NUTRITIONAL PROFILE OF TOASTED *CANAVALIA ENSIFORMIS* SEED AND ITS POTENTIAL AS PARTIALLY REPLACEMENT FOR SOYBEAN IN THE DIET OF *CLARIAS GARIEPINUS*

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ABSTRACT

Tiamiyu, L.O.; Okomoda V.T. & AKPA, P.O., (2016). Nutritional profile of toasted *Canavalia ensiformis* seed and its potential as partially replacement for soybean in the diet of *Clarias gariepinus*. Braz. J. Aquat. Sci. Technol. 20(2). eISSN 1983-9057. DOI: 10.14210/bjast.v20n2. The nutritional value of Jack bean (*Canavalia ensiformis*) in animal feeds have been limited by the presence of antinutritional factors. This study investigates the efficacy of toasting as a processing method in improving the nutritional value and the utilization of *C. ensiformis* seeds in the diet of *Clarias gariepinus*. Result obtained reveals that the proximate composition of toasted *C. ensiformis* seed was not significant affected when compared to the raw seed. However, many essential amino acids were significantly reduced by toasting. Of all phytonutrient isolated in the seed, lectin and canavaline were not markedly reduced with toasting. Fingerlings of *C. gariepinus* fed diets (35%CP) formulate by substituting soybeans (inclusion at 38.19%) with *C. ensiformis* at 0, 5, 10, 15 and 20% revealed significant reduction in growth as the substitution levels increased. It was concluded that toasting alone is not an effective method for improving utilization of *C. ensiformis* in the diet of African catfish. Research on other processing methods or are recommended.

Keywords: Unconventional feeds, Alternative feeds, Jack bean, Processing, African catfish.

INTRODUCTION

Fish feed plays a major role in aquaculture viability and profitability, because it accounts for at least 40–60% of the total cost of fish production (Tiamiyu et al. 2014). However, the prices of conventional feed source are continuously increasing. The competitive uses of conventional protein sources by man and industries have lead to increasing emphasis on research into alternative plant protein feedstuff for fish nutrition (Fagbenro et al. 2004). Among alternatives considered are the underutilized grain legume seeds (Fagbenro, 1999).

The genus *Canavalia* comprising of 48 species of these underutilized legumes. They are widely distributed and indigenous to the tropics (Fagbenro et al. 2004), rarely eating by man (Okonkwo and Udedibie 1991) and their nutritional potential has been well studied in monogastrics and poultry industry (Wyss and Bicjel 1988, Udedibie 1990, Udedibie and Nkwocha 1990). Nutritional trial in fish includes the works of Martinez-Palacios et al. (1988), Akinbiyi (1992), Abdo de la Parra et al. (1998), Osuigwe et al. (2002), and Fagbenro et al. (2004).

As in other legumes, a major drawback to the commercial use of *Canavalia* seeds in animal feeding is the presence of several endogenous toxic antinutritional factors (Carlini and Gumaraes 1981). This includes canavanine, concanavalin, canavalin, canatoxin, protease inhibitors, lectins, and phytic acid (Abdo de la Parra et al. 1998, Osuigwe et al. 2002, Fagbenro et al. 2004). Fortunately, some of these anti-nutritional factors can be destroyed and inactivated by heat treatment (Tiamiyu et al. 2014). The nutritional importance of processed *Canavalia ensiformis* seed meal have not been well studied for the African catfishes despite been an important aquaculture candidates. More so, previous research had focused on removing anti-nutritional factor without determining the nutritional stability of the feedstuff as a result of processing. This study was designed to investigate the nutritional profile and utilization of toasted *C. ensiformis* meals in the diet of *Clarias gariepinus*.

MATERIALS AND METHOD

Feed procurement, processing, and analysis.

