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EFFECT OF SCENT LEAF (*Ocimum gratissimum*) CURING ON *Clarias gariepinus* SMOKED WITH SOYBEAN (*Glycine max*) SHELL BRIQUETTES AS A SUBSTITUTE FOR FIREWOOD

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ABSTRACT

This study evaluated the effects of scent leaf (*Ocimum gratissimum*) curing on the organoleptic properties, proximate composition, and mineral content of smoked African catfish (*Clarias gariepinus*) processed using soybean shell briquettes as an eco-friendly fuel source. A Completely Randomized Design (CRD) was adopted with three treatments: T1 (control without curing), T2 (fresh scent leaf paste), and T3 (dried scent leaf pulp). The fish samples were smoked and assessed over a five-week storage period. Results showed that scent leaf curing had no significant effect ($p>0.05$) on sensory qualities such as colour and texture. However, significant improvements ($p<0.05$) were observed in the nutritional composition, particularly in essential minerals including potassium, calcium, magnesium, and phosphorus. The dried scent leaf treatment (T3) recorded the lowest moisture content (16.33%) at week five, indicating better preservation ability and shelf stability. The study concludes that combining scent leaf curing with soybean shell briquettes enhances the nutritional quality and preservation of smoked fish without affecting sensory acceptability. This sustainable processing method offers a practical value-addition strategy for small-scale fish processors, contributing to food security, improved fish preservation, and environmental conservation.

Keywords**:** Scent leaf, African catfish, soybean shell briquettes, mineral content, food security, environmental conservation.

Introduction

Fish is an essential component of global food security and human nutrition, contributing significantly to the intake of high-quality animal protein, essential minerals, vitamins, and omega-3 fatty acids necessary for growth and health (Maila *et al.*, 2021). In Nigeria and many developing countries, fish serves as a major source of dietary protein and livelihood for millions of people engaged in fisheries and aquaculture (Saba *et al.*, 2024). Among the commercially important fish species, the African catfish (*Clarias gariepinus*) is widely cultivated due to its rapid growth, adaptability to diverse environmental conditions, and high economic value (Bawa, 2024).

Despite its importance, fish is highly perishable, and substantial post-harvest losses occur due to microbial spoilage and enzymatic deterioration, especially under tropical climatic conditions (Sissoko *et al.*, 2025). To reduce these losses and extend shelf-life, smoking remains one of the most common and affordable preservation methods in Nigeria. Smoking enhances flavour, reduces moisture content, and improves the keeping quality of

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fish (Igbokwe *et al.*, 2025). However, traditional fish smoking largely depends on firewood, which contributes to deforestation, environmental pollution, and health hazards associated with smoke exposure. Consequently, there is increasing interest in sustainable alternative fuels such as soybean shell briquettes, which are eco-friendly, efficient, and capable of converting agricultural waste into useful energy.

In addition to sustainable fuel alternatives, natural plant-based preservatives are gaining attention for improving the quality and safety of smoked fish. Scent leaf (*Ocimum gratissimum*) is a widely used aromatic plant (Agholor *et al.*, 2018) known for its antimicrobial and antioxidant properties due to the presence of bioactive compounds such as flavonoids, tannins, and saponins (Edo *et al.*, 2023). Although commonly used as a spice and medicinal plant, limited information exists on its effectiveness as a natural curing agent in smoked fish processing. Therefore, this study evaluated the effect of scent leaf curing on the nutritional composition, sensory properties, and overall quality of smoked African catfish processed with soybean shell briquettes as a sustainable alternative to traditional firewood. The study aims to promote improved fish preservation, food security, and environmental sustainability.

Materials and Methods

Study Area

The smoking procedure was conducted at the teaching and research farm of the Department of Water Resources, Aquaculture and Fisheries Technology (WAFT), Federal University of Technology, Minna, Nigeria (Latitude 9°31’00.80” N, Longitude 6°26’25.21” E). All subsequent laboratory analyses were performed at the WAFT Departmental laboratory, Gidan Kwano campus.

