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Use of watermelon seed meal as a replacer of soybean meal in African catfish diets: effect on growth, body composition, haematology, and profit margin

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Use of watermelon seed meal as a replacer of soybean meal in African catfish diets: effect on growth, body composition, haematology, and profit margin

Abstract: The effects of replacing soybean meal with watermelon (*Citrullus lanatus*) seed meal (CLM) on growth, body composition, haematology and profit margin in catfish *(Clarias gariepinus)* breeding was evaluated. Juvenile catfish (n = 150) were acclimatised for a week, weighed and allotted into five dietary treatments; D1, D2, D3, D4 and D5 containing 0, 15, 30, 45 and 60 % replacement of soybean meal with watermelon seed meal, respectively. The diets were isonitrogenous and isolipidic. Each treatment was conducted in triplicate with ten fish per replicate. The results from the study indicate that there was no significant difference ($p > 0.05$) in growth, carcass composition, and nutrient utilization. However, a significant variation ($p < 0.05$) existed in the haematological parameters among the fish fed the different dietary treatments. The incidence of cost showed that the production of fish was cheaper when CLM was used as a replacement for soybean meal. The higher carcass yield and profit per kg of fish fed CLM justifies the use of CLM as a substitute for soybean meal in the diet of African catfish.

Key words: aquaculture; fish farming; fish; African catfish; *Clarias gariepinus*; animal nutrition; watermelon seed meal; growth; body composition; haematological parameters; economics; profit margin

Uporaba moke iz lubeničnih semen kot nadomestka sojinih tropin v prehrani afriških somov: vpliv na rast, sestavo telesa, hematologijo in dobiček

Izvleček: V raziskavi smo ocenili učinke zamenjave sojinih tropin z moko iz lubeničnih (*Citrullus lanatus*) semen (MLS) na rast, telesno sestavo, hematološke parametre in dobičkonosnost v prireji afriških somov (*Clarias gariepinus*). Mlade some (n = 150) smo po tednu dni aklimatizacije stehtali in razdelili v pet skupin, ki so prejemale različne krmne mešanice; v poskusnih skupinah smo 0 % (D1), 15 % (D2), 30 % (D3), 45 % (D4) in 60 % (D5) sojinih tropin nadomestili z MLS. Vse krmne mešanice so vsebovale enako količino beljakovin, pa tudi maščob. Vsak tretma smo izvedli v treh ponovitvah z desetimi ribami na ponovitev. Rezultati študije kažejo, da med skupinami ni bilo statistično značilnih razlik ($p > 0,05$) v rasti, sestavi trupa, izkoriščanju krme in hematoloških parametrih. Analiza stroškov je pokazala, da je bila prireja rib cenejša, če smo del sojinih tropin nadomestili z MLS. Boljša klavnost in večji dobiček na kilogram ribjega mesa ob uporabi ribje krme, kjer del sojinih tropin nadomestimo z MLS, upravičuje uporabo MLS kot nadomestka sojinih tropin v prehrani afriških somov.

Ključne besede: akvakultura; ribogojstvo; ribe; afriški som; *Clarias gariepinus*; prehrana živali; lubenična semena; moka iz lubeničnih semen; rast; telesna sestava; hematološki parametri; ekonomika; dobiček