Matured seeds of *C. ensiformis* were collected from Assakio in Lafia Nasarawa State Nigeria. The other ingredients, soybean meal, yellow maize meal, fish meal, vitamin and mineral premises were obtained from the modern market in Makurdi (the Benue State capital). The seeds of soybean and *C. ensiformis* were toasted to remove antinutritional factors. Toasting was not timed, but the seeds were visually observed for browning (an indication of complete toasting process according to Tiamiyu and Solomon, 2008) during the process. Charring of seed was avoided as much as possible. Charred seeds were handpicked and the good seeds were stored at room temperature. A portion of the toasted and raw *C. ensiformis* seeds were sent to the University of Jos for analysis of proximate composition, amino acid profile, and phytochemicals. The proximate composition was determined using standard methods according to AOAC, (2000) while amino acid profile was determined using the method described by Spackman et al. (1958). Qualitative analysis of phytonutrients was done according to the procedure described by Harborne, (1973); Sofowora, (1993); Trease and Evans, (1989). The remaining batch of processed seeds was ground into fine meal and stored for feed formulation. Proximate composition of the formulated diet, carcass of fish before and after the feeding trial were also determined using the official method by AOAC, (2000).

Diet formulation.

A 35% crude protein (Diet 1) was formulated using person's square method with fishmeal (20.00%), maize meal (36.81%), soybeans meal (38.19%), cassava meal (1%), vitamin/mineral premises (0.5% each), salt (0.50%), Oil (0.50%). The other four diets were formulated by simply substituting soybean for *C. ensiformis* at 5%, 10%, 15% and 20% (included at 1.91, 3.82, 5.73, and 7.64 respectively). Respectively the diets were denoted as Diet 2, Diet 3, Diet 4 and Diet 5. Maximum substitution of 20% was chosen to reduce wide variability in the protein content of formulated diets since *C. ensiformis* had significantly low protein compared to soybean (25% CP and 45% CP respectively). The experiment also focuses on the possibility of substituting soybean with *C. ensiformis* (a protein source) hence no deliberate effort was taken to balance energy levels of the feeds. All ingredients were sieved, weighed and mixed uniformly. Hot water at 60ºC was added to the mixture and stirred to form a dough. The dough was pelleted using a 2mm-die and the resulting pellets sun-dried for three days. The diets were packaged and stored for use.

Fish procurement, experimental setup and performance evaluation.

The nutritional trial was conducted at the research farm of the departmental of Fisheries and Aquaculture, University of Agriculture Makurdi, Benue State, Nigeria. One thousand fingerlings of *C. gariepinus* were obtained from the University Fish farm and acclimatized for two weeks before the start of the experiment. Fifteen hapas (for the five treatments with three replicate) measuring 1x1x1 m3 were mounted on two-kuralon ropes and set across a 45x45x2m3 earthen pond. The ropes were properly staked to the dyke of the pond using bamboo sticks. Metal sinkers were attached to the four bottom corners of each hapa. This was to ensure uniform spread and proper extension, hence, allowing easy inflow and outflow of water through each hapa system. The system is set in such a way that hapas were submerged half way below the water level to enable easy access to the fish. Hapas were labeled in triplicates according to the five experimental diets to be administered. Pond water quality was maintained by the addition of fresh River water from the River Benue on daily bases through a network of pipes. Estimated daily water replacement in the pond is about 20%. Water quality parameters such as temperature (26.10±1.50), pH (7.53±0.05), conductivity (543±2.45), total dissolved solids (271.5±6.02) and dissolved oxygen (5.60±0.54) concentration were monitored weekly in the ponds using digital multi-parameter water checker (Hanna water tester Model HL 98126 Made in Romania). 15 batches of 50 fingerlings were weighed and stocked randomly in each of the fifteen hapas for the experiment. A total of 750 fingerlings (1 g) were stocked from the initial 1000 fish obtained.

Fish were hand-fed twice daily (08:00 am and 06:00 pm) and were at a rate of 5% of the body weight per day. The fingerlings of *C. gariepinus* were weighed weekly to determine weight gain and adjust feed rations. After feeding the fish for eight weeks, growth performance and nutrient utilization were assessed using the following indices:

(a) $$Growth\ rate = \frac{Mean\ final\ weight - Mean\ Initial\ Weight}{Duration\ of\ the\ Experiment}$$

(b) $$Specific\ growth\ rate\ (\%/day) = \frac{log_e(wt_2) - log_e(wt_1)}{t_{2-t_1}}$$

Where wt_1= Initial weight

wt_2= Final weight

t_2-t_1= Duration (in days) considered between wt_2 and wt_1.

