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Nutritional value of hydrothermally processed *Jatropha curcas* kernel and its effect on growth and hematological parameters of *Clarias gariepinus* fingerlings (Burchell, 1822)

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ABSTRACT

The anti-nutritional components of *Jatropha curcas* have long limited the use of this unconventional feed ingredient in animal nutrition. In this study, the nutritional value of hydrothermally processed *J. curcas* kernel (JCK) meal in the diet of African catfish *Clarias gariepinus* (Burchell, 1822) was investigated. Upon processing in boiling water (100 °C) for 0, 30, 60, and 90 min, the nutritional characteristics of the JCK improved as the process was prolonged. However, many essential amino acids were reduced beyond 30 min of processing. Four isonitrogenous (35% CP) and isocaloric (315 kcal g^{-1}) diets were then formulated with the inclusion of processed JCK at 29% and fed to the fingerlings of *C. gariepinus* for 56 days. The processed JCK performed better than the control diet. The optimal time of processing which gave the maximum weight gain (9 ± 0.54 g) was 62 mins using the second order polynomial regression analysis. The dietary inclusion of the processed JCK meal resulted in significant improvement in the blood parameters of the fish compared to those fed raw JCK. Similarly, the cost of feed and fish production was substantially reduced with inclusion of the processed JCK. It was therefore concluded that hydrothermal processing improved the nutritional profile of JCK and its dietary utilization by African catfish *C. gariepinus* fingerlings.

1. Introduction

As the world population continues to grow, so does the need to intensify efforts on sustainable fish production. This is to tackle food security challenges and address issues on malnutrition, under-nutrition and microelements deficiencies (FAO, 2008). Over 60% of the total input costs of fish production have been linked to feeding (Eyo, 2001; Gabriel et al., 2007). This is partly due to the competitive interest of other sectors and human consumption for conventional feedstuffs used in aquafeeds, and leads to a continuous price increase (Tiamiyu et al., 2014; Okomoda et al., 2017). As a result, a search for cheap non-conventional feed resource (NCFR) has been intensified over the last decade to reduce reliance on these conventional feed ingredients (Kumar et al., 2010; Solomon et al., 2015; Tiamiyu et al., 2015).

Despite the potential of many NCFR, their inclusion in aquafeeds has been hampered due to the presence of anti-nutritional factors (ANFs) (Grimaud, 1988; Francis et al., 2001). These ANFs have significant effects on growth and other physiological processes when present in higher levels (Okomoda et al., 2016). Therefore, to enhance bioavailability and utilization of the micronutrients in these NCFRs, the ANFs must be reduced. Thermal method is one of the methods that have been exploited in many previous studies in this regard (Alatise et al., 2014, Okomoda et al., 2016). However, despite the efficacy of thermal method in feed processing, many essential nutrients could be denatured if the timing of processing is not optimized (Montagnac et al., 2009; Arinola and Adesina, 2014; Rawat et al., 2015; Tiamiyu et al., 2015). More so, thermal processing incurs extra cost for energy and could substantially increase the overall cost of aquafeed and fish production (Okomoda et al., 2017). Hence, there is a need to strike a balance between improving the feed ingredient without denaturing its nutritional characteristics and producing a low-cost feed.

Jatropha curcas is a plant native to Mexico and tropical South America, however, it wildly available in many tropical and subtropical countries of the world (Makkar 2016). It is one of many NCFR of great interest to animal nutritional scientist around the world. This is partly because of its nutritional profile and availability (Kumar et al., 2010).

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However, the presence of antinutritional factors in this plant constitutes the major constraint to its large scale usage as a protein ingredient in aquafeeds (Francis et al., 2001). The phytic acid molecules in *J. curcas* are capable of binding to iron or the amine group of amino acids, thus reducing their bioavailability for biosynthesis of red blood cells (Kumar et al., 2010). This study is designed to evaluate the efficacy of hydrothermal processing in improving the nutritional value of *J. curcas* kernels (JCK). Also, the nutritional effect of inclusion of the processed feed in the compounded diet on growth and haematological parameters of African catfish *Clarias gariepinus* (Burchell, 1822) was investigated.

2. Materials and methods

2.1. Feed procurement, processing, and nutritional analysis

Fresh *J. curcas* fruits were collected from a farm in Ofoke – Ojope, Apa L.G.A. in Benue State, Nigeria and sundried for one week. The dried fruits were crushed to remove the seed from the husks. The seeds were then crushed to obtain the kernel. The JCK were divided into four batches and hydrothermally processed for 0, 30, 60, and 90 min in boiling water (100 °C). The hydrothermally processed kernels were air dried in an oven (40 °C), and samples analyzed for proximate composition, amino acid profile, and phytochemicals at the University of Jos, Nigeria. The proximate composition was determined using standard methods according to AOAC (2001) while the amino acid profile was determined using the method described by Spackman et al. (1958). ANFs such as phytic acid, total oxalate, cyanogenic glycosides, trypsin inhibitor activity and phytate were quantitatively analyzed according to the procedures described by McCance and Widdowson (1935), Abeza et al. (1968), AOAC (2012), Oberlease (1973) and Arntfield et al. (1985), respectively. The remaining processed kernels were milled and stored for the experimental diet formulation. The other feed ingredients (soybeans seeds, maize meal, fish meal, cassava flour, rice bran, vitamin and mineral premixes) used for the diet formulation were purchased from a feed store (Chiwendu feed store) in the Jos market, in the Plateau State capital. The soybean seeds were toasted according to the method described by Tiamiyu and Solomon (2007) and Okomoda et al. (2016). The other ingredients were used as purchased.

