Growth responses of *Clarias gariepinus* fingerlings fed differently boiled periods of rubber (*Hevea brasiliensis*) leaves-based diets

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**ABSTRACT**

Fingerlings of *Clarias gariepinus* were fed diets containing 0-min, 5-min, 10-min, 15-min and 20-min inclusion periods of different hydrothermally processed rubber leaves-based diets. After 8 weeks of feeding trials in outdoor hapas, it was observed that growth performance indices such as Mean Weight Gain, Feed Conversion Ratio, Feed Conversion Efficiency, Specific Growth Rate, Protein Efficiency Ratio and Apparent Net Protein Utilization were significantly affected (*P* < 0.05) across the treatment, where Diet3 (10-min inclusion of hydrothermal processed rubber leaves meal) gave the best result in all the growth performance indices. Inclusion periods of 10 min of boiled rubber leaves meal (RLM) should not be exceeded in the diet of *Clarias gariepinus*. This limit had no negative effect on growth and also reduces production cost of fish since the leaves are easily available in regions where this plant is cultivated.

**Introduction**

A good nutrition in any animal production system is important so as to economically produce a healthy end product of high quality. In aquaculture (fish farming), nutrition is important because feed represents about 40 – 60% of the production cost of fish [1]. Fish when reared in confinement and in high density, cannot forage freely on natural food thereby a quality-balanced diet that will enhance the fish growth and maintain a healthy status is required. Therefore, information on the nutritional requirement of fish must be adequately provided in order to compound and produce an economical-balanced diet. This information is focused to meet the nutritional needs of different fish species [2]. In managing the cost of feeding and providing a steady supply to the confined animal, local available feedstuff should be utilized [3].

The importance of artificial feeding in Aquaculture cannot be over emphasized because: It promotes faster growth, allows higher stocking density and enhances a short culture period. However, the high cost and competition on some conventional feed ingredients has made it necessary to explore and exploit the use of unconventional materials for fish feed formulation. Rubber Leaves Meal is gotten from the processing of leaves from rubber tree, which belongs to the family Euphorbiaceae [4]. The leaves have a good prospect as an unconventional protein feedstuff [5,6]. So far, there is no record of competition from man in the utilization of the leaves as food. However, animals such as ruminants and...
monogastrics have been fed with the leaves and seed cake of rubber [7].

Rajaguru and Ravindran [8] stated that detoxification is vital in using the leaves and seed cake of rubber as feed ingredients. The Hydrogen Cyanide (HCN) content of rubber leaves is between 0.002% and 0.09%, and this may cause acute toxicity and death [5]. Processing methods carried out during feed preparation is aimed at detoxification and possibly reducing the levels of Anti-Nutritional Factors (ANFs) present in the feedstuffs. Detoxification can be achieved via the following processing methods: fermentation, soaking, heat application either through boiling, drying, blanching and extrusion, etc. [1]. Hence, this study was designed to evaluate the growth response of C. gariepinus fingerlings to diets with rubber leaves at different periods of hydrothermal processing.

**Materials and methods**

**Experimental fish and location**

The fingerlings of Clarias gariepinus were obtained from Mr. Umogbai fish farm in Makurdi, Benue State, Nigeria and acclimatized at the Research Farm of the Department of Fisheries and Aquaculture, University of Agriculture, Makurdi for 2 weeks prior to the experiment.

**Experimental design and set up**

Each experimental diet was fed in triplicate in a completely randomized design (CRD). The feeding trial was carried out using hapas made from nets of dimension 1 m³ with 20 fingerlings having a mean weight of 1.35 ± 0.00 g distributed per hapa. The hapas were mounted on a kuralyon rope and set across the pond surface and properly staked to the dyke of the pond using bamboo sticks. Stones were attached to the four bottom corners of the hapas to serve as sinkers. This enabled the bottom surface of the hapas to spread uniformly and to extend properly. Five diets were formulated and each diet was in triplicate.

