EFFECTS OF SMOKING DURATION ON THE PROXIMATE AND MINERAL COMPOSITION OF SELECTED FISHES FROM LOWER RIVER BENUE, BENUE STATE, NIGERIA

Abstract

The proximate and mineral compositions of selected smoked fish species from the open market were compared to samples smoked for 4 hours, 6 hours and 8 hours. *Clariasgariepinus*, *Synodonthesschall* and *Latesniloticus* randomly sampled from fishermen catches at Lower River Benue were smoked at $70^{O}C$ – $80^{O}C$ temperature using mud type kiln and *Prosopisafricana* as the energy source. The chemical analyses were done using the standard methods. Significant differences ($P<0.05$) was observed in all the parameters examined between all the species and treatments. *Clariasgariepinus*had the highest (50.80±1.26) protein content while *Latesniloticus* was least (40.79±0.81). Also, *Clariasgariepinus* was highest (7.13±0.39) in Lipids content and *Latesniloticus*, lowest (4.34±0.12).Smoking durationhad inverse impact on moisture content (7.44±0.01 - 5.22±0.01) and direct impact on protein content (47.46±0.01 - 54.33±0.01). Lipid was observed to be lowest (6.33±0.01) in the 4-hour smoked sample and highest (8.33±0.01) in the 8-hour smoked *Clariasgariepinus*.*Clariasgariepinus*had higher mineral content than other species with reference to Calcium, Potassium, Iron, Magnesium, Sodium, Zinc and Copper. However, the duration of smoking was observed to have a negative impact on the potassium content of the fish samples while other examined minerals showed positive correlation. It is thus concluded that *Clariasgariepinus* is more nutritious than *Synodonthesschall* and *Latesniloticus* from Lower River Benue and better when smoked for 6 hours. Also, it could be inferred that smoked fish sold in the open market are mostly smoked for 6 hours. However, 8-hour smoking duration is recommended for a prolonged shelf life with consideration for nutrient-specific smoking duration especially when the need for specific micro nutrients is of interest.

1.0 Introduction

Smoking is one of the oldest methods (Adepoju*et al.*, 2018) of food preservation, especially those of animal origin with fish inclusive. A smoked fish enjoy the combined effects of drying by the heat, microbial sterilization by the smoke as well as the flavor improvement by the

smoke(Omodara and Olaniyan, 2012; Erkan*et al.*, 2010). Thus a well smoked fish can be preserved on a long term basis and easily packaged for transportation over a long distance.

However, the quality of smoked fish based on international food safety standards is dependent on the quality of the raw fish, source of energy, handling during processing, and the smoking cycle (time and temperature)(Adepoju*et al.*, 2018). These factors have the tendencies of impacting on the nutritional compositions, hazard load and eventual acceptability of the final products (Tenyang*et al.*, 2020; Adepoju*et al.*, 2018; Tenyang*et al.*, 2016; Adeyeye*et al.*, 2015). As a result of need for long term preservation, transportation and ready to eat product, hot smoked fish is more popular than the cold smoked, especially in Africa. Hot smoking is a process where there is application of both smoke and heat that eventually achieve complete cooking of the fish.

For a fish product to serve its food security purpose, the edible parts have to be of optimum nutritional qualities at the point of consumption. Thus, need to monitor the value chain of the smoked fish at each critical control point. One of the important critical control points in fish smoking is the smoking cycle (Smoking time and temperature) where there can be nutrient loss as well as product contamination.

River Benue, been the second largest river in Nigeria has its stretch sectioned into the Upper Basin (Adamawa and Taraba States) and the Lower Basin (Benue and Kogi States). It empty into River Niger at the extreme downstream at Lokoja, Kogi State. Although, there are lots of fish species in the river, only few are of commercial importance. Thus, there is need for investigation into the nutritional composition such as proximate and minerals especially from the form available to the consumers.

This present study evaluated the proximate and mineral compositions of *Clariasgariepinus*, *Synodonthesschall* and*Latesniloticus* from Lower River Benue in Benue State, Nigeria, subjected to different smoking periods.

