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Nutritional value of toasted pigeon pea, *Cajanus cajan* seed and its utilization in the diet of *Clarias gariepinus* (Burchell, 1822) fingerlings

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ABSTRACT

The nutritional value of toasted pigeon pea *Cajanus cajan* seed in the diet of African catfish *Clarias gariepinus* (Burchell, 1822) was investigated in this study by progressively increasing its inclusion level (100, 200, 300 and 400 g kg^{-1}) in isonitrogenous (35% crude protein) and isoenergetic (17.7 kJ g^{-1}) diets. Toasting of the *C. cajan* seed significantly reduced the anti-nutrients and increased most essential amino acid, protein, and fibre in the seeds. The growth of *C. gariepinus* (1.36 ± 0.05 g) fingerlings fed in triplicate 1 × 1 × $1m^3$ hapa pond system (*n* = 40 in triplicates) was significantly improved by the different inclusion levels of toasted *C. cajan* in the diets after 56 days. Comparing the performance of the fish fed 400 g kg^{-1} of toasted *C. cajan* with that fed raw seed (400 g kg^{-1}) reveal the efficacy of this processing method in improving the utilization of the feedstuff. Mortality was significantly higher (32%) in fish fed the diet containing raw inclusion compared to that fed the control diet or inclusion of toasted *C. cajan* (< 5%). Cost analysis revealed that it was economically cheaper to raise the African catfish using toasted *C. cajan* at 400 g kg^{-1}. It was therefore concluded that toasting improves the nutritional quality of *C. cajan,* resulting in better performance at higher inclusion levels, hence, can possibly reduce the cost of catfish production.

1. Introduction

The cost of fish feed has escalated up to about 70% of the operational costs. This escalation has been the result of competition from human consumption and from the domestic animal feed industry such as dairy and poultry (Tiamiyu et al., 2015a). Hence, several alternative sources of protein are needed to maintain the stability of feedstuffs prices, which are at present very erratic. Currently, alternative high protein raw materials from animal by-product or plants are getting attention (Gatlin et al., 2007). However, when considering the material of plant origin, the protein content and quality are not the only limiting factors to their utilization by animals. The anti-nutritional factors (ANFs) are also important in limiting protein utilization. These ANFs include, but are not limited to alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haemagglutinin, saponegin, mimosine, cyanoglycosides, and linamarin (Alegbeleye et al., 2001), and significantly affect growth and other physiological processes when present at higher levels (Okomoda et al., 2016). Hence, to enhance bioavailability of micronutrients in plant-based diets ANFs need to be eliminated. Several methods such as thermal and mechanical processes, fermentation, soaking, and germination/malting can be applied (Hotz and Gibson, 2007; Tiamiyu et al., 2015b).

Considerable efforts have been focused on legumes as alternatives to expensive feedstuffs, especially in developing countries such as Nigeria. A wide variety of legumes has been researched, most of which are of limited relevance in human nutrition (Ezeagu et al., 2003; Osuigwe, 2003; Tiamiyu et al., 2015b; Okomoda et al., 2016). Pigeon pea (*Cajanus cajan*) seed is one of such tropical legumes that is underutilized in fish feed production (Ogunji et al., 2008). It is ranked among the most important legumes of the world (Morton, 1976). However, it has low human food preference possibly because it takes a longer time to cook compared to other edible legumes such as cowpea (*Vigna unguiculata*) (Adeparasi, 1994). *C. cajan* has been reported to contain 20–22% protein, 1.2% fat, 65% carbohydrate and 3.8% ash (FAO, 1982). It also contains different minerals, vitamins and is a good source of amino acids as well as complex carbohydrates needed by many catfish species (Elegbede, 1998). However, like other legumes, the nutritive value is masked by the occurrence of anti-nutritional factors (ANFs), such as trypsin inhibitors, haemagglutinin, and saponin (Grimaud, 1988; Francis et al., 2001). This has greatly limited its use in animal nutrition. To improve its nutritional value and ensure it utilization at high inclusion levels, this study was designed with the aim of examining the efficacy of toasting of *C. cajan* seeds on the nutritional profile of the feed and its utilization in a formulated diet for *Clarias gariepinus* (Burchell, 1822).

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2. Materials and methods

2.1. Feed procurement, processing, and nutritional analysis

Feed ingredients for this study included soybeans seeds, maize meal, fish meal, *C. cajan* seed, vegetable oil, salt, vitamin and mineral premixes. They were all purchased from a feed store (Chidozie feed store) in the modern market Makurdi, the Benue State capital. The seeds of *C. cajan* and soybeans were toasted by continuously stirring in a fine textured sand heated on a hot plate (100 °C) following the method by Tiamiyu and Solomon (2007). This is to ensure uniformity and prevents charring of the seed by the heat. The process was completed in less than 15 min. The toasted seeds were separated from the sand by sieving and the few charred seeds were handpicked and thrown away. The good toasted seeds and a small portion (600 g) of the raw seeds were then milled and stored separately in a cool, dry place on till the experimental diets were compounded.

Triplicate samples of the toasted and raw *C. cajan* meal prepared were sent to the Department of Fisheries and Hydrological Laboratory, in the University of Jos for nutritional analysis of proximate, amino acids, and phytochemicals. The proximate composition of the seed meal (based on dry matter basis) was determined using standard methods according to AOAC (2001). The amino acids, however, were determined using the method described by Spackman et al. (1958). To determine the efficacy of the toasting process in reducing the ANFs of *C. cajan*, quantitative analysis of tannin, trypsin inhibitor, phytate, haemagglutinin, and alkaloids was done using the methods described by Price et al. (1978), Kakade et al. (1974), Davies and Reid (1979), Arntfield et al. (1985) and Harborne (1973), respectively.

