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Fungal Infestation and Nutrient Quality of Traditionally Smoke-Dried Freshwater Fish

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Abstract

Fungal infestation and nutrient quality of smoke-dried *Clarias gariepinus*, *Chrysichthys nigrodigitatus*, *Sarotherodon galilaeus*, *Heterotis niloticus*, *Heterobranchus bidorsalis*, *Synodontis schall*, *Synodontis clarias* and *Clarias anguillaris* were studied. The fish samples were incubated on potato dextrose agar for seven days for fungal infestation. The fungi isolated and identified were *Fusarium* spp., *Aspergillus* spp., *Rhizopus* spp., *Mucor* spp. and *Penicillium* spp. There was significant difference ($P<0.05$) in moisture contents of *S. galilaeus* and *C. nigrodigitatus*. Ash contents were significantly higher in *H. niloticus*, *S. clarias* and *S. schall* than those in the other five species. There were significant differences in organic matter of *H. niloticus* and *C. anguillaris*; in crude carbohydrate of *C. anguillaris* and *S. schall*; and in crude protein of *C. anguillaris*, *C. gariepinus*, *C. nigrodigitatus* and *H. bidorsalis*. The caloric values and protein contents were high in all fish samples. Each fish species contained seventeen amino acids. These fish species are very rich in protein and dietary minerals such as calcium, sodium, zinc, potassium, phosphorous and iron and so are highly recommended for human consumption.

Key words: fungi, nutrient, smoke-dried, fish, freshwater.

Introduction

Fish have rich source of essential nutrients required for supplementing both infant and adult diets (Abdullahi *et al*., 2001). Dietary responses to short term diets of fish and the positive effects on protein-calorie malnutrition, asthma, arthritis, auto-immunity, coronary heart diseases and arteriosclerosis have been independently and unanimously reported (Gerhard *et al*., 1991; Cobiac *et al*., 1991). Similarly, many evidences on both benefits of fish consumption due to omega-3 fatty acids present in salt water fish have also been reported. However, despite the lack of information on the health benefits from long-term intake of fish and shell fish, there is no obvious draw back in the opportunity to enjoy healthy living, prolonged life and good diet of fish species (Ackman, 1992; Sharekey *et al*., 1992).

Fresh water fish constitute 69.6% of the total fish supply available to Nigeria (FOS, 1990). This represents a major source of animal protein supply to Nigeria, which has a low per capital protein consumption (Afolabi *et al.*, 1984). Fresh water fish constitute an important part of fish distribution in Africa and the marketing trends predict an increase in consumer demands. Many fish species have very good preservation qualities after salting, sun drying and even smoking (Madu *et al*., 1984). Smoke-dried fish are common in Ijebu and other urban centre markets in Southwest in particular and Nigeria as a whole (Fafioye *et al*., 2002).

Despite high demand, commercial value and distribution of fish in Nigeria, there is the need for precise data on the nutrient composition and shelf life span of fresh water fish species in South-west Nigeria where they are highly consumed. The objectives of this study were to provide baseline information on the proximate, mineral, amino acid contents, calorific values and nutritional quality of *Clarias gariepinus*, *Chrysichthys nigrodigitatus*, *Sarotherodon galilaeus*, *Heterotis niloticus*, *Heterobranchus bidorsalis*, *Synodontis schall*, *Synodontis Clarias* and *Clarias anguillaris*, which are economically viable in this country and list of fungi commonly involved in infestation and deterioration of smoke-dried fish in Southwestern Nigeria viz: - Oyo, Ogun, Oshun, Ondo Lagos and Ekiti States where the traditional smoke drying technique of fish processing is mostly practiced.

Materials and Methods

Fish Procurement

Thirty samples of each fish species of *C. gariepinus*, *C. nigrodigitatus*, *S. galilaeus*, *H. niloticus*, *H. bidorsalis*, *S. schall*, *S. clarias* and *C. anguillaris* were obtained from central markets in each state capital of the six south–western Nigeria States (i.e. Oyo, Ogun, Oshun, Ondo Lagos and Ekiti States). Ten samples of each fish species were obtained from three different sellers in the same market and then mixed together to make composite samples of thirty samples. The samples were

handpicked with sterilized glove hands and taken to the laboratory in separate sterilized polythene bags to avoid contamination from the handling.