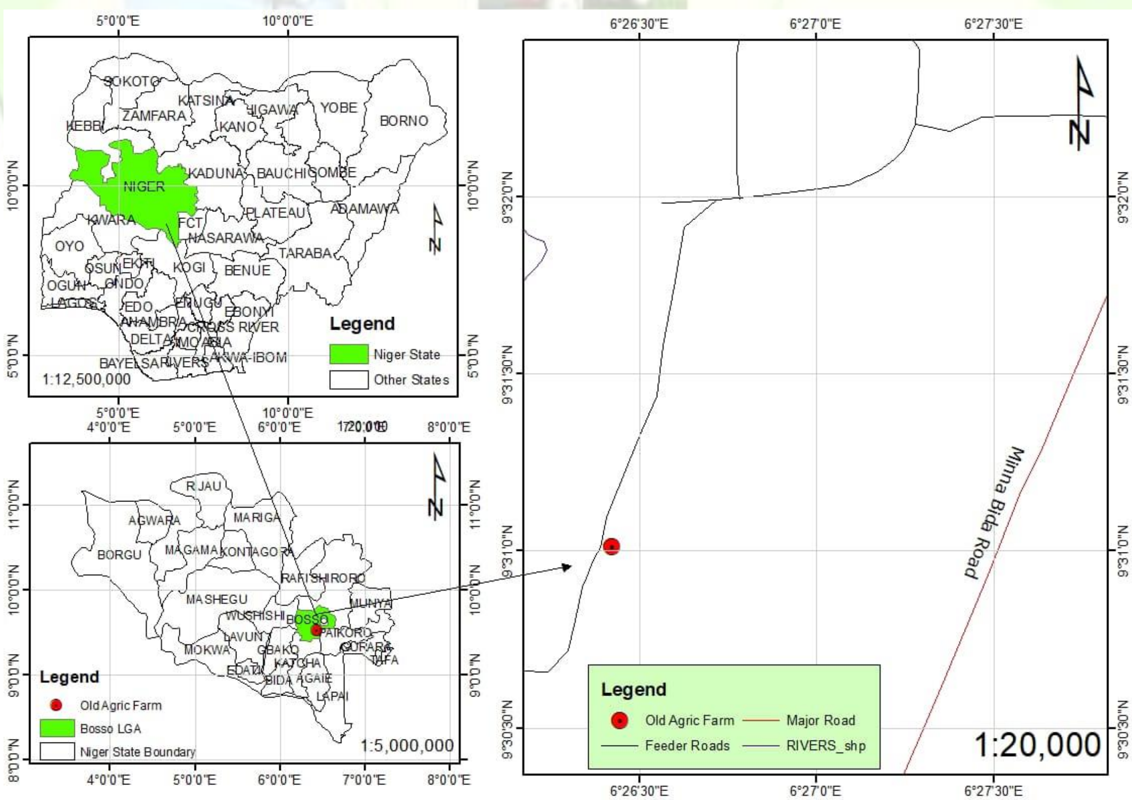

Figure 1: Map of the Study Area

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Procurement and Preparation of Fish Samples

Live specimens of African catfish (*Clarias gariepinus*) were procured from the Mobil fish market in Minna, Niger State. The fish were transported live to the WAFT laboratory. Upon arrival, the fish were euthanized, degutted, and washed thoroughly with clean water to remove all blood and slime. Each fish was then cut into five uniform chunks. The chunks were arranged on smoking racks to allow excess water to drain before the application of treatments.

Preparation of Plant-Based Curing Agents

Scent leaves (*Ocimum gratissimum*) were harvested from the staff quarters of the Federal University of Technology, Minna. The leaves were washed to remove dust and debris and were subsequently processed into two types of curing agents: One-half of the washed leaves was blended while fresh with a minimal amount of water to form a homogenous paste. The second half of the leaves was air-dried at room temperature until brittle. The dried leaves were then ground into a fine powder, which was subsequently soaked in hot water to create a thick pulp.

Preparation of Soybean Shell Briquettes

Soybean shells (Plate 1) were sourced from local soybean processors in the Dama community, Minna, Niger State. The shells were cleaned to remove foreign debris. Waste paper (Plate 2) was utilized as a binding agent for the briquettes. The paper was shredded into small pieces, soaked in water for 48 hours to soften and release its fibres, and then macerated into a pulp-like consistency. The ground soybean shells were thoroughly mixed with the paper pulp, compacted, and formed into briquettes (Plate 3), which were then used as a fuel source for smoking.