2.0 Materials and Methods

2.1 Sample collection and preparation

5 samples each of *Clariasgariepinus*, *Synodonthesschall* and *Latesniloticus* (Average weight of 500g) were collected from the catches of fishermen landing fish at Abinsi and Wadatalanding

sites. Two samples each of the different species were collected from Abinsi landing site while three samples were collected from Wadata, being the largest landing site with highest volume of fish trading in Benue State. The samples were preserved in a cooling box with ice cubes at the ration of 2:1 (Ice:fish) and immediately moved to the laboratory for preliminary processing.

At the multipurpose fish laboratory of the Department of Fisheries and Aquaculture, JS Tarkaa University, Makurdi, Nigeria, the samples were eviscerated and cleaned with a borehole water.

Also, smoked samples of the above mentiond species of fish were also collected from the open market adjoining Abinsi and Wadata landing sites for comparative analysis of the nutrient composition.

2.2 Fish smoking and Packaging

The prevailing traditional smoking method of using Mud type smoking kiln was adopted for this experiment. After cleaning under running water, the fresh raw fish were carefully arranged on a sterilized smoking meshed trays without salting.The kiln's fire place was set using dried Prosopisafricana as the source of energy.The tray was then placed on the oven as soon as the surface temperature rose to 70 °C.

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The actual smoking of the fish was done for varying periods of 4 hours, 6 hours and 8 hours, representing the three treatments in this experiment. The fish were subjected to intermittent turning at equal intervals of 30 minutes.

The smoked fish were allowed to cool at room temperature and packaged alongside with the control sample obtained from the open market in carton that were already labelled according to the treatments as C_1 (Control), T_1 (4hour smoked), T_2 (6 hour smoked), and T_3 (8 hour smoked).

2.3 Laboratory Analysis of Samples

The individual samples were separately reduced into fine particles using an electric blender at 18,000 revolution per minute in batches of the treatments.

20g of each sample was then packaged in sterile sample bottles in triplicates of each sample labelling and presented for proximate and mineral analyses.

2.3.1 Proximate analysis

The samples were analysed for proximate composition based on the official method of AOAC (1990). Moisture content was determined by drying the samples to constant weights in oven at 101°C. This was based on AOAC procedures 925.40. Ash content was determined by incinerating the samples at 550 °C following AOAC procedures 942.05. After determining the Nitrogen (N) content using micro-Kjeldahl method, and according to AOAC procedures 984.13, the crude protein content was estimated as N x 6.25. Soxhlet apparatus was used to analyze for the lipid, using hexane, and based on the AOAC 963.15 procedure.

Determination of mineral composition

2.3.2 Mineral analysis

The ash residue obtained from the determination of ash content as described above was used for the mineral analyses of the samples.

2g of the ash was boiled with 10 mL of 20% HCl in a beaker and then filtered into a 100 mL standard flask. Calcium (Ca), Copper (Cu), Iron (Fe),Magnesium (Mg), Potassium (K),Sodium (Na) andZinc (Zn)were determined by Atomic Absorption Spectrometer (Varian 220FSSpectr AA, Les Ulis, France) as against standard.

2.4 Statistical Analysis

The data obtained from both the proximate and mineral analyses of the samples were subjected to One Way Analysis of Variance (ANOVA) to determine the mean values of each nutritional parameter from the samples.The mean separation was done by multiple comparison using Least Significant Difference (LSD) method.

The statistical analysis was carried out using SPSS 25.0 (SPSS, 2017) while the results were presented in tabular forms as mean values ± standard error of means.

3.0 Results

Table 1 shows the proximate composition of selected smoked freshwater fish species from Lower River Benue. *Clariasgariepinus* was observed to have the highest (50.80±1.26) protein content while *Latesniloticus* was least (40.79±0.81). Also, *Clariasgariepinus* was observed to be highest (7.13±0.39) in Lipids content and *Latesniloticus*, lowest (4.34±0.12).

Also, significant differences were observed in all the proximate components analysed between the different species of fish. Latesniloticus was observed to be least in virtually all the proximate components except in the NFE.