(c) $$Feed\ conversion\ ratio\ (FCR) = \frac{dry\ feed\ intake}{wet\ weight\ gain}$$

(d) $$Feed\ efficiency\ ratio\ (FER) = \frac{wet\ weight\ gain\ x\ 100}{dry\ feed\ intake}$$

(e) $$Protein\ efficiency\ ratio = \frac{wet\ weight\ gain}{protein\ fed}$$

(f) $$Where\ protein\ fed = \frac{\%protein\ in\ diet \times total\ diet\ consumed}{100}$$

(g) $$\%Survival\ rate = \frac{total\ number\ of\ fish - mortality}{total\ number\ of\ fish} \times 100$$

Data analysis

Summary statistics of the different variables measured across the treatment (in triplicate) were obtained using Minitab 14 for windows software. The result was then subjected to Analysis of variance and where significant differences occurred; means were separated using Fisher's least significant difference.

RESULT

Proximate composition of toasted *C. ensiformis*

The protein, fat and ash content of the *C. ensiformis* were not significantly affected (25%, 5.30%, and 3.86% respectively) by toasting the seed (Table 1). However value recorded were significantly lower compared to soybeans (43.8%, 7.03% and 5.87). Fibre content of *C. ensiformis* reduced after toasting (5.38%) and was lower than the value recorded for soybeans (4.38%). The moisture content of toasted *C. ensiformis* was the least in this study (7.00%) while raw *C. ensiformis* had the highest moisture (7.26).

Table 1 - Proximate composition of *C. ensiformis* seed and soybeans meal

Parameters	Raw *C. ensiformis*	Toasted *C. ensiformis*	Soybeans	P-Value
Moisture	7.26± 0.01^{a}	7.00± 0.25^{c}	7.07± 0.005^{b}	0.001
Ash	3.89± 0.01^{b}	3.86± 0.05^{b}	5.87± 0.00^{a}	0.001
Lipid	5.29± 0.10^{b}	5.33± 0.21^{b}	7.03± 0.01^{a}	0.001
Fibre	7.11± 0.01^{a}	5.38± 0.01^{b}	4.38± 0.01^{c}	0.001
Protein	25.22± 0.03^{b}	25.02± 0.31^{b}	43.8± 0.01^{a}	0.002
NFE	51.32± 0.01^{b}	53.72± 0.01^{a}	31.82± 0.01^{c}	0.001

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

Essential amino acid profile and Anti-nutritional component of toasted *C. ensiformis*

The essential amino acids in this study significant reduced with processing. However, lysine content of *C. ensiformis* remain unaffected when compared to raw *C. ensiformis* (Table 2). Methionine (1.42), threonine (3.91), isoleucine (4.63), leucine (7.78), tyrosine (4.21), valine (4.61) and cystine (1.68) were higher in soybean compared to raw and toasted *C. ensiformis*. Four anti-nutrient were isolated in this study namely lectin, saponins, trypsin and canavaline (Table 3). Qualitative analysis reveals high levels of these anti-nutrient in raw *C. ensiformis*. The levels of saponin and trypsin were markedly reduced with toasting (Table 3). However, lectin and canavaline remain unaffected.

Table 2 - Essential amino acid of *C. ensiformis* seed meal and soybeans meal

Parameters	Raw *C. ensiformis*	Toasted *C. ensiformis*	Soybeans	P-Value
Lysine	6.54± 0.01^{a}	6.51 ± 0.01^{a}	6.41 ± 0.01^{b}	0.001
Histidine	2.61± 0.01^{a}	2.43± 0.01^{b}	2.43± 0.01^{b}	0.001
Methionine	1.02± 0.01^{b}	1.02± 0.03^{b}	1.42± 0.02^{a}	0.001
Threonine	3.49± 0.01^{b}	2.99± 0.01^{c}	3.91± 0.01^{a}	0.001
Isoleucine	3.23± 0.01^{b}	2.74± 0.01^{c}	4.63± 0.02^{a}	0.001
Leucine	7.05± 0.05^{b}	5.92± 0.03^{c}	7.78± 0.11^{a}	0.001
Tyrosine	3.19± 0.0^{b}	2.91± 0.04^{c}	4.21± 0.04^{a}	0.001
Valine	4.23± 0.01^{b}	3.61± 0.01^{c}	4.61± 0.01^{a}	0.001
Phenylalanine	5.22± 0.02^{a}	4.65± 0.05^{b}	4.15± 0.15^{c}	0.001
Cystine	1.07± 0.01^{b}	0.91± 0.01^{c}	1.68± 0.01^{a}	0.001

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

Table 3 - Qualitative analysis of the present of some anti-nutritional component in raw and toasted *C. ensiformis* seed.