**Feed ingredients**

The ingredients used in the feed formulation included Fish meal, Soybean meal, Rubber Leaves meal, Maize meal, Vitamin and mineral premixes, Salt, Oil and Starch as binder. The Rubber leaves were harvested from pruned branches and unproductive trees of rubber at no cost from the plantation of Rubber Research Institute of Nigeria (RRIN) out station Igbotako, Ondo State, Nigeria. While other ingredients mentioned where purchased at the Makurdi Modern Market, Benue State Nigeria. The soybean was toasted and milled to eliminate anti-nutritional factor in the feedstuff. Dirt and stones were removed from the maize before milling. The Rubber Leaves were boiled at different time intervals of 0, 5, 10, 15 and 20 min in water and further sundried to a moisture content of less than 10% wet basis. Screening and identification of bioactive constituents of the leaves of rubber was carried out in extracts at the Institute of Tropical Agriculture, Ibadan, Oyo State, Nigeria. The Rubber Leaves were milled using a motorized attrition mill to obtain hydrothermally processed Rubber Leaves Meal (RLM).

**Experimental diets**

Forty percent (35%) crude protein diet was formulated for the fish using Pearson square method. Different periods of hydrothermally processed Rubber leaves were included at 0 min (Diet I), 5 min (Diet II), 10 min (Diet III), 15 min (Diet IV) and 20 min (Diet V) respectively. The diets were pelletized using a pelletizing machine after weighing and thorough mixing of the ingredients; the diets formulated were sinkers and had a size of 0.2 mm. During the period of the experiment the fish were fed at 5% of their body weight twice daily with fecal materials and feed remnants removed weekly from the hapas during sampling (weighing).
The fish were weighed at the beginning of the experiment and after every week for a period of 8 weeks. The quantity of feed was adjusted based on the new body weight of fish in each hapa. Mortalities were recorded accordingly.

**Water quality parameters**

Water quality parameters such as temperature, Dissolved Oxygen and pH where determined using thermometer, dissolved oxygen meter and pH meter, respectively. Dissolved oxygen ranged from 5.05 to 7.85, temperature 25.05–27.05 C and pH 7.05–8.05.

Feed Ingredients, diets formulated as well as initial and final carcass of *Clarias gariepinus* fingerlings were analyzed for proximate composition according to standard methods [9]. Performance indicating feed utilization were determined as:

- Weight gain calculated as: Final weight – initial weight
- Growth rate was determined by calculating the value of \( \frac{\text{Weight gained}}{\text{Duration of experiment (in days)}} \times 100 \)
- Specific growth rate (SGR) was calculated as: \( \frac{\ln \text{Final weight} - \ln \text{initial weight}}{\text{Duration of experiment in days}} \times 100 \)
- Feed conversion ratio (FCR) was measured by: \( \frac{\text{Feed intake}}{\text{Body weight gain}} \)
- Feed conversion efficiency (FCE) was measured by: \( \frac{\text{Weight gained}}{\text{Feed intake}} \times 100 \)
- Protein efficiency ratio (PER) was measured by: \( \frac{\text{Mean weight gained}}{\text{Protein consumed}} \times 100 \)
- Apparent net protein utilization (ANPU) was measured by: \( \frac{\text{Protein gained}}{\text{Protein consumed}} \times 100 \)
- Percentage Survival: \( \frac{N_t}{N_0} \times 100 \)

where \( \ln \) is the natural logarithm, \( N_t \) and \( N_0 \) are the number of fish at the end of the experiment and the initial number of fish stocked at the start of the experiment, respectively.

### Statistical analysis

All data collected was subjected to analysis of Variance (ANOVA). Comparison among diet mean was carried out by using Duncan Multiple Range Test (DMRT) at a significance level of 0.05. All computations were performed using statistical package SPSS 17.0.

### Results

The proximate composition of Rubber Leaves subjected to various hydrothermal periods as determined in the laboratory (Table 1) shows that the percentage moisture content ranged from 1.85 ± 0.08–2.42 ± 0.10%, 17.27 ± 0.08–18.83 ± 0.19% for crude protein, 3.33 ± 0.11–7.47 ± 0.23% for Ash, 2.44 ± 0.22–3.56 ± 0.12% for Fat while Fiber content was 25.46 ± 0.45–28.49 ± 0.13%, and Carbohydrate which was obtained to be 44.32 ± 0.47–46.15 ± 0.40%.