Table 1: Proximate Composition of Smoked *Fresh water Fish Species* from Lower River Benue

Fish Species	Moisture	Ash	Lipid	Fibers	Protein	NFE
Clariasgariepinus	6.18±0.42[b]	3.36±0.30[b]	7.13±0.39[c]	1.47±0.04[a]	50.80±1.26[b]	31.10±1.57[a]
Synodontesschall	4.72±0.19[a]	6.04±0.18[c]	5.98±0.13[b]	2.16±0.05[b]	47.81±0.47[a]	33.14±0.73[a]
Latesniloticus	5.79±0.21[b]	1.52±0.04[a]	4.34±0.12[a]	1.53±0.03[a]	40.79±0.81[a]	46.43±0.85[b]
LSD	0.01	0.00	0.00	0.00	0.00	0.00

**means in the same column with different superscripts differ significantly (P<0.05)*

The proximate composition of *Clariasgariepinus* smoked for different durations are presented in table 2. It was observed that as the duration of smoking was increasing, the moisture content was reducing (7.44±0.01 - 5.22±0.01) with inverse trend in protein content (47.46±0.01 - 54.33±0.01).at the same time, Lipid was observed to be lowest (6.33±0.01) in the least smoked sample and highest (8.33±0.01) in the longest smoked *Clariasgariepinus*.

All the proximate components showed significant differences between the different durations of smoking. The third treatment in which the fish was smoked for 8 hours had the relatively highest percentages of proximate components except for the moisture and NFE where it had the lowest.

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Table 2: Proximate Composition of *Clariasgariepinus*Smoked for different Periods

Smoking Periods	Moisture	Ash	Lipid	Fibers	Protein	NFE
4 hours	7.44±0.01^{c}	2.44±0.01^{a}	6.33±0.01^{a}	1.34±0.01^{a}	47.46±0.01^{a}	35.03±0.01^{c}
6 hours	5.88±0.01^{b}	3.56±0.01^{b}	6.74±0.01^{b}	1.48±0.01^{b}	50.62±0.01^{b}	31.77±0.01^{b}
8 hours	5.22±0.01^{a}	4.08±0.01^{c}	8.33±0.01^{c}	1.60±0.01^{c}	54.33±0.01^{c}	26.49±0.01^{a}
LSD	0.00	0.00	0.00	0.00	0.00	0.00

**means in the same column with different superscripts differ significantly (P<0.05)*

In the proximate composition of *Synodontesschall* as presented in table 3 below, inverse relationships were observed between the duration of fish smoking and the Lipids, ash, fibre and Protein content while the duration of smoking and the moisture and NFE contents were observed to be directly related.The percentage composition of Ash, Lipid, Fibres and protein showed progressive increase with the increasing duration of smoking.

All the proximate components showed significant differences between the different durations of smoking. The fish smoked for 8 hours had the relatively highest percentages of proximate components except for the moisture and NFE where it had the lowest.

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Table 3: Proximate Composition of *Synodontesschall*Smoked for different Periods

Smoking Periods	Moisture	Ash	Lipid	Fibers	Protein	NFE
4 hours	5.26±0.01^{c}	5.48±0.01^{a}	5.64±0.01^{a}	2.01±0.01^{a}	46.46±0.01^{a}	35.19±0.01^{c}
6 hours	4.68±0.01^{b}	6.24±0.01^{b}	5.94±0.01^{b}	2.14±0.01^{b}	47.96±0.01^{b}	33.08±0.01^{b}
8 hours	4.22±0.01^{a}	6.44±0.01^{c}	6.33±0.01^{c}	2.32±0.01^{c}	49.00±0.01^{c}	31.16±0.01^{a}
LSD	0.00	0.00	0.00	0.00	0.00	0.00

**means in the same column with different superscripts differ significantly (P<0.05)*

Table 4 below shows the percentage composition of the selected proximate components of *Latesniloticus* smoked for different period. It was observed that the longer the smoking duration, the lower the moisture and the NFE content while the relationship between the duration of smoking and ash, lipids, fibers and protein contents assume a direct trend.

Significant differences were observed in all the proximate components between the different treatments of the experiment.