Parameters	Raw *C. ensiformis*	Toasted *C. ensiformis*
Lectin	++ve	++ve
Saponins	++ve	+ve
Trypsin	++ve	+ve
Canavaline	++ve	++ve

+ve=present, ++ve=highly present

Table 4 - Gross composition of diet containing partial replacement of soybean meal with toasted *C. ensiformiss* meal

INGREDIENTS	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Fish meal	20.00	20.00	20.00	20.00	20.00
Maize meal	36.81	36.81	36.81	36.81	36.81
Soybean meal	38.19	36.28	34.37	32.46	30.55
C. ensiformis meal	-	1.91	3.82	5.73	7.64
Cassava meal	1.00	1.00	1.00	1.00	1.00
Mineral premix	1.50	1.50	1.50	1.50	1.50
Vitamin premix	1.50	1.50	1.50	1.50	1.50
Oil	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Total	100.00	1.00	100.00	100.00	100.00

Table 5 - Proximate composition of experimental diet containing partial replacement of soybean meal with toasted *C. ensiformiss.*

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	P-Value
Moisture	6.45 ± 0.02^{b}	5.86 ± 0.02^{d}	5.92 ± 0.01^{cd}	5.96 ± 0.01^{c}	6.64 ± 0.04^{a}	0.001
Crude Protein	36.20± 0.01^{a}	36.01± 0.01^{a}	36.15± 0.01^{a}	36.11± 0.01^{a}	35.84 ± 0.00^{a}	0.001
Fat	6.19 ± 0.02^{e}	6.74 ± 0.02^{d}	6.87 ± 0.02^{c}	7.12 ± 0.00^{b}	7.46 ± 0.01^{a}	0.001
Crude Fibre	3.89 ± 0.00^{e}	4.04 ± 0.01^{d}	4.11 ± 0.01^{c}	4.66 ± 0.01^{b}	5.12 ± 0.00^{a}	0.001
Ash	7.01 ± 0.01^{d}	7.11 ± 0.01^{c}	7.56 ± 0.01^{b}	7.69 ± 0.01^{a}	7.69 ± 0.02^{a}	0.001
NFE	40.26± 0.02^{a}	40.26± 0.03^{a}	39.39± 0.02^{c}	38.45± 0.01^{d}	37.26 ± 0.01^{e}	0.001

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

Growth performance and nutrient utilization of *Clarias gariepinus* fed substituted levels of toasted *C. ensiformis* meal.

Growth performance and nutrient utilization as shown in Table 6 and 7 reveals significant reduction in performance of *Clarias gariepinus* despite been included at a low level. The least performance was recorded in the 20% substitution for soybean (3.46g, 2.53g and 2.39% for final wt, wt gain, and ANPU respectively). Survival, however, did not differ significantly among the dietary treatments. Carcass analysis shown in Table 6 follows the same trend as reported for growth performance.