Three anti-nutrients namely Phytate, Hydrogen cyanide (HCN) and Tannins were isolated and qualitatively analyzed as shown in (Table 2). There was a significant reduction in the quantity of these anti-nutrients as the period of boiling increased. Table 3 shows the gross composition of the formulated diets. The proximate composition of the diets formulated as shown in (Table 4) showed that crude protein content varied from 35.28% to 35.37% and

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**Table 1.** Proximate composition of rubber leaves meal treated under different boiling time regime.

| Treatment (T) | % Crude Protein | % Ether Extract | % Ash | % Crude Fiber | % Moisture | NFE |
|--------------|----------------|----------------|-------|---------------|------------|-----|
| T1 (0 min)   | 17.58 ± 0.08b  | 3.34 ± 0.06c   | 7.47 ± 0.23c | 25.46 ± 0.45a | 1.85 ± 0.08a | 44.32 ± 0.47a |
| T2 (5 min)   | 17.89 ± 0.02b  | 3.56 ± 0.12c   | 4.83 ± 0.16c | 26.72 ± 0.06b | 2.14 ± 0.04c | 44.88 ± 0.05a |
| T3 (10 min)  | 18.83 ± 0.19c  | 3.30 ± 0.04bc  | 3.46 ± 0.04c | 28.49 ± 0.13c | 2.25 ± 0.04bc | 45.19 ± 1.41a |
| T4 (15 min)  | 17.74 ± 0.07b  | 2.89 ± 0.10ab  | 3.33 ± 0.11c | 28.38 ± 0.06c | 2.19 ± 0.04bc | 45.49 ± 0.04a |
| T5 (20 min)  | 17.27 ± 0.08a  | 2.44 ± 0.22a   | 3.83 ± 0.06a | 27.91 ± 0.10c | 2.42 ± 0.10c | 46.15 ± 0.40a |

*Mean in the same column with different superscripts differed significantly (P < 0.05)*

NFE: Nitrogen Free Extract

T: Time of Boiling
Table 2. Anti-nutrient of rubber leaves meal treated under different boiling time regime (mg/100g).

| Treatment (T) | Phytate | HCN | Tanin |
|---------------|---------|-----|-------|
| T₁ (0 min)    | 0.67 ± 0.03a | 62.56 ± 0.15a | 2.71 ± 0.10a |
| T₂ (5 min)    | 0.61 ± 0.04b | 53.18 ± 0.06b | 2.52 ± 0.48a |
| T₃ (10 min)   | 0.57 ± 0.04c | 51.73 ± 0.07c | 2.38 ± 0.34a |
| T₄ (15 min)   | 0.54 ± 0.04d | 48.93 ± 0.08d | 2.28 ± 0.19a |
| T₅ (20 min)   | 0.51 ± 0.03e | 47.25 ± 0.20e | 2.14 ± 0.13a |

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

T: Time

Table 3. Gross composition of formulated diets.

| Ingredients       | Diet 1 (0 min) | Diet 2 (5 min) | Diet 3 (10 min) | Diet 4 (15 min) | Diet 5 (20 min) |
|-------------------|---------------|---------------|----------------|----------------|----------------|
| Fish Meal         | 10.00         | 10.00         | 10.00          | 10.00          | 10.00          |
| Soybean meal      | 56.42         | 56.23         | 55.62          | 56.32          | 56.63          |
| Rubber Leaves Meal| 20.00         | 20.00         | 20.00          | 20.00          | 20.00          |
| Maize Meal        | 5.59          | 5.77          | 6.38           | 5.69           | 5.38           |
| Mineral** and Vitamin* premix | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Salt              | 1.00          | 1.00          | 1.00           | 1.00           | 1.00           |
| Oil               | 3.00          | 3.00          | 3.00           | 3.00           | 3.00           |
| Starch (Binder)   | 2.00          | 2.00          | 2.00           | 2.00           | 2.00           |
| Total             | 100           | 100           | 100            | 100            | 100            |

**Contained (as g/kg of diet): MgSO₄·7H₂O, 20.40; NaCl, 8.00; KCl, 6.04; FeSO₄·7H₂O, 4.00; ZnSO₄·4H₂O, 0.88; MnSO₄·4H₂O, 0.41; CuSO₄·5H₂O, 0.13; CuSO₄·7H₂O, 0.08; CaO₂, 6H₂O, 0.05; CrCl₃·6H₂O, 0.02.