Fungal Infestation Culture and Examination

Fifteen fish samples out of the thirty collected for each fish species were surface sterilized with 70% ethanol and rinsed with three changes of sterile distilled water. A 10 g tissue portion of each fish species was cut from the abdominal region with a sterile forceps, grinded aseptically in a porcelain mortal and mixed in 10 ml of sterile peptone water. From this mixture, further tenfold dilution were made up to 10^5 and 0.1 millilitre of each dilution was plated in triplicate on potato dextrose agar (PDA) supplemented with streptomycin to inhibit bacterial growth. Plates were incubated at 28±2°C. and examined daily for 7 days. The mean number of all fungal colonies appearing in the three plates was taken as the average number of colonies per plate for each fish species. This was used to estimate the number of colonies per gram of fish sample using a known dilution series. Each different appearing culture was transferred with a sterile needle to a slide, teased apart and stained with lacto phenol cotton blue and examined microscopically (Carter, 1979). Cultures were identified to species using the keys of Samson *et al*. (1981).

Proximate Analysis

The internal organs of the remaining fifteen fish samples of each fish species were eviscerated, weighed and used for proximate analysis. The moisture content was determined by difference methods of AOAC (1990). The dried samples of each species were milled into homogenous powder and stored in labelled sample bottles for further analysis. 10 g was placed in a pre-weighed porcelain crucible and ignited in an ashing furnace maintained at 600°C. The ash content was estimated when a constant weight was obtained. Total organic matter was estimated by subtracting the ash weight from the dry powder weight (Linghstein and Oginsky, 1965).

Crude carbohydrate, crude protein, lipid and fibre were estimated according to the procedure of AOAC (1990). Caloric values were determined using the conversion factors of 9.5 Kcal/100 g for lipid, 5.5 Kcal/100 g for protein and 4.1 Kcal/100 g for carbohydrate (Winberg, 1971).

Amino Acid Determination and Nutritional Value

Amino acid was determined using the Technicon Sequential Multi-sample amino acid Analyzer (TSM), which is designed to separate, detect and quantify amino acids. The nutritional values were calculated and compared with the FAO/WHO (1973) reference values using the following indices: Essential to non-essential amino acid ratio (EN); essential amino acid index (EAAI); essential amino acid to total nitrogen ratio (E:T); chemical/protein score (CS/PS); essential amino acid to protein ratio (E:P). These parameters were calculated from data obtained from the results of protein and amino acid determinations using the following equations:

E:N = (Essential amino acids of test protein / Non-essential amino acids of test protein) x 100

E:T = (Essential amino acids of test protein / Total amino acids of test protein) x 100

EAAI = (Essential amino acids of test protein / Essential amino acids of whole hen's egg) x 100

CS/PS = (Essential amino acids of test protein / Total amino acids of whole hen's egg) x 100

E:P = (Essential amino acids of test protein / 1000 g test protein) x 100

Mineral Contents

The minerals in the homogenous fish powder were brought into solution by wet digestion using the method of Harris (1979). Potassium and sodium were determined by Allen's method using Collins and Polkin-Horne flame photometer (Allen, 1974); phosphorous by Bausch-Lomb spectronic 20 (Allen, 1974); zinc, calcium, iron, magnesium and copper by using Perkin-Elmer atomic absorption Spectrophotometer (AOAC, 1990).

Statistical Analysis

All statistical analyses and data presentations were accomplished using SAS statistical package for Windows (SAS, 1989). For proximate composition, significance differences in each content value of the different fish species and the US/RDA were first evaluated for normality of data and variance using T-tests followed by one-way analysis of variance. Level of significance was set at $P<0.05$. Amino acids and mineral content means were separated by Duncan multiple range test (Steel and Torie, 1981). Level of significance was set at $P<0.05$.

