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Evaluation of *Cirina butyrospermi* caterpillar's meal as an alternative protein source in *Clarias gariepinus* (Burchell, 1822) larvae feeding

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Abstract

The present study was carried out to evaluate the *Cirina butyrospermi* caterpillar meal (CBM) as a partial or total replacement of fish meal (FM) in *Clarias gariepinus* larvae diet. Three days old African catfish larvae (initial mean weight = 3±0.05 mg) were fed with five formulated diets in which CBM progressively replaced FM at 0 (D1), 25 (D2), 50 (D3), 75 (D4) and 100% (D5) levels; and one commercial diet (Gemma micro), during 35 days. Larvae group fed on Gemma exhibited significant better mean weight gain (MWG) (1344±110 mg), low feed conversion ratio (FCR) (1.27±0.1) and high survival rate (SR) (80.67±1.45%). Regarding formulated diets, better MWG (953±101 mg), lower FCR (1.59±0.15) and higher SR (65.33±7.33%) were obtained in larvae fed with D2. The proximate whole body composition of *C. gariepinus* larvae fed the different diets showed similar moisture, lipid and protein contents. However, ash decreased in whole body when CBM was increased above 25% in the diet. The higher gross profit was obtained with D2 (1.27 €), while it was negative with Gemma (-51.29€). This study demonstrates that 25% inclusion level of CBM in *C. gariepinus* larvae diet improves growth performances for a profitable feed for catfish larvae.

Keywords: *Clarias gariepinus* larvae, *Cirina butyrospermi* caterpillar, feeding, growth performance.

1. Introduction

Aquaculture is one of the most rapidly increasing food production systems in the world (Koeleman, 2009) [16]. The expansion of aquaculture, especially the culture of African catfish, *Clarias gariepinus* is due to the tolerance to drastic rearing conditions (wide range of temperatures, low oxygen and high salinity levels), high nutritive value, good taste, and few bones of this species. In addition his high fecundity and growth rate made it to an important commercial species mainly in Africa (Hecht *et al*., 1996) [13].

In spite of *C. gariepinus* potential for aquaculture and the fact that it is native in tropical and subtropical fresh water, the culture of this fish in Africa depends on the availability of supply of fingerlings which appear to be a major constraint. Indeed, the reproduction of this species constituted for long time the main limiting factor and bottleneck in *C. gariepinus* production (Verreth, 1994) [32] because of its dependence on live *Artemia* which is costly, time consuming and not always available for the fish breeders (Vandecan *et al*., 2011) [30].

Recently, an alternative to *Artemia* live food was developed for fish larvae. This starter feed was described by the producers as more digestible, metabolizable and with a better formulation (Gemma micros, Skretting, commercial prospectus) (Vandecan *et al*., 2011) [30]. Nevertheless, it is expensive especially for the aquaculturists of developing countries. Fish meal is generally used as the main protein source in starter feeds due to its high protein content, balanced amino acids profile, essential fatty acids content, minerals and vitamins content, palatability and highly digestibility to most fresh water and marine fish (Miles and Chapman, 2011) [19]. But, the high cost and fluctuating quality of fish meal as well as its uncertain availability (Alceste, 2000) [4] have led to many investigations to seek alternative protein sources.

Besides, *C. gariepinus* larvae protein requirement is 55% of dry feed (Uys and Hecht, 1985) [29]. Therefore, the formulation of feed for those larvae requires the use of ingredient (main source of protein) having more than 55% of protein content.

Currently, insects are being considered as a new protein source for animals feed (Premalatha *et al*., 2011; Kelemu *et al*., 2015) [24, 15] such as poultry, pig, and all cultivated species of fish, including invertebrates, such as oligochaeta, crustaceans and insects (Sánchez-Muros *et al.*, 2014) [25]. The crude protein content of insects ranges from 40 to 75% on a dry weight basis. In addition, they have a beneficial amino acids profile and a variable fat content (Verkerk *et al.*, 2007) [31].

Cirina butyrospermi is an insect pest of *Vitellaria paradoxa*, the sheabutter tree. Its larvae (caterpillar) contain 63% protein (Ouedraogo, 1993) [22] and could be used as ingredient in the feeding of carnivorous animals such as Catfish (Anvo *et al*, 2016) [7]. Given to its nutritional quality (high protein, moderated lipid and appreciable minerals contents), its availability and less expansive price, *C. butyrospermi* caterpillar might be an ideal candidate to substitute conventional protein source in the feeding of *C. gariepinus* larvae diet in order to reduce fish production cost in Burkina Faso where fisheries produce only a third of the population fish consumption.