*contain (as mg/kg of diet): Thiamine (B1), 85.00; Riboflavin (B₂), 60.00; Pyridoxine (B₆), 25.00; Pantothenic acid, 105.00; Inositol, 500.00; Biotin, 1.80; Folic acid, 20.00; Ethoxyquin, 4.00; Choline, 1481.00; Nicotinic acid (Niacin), 250.00; Cyanocobalamin (B₁₂), 0.03; Retinol palmitate (A), 20.00; Tocopherol acetate (E), 140.00; Ascorbic acid (C), 750.00; Menadione (K), 30.00; Cholecalciferol (D₃), 0.08.

were statistically the same for all the diets formulated.

Table 4. Proximate composition of the hydrothermally processed rubber leaves-based diets.

| Parameters       | % Moisture | % Ash | %Ether Extract | % Crude Fiber | % Protein | NFE |
|------------------|------------|-------|----------------|---------------|-----------|-----|
| DT₁              | 6.42 ± 0.02c | 9.33 ± 0.00a | 7.23 ± 0.00a | 5.09 ± 0.01d | 35.30 ± 0.01a | 37.38 ± 0.03b |
| DT₂              | 6.54 ± 0.01ab | 9.14 ± 0.01b | 7.29 ± 0.01a | 5.82 ± 0.01c | 35.31 ± 0.01a | 35.56 ± 0.04c |
| DT₃              | 6.44 ± 0.01c | 8.91 ± 0.01c | 7.26 ± 0.01b | 5.80 ± 0.01c | 35.34 ± 0.01a | 36.76 ± 0.02c |
| DT₄              | 6.25 ± 0.01d | 8.71 ± 0.01d | 7.20 ± 0.01c | 5.85 ± 0.01b | 35.34 ± 0.01a | 36.57 ± 0.02d |
| DT₅              | 6.19 ± 0.01e | 8.61 ± 0.01e | 7.21 ± 0.01c | 6.06 ± 0.01a | 35.28 ± 0.01a | 36.78 ± 0.01c |
| DT₆              | 6.58 ± 0.01a | 8.44 ± 0.01f | 6.34 ± 0.01a | 4.87 ± 0.01e | 35.37 ± 0.01a | 38.12 ± 0.01a |

*mean in the same column with different superscripts are significantly different (P < 0.05)

Diet 1 (DT₁): 0 min
Diet 2 (DT₂): 5 min
Diet 3 (DT₃): 10 min
Diet 4 (DT₄): 15 min
Diet 5 (DT₅): 20 min
Diet 6 (DT₆): Without Rubber Leaves Meal as Reference diet.

The growth performance and nutrient utilization of *Clarias gariepinus* fed different periods of hydrothermally processed Rubber Leaves as shown in (Table 5) revealed that the mean initial weight (MIW) were the same in all the treatments. The study also revealed that the mean final weight (MFW) differed significantly (P < 0.05) ranging from 3.81 ± 0.01 in DT₁ to 4.11 ± 0.04 g in DT₃. Moreover, the mean weight gain (MWG) varied significantly (P < 0.05) ranging from 2.46 ± 0.01 in DT₁ to 2.76 ± 0.04 g in DT₃. The values of the specific growth rate (SGR) differed significantly (P < 0.05) and it ranged from 0.36 ± 0.00 in DT₃ to 0.38 ± 0.01 in DT₁. Similarly, protein efficiency ratio (PER) differ significantly (P < 0.05) and the values ranged from 7.47 ± 0.13 in DT₁ to 7.84 ± 0.05 in DT₃. The study also revealed that the apparent net protein utilization (ANPU) varied significantly (P < 0.05) and the values ranged from 12.05 ± 0.03 in DT₂ to 12.75 ± 0.04% as seen in DT₅. Figure 1 shows the weekly growth trend of catfish fingerlings fed hydrothermally processed rubber leaves meal diets. It was found that the fingerlings of *Clarias gariepinus* gained weight in all the weeks in response to the dietary treatments. Weight gain increased tremendously from the 2nd week of the experiment to the end of trial which lasted for 8 weeks.
The percentage survival at the end of the feeding trial ranged from 91.67% in DT2 to 95.00% as recorded in DT1. The proximate analysis revealed significant difference (P < 0.05) for moisture, crude protein, ether extract, crude fiber, ash and nitrogen-free extract (NFE) of the experimental fish before and after the feeding trial. The result of the proximate analysis of the fish carcass fed the experimental diets as shown in (Table 6) indicated an increase in crude protein, ash, ether extract and crude fiber but decreased in moisture content and nitrogen-free extract when compared with the initial carcass.