Plate 1

Plate 2

Plate 2

Experimental Design and Treatments

The experiment was conducted using a Completely Randomized Design (CRD). A total of 30 fish chunks were randomly allocated to three treatment groups, with each treatment having two replicates of five chunks each (n=10 chunks per treatment). The treatments were defined by the curing method applied before smoking: Treatment 1 (T1 - Control): Fish chunks were smoked without any curing agent. Treatment 2 (T2 - Fresh Scent Leaf): Fish chunks were coated with the

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fresh *O. gratissimum* paste before smoking. Treatment 3 (T3 - Dried Scent Leaf): Fish chunks were coated with the pulp derived from dried *O. gratissimum* before smoking. Following the application of treatments, all fish chunks were smoked using a combination of charcoal and the prepared soybean shell briquettes.

Data Collection and Analysis

After the smoking process, the organoleptic properties of the fish samples from each treatment were evaluated. The samples were assessed for colour, texture, appearance, taste, and odour/aroma. A 4-point hedonic scale (ranging from 0 to 3) was used for the evaluation, with the following descriptors: Colour: 0 = rejected, 1 = dull, 2 = glossy, 3 = very bright; Texture: 0 = rejected, 1 = soft, 2 = firm, 3 = very firm; Appearance, Taste, and Odour/Aroma: 0 = dislike extremely, 1 = neither like/dislike, 2 = moderately like, 3 = like extremely.

Biochemical Analysis

Samples from each treatment were analysed for their proximate and mineral compositions at the WAFT laboratory. The proximate composition of the smoked fish was determined using standard methods of the AOAC (2000). Analyses included crude protein, crude fat (ether extract), moisture content, ash content, and crude fibre. Nitrogen-Free Extract (NFE) was determined by difference using the formula: NFE (%) = 100 – (% moisture + % crude protein + % ether extract + % ash + % crude fibre). For mineral analysis, 2 g of each sample was weighed (using an Atom-110C balance) into a crucible and subjected to dry ashing in a muffle furnace (M110) at 500 °C for 4 hours. The resulting ash was digested with 10 ml of HCl, and the solution was filtered into a 50 ml volumetric flask. The concentrations of specific minerals were determined using the following methods: The Sodium (Na) and Potassium (K) were determined using flame photometry (Jenway FF-200). Phosphorus (P) was determined using spectrophotometry (Jenway 741501). The calcium (Ca) was determined by EDTA titration using 10% KOH and a casein indicator. Magnesium (Mg) was determined by EDTA titration using an ammonia buffer and an Eriochrome black T indicator.

Data Analysis

Data were analysed using a one-way analysis of variance (ANOVA). Significant differences between treatment means were determined using Duncan's Multiple Range Test (DMRT) at a significance level ($p<0.05$). The Statistical Package for Social Sciences (SPSS V22) was used for all analyses.

Results and Discussion

Table 1 shows the effects of scent leaf (*Ocimum gratissimum*) treatment on the organoleptic properties of *Clarias gariepinus*, over five weeks. There were no significant differences ($p>0.05$) among the treatment means in colour, flavour and texture. However, Chinasa *et al.* (2022) reported a significant difference ($p<0.05$) among the treatments means in appearance, texture, taste and aroma. Ojutiku *et al.* (2009) stated that, the organoleptic properties such as colour, flavour, texture, and aroma are critical determinants of consumer acceptance and perceived quality of food products, especially processed fish. This result suggests that the application of scent leaf, regardless of concentration (within the range tested), did not alter the visible colour of the *Clarias gariepinus* product. The colour of processed fish is primarily determined by the processing method itself and the natural pigmentation of the fish skin and flesh (NurSyahirah and Rozzamri, 2022). The chemical constituents of scent leaf extract are not potent pigments (Ujah *et al.*, 2021) and, when applied to the fish, are not concentrated enough to cause a discernible colour change. The results indicate that the scent leaf treatment did not significantly impact the fish's muscle fibre content and water-holdingcapacity. However, Tairu *et al.* (2017) stated that smoking is a traditional preservation method that imparts desirable flavour and colour while reducing water activity, thus inhibiting microbial spoilage. The texture in fish muscle is a function of its protein structure and moisture content (Sankar, 2009). Processing method such as smoking denatures proteins and reduce water activity, which are the primary factors affecting the final texture (Khalid *et al.*, 2023). Edo *et al.* (2023) reported that the bioactive compounds in scent leaf, act primarily on a microbial and chemical level rather than on a structural level.