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1 INTRODUCTION

Soybean meal (SBM) is known for its high protein content, high digestibility, and relatively well-balanced amino acid profile and is widely used as a feed ingredient for many aquaculture species (Storebakken et al., 2000). It is currently the most commonly used plant protein source in fish feed (El-Sayed, 1999; Fadel et al., 2017; Fagbenro et al., 2003; Jimoh et al., 2020a). Lim and Akiyama (1992) and Jimoh (2020) reported that soybean products have been used to replace a significant portion of fish meal in fish feed with nutritional, environmental, and economic benefits. However, the wider utilization and availability of this conventional source for fish feed is limited by the increasing demand for human consumption and by other animal feed industries (Jimoh et al., 2020b; Siddhuraju & Becker, 2001). The rapid expansion of fish culture in recent years requires the development and improvement of low-cost and nutritious fish feeds, mainly because increasing the feed cost may increase the cost of fish production by 50–80 % (Cavalheiro et al., 2007; Jimoh et al., 2019). Feed contributes between 60 and 70 % to the variable cost of fish production (Gabriel et al., 2007), making it one of the factors that determine the profitability of aquaculture production (Jimoh et al., 2019). Hence, the need to focus on using less expensive and readily available vegetable sources of protein to replace soybean meals without reducing the nutritional quality of the feed is imperative (Barros et al., 2002). In the past, research was mostly focused on the underutilised vegetable proteins in the fish diet among which were groundnut cake (Fasakin & Balogun, 1996), lima bean (Adeparusi & Ajayi, 2004), pigeon pea (Adeparasi, 1994), sunflower, sesame (Fagbenro et al., 2010a, 2010b, 2013), and jack bean (Fagbenro et al., 2007; Jimoh et al., 2010).

Watermelon (*Citrullus lanatus*) is a drought-tolerant crop that belongs to the family *Cucurbitaceae*. It is cultivated in a wide range of tropical, semi-tropical, and arid regions of the world (Razavi & Milani, 2006). The seeds of the watermelon have a nutritional quality comparable to that of oilseed proteins including soybean and other conventional legumes (Mustafa & Alamin, 2012). Wani et al. (2011) reported that watermelon seed meal contains an adequate amount of nutritional protein that could be used as an ingredient in feed products. More so, there is a paucity of information on the use of watermelon seeds as a dietary protein source in fish feed. Therefore, this work seeks to study the replacement of soybean meal with watermelon seed meal in the diet of African catfish (*Clarias gariepinus*).

2 MATERIALS AND METHODS

2.1 SOURCES AND PROCESSING OF INGREDIENTS

The dried watermelon seeds were obtained in Bodija market, Ibadan, Nigeria. The watermelon seeds were rinsed with water and boiled for 15 minutes, after which they were sundried for several days and ground in a hammer mill. The oil therein was removed using the pressure generated from a locally made screw press (cassava-presser type). The cakes and other feedstuffs obtained from commercial sources in Nigeria were separately milled and screened to fine particles size. Triplicate samples were analysed for their proximate composition (AOAC, 2010).

2.2 EXPERIMENTAL DIETS

Based on the nutrient composition of different sources of protein (Table 1), the experimental diets were formulated, containing cooked watermelon seed meal (CLM) substituting soybean meal at the shares of 0, 15, 30, 45, and 60 % instead of soybean meal (designated as D1, D2, D3, D4, and D5), respectively (Table 2). The diets were isolipidic and isonitrogenous, containing 40 % crude protein and 12 % crude lipid. The feedstuff was separately ground mixed with hot water, introduced into a Hobart-200T pelleting and mixing machine to obtain a homogenous mass, and then passed through a mincer to produce 2 mm size pellets, which were immediately sundried at 30–32 °C. After drying for three days, the diets were kept in a freezer (−4 °C). The diets were analysed for their proximate composition. It was observed that the value of crude fibre increased as the amount of CLM in the diet increased. However, there was no significant difference ($p > 0.05$) in the proximate composition parameters of the diets.

Table 1: Proximate composition of the different sources of protein in the experimental diets

Parameter	Fish meal	Soybean Meal	CLM**
Moisture	9.75	10.70	9.69
Crude Protein	72.4	45.74	27.55
Crude Lipid	10.45	9.68	11.35
Crude Fibre	-	5.10	4.97
Ash	8.32	4.48	5.39
NFE*	-	30.00	41.05

* Nitrogen Free Extract
** Watermelon (Citrullus lanatus) meal

Table 2: Gross (g/100g) and proximate composition (%) of experimental diets containing watermelon seed meal (CLM)