Table 5. Growth performance and nutrient utilization of *Clarias gariepinus* fingerlings fed different periods of hydrothermally processed rubber leaves-based diets.

| DIET  | MIW     | MFW     | MWG     | SGR   | FCR     | FCE     | PER    | ANPU   | % SURVIVAL |
|-------|---------|---------|---------|-------|---------|---------|--------|--------|------------|
| DIET 1| 1.35 ± 0.00ns | 3.81 ± 0.01a | 2.46 ± 0.01a | 1.86 ± 0.00a | 0.38 ± 0.01b | 2.61 ± 0.05a | 7.47 ± 0.13a | 12.45 ± 0.03a | 95.00       |
| DIET 2| 1.35 ± 0.00ns | 3.90 ± 0.01ab | 2.55 ± 0.01ab | 1.90 ± 0.00ab | 0.38 ± 0.01b | 2.67 ± 0.04ab | 7.62 ± 0.11ab | 12.34 ± 0.03b | 91.67       |
| DIET 3| 1.35 ± 0.00ns | 4.11 ± 0.04d | 2.76 ± 0.03d | 1.99 ± 0.02d | 0.36 ± 0.00b | 2.75 ± 0.02b | 7.84 ± 0.05b | 13.37 ± 0.07c | 93.33       |
| DIET 4| 1.35 ± 0.00ns | 3.91 ± 0.04d | 2.56 ± 0.04d | 1.90 ± 0.02d | 0.37 ± 0.01d | 2.69 ± 0.04d | 7.69 ± 0.13d | 12.72 ± 0.04b | 93.33       |
| DIET 5| 1.35 ± 0.00ns | 3.97 ± 0.04bc | 2.62 ± 0.04bc | 1.93 ± 0.02bc | 0.37 ± 0.00d | 2.78 ± 0.05bc | 7.70 ± 0.06bc | 12.75 ± 0.04b | 93.33       |
| DIET 6| 1.35 ± 0.00ns | 4.05 ± 0.03cd | 2.70 ± 0.03cd | 1.97 ± 0.02cd | 0.36 ± 0.01a | 2.70 ± 0.02bc | 7.95 ± 0.13c | 12.77 ± 0.03b | 91.67       |

*mean in the same column with different superscripts are significantly different (P < 0.05)
NS: Not Significant
Diet1 (DT1): 0 min
Diet 2 (DT2): 5 min
Diet 3 (DT3): 10 min
Diet 4 (DT4): 15 min
Diet 5 (DT5): 20 min
Diet 6 (DT6): Without Rubber Leaves Meal as Reference diet

Figure 1. Weekly weight of *Clarias gariepinus* fingerlings fed diets containing different hydrothermally processed periods of rubber leaves-based diets.
Table 6. Proximate composition of carcass of C. gariepinus fingerlings fed diets of different hydrothermally processed periods of rubber leaves-based diets.