The aim of the present study is to assess the growth performance, feed utilization, and carcass composition of *Clarias gariepinus* larvae fed with diets in which fish meal (FM) was progressively replaced by *Cirina butyrospermi* caterpillar meal (CBM).

2. Materials and methods

2.1 *Cirina butyrospermi* meal preparation

Caterpillars of *Cirina butyrospermi* were handpicked from sheabutter trees directly from the trunk and from or under the soil, were then transported to the laboratory for identity confirmation, washed, precooked at 100 °C and dried in an oven at 60 °C for 72 hours. Dried larvae were ground and stored for analysis and use in fish diets formulation.

2.2 Experimental diets, fish and system

C. gariepinus larvae group were fed with six experimental diets: Gemma micro (commercial diet developed for fish larvae) and five isonitrogenous (55% crude protein), approximately isolipidic (15.08% crude lipid) and isocaloric (22.10 Kjg^{-1}) formulated diets (Table 4) in which fish meal (FM) was gradually replaced by *Cirina butyrospermi* meal (CBM) at 0, 25, 50, 75 and 100% levels (Table 1). The diets were coded D1 to D5. The size of feed particles was 0.25 mm. Larvae were fed at 25% of the total fish body weight as recommended by Uys and Hecht (1985) [29] during 35 days. Larvae of *C. gariepinus* were obtained by artificial reproduction of broodstock at the Study of Natural's Resources and Environment Sciences Laboratory, Unit of Aquaculture Research and Aquatic's Biodiversity of Polytechnic University of Bobo-Dioulasso, Burkina Faso

Table 1: Composition (g/100g) of formulated diets

Ingredients (%)	**Diets**				
	D1	**D2**	**D3**	**D4**	**D5**
C. butyrospermi meal	0	19	38	57	76
Fish meal	76	57	38	19	0
Soya meal	4.5	7	8	10.5	14
Maize meal	13	10.5	9.5	7	3.5
Fish oil	3	3	3	3	3
L-lysine	0.5	0.5	0.5	0.5	0.5
DL-methionine	0.5	0.5	0.5	0.5	0.5
Vitamin premix[1]	1	1	1	1	1
Mineral premix[2]	0.5	0.5	0.5	0.5	0.5
Betaine	1	1	1	1	1

[1]**Vitamin Mixture**: Vit A: 2500000 IU; Vit D3: 500000 IU; Vit E : 30000 mg ; Vit K3 : 2000 mg ; Vit B1 : 2000 mg ; Vit B2 : 5000 mg ; Panthotenic acid: 10000 mg ; Niacin 5000 mg; Vit B6: 4000 mg; Folic acid:2000 mg; Vit B12: 80 mg; Vit C: 20000 mg; Biotin: 200 mg and Inositol: 80000 mg

[2]**Mineral premix**: Calcium= 23 g, Phosphore = 18g, Magnesium = 0.21 g, Copper Sulphate = 0.8g, Cobalt sulphate= 0.02 g, Manganese Sulphate = 0.6 g, ZincSulphate = 8.15 g, Selenium Sulphate= 0.04 g. ferrous sulphate= 0.9 g.

Table 2: Composition of Gemma

Fish meal	71
Phospholipids	>12
Lecithin	12
Wheat gluten	5
Starch	2.5
Fish oils	<5
Vitamins	4
Minerals	4
Betaine	1

Source: Vandecan *et al.* (2011) [30]

Three days after post-hatching, the larvae (initial mean weight = 3 ± 0.05 mg) were separated into six lots according to experimental diets with three replicates and stocked at 300 fish/50L in 50 L aquarium, which were connected to a recirculation system. Fish were weighed and counted weekly and the feed amount was adjusted accordingly. Fish were taken from each group at the beginning and at the end of the experiment, sacrificed and used for whole body analysis.

Water flow through each aquarium was maintained constant at 0.5 L.min^{-1}. Water parameters such as dissolved oxygen, pH, conductivity and temperature were measured twice a day at 8 AM and 5 PM with multi-meter (HACH, HQ40D). Average values for water quality parameter monitored in the aquarium during the experiment were: pH, 6.16 ± 0.46; temperature, 29.07 ± 0.72 °C dissolved oxygen, 4.51 ± 0.25 mgL^{-1} and conductivity, 16.53 ± 3.93 µScm^{-1}. Each morning before feeding, excess feed and feces were collected (siphoning), and dead larvae were removed and counted.