Ingredients	D1	D2	D3	D4	D5
Fish meal (72%)	27.70	27.70	27.70	27.70	27.70
SBM (45%)	44.40	37.70	31.10	24.40	17.78
CLM (27.55%)	-	10.88	21.77	32.66	43.55
Fish oil	5.00	5.00	5.00	5.00	5.00
ᶲVitamin premix	5.00	5.00	5.00	5.00	5.00
Starch	17.90	13.72	9.43	5.24	0.97
Proximate Analysis					
Moisture	9.38 ± 0.08	9.87 ± 0.31	9.95 ± 0.11	9.56 ± 0.92	9.50 ± 0.72
Crude Protein	40.17 ± 0.08	40.19 ± 0.02	40.14 ± 0.01	40.19 ± 0.11	40.18 ± 0.06
Crude Lipid	12.00 ± 0.16	11.74 ± 0.83	12.29 ± 0.45	12.00 ± 0.04	12.16 ± 0.23
Crude Fibre	5.51 ± 0.26	5.53 ± 0.28	5.86 ± 0.59	6.20 ± 1.18	6.51 ± 0.37
Ash	6.20 ± 0.06	6.30 ± 0.04	6.00 ± 0.17	5.95 ± 0.33	5.44 ± 0.33
*NFE	26.76 ± 0.32	26.42 ± 1.40	25.76 ± 0.22	26.11 ± 0.44	26.19 ± 0.22

Means without superscript in the same row are not significantly different ($p > 0.05$) from each other
* Nitrogen free extract
ᶲ Specification: each kg contains: Vitamin A = 4,000,000 IU; Vitamin B = 800,000 IU; Vitamin E = 16,000 mg, Vitamin K_3 = 800 mg; Vitamin B_1 = 600 mg; Vitamin B_2 = 2,000 mg; Vitamin B_6 = 1,600 mg, Vitamin B_{12} = 8 mg; Niacin = 16,000 mg; Caplan = 4,000 mg; Folic Acid = 400 mg; Biotin = 40 mg; Antioxidant = 40,000 mg; Chlorine chloride = 120,000 mg; Manganese = 32,000 mg; Iron = 16,000 mg; Zinc = 24,000 mg; Copper = 32,000 mg; Iodine = 320 mg; Cobalt = 120 mg; Selenium = 800 mg, manufactured by DSM Nutritional products Europe Limited, Basle, Switzerland.

2.3 EXPERIMENTAL FISH AND THE AQUACULTURE SYSTEM

The experiment was conducted at the hatchery unit of the Federal College of Animal Health and Production Technology, Moor Plantation Ibadan, Nigeria. The fingerlings were obtained from a reputable hatchery, Ibadan, Oyo State, Nigeria, and transported to the experimental site inside an aerated bag. The initial average weight of the fish ranged from 10.80 to 10.97 g. A total of 150 fingerlings were acclimated to laboratory conditions for 14 days before the feeding trial while being fed on a commercial pelleted diet. Experimental diets were assigned randomly to the tanks with three replicates per dietary treatment. Each culture tank contained 10 fish that were fed 5 % body weight per day in two equal proportions between 9:00–10:00 a.m. and 5:00–6:00 p.m. for 56 days. Fish – from each tank were batch – weighed every other week and the amount of feed was adjusted accordingly. The mortality was monitored daily and recorded. The growth performance and feed utilization indices were estimated following the method explained in Jimoh and Aroyehun (2011). The water quality parameters were monitored and recorded throughout the experiment (oxygen 6.84 ± 0.55 mg/l, temperature 28.28 ± 0.29 °C and pH 6.88 ± 0.30) using a combined digital YSI dissolved oxygen meter (YSI Model 57, Yellow Spring Ohio) and the pH was monitored weekly using a pH meter (Mettler Toledo – 320, Jenway UK). Eight catfish per treatment were euthanized in clove oil (100 mg/l) at the beginning and end of the feeding trial and analysed for their carcass composition (AOAC, 2010).