| Parameters     | % Moisture | % Ash  | % Ether Extract | % Crude Fiber | % Crude Protein | NFE  |
|---------------|------------|--------|-----------------|---------------|-----------------|------|
| Initial       | 72.65 ± 0.01<sup>a</sup> | 1.45 ± 0.01<sup>e</sup> | 0.87 ± 0.01<sup>e</sup> | 0.93 ± 0.01<sup>g</sup> | 10.85 ± 0.01<sup>f</sup> | 13.28 ± 0.02<sup>c</sup> |
| Diet 1        | 66.36 ± 0.01<sup>e</sup> | 2.69 ± 0.01<sup>b</sup> | 1.34 ± 0.00<sup>b</sup> | 1.22 ± 0.00<sup>b</sup> | 15.13 ± 0.01<sup>e</sup> | 13.27 ± 0.01<sup>c</sup> |
| Diet 2        | 67.87 ± 0.02<sup>b</sup> | 2.68 ± 0.01<sup>b</sup> | 1.37 ± 0.01<sup>a</sup> | 1.25 ± 0.01<sup>a</sup> | 15.23 ± 0.01<sup>g</sup> | 11.63 ± 0.02<sup>e</sup> |
| Diet 3        | 65.36 ± 0.02<sup>g</sup> | 2.71 ± 0.00<sup>a</sup> | 1.34 ± 0.01<sup>b</sup> | 1.19 ± 0.01<sup>c</sup> | 15.49 ± 0.02<sup>a</sup> | 13.93 ± 0.01<sup>b</sup> |
| Diet 4        | 66.56 ± 0.00<sup>d</sup> | 2.74 ± 0.01<sup>a</sup> | 1.36 ± 0.00<sup>a</sup> | 1.23 ± 0.01<sup>b</sup> | 15.34 ± 0.01<sup>c</sup> | 12.78 ± 0.02<sup>f</sup> |
| Diet 5        | 67.57 ± 0.03<sup>c</sup> | 2.14 ± 0.02<sup>d</sup> | 1.21 ± 0.02<sup>d</sup> | 1.09 ± 0.01<sup>d</sup> | 15.32 ± 0.01<sup>c</sup> | 12.69 ± 0.05<sup>d</sup> |
| Diet 6        | 65.48 ± 0.00<sup>c</sup> | 2.58 ± 0.02<sup>c</sup> | 1.31 ± 0.01<sup>c</sup> | 1.25 ± 0.01<sup>a</sup> | 15.39 ± 0.01<sup>b</sup> | 13.99 ± 0.03<sup>a</sup> |

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

NFE: Nitrogen Free Extract

Diet 1 (DT<sub>1</sub>): 0 min
Diet 2 (DT<sub>2</sub>): 5 min
Diet 3 (DT<sub>3</sub>): 10 min
Diet 4 (DT<sub>4</sub>): 15 min
Diet 5 (DT<sub>5</sub>): 20 min
Diet 6 (DT<sub>6</sub>): Without Rubber Leaves Meal as Reference diet

Growth Rate (SGR), Feed Conversion Ratio (FCR), Feed Conversion Efficiency (FCE), Protein Efficiency Ratio (PER) and Apparent Net Protein Utilization (ANPU).

Discussion

The proximate composition of the experimental diets of the study revealed that all the diets met the target crude protein requirement for C. gariepinus. According to Craig and Helfrich [10], crude protein level in aquaculture feeds generally average 18% to 20% for marine shrimps, 20% to 30% for tilapia, 38% to 42% for striped bass and 35% to 40% for catfish.

The present study showed no significant difference among the experimental diets in terms of crude protein. However, the percentage of crude fiber in each of the diets exceeded the recommended 4% as stated by Cowey [11]. According to Galtin [12], the quantity of crude fiber in the diet of fish is usually less than 7% of the fish diet to limit the amount of undigested materials entering the culture medium. A high fiber and ash content reduces the digestibility of other ingredients in the diets resulting in poor growth of the fish [13]. Despite the high levels of crude fiber in the diets than what was reported by Cowey [11], the growth of the experimental fish was not adversely affected. This might be due to the heat treatment given to the rubber leaves before inclusion into the diets. This is in agreement with the findings of Udensi et al. [14] who stated that boiling cowpea seeds in water for 15 to 45 min reduced the anti-nutritional factors. In addition, Bell et al. [15] stated that cooking renders feed-stuffs more palatable, digestible and also destroys bacteria at the same time the fiber shrinks, becomes loose and softens. Similarly, Wang et al. [16] stated that boiling and soaking resulted in the reduction of anti-nutrients present in flour made from different lentil varieties. Khattab et al. [17] concluded that there can be a complete removal of trypsin inhibitor activity for pea seeds via toasting or boiling.