2.2. Diet formulation, experimental conditions, and performance evaluation of fish

Four isonitrogenous (35% CP) and isocaloric (315 kcal g^{-1}) diets were formulated using the processed JCK meal (Table 3). All ingredients were sieved, weighed and mixed uniformly. Hot water at 60 °C was added to the mixture, which was then stirred to form a dough. The dough was pelleted using a 2 mm-die and the resulting pellets sundried. The diets were packaged and stored for use. Fingerlings of *C. gariepinus* from the same breeding history were purchased from the Fishery Expert hatchery/Farm at Jos, Plateau Nigeria. These were transported to Miracle fish farm where the feeding trial was conducted. Fifty fish were subsequently distributed in triplicate to twelve hapas installed individually in 2 × 1 × 1 m concrete tanks with flow-through system and continuous aeration. The water level was maintained at two-thirds the height of each hapa. Water quality parameters were monitored and maintained weekly at acceptable levels (T °C = 25.5 ± 0.9 °C; pH = 7.00 ± 0.33; Conductivity = 621 ± 0.21 µS/cm; Total Dissolved Solids = 199.5 ± 0.9 mgL^{-1}; Dissolved Oxygen = 4.5 ± 1.13 mgL^{-1}) (Numbers are means of weekly measurements ± standard errors; N = 8weeks) using a digital multi-parameter water checker (Hanna water tester Model HL 98126). During the time of the study, the fish were fed twice daily at 5% body weight per day, with the ration divided into two equal parts. Fish from each hapa were bulk weighed biweekly using sensitive weighing balance (nearest 0.00 g) to record the weight of the fish and adjust the ration. At the end of the 56-day feeding trial, growth and nutrient utilization were assessed using the relations shown below:

(a) Growth rate (g/d) = $\frac{W_2 - W_1}{t_2 - t_1}$.
Where W_1 = initial weight (g).
W_2 = final weight (g).
t_2-t_1 = duration between W_2 and W_1 (days).

(b) Specific growth rate (%/day) = $\frac{\log_e(W_2) - \log_e(W_1)}{t_2 - t_1} \times 100$.

(c) Feed conversion ratio (FCR) = $\frac{dry\ feed\ intake}{W_2 - W_1}$.

(d) Feed conversion efficiency (% FER) = $\frac{(W_2 - W_1) \times 100}{dry\ feed\ intake}$.

(e) Protein efficiency ratio = $\frac{W_2 - W_1}{protein\ fed}$.
Where protein fed = $\frac{\%\ protein\ in\ diet \times total\ diet\ consumed}{100}$.

(f) %Survival = $\frac{fish\ stocked - mortality}{fish\ stocked} \times 100$.

Cost analysis was done by computing the cost of compounding each diet estimated from the amount of feedstuff used and the cost of producing 1 kg of the flesh of the fish as dictated by the FCR (method adapted from Okomoda et al., 2016). It is important to note at this point that the present study did not take cognizance of the opportunity cost of time or labor; hence authors made conservative assumptions that these are free (zero cost). Only the cost of purchasing the material was estimated for each ingredient.

The proximate composition of the formulated diet (as presented in Tables 3 and 4) and of the carcass of the fish before and after the feeding trial were also determined according to AOAC (2001).

2.3. Blood collection and haematological analysis

The fish were anesthetized in 1% benzocaine (Klontz and Smith, 1968) before blood collection was done. Blood was pooled from 3 to 5 fishes by cutting the peduncle and letting the blood flow by capillary action into heparinized microhaematocrit tubes. The haematocrit value was determined by the method of Wedemeyer and Yasutake (1977). The haemoglobin concentration was estimated as one-third of the haematocrit (Dacie and Lewis, 2001). The Red Blood Cell (RBC) Count was done using a coulter-model T 540 cell counter. RBCs were counted by using the improved Neubauer haemocytometer (specialized counting chamber). Mean corpuscular volume (MCV; fl), mean corpuscular haemoglobin (MCHb; pg) and mean corpuscular haemoglobin concentration (MCHC; %) were calculated for each sample according to the method of Klinger et al. (1996) as follows:

$$MCV = \frac{PCV \times 1000}{RBC \times 10^{12}}$$

where PCV = Packed Cell Volume
RBC = Red Blood Cell Count

$$MCH = \frac{Hb(g.\ L^{-1})}{RBC \times 10^{12}.\ L^{-1}}$$

where Hb = haemoglobin concentration
RBC = Red Blood Cell Count

$$MCHC = \frac{Hb(g.\ L^{-1})}{PCV\ (L.\ L^{-1})}$$

2.4. Data analysis

Summary statistics of the different variables measured across the treatment (in triplicate) were obtained using Minitab 14 for Windows (Minitab Inc, State College, Pennsylvania. USA). The result of the nutritional profile of the processed JCK, experimental diet, fish proximate analysis, growth parameters and haematological parameters were tested for normality and homogeneity of variance before been subjected to Analysis of Variance (ANOVA). Where significant differences occurred, means were separated using Fisher's least significant difference