Table 6 - Growth and nutrient utilization of clarias gariepinus fingerling fed diet containing partial replacement of soybean meal with *C. ensiformiss* meal.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	P-Value
MIW	0.94 ± 0.01	0.93 ± 0.01	0.92 ± 0.003	0.92 ± 0.01	0.94 ± 0.01	0.240
MFW	4.52 ± 0.07^{a}	4.34 ± 0.03^{b}	4.18 ± 0.00^{c}	3.91 ± 0.07^{d}	3.46 ± 0.01^{e}	0.001
MWG	3.57 ± 0.06^{a}	3.41 ± 0.03^{b}	3.26 ± 0.00^{c}	2.99 ± 0.08^{d}	2.53 ± 0.01^{e}	0.001
GR	0.064 ± 0.01^{a}	0.061 ± 0.001^{a}	0.058 ± 0.01^{b}	0.053 ± 0.001^{c}	0.045 ± 0.001^{d}	0.002
SGR	2.80 ± 0.02^{a}	2.75 ± 0.02^{a}	2.71 ± 0.003^{a}	2.58 ± 0.05^{a}	2.34 ± 0.02^{a}	0.001
Feed Fed	8.49 ± 0.07^{a}	8.19 ± 0.03^{b}	7.91 ± 0.03^{c}	7.37 ± 0.01^{d}	6.64 ± 0.05^{e}	0.002
FCR	2.38 ± 0.02^{b}	2.40 ± 0.03^{b}	2.42 ± 0.01^{b}	2.47 ± 0.07^{b}	2.63 ± 0.01^{a}	0.02
FCE	42.11 ± 0.38^{a}	41.61 ± 0.55^{a}	41.27 ± 0.19^{a}	40.59 ± 1.11^{b}	38.02 ± 0.14^{c}	0.025
ANPU	4.67 ± 0.01^{a}	4.61 ± 0.01^{ab}	4.54 ± 0.03^{b}	3.97 ± 0.02^{d}	2.39 ± 0.01^{a}	0.001
PER	0.102 ± 0.001^{a}	0.097 ± 0.002^{b}	0.093 ± 0.007^{c}	0.085 ± 0.002^{d}	0.072 ± 0.001^{e}	0.001
Survival	87.50 ± 2.50	82.50 ± 2.50	82.50 ± 7.50	85.00 ± 0.007	82.50 ± 7.50	0.867

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

Table 7 - Carcass analysis of clarias gariepinus fingerling fed diet containing partial replacement of soybean meal with *C. ensiformiss* meal.

Parameters	Initial	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Moisture	59.09 ± 0.00^{f}	62.33 ± 0.01^{e}	61.54 ± 0.01^{e}	61.77 ± 0.01^{d}	62.09 ± 0.01^{c}	62.29 ± 0.01^{b}
Ash	1.13 ± 0.00^{f}	1.23 ± 0.01^{e}	1.45 ± 0.01^{a}	1.29 ± 0.01^{d}	1.34 ± 0.01^{c}	1.36 ± 0.01^{b}
Fat	2.13 ± 0.01^{e}	2.52 ± 0.01^{a}	2.43 ± 0.00^{b}	2.35 ± 0.01^{c}	2.33 ± 0.01^{d}	2.53 ± 0.01^{a}
Crude Fibre	1.21 ± 0.01^{e}	1.44 ± 0.00^{a}	1.36 ± 0.01^{b}	1.44 ± 0.01^{a}	1.29 ± 0.00^{d}	1.33 ± 0.01^{c}
CrudeProtein	14.91 ± 0.01^{e}	16.56 ± 0.01^{a}	15.76± 0.01^{d}	16.31 ± 0.01^{c}	16.51 ± 0.01^{b}	16.54 ± 0.01^{ab}
NFE	21.54 ± 0.02^{a}	15.94 ± 0.01^{e}	17.48± 0.01^{b}	16.85 ± 0.01^{c}	16.45 ± 0.01^{d}	15.96 ± 0.02^{e}

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

DISCUSSION

Thermal processing of feed is with the aim of improving the utilization of the feed by reducing or removing its anti-nutrient. This study shows that toasting is effective for the removal of trypsin and saponin. However, lectin and canavaline were not markedly reduced using this processing method. Canavaline, has long been reported as a thermostable, poisonous, alkaline amino acid with a structural analogue of arginine (Osuigwe et al. 2002; 2003; 2005). However, it could be rightly said that the duration of time used for toasting was too short to cause a marked reduction in saponin despite not been thermostable.

The need to determine nutrient composition before and after heat treatment is justified by the fact that heating sometimes denatures nutritional content of processed feedstuffs (Tiamiyu et al. 2015). This study shows that toasting *C. ensiformis* did not affect the protein nor fat content of seeds despite causing a significant reduction in essential amino acids. Ndidi et al. (2014) had earlier reported that the crude protein and fat of *Sphenostylis stenocarpa* seeds were significantly reduced by boiled and roasted. However, Akande and Fabiyi (2010) stated that the nutritive quality of most tropical legume grains is notably improved by heat treatment. Audu and Aremu (2011) had also reported higher protein content of processed red kidney bean (*Phaseolus vulgaris* L.). It should be noted that the efficacy of different kinds of processing method and susceptibility of antinutrients in the feed to applied method differs depending on the nature of the feedstuffs, strains, and environmental factors.