2.4 BLOOD SAMPLING AND ASSESSMENT

The assessment of the haematological parameters was conducted following the methods explained in Jimoh et al. (2015a). Briefly, fish (n = 6) from each treatment were mildly euthanized with clove oil (100 mg/l) at the end of the feeding trial for blood sampling. The blood (1 ml) was obtained by caudal vein piercing using a 1ml disposable syringe and 25G EDTA treated needle and placed in EDTA treated test tubes for haematological examination. The primary haematological parameters such as packed cell volume (PCV), haemoglobin concentration (Hb) were measured by the microhematocrit method and the cyanmethaemoglobin method (Coles, 1986; Schalm et al., 1975) and total blood cell counts such as red blood cell count (RBC) and white blood cell count (WBC) were determined by the use of hemocytometer, respectively. The secondary haematological parameters such as mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were calculated using the standard formulae (Coles, 1986; Schalm et al., 1975).

Table 3: Carcass composition of African catfish fed diets containing watermelon seed meal (CLM)

	Initial	D1	D2	D3	D4	D5
Moisture	77.88 ± 0.18	75.57 ± 0.11	74.89 ± 0.46	74.16 ± 1.09	74.20 ± 2.20	74.58 ± 3.19
Crude Protein	15.11 ± 0.14[b]	17.32 ± 0.16[a]	17.45 ± 0.12[a]	17.37 ± 0.12[a]	17.10 ± 0.44[a]	17.14 ± 1.21[a]
Crude Lipid	3.13 ± 0.18	3.84 ± 0.25	3.41 ± 0.21	3.59 ± 0.23	3.56 ± 0.38	3.62 ± 0.33
Ash	3.89 ± 0.18	3.84 ± 0.25	4.26 ± 0.13	4.88 ± 0.74	5.14 ± 1.20	4.67 ± 1.66

Row means with the different superscripts are significantly different ($p < 0.05$) from each other

2.5 ECONOMIC ANALYSIS

The economic analysis of feeding watermelon seeds was assessed following the procedure explained in Jimoh et al. (2015b).

$$\text{Incidence of Cost} = \frac{\text{Cost of Feed}}{\text{Weight of Fish}}$$

$$\text{Profit Index} = \frac{\text{Value of Fish}}{\text{Cost of Feed}}$$

$$\text{Profit / kg} = \text{Value of 1 kg fish} - \text{Incidence of cost}$$

2.6 STATISTICAL ANALYSIS

Data obtained from the experiment were expressed in mean ± SD and subjected to one-way analysis of variance (ANOVA) using SPSS version 16.0. Duncan multiple range tests were used to compare differences among individual treatment means to reveal significant differences ($p < 0.05$).

2.7 ETHICAL STATEMENT

Standard regulations and guidelines of Federal College of Animal Health and Production Technology, PMB 5029, Ibadan, Nigeria on the care and use of laboratory animals were followed throughout the experiment.

3 RESULTS AND DISCUSSION

3.1 CARCASS COMPOSITION

Uys and Hecht (1985) reported that the best growth rate and feed conversion efficiency in juvenile and sub-adult African catfish (*Clarias gariepinus*) are achieved with diets containing 38–42 % crude protein and lipid content of 10–11 %. The carcass composition of African catfish-fed diets containing CLM is presented in Table 3. Significant differences ($p < 0.05$) were observed only in carcass protein content between the fish at the beginning and at the end of the experiment. However, no significant difference was recorded in the carcass protein content of fish fed different experimental diets. A similar observation was reported by Tiamiyu et al. (2015), using CLM as a replacer of soybean meal. The groups fed with the inclusion of CLM up to 30 % (D2 and D3) had higher

Table 4: Growth and nutrient utilization of African catfish fed diets containing watermelon seed meal

