata namakale u otopinama te potom bile dimljene dvanaest sati. Nakon dimljenja, ribe su spremane u vakuumske mrežaste kutije te su ostavljene na policama laboratorija na sobnoj temperaturi (37±2 °C) tijekom 8 tjedana. Uzimani su uzorci svakih sedam dana za kemijsku i senzornu analizu. Neposredna analiza je pokazala da je marinada *Moringa oleifera* (MOM) smanjila udio vlažnosti kod dimljenih uzoraka ribe tijekom skladištenja.

Dehidrirajuće svojstvo MOM-a je ovisilo o koncentraciji te su uzorci tretiranih s MOM-om od 3% imali najniži udio vlažnosti, što se znatno razlikovalo od drugih načina obrade. Nije bilo značajnije razlike u dehidrirajućim svojstvima MOM-a od 1% i 2% te uzoraka koji su tretirani solju. Sve razine MOM-a su poboljšale i održale udio proteina, pepela i masti kod uzoraka dimljene ribe. Senzorne ocjene nisu pokazale značajne razlike među načinima obrade u smislu boje, okusa, sočnosti i ukupne prihvatljivosti uzoraka ribe. Marinada *Moringa oleifera* se može koristiti za očuvanje kvalitete dimljenog afričkog soma koji se skladišti dva mjeseca.

Ključne riječi: Moringa, marinada, dimljena riba, rasol

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