The efficacy of heat treatments in effectively destroying antinutritional factors in feeds without damaging the nutritional quality of the feeds has not been well studied (Fagbenro et al. 2004). The reduction in essential amino acids as a result of processing of the *C. ensiformis* meal is likely due to amino acids denaturation. The leucine / isoleucine ratio recorded in this study is higher (in value) but similar (in ratio) to those reported for fishmeal by NRC (1977). According to Tiamiyu et al. (2013), this ratio is an important factor limiting inclusions of some conventional and unconventional feedstuffs at a higher level in the diet of fish. Antagonistic actions between leucine and isoleucine have been reported in previous nutritional trials (Crawshaw, 1994). The level of lysine reported in this study for both raw and toasted *C. ensiformis* make them useful supplement for many conventional cereal grains (Mostafa et al 1987; Cheng et al 2003).

Fagbenro et al. (2004) they had earlier opined that biological indicators such as growth performance, survival, feed utilization efficiency, nutrient availability, gross or sub-clinical abnormal signs are basic means employed in determining the efficacy and adequacy of heat treatment of feeds. The present study noted that all fish fed toasted *C. ensiformis* included diet performed lesser than the control. The severity of these negative performance increased as the inclusion levels increases. Hence, it may be concluded that reduction in amino acids may have significantly affected growth. However, the markedly presence of canavaline and saponin in *C. ensiformis* are also possible causes of reduced growth observed in this study. Osuigwe et al. (2002, 2003, 2005) among other authors have previously reported the effect of canavaline which is thermostable, poisonous, alkaline aminoacid with a structural analogue of arginine (= lines 144, 145) no the performance of fish growth. Martinez-Palacios et al. (1998), Akinbiyi (1992), and Abdo de la Parra et al. (1998) had earlier reported that *Clarias gariepinus* can tolerate higher inclusion of raw *C. ensiformis* meal (11% level of inclusion) better than *O. niloticus* (5% level of inclusion). Fagbenro et al. (2004) also reported improvement of growth, nutrient utilization and bioavailability of *O. niloticus* with dietary inclusion of 20% cracked *C. ensiformis* seeds cooked in distilled water and also at 30% inclusion level of cooked *C. ensiformis* seeds in trona solution. The differences in the findings of the present study and those of the cited studies are largely due to processing methods, dietary inclusions levels, test organism and nature of other feed ingredient used. Despite depressed growth recorded with increasing levels of toasted *C. ensiformis*, mortality of fish were not significantly affected, this is contrary to the observations of Martinez-Palacios et al. (1988) who reported significant mortality for *O. mossambicus* fry fed with *C. ensiformis* seed meal. However from the result of this study it may be concluded that the detrimental effect of feeding *C. ensiformis* meal was not lethal at 20% replacement for soybeans meal. More so, the susceptibility of different species to varying levels of such unconventional feed may be the reason for the discrepancies in observations.

The observed trend for carcass composition in this study negates the hypothesis of Abbas (2007) and Manjappa et al. (2011) who stated that the level of nutrient utilization and retention in carcass of fish fed experimental diet is related to both the dietary protein levels and the availability of non-protein energy sources with lower inclusion of dietary fiber. Though experimental diet recorded significantly higher protein compared to the initial value before, they were lower compared to the control. According to Fafioye et al. (2005), better carcass composition is an indication of protein addition and true growth involving an increase in the structural tissues such as muscles. Reinitz and Hitzel (1980) and Tiamiyu et al. (2015) also rightly opined that nutritional quality of feed ingested is the main factors affecting fish carcass composition.

CONCLUSION

This study has established the need to focus attention on alternative processing method other than toasting for *C. ensiformis* meal. This is to enable better detoxification of *C. ensiformis* seeds so that it's potential in fish nutrition can be fully realized. Thermolabile antinutritional factors in *Canavalia* seeds are suggested to be easily inactivated by wet thermal processing. Also, the efficacy of solvent extraction in combination with heat is hypothesized. Hence, it is recommended that further study be conducted to investigate the viability of these methods in improving the nutritional utilization of *C. ensiformis* meal in the diet of African catfish *Clarias gariepinus*.

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