	D1	D2	D3	D4	D5
Initial weight (g)	10.88 ± 0.02	10.97 ± 0.04	10.80 ± 0.03	10.87 ± 0.11	10.88 ± 0.03
Final weight (g)	24.31 ± 2.09	32.34 ± 7.81	30.95 ± 5.56	27.66 ± 6.42	21.37 ± 0.45
[1]Weight gain (g)	13.43 ± 2.11	21.37 ± 7.83	21.65 ± 7.71	16.79 ± 6.53	10.49 ± 0.47
[2]% weight gain	124.50 ± 21.92	190.93 ± 76.27	200.56 ± 71.89	154.78 ± 61.72	96.37 ± 4.61
[3]SGR	1.43 ± 0.16	1.90 ± 0.44	1.94 ± 0.43	1.64 ± 0.44	1.20 ± 0.04
[4]FCR	1.47 ± 0.45	1.16 ± 0.08	1.30 ± 0.03	1.33 ± 0.06	1.36 ± 0.04
[5]PER	1.64 ± 0.76	2.16 ± 0.16	1.92 ± 0.04	1.88 ± 0.08	1.84 ± 0.05
[6]% Survival	77.77 ± 15.71	88.89 ± 15.72	88.89 ± 15.72	88.89 ± 15.72	88.88 ± 15

Row means without superscript are not significantly different ($p > 0.05$) from each other.
[1] Mean weight gain = final mean weight – initial mean weight; [2] Percentage weight gain = (final weight – initial weight / initial weight) × 100;
[3] Specific growth rate = (In final weight – In initial weight) × 100; [4] Feed conversion ratio = dry weight of feed fed / Weight gain (g);
[5] Protein efficiency ratio = fish body weight (g) / Protein fed; [6] Percentage survival = ((total number of fish – mortality) / total number of fish) × 100

Table 5: Haematological profile of African catfish fed the experimental diets

	D1	D2	D3	D4	D5
PCV (%)	16 ± 1.41[c]	17 ± 1.41[bc]	19 ± 1.41[ab]	20 ± 1.41[a]	20 ± 1.41[a]
Hb (g/dL)	5.0 ± 1.41	5.0 ± 1.41	6.4 ± 0.57	6.8 ± 1.41	6.9 ± 0.14
RBC ($\times 10^{12}$/L)	1.42 ± 0.03[d]	1.62 ± 0.03[b]	1.73 ± 0.00[a]	1.50 ± 0.00[c]	1.60 ± 0.00[b]
WBC ($\times 10^{7}$/L)	158.8 ± 0.28[d]	205.2 ± 1.41[c]	342.6 ± 3.39[b]	340.2 ± 0.28[b]	400.2 ± 0.28[a]
MCV (fL)	112.7 ± 1.41[c]	123.0 ± 1.41[b]	109.8 ± 2.83[c]	133.0 ± 0.00[a]	125.0 ± 1.41[b]
MCH (ρg)	35.2 ± 0.83[c]	40.4 ± 0.34[b]	37.0 ± 1.41[c]	40.0 ± 0.00[b]	43.1 ± 1.41[a]
MCHC (g/dL)	31.3 ± 1.41[b]	33.3 ± 0.42[a]	34.0 ± 1.41[a]	34.0 ± 0.00[a]	35.0 ± 1.41[a]
WBC Differential					
Lymphocytes (%)	69.0 ± 1.41[c]	78.0 ± 2.83[b]	78.0 ± 2.83[b]	81.0 ± 1.41[b]	88.0 ± 1.41[a]
Neutrophil (%)	30.0 ± 2.83[a]	22.0 ± 2.83[b]	21.0 ± 1.41[c]	19.0 ± 0.00[c]	11.0 ± 0.71[d]

Row means with different superscripts are significantly different ($p < 0.05$) from each other.
Hb = Haemoglobin content; PCV = Packed Cell Volume; WBC = White Blood Cell Count; RBC = Red Blood Cell Count; MCHC = Mean Corpuscular Haemoglobin Concentration; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin

carcass crude protein levels than the controls (D1), but the difference was not statistically significant ($p > 0.05$).