2.3 Evaluation of growth, nutrient utilization and economic parameters

IMW: initial mean weight; FMW: final mean weight; FTML: final total mean length; mean weight gain (MWG) = (final weight – initial weight)/number of fish; specific growth rate (SGR) = 100 [(ln final weight – ln initial weight) / number of experimental days]; feed conversion ratio (FCR) = feed intake (g)/fish weight gain (g); protein efficiency ratio (PER) = weight gain/protein intake; survival rate (SR) = 100 (final number/initial number); cannibalism rate (CR) = 100 – [survival rate + observed mortality rate]; coefficient of variation of mean weight (CVW) = 100 [standard deviation of final weight/mean weight]; condition factor (K) = 100 [final weight (g) / (final length (cm))^3]; net profit value (NPV) = mean weight gain of fish cropped x total number of the survival x cost per kg; investment cost analysis (ICA) = cost of feeding x feed intake; gross profit (GP) = net profit value - investment cost analysis; profit index (PI)= value of fish/cost of feed; and benefit: cost ratio (BCR) = total cost of fish cropped/total expenditure.

2.4 Biochemical analysis

Proximate composition of ingredients, diets and fish whole body composition before and after the experiment were analyzed for crude protein, crude lipid, crude fiber, ash, moisture, and Nitrogen free extract according to (AOAC, 1995) [8]. Gross energy was calculated on the basis of 23.7

KJg^{-1} for protein; 39.5 KJg^{-1} for lipid and 17.2 KJg^{-1} for carbohydrate (Jobling, 1983) [14]. Chitin in CBM was determined according to Stelmock *et al.* (1985) [28]. Chitin content in diets was quantified according to CBM proportion. Essential Amino acids in ingredients and experimental diets were determined after preliminary acid hydrolysis of samples in 6N HCl, followed by high performance liquid chromatography (HPLC). Tryptophan was not determined because of its destruction during acid hydrolysis.

Table 3: Chemical composition (% dry matter) of feedstuff and the essential amino acids profile of FM and CBM (g/100 g protein)

Parameters	**FM**	**CBM**	**SM**	**MM**
Crude protein	69.49	62.74	42.18	9.3
Crude lipid	12.02	14.51	14.08	3.37
Crude fiber	-	5.02	4.76	3.79
Chitin	-	5.02	-	-
NFE	4.82	12.63	34.87	80.36
Ash	13.67	5.10	4.11	3.18
EAA				
Arginine	4.01	4.86		
Histidine	2.42	2.80		
Isoleucine	4.80	3.11		
Leucine	6.33	4.08		
Lysine	7.56	6.13		
Methionine	2.93	1.58		
Phenylalanine	5.32	3.45		
Threonine	4.17	2.31		
Valine	4.73	5.22		

EAA: Essential Amino Acids, CBM: *Cirina butyrospermi* meal, FM: Fish meal, SM: soya meal, MM: Maize meal, NFE: nitrogen-free extract =100-(crude protein + crude lipid+ crude fiber + ash).

2.5 Statistical analyses

Data were expressed as means ± SD (n=3). The effects of diet were tested with one way analysis of variance (ANOVA), followed by Tukey's test. Differences were considered significant when $p<0.05$. Statistical analyses were performed using STATISTICA 7.1 software.

3. Results

Proximate analysis of major ingredients indicated that the *Cirina butyrospermi* meal (CBM) used in our study had a good nutritive value which was near that of fish meal (FM), although the protein amount of FM (69.49%) is higher than CBM (62.74%) protein content (Table 3). Proximate composition and amino acid profiles of trial diets were shown in table 4.

In formulated diets, the crude protein ranged from 54.81 to 55.78% with higher value observed in D1 and the lowest in D3. Lipid ranged from 13.77 to 15.26%. Highest lipid concentration was observed in D5 while the lowest in D1. D5 and D1 showed respectively the highest and lowest fiber content. Concerning amino acids, arginine, histidine and valine increased with CBM incorporation levels, whereas the other decreased.

Table 4: Proximate composition (% dry weight), gross energy (Kjg^{-1}) essential amino acids (g/100 g protein) profiles of experimental diets.