Results

The species of fungi isolated and identified were *Fusarium* spp., *Aspergillus* spp., *Rhizopus* spp., *Mucor* spp. and *Penicillium* spp. (Table 1). The number of fungi isolated from fish ranged from three to six. The prevalent fungus was *Aspergillus* spp., which was found in all the fish samples (Table 1). The degree of analysis on the most frequently encountered

Table 1. The colony counts and fungal species isolated from each fish sampled

Fish species	Fungi species	Frequency of isolation (%)	Colony counts
Clarias gariepinus (Burchell)	*Aspergillus flavus*	65	$1.5x10^4$
	A. ochraceus	36	
	Fusarium solani	21	
	F. avenaceum	15	
	Mucor racemosus	40	
	Rhizopus stolonifer	12	
Chrysichthys nigrodigitatus (Lacepede)	*R. oryzae*	16	$1.4x10^{10}$
	A. flavus	43	
	M. hiemalis	20	
	M. racemosus	38	
	A. fumigatus	40	
Heterobranchus bidorsalis (Geoffrey)	*A. fumigatus*	30	$9.0x10^4$
	A. ochraceus	18	
	A. flavus	35	
	A. avenaceum	6	
	F. solani	13	
Clarias anguillaris (Linnaeus)	*A. fumigatus*	48	$1.6x10^5$
	M. racemosus	35	
	F. solani	14	
	A. flavus	40	
Heterotis niloticus (Cuvier)	*F. equiseti*	11	$8.4x10^4$
	F. sporotrichides	16	
	A. fumigatus	24	
Sarotherodon galilaeus (Trewavas)	*A. flavus*	50	$8.1x10^4$
	A. fumigatus	34	
	M. hiemalis	02	
Synodontis clarias (Linnaeus)	*M. mucedo*	53	$9.0x10^3$
	A. niger	06	
	Penicillium glaucum	17	
	A. flavus	27	
Synodontis schall (Boulenger)	*A. flavus*	23	$8.7x10^6$
	A. niger	18	
	F. avenaceum	14	

fungi on all the fish species can be described as *A. flavus* > *A. fumigatus* > *M. racemosus*. The fungal counts varied from fish species to species.

The proximate composition and caloric values of *Clarias gariepinus*, *Chrysichthys nigrodigitatus*, *Sarotherodon galilaeus*, *Heterotis niloticus*, *Heterobranchus bidorsalis*, *Synodontis schall*, *Synodontis clarias* and *Clarias anguillaris* are given in Table 2. The moisture contents of the samples ranged from 62.74±1.33 to 78.00±4.50 g. However, these values, when compared with the US/RDA (1994) of 70 g/100 g were significantly higher ($P<0.05$). The values of ash were significantly higher in *H. niloticus* (16.14/100 g), *S. clarias* (15.51/100 g) and *S. schall* (15.48/100 g) than in the remaining five fish. The values of organic matter were significantly higher in *C. anguillaris* (91.03±1.5/100 g) and *H. niloticus* (90.30±1.3/100 g) than the other fish species. The crude carbohydrate values were higher in *C. gariepinus* (10.14±0.83), *C. anguillaris* (10.11±0.49), and *H. bidorsalis* (10.10±1.00) than in the remaining five fish. The values of crude lipid ranged between 26.27±0.08 and 32.20±1.43 and were significantly higher in *S. galilaeus*, *H. niloticus*, *S. clarias* and *S. schall* than the rest four species. The crude protein values of over 50 g/100 g recorded for *C. anguillaris*, *C. gariepinus*, *C. nigrodigitatus* and *H. bidorsalis* were higher than the other fish species. The calorie values of the fish were same for all the fish.

Table 3 documents the pooled means of amino acid composition of experimental fish with the FAO/WHO (1973) reference values. There were seventeen amino acids and Glutamic acid dominated the amino acid pool of the fish species with the highest at 16.25/16 g N in *C. nigrodigitatus.* This was followed by Lysine and Aspartic acid, while Methionine was the least.

The chemical indices used to evaluate the essential and non-essential amino acids of protein were shown on Table 4. *Heterotis niloticus*, *H. bidorsalis* and *S. clarias* had the highest value of E: TN (51.13), EI (125.29) and C/P (57.45), respectively.

The mean mineral contents of the experimental fish were dominated by calcium, potassium and sodium with values 3930, 635 and 260 mg/100 g, respectively, while the others had values less than 50 mg/100 g (Table 5).