The result of the study revealed that the percentage of lipids and nitrogen-free extract differed significantly, however, the values fall within the recommended range as stated by Craig and Helfrich [10] who reported that the lipid content of fish is between 10% and 25%, as up to about 20% dietary carbohydrate can be utilized by fish. The lipid content of a diet is important as a source of dietary energy, but also fundamental for supplying adequate amount of essential fatty acid [18]. It was also observed in the result that the moisture contents of the experimental diets were less than 10% dry basis. Andras et al. [19] reported that moisture content is very critical for fish feed to avoid mold development; high moisture content in diets enhances mold development and


other microbial agents, mold carries the risk of contamination, disease factor and may also cause toxicological problems.

The result of the growth performance and nutrient utilization of *Clarias gariepinus* fingerlings fed hydrothermally processed rubber leaves-based diets revealed that all the diets which were hydrothermally processed were utilized by the experimental fish when compared with the raw (0 min), which served as the control diet. This tally with the report of Wang et al. [16] which stated that the nutritive value of legume seeds improved when subjected to heat treatment. Furthermore, heat treatment of the rubber leaves for up to 20 min was not detrimental to the growth of the fish despite a significant reduction in the percentage crude protein of the rubber leaves. More so, the addition of other high-quality feedstuffs such as soybean and fish meal was likely to have masked the effect of the reduced crude protein in the hydrothermally processed rubber leaves meal. In line with the result of this study, Tiamiyu et al. [20] demonstrated that boiling watermelon seed up to 40 min did not affect the protein content or feed utilization by *C. gariepinus*. However, a feeding trial with *Cyprinus carpio* showed a significant reduction in performance beyond 30 min of hydrothermal processing [21].

Despite the substantial level of hydrocyanic acid (HCN) in the hydrothermally processed leaves of rubber and a significant reduction in the level of crude protein, growth performance of *C. gariepinus* fed the diets containing hydrothermally processed rubber leaves meal was significantly improved with increased period of boiling. Hydrothermal processing for 10 min resulted in the best final weight, weight gain, growth rate, feed conversion ratio, feed conversion efficiency, protein efficiency ratio and apparent net protein utilization.

The high or superior performance of hydrothermally processed leaves of rubber over the raw (control) is likely to be as a result of the reduction in other anti-nutrients aside the heat labile hydrocyanic acid (HCN). More so, at 20% inclusion level of the hydrothermally processed rubber leaves meal, the dietary levels of HCN could still have been within the tolerable range for *C. gariepinus*. In addition, the result showed a high survival rate in all the treatments indicating that *C. gariepinus* were in good condition and the diets were not detrimental to the health of the fish. Furthermore, this study revealed that the body composition of the experimental fish was affected by the inclusion of the hydrothermally processed rubber leaves meal in the diets. Both the crude protein and lipid content of the fish carcass increased as hydrothermal processing of the leaves were employed when compared with the initial fish carcass indicating that the protein in the diet was deposited in the flesh of the fish.

There were appreciable differences in moisture content; crude fiber and nitrogen-free extract between the carcasses of the fish fed the experimental diets and the initial fish carcass. This is an indication of protein addition and true growth involving an increase in the structural tissues such as muscles and the various organs [22, and 20]. Reinitz and Hitzel [23] also stated that the type of feed ingested and their nutritional quality is known to be one of the major factors affecting fish carcass composition.

**Conclusion**

The experiment on the growth response of *C. gariepinus* fingerlings fed different hydrothermally processed rubber leaves-based diets revealed that DT₃ at 10 min of hydrothermal processing of rubber leaves-based diet emerged the best in all the performance indices whereas, DT₁ (raw) exhibited the poorest growth performance among the treatments. Furthermore, it is evident in this research that the use of rubber leaves in the diets of catfish (*C. gariepinus*) was successful, without any adverse effects on the growth responses and nutrient utilization of the fish. It is therefore recommended that the inclusion of rubber leaves in the diet of fish be limited to 10 min of hydrothermal processing, for better growth performance of *C. gariepinus*. 
Disclosure statement

No potential conflict of interest was reported by the authors.

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