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Table 4: Proximate Composition of *Latesniloticus*Smoked for different Periods

Smoking Periods	Moisture	Ash	Lipid	Fibers	Protein	NFE
4 hours	6.22±0.01^{c}	1.53±0.01^{b}	4.03±0.01^{a}	1.44±0.01^{a}	38.41±0.01^{a}	48.42±0.01^{c}
6 hours	6.03±0.01^{b}	1.60±0.01^{a}	4.36±0.01^{b}	1.54±0.01^{b}	41.14±0.01^{b}	47.56±0.01^{b}
8 hours	5.13±0.01^{a}	1.64±0.01^{c}	4.66±0.01^{c}	1.59±0.01^{c}	42.82±0.01^{c}	44.22±0.01^{a}
LSD	0.00	0.00	0.00	0.00	0.00	0.00

**means in the same column with different superscripts differ significantly (P<0.05)*

The percentage crude protein composition of selected fish species from Lower River Benue is as shown in figure 1 below. It is observed that smoking the different species of fish for 8 hours gives the highest crude protein content when compared to the other samples of same species sold in the open market and those smoked for lesser duration. *Clariasgariepinus* however appears to be the best at 54%.

The various species of fish smoked four 4 hours appears to be the least in crude protein content and with *Latesniloticus* at 38% crude protein.

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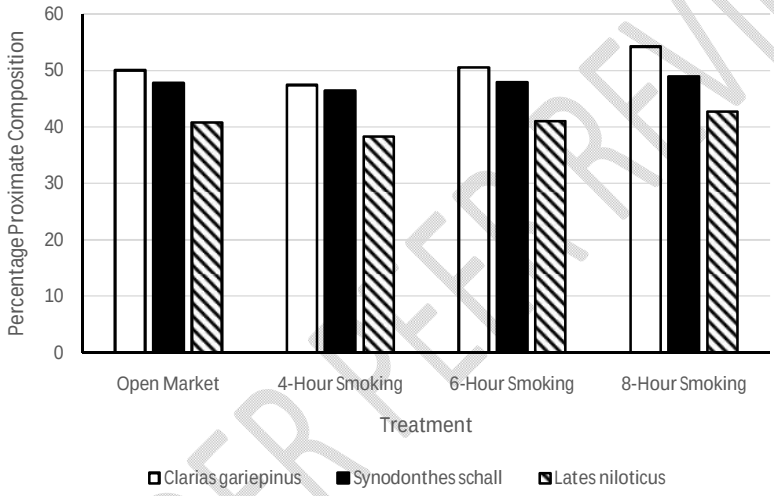

Figure 1: Percentage crude protein composition of smoked selected fish species from Lower River Benue

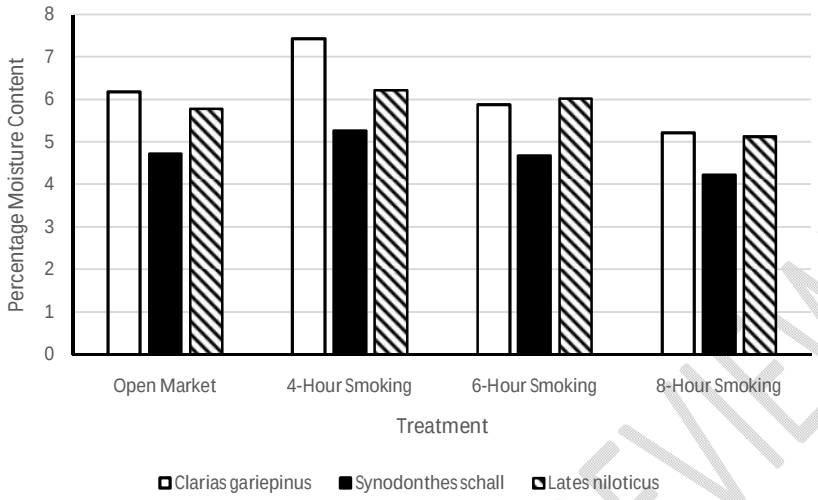

Figure 2: Percentage Moisture composition of smoked selected fish species from Lower River Benue

Tables 5, 6, 7 and 8 present the compositions of selected minerals in *Clariasgariepinus, Synodontesschall* and *Latesniloticus* sold in the open market as well as those smoked for different durations. It was observed that *Clariasgariepinus* is relatively better in mineral content when compared to *Synodontesschall* and *Latesniloticus* with reference to Calcium, Potassium, Iron, Magnesium, Sodium, Zinc and Copper compositions. However, the duration of smoking was observed to have a negative impact on the potassium content of the fish samples while other examined minerals showed positive correlation between their individual content and the duration of smoking.