Table 2. Proximate composition (g/100 g) and calorie (kcal/100 g) for eight freshwater fish species

Fish species	Moisture	Ash	Proximate OM	CC	Composition CL	CP	Calorie
Clarias gariepinus	76.06±2.4[a]	10.53±0.2[b]	88.79±1.6[a]	10.14±0.83[b]	27.00±1.2[b]	52.34±0.44[a]	592.64[a]
Chrysichthys nigrodigitatus	68.04±1.8[b]	9.00±0.4[c]	80.00±1.4[b]	8.50±1.26[c]	26.27±0.8[b]	58.42±0.83[a]	589.06[a]
Heterobranchus bidorsalis	75.04±3.6[a]	10.01±0.7[b]	89.47±1.3[a]	10.10±1.00[b]	26.30±1.36[b]	53.13±1.77[a]	591.45[a]
Clarias anguillaris	74.44±3.7[a]	9.41±0.6[c]	91.03±1.5[a]	10.11±0.49[b]	26.34±1.55[b]	54.60±1.23[a]	597.26[a]
Heterotis niloticus	78.00±4.5[a]	16.14±0.2[a]	90.30±1.3[a]	9.50±1.21[b]	30.41±0.83[a]	47.50±0.66[a]	583.21[a]
Sarotherodon galilaeus	62.74±1.3[c]	7.8±1.1[d]	74.22±0.6[c]	9.12±0.14[c]	32.30±1.43[a]	41.17±2.46[b]	564.61[a]
Synodontis clarias	77.04±6.5[a]	15.51±1.2[a]	85.21±1.4[a]	9.65±1.06[b]	31.63±1.36[a]	43.64±1.47[b]	577.46[a]
Synodontis schall	77.16±7.2[a]	15.48±1.5[a]	84.47±0.8[b]	9.70±0.22[b]	31.42±0.40 [a]	43.25±1.13[b]	593.42[a]
US/RDA 1994	70[b]	12[b]	84[b]	12-16[a]g/day	30-35g/day [a]	30-45g/day[b]	450-600[a]

Key: OM= organic matter; CC= Crude carbohydrate; CL= Crude lipid; CP= Crude protein.
Note: Values represent pooled means and standard deviations of triplicate determinations of dry weight.
* Values with different superscript letters vertically in a column are significantly different (P<0.05)

Table 3a. Mean amino acids composition (g/16 g N) of eight smoke dried freshwater fish species

Fish Spp.	Ala[1]	Arg[2]	Asp[3]	Cys[4]	Amino Glu[5]	AcidsGly[6]	His[7]	Isa[8]	Leu[9]
Clarias anguillaris	3.97[c]	3.87[d]	8.45[b]	2.80	15.00[c]	2.87	2.20	3.20[c]	6.85
Clarias gariepinus	4.90[b]	4.43[b]	8.32[c]	2.60	14.95[c]	2.80	2.85	5.10[a]	5.55
Chrysichthys nigrodigitatus	5.33[a]	5.14[a]	10.35[a]	3.01	16.25[b]	2.59	2.71	3.85	5.80
Heterobranchus bidorsalis	4.95[b]	4.83[b]	10.51[a]	2.88	15.82[b]	2.85	2.68	4.90[a]	5.25
Heterotis niloticus	3.58[d]	4.69[b]	8.35[c]	2.95	16.08[b]	2.89	3.05	5.15[a]	5.78
Sarotherodon galilaeus	3.61[d]	3.96[c]	7.92[c]	3.11	15.25[c]	2.55	2.42	2.75[c]	4.60
Synodontis clarias	4.12[c]	4.00[c]	10.44[a]	3.32	16.00[b]	2.95	3.13	2.60[c]	5.15
Synodontis schall	3.46[d]	3.80[d]	9.00[b]	3.30	15.33[c]	2.90	3.00	4.45	5.40
Egg protein	3.50[d]	6.70[a]	10.40[a]	3.00	25.20[a]	3.60	3.50	5.80[a]	3.60
FAO/WHO 1990	6.10[a]	5.20[a]	7.70[d]	3.00	14.7[c]	2.20	2.50	2.80[c]	6.60

Key: 1-Alanine; 2-Arginine; 3-Aspartic acid; 4-Cystine; 5-Glutamic acid; 6- Glycine; 7-Histidine; 8-Isoleucine; 9-Leucine;

Table 3b. Mean amino acids composition (g/16 g N) of eight smoke dried freshwater fish species