3.2 GROWTH AND NUTRIENT UTILIZATION

The growth and nutrient utilization of African catfish fed different diets are shown in Table 4. The results of this experiment indicated that the growth and nutrient utilization of *C. gariepinus* were not significantly affected ($p > 0.05$) by up to 60 % replacement level of soybean meal with CLM in the diet. This result agrees with the studies conducted by Davies et al. (2000) using sesame and other oil seeds residue as fish meal replacer in diets fed to Nile tilapia (*Oreochromis niloticus*), Olvera-Novoa et al. (2002), and Sahar et al. (2003) using sunflower seed meal as a protein source in diets fed to red beast tilapia (*Tilapia rendalli*) and common carp (*Cyprinus carpio*), respectively. The D5-fed group had a lower weight gain compared to the control group (D1) but the difference was not significant ($p > 0.05$). Lower growth at higher inclusion is customary of alternative vegetable protein sources used in fish feed, as they may be deficient in some essential amino acids and may possess antimetabolites which may reduce the growth performance of fish (Jobling, 2012). Antimetabolites at higher inclusion can reduce palatability and bioavailability of nutrients in the feed (Jimoh et al., 2014).

3.3 HAEMATOLOGICAL PROFILE

Table 5 shows the haematological profile of African catfish fed the experimental diets. Fish fed diets containing CLM had significantly higher ($p < 0.05$) values of PCV, RBC, WBC, and lymphocytes than animals from the control group. The difference in haemoglobin content was not significant ($p > 0.05$) between the groups. The values recorded for haemoglobin contents, PCV, RBC of the fish were all within the range of normal

Table 6: Cost of producing 1 kg feed containing watermelon seed meal

	Price (₦)/kg*	D1	D2	D3	D4	D5
Fish meal	480	132.96	132.96	132.96	132.96	132.96
SBM	136	60.43	51.36	42.29	33.18	24.18
C.L.M	48	-	5.22	10.44	15.67	20.90
Fish oil	500	100	100	100	100	100
Vit. Premix	262	52.40	52.40	52.40	52.40	52.40
Starch	200	35.80	27.44	18.86	10.48	1.94
Cost (₦/kg)		381.59	369.38	356.95	344.69	332.38

* 1 Euro = ₦194.85

healthy fish (Clark et al., 1979; Erondu et al., 1993; Fagbenro et al., 1993; Khan & Abidi, 2010, 2011; Omitoyin, 2006; Rastogi, 2007). According to Lenfant and Johansen (1972), an erythrocyte count greater than $1 \times 10^6/mm^3$ is considered high and is indicative of the high oxygen-carrying capacity of the blood, which is characteristic of fishes capable of aerial respiration and with high activity. Watermelon seeds and flour are known to contain bioactive compounds such as tannins, stachyose, phytic acids, raffinose, and verbascose that could have immunomodulatory and immunostimulatory properties thus could enhance the innate defence mechanism of fish (El-Adawy & Taha, 2001; Erhirhie & Ekene, 2014; Tarazona-Díaz et al., 2011). We observed a significant rise ($p < 0.05$) of WBC in fish fed CLM-enriched diets, demonstrating possible ability to boost innate immunity when compared to the control-fed group (Hoseinifar et al., 2020). Fish fed diets D2, D3, D4, and D5 had decreased neutrophil counts compared to the fish fed the control diet. Similar was observed in in African catfish fed dietary combinations of onion-pawpaw where Fawole et al. (2020b) discovered an inverse relationship between lymphocyte and neutrophil counts, while Tiamiyu et al. (2019) discovered the same in African catfish fed *Talinum triangulare*.

3.4 COST OF PRODUCING 1 KG OF DIET

Table 6 shows the cost of producing 1 kg of feed containing CLM. There was a reduction in the cost of producing 1 kg of diets with an increasing replacement level of soybean meal by CLM.