Table 1:Effect of Scent Leaf Treatment on the Organoleptic Properties of *Clarias gariepinus*

Treatment / Weeks	**T1**	**T2**	**T3**	**±SE**
	Colour			
1	2.30±0.60^{a}	2.10±0.64^{a}	2.00±0.84^{a}	0.14
2	1.80±0.64^{a}	1.72±0.82^{a}	1.70±0.88^{a}	0.16
3	2.20±0.78^{a}	2.10±0.64^{a}	2.06±0.70^{a}	0.15
4	2.00±0.40^{a}	1.98±0.41^{a}	1.80±0.34^{a}	0.14
5	2.00±0.63^{a}	1.90±0.43^{a}	1.88±0.42^{a}	0.13
	Flavour			
1	2.20±0.50^{a}	2.10±0.04^{a}	1.70±0.84^{b}	0.14
2	2.20±0.44^{a}	2.40±0.42^{a}	2.30±0.88^{a}	0.12
3	2.20±0.74^{a}	2.30±0.84^{a}	2.36±0.70^{a}	0.12
4	2.10±0.60^{a}	1.40±0.64^{b}	2.00±0.04^{a}	0.11
5	2.00±0.40^{a}	1.60±0.64^{b}	2.00±0.80^{a}	0.10
	Texture			
1	1.30±0.30^{a}	1.40±0.44^{a}	1.10±0.44^{a}	0.11
2	2.20±0.44^{a}	2.16±0.42^{a}	2.10±0.38^{a}	0.13
3	1.90±0.68^{a}	1.80±0.34^{a}	1.76±0.60^{a}	0.10
4	1.30±0.30^{a}	1.20±0.24^{a}	1.00±0.14^{a}	0.10
5	2.20±0.60^{a}	1.80±o.64^{a}	2.00±0.84^{a}	0.14
	Aroma			
1	2.10±0.32^{a}	2.00±0.44^{a}	1.60±0.52^{b}	0.34
2	1.40±0.64^{b}	2.06±0.62^{a}	1.70±0.68^{b}	0.26
3	2.00±0.74^{a}	2.00±0.66^{a}	1.60±0.80^{b}	0.35
4	2.20±0.50^{a}	2.18±0.63^{a}	2.03±0.33^{a}	0.22
5	1.90±0.40^{a}	2.00±o.64^{a}	2.00±0.84^{a}	0.20

Means with the same superscript along the same row are not significantly different (p>0.05)

The poor score for T3 in Week 1 for flavour suggests that the high concentration of scent leaf may have imparted an overpowering off-flavour that was perceived as unpleasant by the sensory panel. Lawless and Heymann (2010) The lack of significant differences (p>0.05) in weeks 4 and 5 is likely due to the natural dissipation of volatile aromatic compounds over time. As the storage period lengthens, the potent aroma of the scent leaf could fade, making the treated samples less distinguishable from the control. This is a common phenomenon with products treated with volatile essential oils (Tainter and Grenis, 2001). Wang *et al.* (2024) stated that aroma is directly related to volatile organic compounds. The aroma of scent leaf is potent due to its high concentration of essential oils (Evbuomwan and Monday, 2020).