Fish Spp.	Acids Lys[10]	Met[11]	Phe[12]	Pro[13]	Ser[14]	Thr[15]	Tyr[16]	Val[17]
Clarias anguillaris	10.18[a]	2.03	3.00[c]	2.40[c]	2.06	3.99	2.60	3.03[d]
Clarias gariepinus	10.15[a]	1.99	2.05[d]	2.55[c]	2.05	2.85	2.95	3.00[d]
Chrysichthys nigrodigitatus	10.22[a]	1.95	3.05[c]	2.57[c]	2.07	3.50	2.90	2.98[d]
Heterobranchus bidorsalis	9.53[a]	2.05	4.58[b]	3.20[b]	2.38	3.00	3.11	5.60[b]
Heterotis niloticus	9.88[a]	2.01	3.52[c]	2.84[b]	2.12	3.38	3.04	4.05[c]
Sarotherodon galilaeus	6.90[b]	1.73	2.77[c]	2.38[c]	2.03	2.00	2.01	3.15[d]
Synodontis clarias	9.80[a]	1.70	3.08[c]	3.00[b]	2.35	3.44	3.80	4.00[c]
Synodontis schall	9.85[a]	1.85	3.00[c]	2.50[c]	2.00	2.20	2.88	3.10[d]
Egg protein	6.70[b]	2.30	6.70[a]	2.80[b]	6.00[a]	5.10	3.60	7.50[a]
FAO WHO 1990	5.80[b]	2.50	6.30[a]	10.70[a]	7.70[a]	3.40	1.10	5.00[b]

Key:- 10-Lysine; 11-Methionine; 12-Phenylalanine; 13-Proline; 14-Serine; 15-Threonine; 16-Tyrosine; 17-Valine
Note: - Values represent pooled means of triplicate determinations of dry samples.
* Values with different superscript letters vertically in a column are significantly different (P<0.05)

Table 4. The essential to non-essential amino acid (E:N) to total nitrogen (E:TN) and to protein (E:P) ratios, essential amino acid index (EI) and chemical/protein score(CP) of the eight freshwater fish species

Fish species	E: N[1]	E: TN[2]	EI[3]	C/P[4]	E: P[5]
Clarias gariepinus	0.89	50.82	122.76	56.55	0.87
Chrysichthys nigrodigitatus	0.99	50.74	120.55	52.81	0.91
Heterobranchus bidorsalis	0.96	50.85	125.29	57.06	0.85
Clarias anguillaris	0.97	50.70	124.54	57.38	0.75
Heterotis niloticus	1.04	51.13	121.31	53.66	0.79
Sarotherodon galilaeus	1.00	50.51	115.00	51.00	1.01
Synodontis clarias	1.03	51.10	124.29	57.45	0.94
Synodontis schall	1.00	50.15	122.50	56.45	1.27
FAO/WHO 1990	1.00	50.00	100.00	50.00	1.00

Key: 1. Essential to non-essential amino acid ratio; 2-Essential amino acid to total nitrogen ratio; 3- Essential amino acid index; 4-Chemical/protein score; 5-Essential amino acid to protein ratio.

Table 5. Mean mineral contents of eight freshwater fish species (mg/100 g)