Parameters	**Experimental diets**						
	Gemma	**D1**	**D2**	**D3**	**D4**	**D5**	*****
Moisture	6.51	7.05	7.27	6.98	7.24	6.89	NG
Crude protein	58.22	55.78	55.32	55.11	54.81	55.08	55.4
Crude lipid	16.17	13.77	14.35	14.81	15.18	15.26	9.11
Crude fiber	0.32	0.63	1.61	2.66	3.49	4.64	NG
Chitin	-	-	0.95	1.90	2.86	3.81	NG
NFE	12.86	18.00	18.72	18.28	18.29	17.82	NG
Ash	12.43	10.82	9.98	9.14	8.23	7.20	NG
Gross Energy	22.39	21.92	21.98	22.05	22.12	22.14	NG
EAA							
Arginine	4.45	4.24	4.36	4.67	5.02	5.18	4.30
Histidine	2.33	2.13	2.40	2.55	2.74	2.69	1.5
Isoleucine	5.23	4.69	4.33	4.09	4.17	4.04	2.60
Leucine	6.41	6.02	5.22	5.12	4.51	3.96	3.50
Lysine	4.97	5.97	5.41	5.02	5.33	5.12	5.00
Methionine	3.07	2.67	2.19	1.57	1.41	1.54	1.7
Phenylalanine	5.11	5.36	5.09	4.81	4.93	4.76	5.00
Threonine	3.05	3.89	3.43	2.98	2.32	2.54	0.5
Valine	7.92	4.34	4.71	4.69	5.04	5.32	0.5

NFE: nitrogen-free extract =100-(crude protein+crude lipid+ crude fiber + ash), EAA: Essential Amino Acids,
*****Nutriments requirements of *Clarias gariepinus* larvae, source: Uys et Hecht (1985) [29], NG: Not given.

The MWG and SGR were respectively 1344 mg and 17.44% /days in larvae group fed with Gemma, and were higher than those fed with the other diets. These parameters ranged respectively from 321 to 953 mg, and 13.37 to 16.46% /days in larvae fed formulated diets with highest and lowest values recorded respectively in D2 and in D5 (Table 5).

There was significant difference ($P<0.05$) between feed intake, FCR and PER in fish fed experimental diets. Highest feed intake (1705 mg) was exhibited in the larvae fed with Gemma, the second with D2 (1515 mg), while the lowest (790 mg) was recorded with D5. The FCR and PER ranged respectively from 1.27 to 2.46 and from 0.73 to 1.43. Larvae fed with Gemma expressed lowest FCR, followed by D2 (1.59) and the highest in larvae fed with D5. Contrary to FCR, highest PER was recorded in larvae fed with Gemma followed by D2 (1.14), and lowest in those fed with D5. There was significant difference (*P*<0.05) in survival rate between fish fed experimental diets. The fish fed with Gemma exhibited highest survival rate (80.67%), the second best survival rate (65.33%) was observed in larvae fed with D2 and the lowest was recorded with D5 (30.83%). According to figure1 daily count of dead larvae indicated that the mortality peak occurred generally around 10 days post-hatch in larvae fed with experimental diets.

Table 5: Growth performance and nutrient utilization indices of *C. gariepinus* larvae fed experimental diets.

Indices	Experimental diets					
	Gemma	***D1***	***D2***	***D3***	***D4***	***D5***
IMW (mg)	3± 0.05	3± 0.05	3± 0.05	3± 0.05	3± 0.05	3± 0.05
FMW (mg)	1347 ±110^{a}	878 ± 69^{b}	956 ±101^{b}	687 ± 59^{c}	654 ± 55^{c}	324 ± 25^{d}
FTML (cm)	5.08±0.16^{a}	4.62±0.9^{ab}	4.66 ± 0.13^{ab}	4.21 ± 0.19^{b}	4.22 ± 0.18^{b}	3.49 ± 0.1^{c}
MWG (mg)	1344 ± 110^{a}	875 ± 69^{b}	953 ±101^{b}	684 ± 59^{c}	651 ± 55^{c}	321±25^{d}
SGR (%/day)	17.44±0.23^{a}	16.22±0.22^{b}	16.46±0.29^{b}	15.52±0.24^{c}	15.38±0.24^{c}	13.37±0.09^{d}
Feed Intake (mg)	1705 ± 20^{a}	1455 ± 45^{b}	1515 ± 17^{b}	1300 ±14^{c}	1375 ± 16^{d}	790 ± 16^{e}
FCR	1.27 ± 0.1^{a}	1.66 ±0.09^{b}	1.59 ± 0.15^{ab}	1.9 ± 0.14^{bc}	2.1 ± 0.16^{c}	2.46 ±0.15^{c}
PER	1.43 ± 0.12^{a}	1.09 ± 0.06^{b}	1.14 ± 0.11^{b}	0.95 ± 0.07^{bc}	0.86 ± 0.06^{c}	0.73 ±0.04^{c}
SR (%)	80.67±1.45^{a}	61.5 ±3.42^{b}	65.33±7.33^{b}	35.66±2.33^{c}	35.00±4.17^{c}	30.83±6.88^{c}
CR (%)	4.67 ± 0.88^{a}	8.66 ± 0.88^{b}	9.22 ± 1.50^{b}	5.00 ± 0.83^{a}	5.67 ± 0.88^{a}	4.33 ± 0.66^{a}
K	1.02 ± 0.06	0.89 ± 0.09	0.94 ± 0.03	0.92 ± 0.16	0.87 ± 0.16	0.76 ± 0.1
CVW (%)	8.16 ±1.17	7.86±1.30	10.56 ±1.65	8.58± 1.52	8.41± 0.67	7.77 ±0.21