3.5 ECONOMIC ANALYSIS

Table 7 reveals the incidence of a cost analysis of producing 1 kg of African catfish with diets containing CLM. The cost analysis of producing 1kg of fish, showed that it was cheaper to produce 1 kg of fish with diets containing CLM than with diets containing only soybean meal. A significant difference ($p < 0.05$) was shown in the incidence of cost and profit (₦/kg) of fish fed the different dietary treatments. The cost of the feed D5 was significantly the lowest, while D1 was significantly the highest. A reverse trend was noted for Profit (₦/kg) of fish fed the different dietary treatments. However, there was no significant difference ($p > 0.05$) in the value of fish produced and their profit margin among the fish fed various dietary treatments. The profit index reveals a trend of increasing profitability when feeding CLM based diets to African catfish ($p > 0.05$). A profit index above one (Table 7) shows that it is profitable to feed the fish with the diet. There was a general increase in the profit index observed with an increased dietary level of inclusion of CLM. This agrees with our earlier studies (Jimoh et al., 2012; Jimoh, 2004; Jimoh et al., 2019) that reported a general increase in the profit index with an increase in the replacement level of lesser-known vegetable protein

Gross margin was reported to be a good measure of profitability (Olagunju et al., 2007). The experiment showed that it is profitable to replace soybean meal with watermelon seed meal. This result agrees with the findings of Fagbenro et al. (2001) and Abu et al. (2010), who reported that feeding fish with cheaper and lesser-known feed ingredients left some profit margin. Although the economic implication of using the different dietary treatments might not be well appreciated since the margin is small, it will be much clearer when the magnitude of total cost and expected revenue of its large scale operation is critically and objectively considered (Faturoti, 1989; Jimoh et al., 2019). Adeparusi and Balogun (1999) reported profit margin increasing when the fish meal was replaced by roasted pigeon peal meal in a diet fed to African catfish. Jimoh (2004) also reported an increase in the profit margin in the production of tilapia by replacing up to 30 % of soybean meal with jack bean meal. Jimoh et al. (2019) and Jimoh et al. (2020b) observed similar trends when *Jatropha curcas* was fed African catfish (*Clarias gariepinus*) and Nile tilapia (*Oreochromis niloticus*), respectively.

Table 7: Cost analysis of producing 1kg of African catfish fed diets containing watermelon seed meal

	D1	D2	D3	D4	D5
Cost of feed fed	3.55 ± 1.01	3.73 ± 3.61	3.91 ± 3.44	3.51 ± 2.17	3.65 ± 0.67
Weight gain of fish	0.013 ± 0.02	0.014 ± 0.02	0.015 ± 0.01	0.017 ± 0.01	0.019 ± 0.01
Value of fish	5.20 ± 1.05	5.60 ± 3.92	6.0 ± 3.85	6.80 ± 3.27	7.60 ± 0.23
Profit index	1.46 ± 0.01	1.50 ± 0.01	1.54 ± 0.01	1.93 ± 0.57	2.08 ± 0.33
Incidence of cost	273.08 ± 1.25^{a}	266.42 ± 2.40^{ab}	260.67 ± 4.07^{b}	206.47 ± 8.31^{c}	192.10 ± 9.86^{d}
Profit (₦)/kg of fish	126.92 ± 1.05^{e}	133.58 ± 2.43^{d}	139.33 ± 2.19^{c}	193.53 ± 4.24^{b}	207.90 ± 1.21^{a}

Row means without superscript are not significantly different ($p > 0,05$) from each other.
Price/kg of African catfish Clarias gariepinus = ₦400

4 CONCLUSIONS

Conclusively, the result of this study indicated that CLM can replace soybean meal up to 60 % without affecting health, and at least up to 45 % without affecting the growth of African catfish. Higher carcass yield and profit per kg of fish fed diets containing watermelon seed meal compared to controls justifies the use of CLM as soybean meal replacer in the diets of African catfish.

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