Fish species	Calcium	Potassium	Iron	Magnesium	Sodium	Copper	Phosphorous	Zinc
Clarias gariepinus	3930.0±1.04^{c}	635±0.37^{d}	53±0.11^{b}	31±0.14^{e}	260.0±0.08^{d}	2.0±0.02^{a}	14.0±0.02^{c}	19±0.02^{a}
Chrysichthys nigrodigitatus	4536.0±1.07^{a}	628±0.21^{c}	57±0.01^{a}	30±1.21^{e}	317.2±0.03^{c}	1.9±0.14^{c}	20.0±0.08^{a}	17±0.01^{b}
Heterobranchus bidorsalis	4000.0±1.12^{b}	643±0.23^{c}	55±0.03^{a}	34±0.02^{e}	312.5±0.32^{c}	2.0±0.01^{b}	15.8±0.04^{b}	19±0.01^{a}
Clarias anguillaris	4004.0±1.04^{b}	685±0.71^{b}	58±0.04^{a}	31±0.02^{e}	318.0±0.20^{c}	2.0±0.04^{b}	16.0±0.02^{b}	16±0.01^{b}
Heterotis niloticus	4033.0±0.08^{b}	722±0.18^{b}	48±0.01^{b}	133±1.33^{c}	300.1±0.35^{c}	2.0±0.04^{b}	14.5±0.02^{c}	20±0.01^{a}
Sarotherodon galilaeus	3584.0±1.14^{c}	680±0.05^{b}	43±0.12^{c}	114±1.24^{d}	244.0±0.06^{d}	1.4±0.05^{d}	22.3±0.04^{a}	12±0.04^{c}
Synodontis clarias	4814.0±1.64^{a}	760±0.46^{a}	38±0.01^{d}	143±0.30^{b}	405.0±0.38^{b}	2.0±0.07^{b}	23.0±0.02^{a}	21±0.03^{a}
Synodontis schall	4002.0±0.66^{b}	810±0.35^{a}	35±0.23^{d}	141±1.21^{b}	407.0±0.41^{b}	3.0±0.04^{a}	24.0±0.05^{a}	21±0.01^{a}
WHO (1974)	1000-1400^{d} /day	220^{e}/day	6-15^{e} /day	460^{a}/day	500-2000^{a} /day	0.2-1.3^{e} /day	20-23.8^{a}/day	3-5^{d}/day

*Values represent pooled means and standard deviations of triplicate determinations.
** Values with different superscript letters vertically in a column are significantly different (P<0.05)

Discussion

The South–western Nigeria where this study was carried out falls in hot climate thereby provides favourable condition for mould spore to germinate and grow on dried fish. The results indicate that smoke dried and stored fish in this part of the country are infested by *Aspergillus flavus*, *A. ochraceus*, *A. niger*, *A. fumigatus*, *Fusarium solani*, *F. avenaceum*, *F. equiseti*, *F. sporotrichides*, *Mucor racemosus*, *M. hiemalis*, *Rhizopus stolonifer*, *R. oryzae* and *Penicillium glaucum.* These are the common fungi invading smoke dried fish species in the studied areas and the results were similar to those observed by Doe (1983), Ockiya and Akeodi (1998) and Fafioye *et al.* (2002).

The fungi isolated from the dried fish were somehow specific in that while *Aspergillus* spp. were observed in all the eight fish, *Fusarium* spp. and *Mucor* spp. occurred in five different species each, *Rhizopus* spp. occurred twice and *Penicillium glaucum* occurred once in the experimental fish. *Clarias gariepinus* haboured the highest number (6) of different fungal species followed by five species each on *Chrysichthys nigrodigitatus* and *Heterobranchus bidorsalis*, four species on *Clarias anguillaris* and *Synodontis clarias*, while three species of fungi were observed on *Heterotis niloticus*, *S. schall* and *Sarotherodon galilaeus*. This fungal specificity may be due to the differences in the chemical composition of the fish species and to which different moulds react differently (Reed *et al*., 1967; Fafioye *et al*., 2002).

The high moisture contents recorded for all the fish are comparable to those reported in other fresh water fish species such as *Mormyrus rume*, *Oreochromis niloticus* and *Clarias lazera* (Otitologbon *et al*., 1997), *Citharinus citharus* and *C. latus* (Abdullahi, 1999), *Alestes nurse*, *A. macrolepidotus*, *Hydrocynus brevis* and *Hepsetus odoe* (Abdullahi, 2000a), *Labeo coubi*, *L. senegalensis* and *Barbus occidentalis* (Abdullahi, 2000b). The values recorded for all the fish except *S. galilaeus* and *C. nigrodigitatus* were not significantly different (P>0.05). However, the values recorded for *S. clarias*, *S. schall*, *C. gariepinus* and *C. anguillaris* are similar to those reported by Abdullahi *et al*. (2001). The crude carbohydrate values of the eight fish species were lower than the US/RDA (1994) recommended values of 12-16 g/day and 12 g/100 g reference value of Ackman (1992). All the species could be dependable sources of low dietary carbohydrate.