The result (Table 2) showed that, the sodium content remains relatively stable across all treatments for the first four weeks, with no significant differences (p>0.05). however, in week 5, T2 shows a drop in sodium concentration (216.28 mg/100g) and differed significantly (p<0.05) from T1 and T3. The variation could be due to a specific interaction between the scent leaf concentration in T2 and moisture migration, potentially causing some leaching of the highly soluble sodium salt. This result does not corroborate with the findings of Emmanuel *et al.* (2024) who reported non-uniform variations in mineral compositions while investigating the effects of smoking duration on the proximate and mineral composition of selected fishes from lower river Benue, Benue State, Nigeria. Lower fish sodium levels potentially reflecting low environmental sodium concentrations and reduced trophic transfer (Rebholz *et al.*, 2012). The result further revealed a dose-dependent reported that, consumer preference for flavour additives is often concentration dependent. Flavour is a direct consequence of the volatile and non-volatile chemical compounds present (Bai *et al.*, 2016).
increase (Week 5) in potassium content in T3 (871.13 mg/100g) compared to T1 (850.71 mg/100g) and T2 (861.28 mg/100g) respectively. *Ocimum gratissimum* is known to be a rich source of potassium (Edeoga *et al.*, 2005). The data could suggest that during the storage period, potassium from the scent leaves migrates into the fish flesh. Saadi *et al.* (2025) reported that potassium is an essential electrolyte that plays a crucial role in maintaining fluid balance, nerve function, and regulating blood pressure. Enhancing the potassium and sodium ratio in a food product is considered a positive nutritional modification (He and MacGregor, 2009). The phosphorus, often found in conjunction with calcium, is a major component of bones, teeth, and cell membranes. Fish is an excellent natural source of phosphorus (Sugiura, 2024). This result demonstrates that the scent leaf treatment significantly increases the phosphorus content of the smoked fish from the very beginning of the storage period. This enrichment could likely occur during or immediately after processing.

Table 3 shows the results of proximate analysis conducted on smoked *Clarias gariepinus* treated with scent leaf and stored over five weeks. The moisture content fluctuates significantly (p<0.05) throughout the storage period for all treatments. In week 1, the treated groups (T2 and T3) show significantly lower moisture content than the control (T1). However, by week 4, T2 (21.33%) has the lowest moisture content, followed by T1 (21.91%), and then T3 (22.63%).

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Table 2: Effect of scent leaf treatment on the Mineral Compositions (mg/100g) of smoked *Clarias gariepinus*

Treatment / Weeks	T1	T2	T3	±SE
	Sodium			
1	256.28±53.24[a]	255.28±33.04[a]	250.20±33.04[a]	30.7
2	238.12±29.26[a]	237.08±23.21[a]	239.21±33.04[a]	16.8
3	243.52±0.91[a]	243.28±13.23[a]	244.08±33.04[a]	0.52
4	244.55±10.31[a]	243.08±13.04[a]	246.18±33.04[a]	5.90
5	253.76±7.12[a]	216.28±3.14[b]	256.23±33.04[a]	4.11
	Potassium			
1	871.80±12.24[a]	876.28±13.04[a]	877.21±22.04[a]	7.08
2	877.78±10.26[a]	879.08±23.21[a]	879.20±3.04[a]	5.90
3	833.79±24.41[a]	832.18±13.23[a]	831.08±13.04[a]	14.1
4	875.15±12.61[a]	874.08±03.04[a]	873.16±23.04[a]	17.2
5	850.71±29.8[c]	861.28±30.14[b]	871.13±03.04[a]	4.11
	Calcium			
1	558.51±51.24[a]	559.20±23.04[a]	560.20±31.04[a]	13.04
2	541.55±54.26[a]	542.06±13.21[a]	544.21±30.04[a]	3.30
3	554.40±44.01[a]	556.18±23.23[a]	555.06±13.04[a]	10.20
4	565.12±12.31[a]	567.08±33.04[a]	566.10±23.04[a]	6.10
5	550.06±65.12[b]	554.20±30.14[c]	560.20±30.04[a]	9.30
	Magnesium			
1	319.70±53.24[b]	330.28±33.04[a]	333.20±23.06[a]	3.30
2	337.37±29.26[b]	343.08±23.21[a]	338.21±13.24[a]	7.00
3	347.30±0.91[b]	348.28±13.23[a]	348.08±3.04[a]	10.32
4	355.44±10.31[b]	362.08±13.04[a]	366.18±36.20[a]	7.80
5	354.19±7.12[b]	346.28±3.14[a]	356.23±12.11[a]	1.41
	Phosphorus			
1	248.51±44.35[b]	234.38±30.04[a]	238.10±13.04[a]	25.6
2	273.88±35.85[b]	283.06±20.20[a]	280.11±3.04[a]	20.7
3	274.20±38.12[b]	283.28±13.23[a]	288.08±13.00[a]	22.00
4	307.99±7.56[b]	308.00±13.04[a]	316.08±30.06[a]	4.30
5	314.44±0.19[b]	316.06±3.14[a]	326.03±3.00[a]	4.71

Means with the same superscript along the same row are not significantly different (p>0.05)