Data are mean values ± SD (n=3); means in the same row with the same superscript were not significantly different (P>0.05).

Table 6: Economic indices of *C. gariepinus* larvae fed experimental diets

Indices	**Diets**					
	Gemma	**D1**	**D2**	**D3**	**D4**	**D5**
Cost of feed (€/Kg)	110	4.3	3.5	2.7	1.9	1.08
ICA (€)	56.26±0.66^{a}	1.87±0.04^{b}	1.59±0.01^{bc}	1.05±0.01^{cd}	0.78±0.09^{de}	0.38±0.00^{e}
NPV (€)	4.97±0.13^{a}	2.47±0.23^{b}	2.86±0.03^{b}	1.12±0.03^{c}	1.05 ±0.14^{c}	0.42±0.08^{d}
GP (€)	-51.27±0.96^{a}	0.60±0.30^{b}	1.28±0.59^{b}	0.17±0.01^{b}	0.27±0.02^{b}	0.20±0.12^{b}
PI	0.08±0.01^{a}	1.32±0.15^{bcd}	1.81±0.37^{bcd}	0.82±0.43^{abd}	1.34±0.26^{bcd}	1.80±0.49^{bc}
BCR	0.08±0.00^{a}	0.86±0.11^{bcd}	1.11±0.23^{bc}	0.54±0.01^{bd}	0.59±0.11^{bd}	0.37±0.1^{ad}

Data are mean values ± SD (n=3); means in the same row with the same superscript were not significantly different (P>0.05).

There was significant difference (*P*<0.05) in cannibalism rate between fish fed with different diets. The highest cannibalism rate of 9.22% exhibited in the group fed with D2. In all groups, cannibalism rate increased with time and larvae weight during the trial period (Figure1).

The proximate composition of the whole body of fish fed trial diets is given in Table 7. There was no significant difference between whole body protein, lipid and moisture of larvae fed with experimental diets. Nevertheless, the whole body ash decreased significantly in groups that received high inclusion levels of CBM (more than 25%).

Analysis of the economic parameters of the diets (Table 6) showed that ICA and NPV decreased significantly from Gemma to D5 and ranged from 0.38 to 56.26€ and 0.42 to 4.97€. The highest GP, PI and BCR were obtained with D2 when the lowest were recorded with Gemma.

4. Discussion

The results of biochemical compositions of ingredients showed that *Cirina butyrospermi* caterpillar meal (CBM) has a nutritional value close to the fish meal (FM). However, the compositions of essential amino acids of these two ingredients are substantially different. Indeed, the CBM contents of arginine, histidine, and valine were higher than those of FM. While the other amino acids were lower. Protein levels of formulated diets closed to that of *Artemia Salinia* (57.28%; Alla *et al*., 2010) [6]. This protein content and the percentage of lipid met the nutrient requirements of *C. gariepinus* larvae (Uys and Hecht, 1985) [29]. Moreover, the Gemma which contains 71% of fish meal and 12% of phospholipids (table 2) has the highest percentages of protein (58.22%), lipid (16.17%) and ash (12.43%), but has the lowest fiber content (0.32%). Contrary to the percentage of ash which decreases, the levels of lipid, fiber and chitin increased with the inclusion rate of the CBM in formulated diets (Table 4). As regards the amino acids measured, their amounts were in accordance to *C. gariepinus* larvae requirements (Uys and Hecht, 1985) [29]. Nevertheless, methionine amount is insufficient in diets with CBM inclusion superior or equal to 50%.