The crude lipid contents concurred with the recommended values of US/RDA (1994), classification of Ackman (1989) and range of low fat category of Abdullahi *et al*. (2001) and Abdullahi (1999). These fish species might be very good sources of fish oil, which is required for food therapy in humans. The crude protein values were higher than those reported in pork (100 g kg^{-1}), beef (180 g kg^{-1}) and lamb (160 g kg^{-1}) by Bhuryan *et al*. (1993) and mackerel (120 g kg^{-1}) by Pearson (1981). The fish specimens might be taken as the best source of crude protein for human consumption for the desired body growth.

The high calorie values of the fish species are within the recommended values of 450 to 600 Kcal/100 g for human and so could contribute to caloric requirement of consumers. The recorded amino acids and their values might be grouped into essential (values 5 and above e.g. Glutamic) and non-essential (below 5) for the different fish species. Values of essential amino acid to total nitrogen ratio (E:TN), essential amino acid index (EI) and chemical/protein score (C/P) were higher than the reference values of 50.0, 100.0 and 50.0, respectively. The two groups of amino acids readily combine to contribute the required nitrogen levels of consumers, which will definitely spare the essential amino acids

in nitrogen metabolism (Fafioye and Ogunsanwo, 2006 in press). The values of calcium, potassium, copper, zinc and iron recorded for all the fish were significantly higher than the reference values of WHO (1974). All the species could be dependable sources of high dietary minerals.

In conclusion, it can be deduced from this study, that all the eight fish species are good sources of high quality protein, minerals and amino acids compared to salt water fish and they may increase rich sources of essential nutrients required for supplementing both infant and adult human diets. Also, the fish species are highly infested with fungi especially when not properly smoke dried. However, the fourteen different fungal species isolated and identified are common occurrence in the smoke dried fish in south–western Nigeria. It is being suggested that low fungi infested smoke dried fish like *S. schall*, *S. galilaeus*, *H. niloticus* and *C. anguillaris* should be embraced to boost market values since they would have long shelf life.

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References

Abdullahi, S.A., Abolude, D.S. and Ega, R.A. 2001. Nutrient quality of four oven dried freshwater catfish species in Northern Nigeria. J. Tropical Biosciences, 1(1): 70-76

Abdullahi, S.A. 2000a. Evaluation of the nutrient composition of some fresh water fish families in Northern Nigeria. J. Agriculture and Environment, 1(2): 141-150.

Abdullahi, S.A. 2000b. Studies on the nutrient contents of the fresh water fish species *Labeo coubie*, *L. senegalensis* and *Barbus occidentalis*: Family Cyprinidae (Ruppel). Nigerian J. Biochemistry and Molecular Biology, 15(1): 166-169.

Abdullahi, S.A. 1999. Nutrient content of *Citharinus citharus* and *C. latus* (Family: Citharinidae) Geoffrey. J. Pure and Applied Sciences, 2(1): 65-68.

Ackman, R.G. 1992. Sources of n-3 fatty acids. In: J.C. Frolich and C.V. Schacky (Eds). Fish, Oil and Human Health, Clinical Pharmacology, W. Zuckschwerds Verlag, Munchen: 5: 14-24.

Ackman, R.G. 1989. Nutritional composition of fats in seafoods. Progresses on Food Nutrition Science, 13: 161-241.

Afolabi, A.O., Arawomo, O.A. and Oke, O.L. 1984. Quality changes of Nigerian traditionally processed fresh water fish species I. Nutritive and organoleptic changes. J. Food Techno., 19: 333-340.

Alfed-Ockiya, J.F. and Akeodi, J. 1998. Comparative study of fungal infestation of three traditionally smoke-dried fresh water fishes in Rivers State. J. Aquatic Sci., 13: 41-43.

Allen, S.G. 1974. Chemical analysis of ecological materials. Blackwell Scientific Publications Oxford, UK Oxford, 180 pp.

AOAC, 1990. Association of official analytical chemists. Official methods of analysis of the Association of Official analytical Chemists (13th edition). Arlington, VA, 15: 32-36.

Bhuryan, A.K.M., Ratanayake, W.M.N. and Ackman, R.G. 1993. Nutritional composition of raw and smoked Atlantic Mackerel (*Scomber sconbrus*): Oil and water-soluble vitamins. J. Food Composition Analysis, 6*:* 172-184.

Carter, G.R. 1979. Diagnostic procedures in veterinary bacteriology and mycology, 3rd edition, IL: Charles C. Thomas Publishers, Springfield: 157-171.