Table 5: Mineral Composition of Smoked *Fresh water Fish Species* from Lower River Benue

Species	**Calcium**	**Potassium**	**Iron**	**Magnesium**	**Sodium**	**Zinc**	**Copper**
Clariasgariepinus	4.75±0.08b	1.73±0.04b	0.89±0.01c	0.52±0.01ab	3.56±0.02b	0.30±0.00c	1.14±0.04b
Synodontesschall	4.26±0.03ab	1.26±0.03a	0.19±0.01b	0.38±0.02a	2.40±0.06a	0.09±0.00a	0.36±0.21a
Latesniloticus	3.90±0.32a	1.31±0.18a	0.13±0.02a	0.59±0.10b	2.36±0.17a	0.20±0.03b	0.03±0.01a
LSD	0.02	0.02	0.00	0.07	0.00	0.00	0.00

**means in the same column with different superscripts differ significantly (P<0.05)*

Table 6: Mineral Composition of *Clariasgariepinus*Smoked for different Periods

Smoking Periods	**Calcium**	**Potassium**	**Iron**	**Magnesium**	**Sodium**	**Zinc**	**Copper**
4 hours	4.73±0.01^{b}	1.84±0.01^{c}	0.93±0.01^{c}	0.49±0.01^{a}	3.56±0.01^{b}	0.28±0.01^{a}	1.14±0.01^{b}
6 hours	4.56±0.01^{a}	1.66±0.01^{a}	0.86±0.01^{a}	0.52±0.01^{b}	3.48±0.01^{a}	0.30±0.01^{a}	1.02±0.01^{a}
8 hours	4.99±0.01^{c}	1.69±0.01^{b}	0.89±0.01^{b}	0.54±0.01^{c}	3.61±0.01^{c}	0.29±0.01^{a}	1.24±0.01^{c}
LSD	0.00	0.00	0.00	0.01	0.00	0.14	0.00

**means in the same column with different superscripts differ significantly (P<0.05)*

Table 7: Mineral Composition of *Synodontesschall*Smoked for different Periods

Smoking Periods	Calcium	Potassium	Iron	Magnesium	Sodium	Zinc	Copper
4 hours	4.28±0.01^{b}	1.21±0.01^{a}	0.16±0.01^{a}	0.31±0.01^{a}	2.22±0.01^{a}	0.08±0.00^{a}	1.02±0.01^{b}
6 hours	4.32±0.01^{c}	1.34±0.01^{b}	0.18±0.01^{a}	0.42±0.01^{c}	2.43±0.01^{b}	0.09±0.00^{a}	0.03±0.00^{a}
8 hours	4.18±0.01^{a}	1.22±0.01^{a}	0.21±0.01^{b}	0.39±0.01^{b}	2.53±0.01^{c}	0.09±0.01^{a}	0.03±0.00^{a}
LSD	0.00	0.00	0.01	0.00	0.00	0.12	0.00

**means in the same column with different superscripts differ significantly (P<0.05)*

Table 8: Mineral Composition of *Latesniloticus*Smoked for different Periods

Smoking Periods	Calcium	Potassium	Iron	Magnesium	Sodium	Zinc	Copper
4 hours	3.02±0.01^{a}	1.78±0.01^{c}	0.08±0.00^{a}	0.56±0.01^{b}	2.01±0.01^{a}	0.13±0.01^{a}	0.02±0.01^{a}
6 hours	3.89±0.01^{b}	0.78±0.01^{a}	0.19±0.01^{b}	0.87±0.01^{c}	2.16±0.01^{b}	0.26±0.01^{c}	0.03±0.00^{ab}
8 hours	4.78±0.01^{c}	1.34±0.01^{b}	0.10±0.01^{a}	0.32±0.01^{a}	2.89±0.01^{c}	0.20±0.01^{b}	0.05±0.00^{b}
LSD	0.00	0.00	0.00	0.00	0.00	0.00	0.07