The feeding trial for this study was done at the Department of Fisheries and Aquaculture Research Farm, University of Agriculture Makurdi, (UAM) Benue state Nigeria for 56 days. The proximate composition of the formulated diets (based on dry matter basis) and of the carcass of the fish before and after the feeding trial (based on wet matter basis) was determined according to AOAC (2001) at the University of Jos.

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

Five isonitrogenous (35% crude protein) and isocaloric (17.70 kJ g^{-1}) diets were formulated (Table 2) by replacing maize and soybean meal with toasted *C. cajan* included at 0, 100, 200, 300 and 400 g kg^{-1} (respectively denoted as CC-0, CC-100, CC-200, CC-300 and CC-400). To determine the efficacy of the toasting method in improving nutrient utilization by the fish, a sixth diet (CC-400r) was formulated with raw *C. cajan* included at 400 g kg^{-1}. All ingredients were sieved, weighed and mixed uniformly. Water at 60 °C was added to the mixture and stirred to form a dough. The dough was pelleted using a 2 mm-die and the resulting pellets sun-dried (T °C = 24.9 ± 3.0) for three days (between 9 am to 3 pm daily). The diets were packaged and stored for use.

Eighteen hapas measuring 1 × 1 × 1m^3 were mounted on two-kuralon ropes and set across a 45 × 45 × 2 m^3 earthen pond. The ropes were properly staked to the dike of the pond using bamboo sticks. With the aid of metal sinkers, the four bottom corners of each hapa were properly extended to allow easy inflow and outflow of water through each hapa system. The hapas were submerged half way below the water level to enable easy access to the fish. Hapas were labeled appropriately in triplicates according to the six experimental diets to be administered. Pond water quality was maintained by the addition of filtrated/screened river water from the River Benue on a daily basis. Estimated daily water replacement in the pond was 20%. Water quality parameters were monitored weekly using a digital multi-parameter water checker (Hanna water tester Model HL 98126) (T = 27.2 ± 1.3 °C; pH = 7.50 ± 0.54; Conductivity = 515 ± 0.93 μS/cm; TDS 232.5 ± 1.5 mg/L; DO = 5.4 ± 0.09 mg/L).

Seven hundred and fifty fingerlings of *C. gariepinus* were obtained from the UAM Fish Farm and acclimatized for two weeks (feeding on Coppen commercial diet of 45% CP) (Alltech company). Eighteen batches of 40 fingerlings (1.36 g ± 0.06) were weighed and stocked randomly in each of the eighteen hapas and fed the experimental diets for 56days. Feeding was done at 5% of the bulk weight of the fish in each system. Fish from each hapa were bulk weighed biweekly (using sensitive weighing balance) to record the weight of the fish and adjust feed administered. At the end of the 56 day feeding trial, growth and nutrient utilization were assessed using the relations shown below;

$$(a)\text{Growthrate}(g/d) = \frac{W_2 - W_1}{t_{2-t_1}}$$

Where W_1 = initial weight (g)W_2 = final weight (g)$t_2 - t_1$ = duration between W_2 and W_1 (days)

$$(b)\text{Specificgrowthrate}(\%/\text{day}) = \frac{log_e(W_2) - log_e(W_1)}{t_{2-t_1}}$$

$$(c)\text{Feedconversionratio}(FCR) = \frac{dryfeedintake}{W_2 - W_1}$$

$$(d)\text{Feedconversionefficiency}(\%FER) = \frac{(W_2 - W_1)x100}{dryfeedintake}$$

$$(e)\text{Proteinefficiencyratio} = \frac{W_2 - W_1}{proteinfed}$$

$$\text{Whereproteinfed} = \frac{\%proteinindiet \times totaldietconsumed}{100}$$

$$(f)\%\text{Survival} = \frac{fishstocked - mortality}{fishstocked} \times 100$$

Cost analysis was also done by computing the cost of compounding each diet estimated from the amount of feedstuff used. The cost of producing 1 kg of fish in this study was computed by multiplying the cost of producing 1 kg of each formulated diet by the corresponding value of FCR at the end of the feeding trial.

2.3. 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 raw and toasted *C. cajan* was compared using Student's *t*-test. The results of the diet and fish proximate analysis, as well as the growth parameters were tested for normality and homogeneity of variance before been subjected to Analysis of Variance (ANOVA). When mean was not normally distributed, Kruskal Willis test (non parametric test) was used. Where differences occurred, means were separated using Fisher's least significant difference (ANOVA) or Dunn's multiple comparison test (Kruskal Willis test) at a significance level of α = 0.05.

3. Results

3.1. Nutritional profile of raw and toasted C. cajan

Nutritional comparison of raw and toasted *C. cajan* revealed higher protein and fibre content in processed meal (247.6 and 16.2 g kg^{-1}, respectively) than in the raw meal (Table 1). However, the fat content was not significantly affected as a result of toasting. All other constituents were higher in raw compared to toasted *C. cajan*. Overall observation revealed a significant increase in many of the essential amino acids isolated in this study with toasting. However, lysine and leucine were significantly reduced while threonine was not affected by