Cobiac, L., Clifton, P.M., Abbey, M., Belling, G.B. and Nestel, P.J. 1991. Lipid, lipoprotein and haemostatic effects of fish and fish oil, n-3 fatty acids in mildly hyperlipidemic males. American J. Clinical Nutrition, 53: 1210-1216.

Doe, P.E. 1983. Spoilage of dried fish. The need for more data on water activity and temperature effects on spoilage organisms. FAO Fisheries Report, Rome, 27(9): 126-129.

Fafioye, O.O., Efuntoye, M.O. and Osho, A. 2002. Studies on the fungal infestation of five traditionally smoke-dried fresh water fish in Ago-Iwoye, Nigeria. Mycopathologia, 154: 177-179.

Fafioye, O.O. and Ogunsanwo, B.M. 2006. Carbohydrate reserves and metal accumulation of the Nile tilapia, *Oreochromis niloticus* after treatment with heavy metals. J. Aquatic Ecology, (In press).

FAO/WHO. 1973. Amino acids requirements of human A WHO Technical Services at No. 52. Energy and Protein requirements Reports of Joint FAO/WHO Nutrition Report Series. 430 pp.

FAO/WHO. 1990. Protein quality evaluation. In: Report of A Joint FAO/WHO Expert Consultations. FAO of The United Nations, Rome. 40 pp.

FOS. 1990. Federal Office of Statistics. Nigerian Fish Production by Sectors. Lagos Nigerian Government Printers. Nigeria. 40 pp.

Gerhard, G.T., Patton, B.D. and Lindquist, S.A. 1991. Comparism of three species of dietary fish. Effects on serum concentrations of low density lipoprotein cholesterol and apolipo protein in normptriglyceridemic subjects. American J. Clinical Nutrition, 54: 334-339.

Harris, E. 1979. Nutrition Research Techniques for Domestic and Wild Animals. Utah, USA, 140 pp.

Linghstein, H.C. and Oginsky, E.L. 1965. Experimental Microbiology and Physiology (1st Edition). Freeman. San Francisco, 138 pp.

Madu, C.T., Okoye, F.E., Sado, E.K., Omorinkoba, W.S., Bankole, W.O. and Ita, E.O. 1984. A preliminary report of induced breeding trials with the mud fish (*Clarias anguillaris*) KLRI Animal Report. 144-159.

Otitologbon, S.A., Oniye, S.J., Peters, O.A. and Agbaji, E.B. 1997. Proximate and mineral composition of three Nigerian fresh water fishes. J. Food Science and Agriculture, 75: 312-314.

Pearson, D. 1981. The Chemical Analysis of Foods. Churchill, Livingstone, Edinburg, UK, 530 pp.

Reed, W., Burchard, J., Hopson, A.J., Jenness, J. and Yaro, L. 1967. Fish and fisheries of Northern Nigeria. Gaskiya Corporation, Zaria, Northern Nigeria, 226 pp.

Samson, R.A., Hoestra, E.S. and Van Oovshot, C.A. 1981. Introduction to food borne fungi. Institute of the Royal Netherlands Academy of Arts and Sci., 125 pp.

SAS. 1989. SAS users guide: Statistics, version 5, Cary, NC: SAS Incorporated, 235 pp.

Sharkey, S.J., Sharkey, K.A., Sutherlands, L.R. and Church, D.L., 1992. GI/HIV Study group. Nutritional status and food intake in human immune deficiency virus infection. J. Acquired Immune Deficiency Syndrome, 5: 1091-1098.

Steel, R.G.D. and Torie, J.H. 1981. Principles and procedures of Statistics. A Biometrical Approach, 2nd Edition. Mc Graw Hill International, Auckland, 102 pp.

US-RDA. 1994. United States Recommended Dietary Allowance for carbohydrate, lipid, protein and energy for all ages. USA, 65 pp.

WHO. 1974. Recommended intakes of nutrients, requirements of energy, protein, vitamins, calcium and iron for humans of all ages. Report of a joint FAO/WHO Expert group FAO, Rome, 315 pp.

Winberg, G.C. 1971. Symbol, Units and Conversion factors in studies of fresh water productivity. BP. Section P. FIB. Central Office; London, 184 pp.