**means in the same column with different superscripts differ significantly (P<0.05)*

4.0 Discussion

4.1 Proximate composition

The proximate composition of the fish samples indicated that *Synodonthesschall* and *Latesniloticus* dried faster than *Clariasgariepinus* subjected to the same smoking cycle. This could be due to the nature of the muscles of the different fish species. It can be confirmed from the reports of Popoola and Fasakin(2019), Ogbonnaya and Ibrahim (2009) and Sadiku and Oladimeji(1991) that *Clariasgariepinus* is a more fatty fish than *Synodonthesschall* and *Latesniloticus* being the least fatty fish of the three. Thus, the observations on the relationship between the moisture content and the other proximate components in this current research is in line with the findings of Adepoju*et al*., (2018)who pointed out that the decline of the moisture content in smokedmilkfish steaks gives rise to increase in the percentage protein, lipids, crude fibre composition of fish as a whole. This is due to the concentration of these proximate components within the drying or dried fish muscles. However, this is at variance to the observation of Ibrahim (2017) who assessed the nutritional qualities of smoke *Clariasgariepinus* sold in Lapai, Nigeria. Also, Ajai*et al*. (2019) a slight different trend in the proximate composition of smoked *Clariasgariepinus* sold in Minna, Nigeria in which the fibre, ash and fat contents exhibited a direct relationship with the trend of moisture content. This could be due to the continuous smoking used to preserve smoked fish in the market which might cause some destructions in the nutritional components of fish. Storage over time can also cause decrease in the proximate composition of fish samples except for moisture content (Ayeloja*et al.*, 2020).

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Also, it was observed in this current research and confirmed in the report of Adepoju*et al.* (2018) that increased smoking time, even at a constant temperature has a decreasing effect on the moisture content and increasing effects on the other proximate components.

4.2 Mineral Compositions

The mineral composition of smoked freshwater fishes sold in the open markets of the floodplain as shown in table 5 shows that *Clariasgariepinus* from Lower River Benue is richer in minerals than *Synodonthesschall* and *Latesniloticous* from the same water body. This further confirm *Clariasgariepinus* as a load of minerals which Babalola*et al*. (2011) has also identified as one of the commercial fishes with high mineral compositions in Nigeria. However, fluctuating

variationswas observed in the individual mineral elements between the three examined species of fish. This fluctuation showed that *Clariasgariepinus* has the most consistent highest mineral composition while the fluctuation was basically observed between *Latesniloticus* and *Synodonthesschall*. This is in agreement with the findings of Ahmed*et al.* (2017) who observed non-uniform variations in the mineral compositions of some commercially important fishes of JeblAwlia Reservoir in Sudan.*Synodonthesschall* was observed to be higher in Calcium, Iron, Sodium and Copper than *Latesniloticus* while *Latesniloticus* was observed to be higher in Potassium, Magnessium and Zinc.

From observation, different mineral elements responds to the different smoking duration differentially. This makes the different mineral elements available in the smoked fishes at different concentrations when smoked for varying durations. However, *Clariasgariepinus* performed best when smoked for 4 hours and 8 hours compared to the mineral compositions when smoked for 6 hours. *Synodonthesschall* can be observed to be higher in mineral composition when smoked at 6 hours and 8 hours except for copper which is higher when the fish is smoked for 4 hours.*Latesniloticus* was however observed to be higher in most mineral elements when smoked for 6 hours, followed by 8 hours and least at 4 hours.

5.0 Conclusion

The observations from this research has been able to show that *Clariasgariepinus* from Lower River Benue is richer in proximate and mineral composition than *Synodonthesschall* and *Latesniloticus* from the same source. However, the three species of fish examined in this research are good source of nutrients, both proximate and mineral nutrients.

Also, based on the observation of the crude protein and moisture contents as shown in figure 1 and figure 2 respectively, it could be inferred that most fish sold in the open market are smoked for 6 hours as a result of the relatively equal crude protein contents in all the species tested between the samples from open market and those smoked for 6 hours.

6.0 Recommendation

Based on the various observations made in this research, it is recommended to smoke freshwater for a duration not less than 8 hours. This is so that the shelf life of the smoked fish can be

prolonged as this smoking duration reduces the moisture content to a greater extent than those smoked for 4 and 6 hours and also gives highest percentages of most of the nutrient components.

Also, a nutrient-specific smoking regime could be of advantage in smoking fish samples as various mineral components were observed to be differentially relative to the smoking durations

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Introduceand comment:

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Comment [KB2]:

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