Table 3. Effects of Scent Leaf on the Proximate Compositions (%) of Smoked *Clarias gariepinus*

Treatments / Weeks	T1	T2	T3	±SE
	Moisture Content			
1	20.63±0.50^{a}	19.33±0.30^{b}	19.30±0.53^{b}	0.29
2	24.99±2.52^{c}	20.33±0.03^{b}	25.43±0.33^{a}	1.51
3	24.07±1.90^{b}	25.23±0.40^{a}	22.43±0.30^{c}	1.10
4	21.91±1.23^{b}	21.33±0.60^{c}	22.63±0.54^{a}	0.70
5	21.91±1.23^{a}	20.63±0.33^{b}	16.33±0.42^{c}	1.32
	Ash Content			
1	5.38±0.37^{b}	5.36±0.30^{c}	6.08±0.03^{a}	0.21
2	6.66±0.70^{a}	6.08±0.63^{b}	6.00±0.33^{c}	0.40
3	6.74±0.63^{a}	6.34±0.00^{b}	6.33±0.30^{c}	0.36
4	7.35±0.32^{a}	6.00±0.60^{c}	6.03±0.34^{b}	0.18
5	7.21±0.21^{a}	7.04±0.23^{b}	5.08±0.42^{c}	0.12
	Ether Extract			
1	16.12±1.9^{a}	16.06±0.04^{c}	16.10±0.03^{b}	1.09
2	14.06±3.55^{c}	14.08±0.30^{b}	14.33±0.08^{a}	2.05
3	12.40±1.36^{a}	10.00±0.40^{c}	10.06±0.30^{b}	1.36
4	14.81±0.26^{a}	12.20±0.60^{b}	12.08±0.08^{c}	0.26
5	14.16±0.35^{a}	13.08±0.34^{b}	11.12±0.04^{c}	0.35
	Crude Protein			
1	52.66±2.7^{b}	51.33±1.04^{c}	56.08±0.13^{a}	1.58
2	52.36±4.4^{a}	49.00±1.30^{c}	50.08±0.08^{b}	2.56
3	48.32±1.50^{a}	46.00±0.60^{b}	44.34±0.33^{c}	0.88
4	51.02±1.17^{a}	46.30±0.80^{b}	45.06±0.38^{c}	0.67
5	53.25±4.02^{a}	52.20±0.24^{b}	50.03±0.34^{c}	2.32
	Crude Fibre			
1	1.73±0.11^{a}	1.70±0.04^{a}	1.71±0.13^{a}	0.60
2	1.40±0.10^{a}	1.41±0.30^{a}	1.43±0.18^{a}	0.05
3	1.50±0.26^{a}	1.50±0.40^{a}	1.56±0.30^{a}	0.15
4	1.40±0.10^{a}	1.42±0.60^{a}	1.44±0.60^{a}	0.05
5	1.60±0.30^{a}	1.63±0.34^{a}	1.62±0.24^{a}	0.13

Means with the same superscript along the same row are not significantly different (p>0.05)

Chukwu and Abdullahi (2015) stated that a lower moisture content is desirable for longer preservation. Moisture content is the single most critical factor determining the shelf life of dried and smoked fish, as it directly influences microbial growth and the rate of chemical and enzymatic spoilage reactions (Mafe *et al.*, 2024). The initial (week 1) higher protein in T3 may be due to the contribution of protein from the scent leaf itself. However, the subsequent lower protein percentage (week 2 - 5) in the treated groups (T2 and T3) compared to the control is likely an interplay of several factors. Synnes *et al.* (2007) stated that higher protein content could be due to subsequent dehydration of the fish samples during storage. Fish is a primary source of high quality protein (Noreen *et al.*, 2025).

Conclusion

This study demonstrated that scent leaf (*Ocimum gratissimum*) curing enhances the sensory and nutritional quality of smoked *Clarias gariepinus* using soybean (*Glycine max*) shell briquettes as fuel. While no significant differences in colour or texture were observed, improved taste and aroma were evident with specific curing methods. Nutritional analysis showed an increase in essential minerals, particularly phosphorus. The briquette smoking technique proved to be an environmentally sustainable alternative, addressing deforestation concerns. Therefore, the findings highlight the integration of natural curing methods and biomass fuels as a sustainable approach to enhance aquaculture practices and food security.

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