At the end of the try, the analysis of zootechnic performances reveals that the growth performance, feed utilization and mortality rate of *Clarias gariepinus* larvae are influenced by distributed diets. As regards the formulated diets, larvae fed with D2 gave the best growth performance and feed utilization when compared to other formulations. This difference could be related to the fact that D2 contained two animal sources of protein (FM and CBM), making it better than D1 which contained only one animal protein source (FM). This observation is in agreement with previous authors who reported that combine protein sources is better than single protein source for fish diets, resulting from the synergism when various dietary protein sources are mixed in feeds (Sogbesan and Ugwumba, 2008; Adewolu *et al*., 2010; Alegbeleye *et al*., 2012) [26, 2, 5]. In addition, the presence of a low amount of chitin in D2 could also explain the good results obtained with this diet. Indeed, previous studies showed that low levels of chitin improve growth performance and nutrient absorption in fish through the stimulation of probiotic bacteria such as *bifidobacterium* (Spreen, 1984) [27]. More specifically, Alegbeleye *et al*. (2012) [5] have obtained similar results in fingerlings of *C. gariepinus* fed a diet containing 25% of grasshopper (*Zonocerus variegatus*) meal.

However, growth was negatively influenced in *C. gariepinus* larvae when CBM inclusion in diets was superior or equal to 50%. That may be due to a number of factors: The decreasing of methionine quantity (under 1.7 g/100g of protein) caused by the lowering of fish meal in diets D3, D4 and D5, since methionine amount requirement of *C. gariepinus* larvae was 1.7 g/100g of protein (Uys and Hecht, 1985) [29]. This inadequate amount of this essential amino acid in these diets could reduce the voluntary feed intake and growth (Gómez-Requeni *et al*., 2004) [12]. Besides, the increasing of FCR, and the lowering of feed intake and PER consecutive to the increasing of CBM level in diet, could be other reasons. Indeed, the increasing of chitin amount in diets (D3-D5) which is a consequence of the raising of CBM level in diets could result in low feed intake and high FCR (Olsen *et al*., 2006) [21]. As fiber, chitin could bind nutrients like fat, protein and minerals (Ward and Reichert, 1986) [34], interferes with the use of these nutrients and reduces their bioavailability (Longvah *et al*., 2011) [17]. In the present study, the level of chitin that *C. gariepinus* larvae could tolerate is 0.95% of diet. This rate was lower than the chitin level (1.44%) reported by Alegbeleye *et al*. (2012) [5] for the better growth of *C. gariepinus* fingerlings. This difference is due to the change in chitinolytic activity that is based on the age and nutritional requirements of the fish (Pérès, 1981) [23].

Compared to the commercial feed (Gemma), which gave the best growth performances and feed utilization in the present study, D2 (formulated with 25% CBM and 75% of FM) is the one which comes closest. However, specific growth rates (SGR) obtained with Gemma and D2 were substantially close to the value of 17.3%/day observed in larvae of *C. gariepinus* fed *Artemia* nauplii during 25 days (Achionye-Nzeh *et al*. 2010) [1]. Moreover, they were inferior to the value of 22.87%/day obtained by Faruque *et al*. (2010) [10] in larvae fed with a mixture (*Artemia* and inert food), and better than the values of 11.28 and 14.3%/day obtained by Agadjihouèdé *et al*. (2012) [3] in larvae fed respectively with Zooplankton and *Artemia* nauplii. The differences observed in these specific growth rates may be explained by the quality rather than the content of the different components (proteins, lipids, amino and fatty acids, minerals…) of distributed diets and some abiotic factors such as temperature (Gastesoupe *et al*., 1999) [11], the loading density and duration of rearing.

Regarding other zootechnic parameters, the results reveal a decrease in survival with increasing FCB incorporation rate in diets and this might be caused to the decreasing of feed intake. However, the peak of daily count of dead larvae occurred around 10 days post-hatch. This suggests that better survival and growth rates could be reached if *C. gariepinus* larvae were weaned after 10 days post-hatch with experimental diets. Our results were in agreement with Verreth and Van Tongeren (1989) [33] who recommended weaning *C. gariepinus* larvae after 10 to 14 days post-hatch, because the stomach became completely functional during this period.

There was no significant difference between the CVW observed in the different groups of larvae. However, the group of larvae fed with D2 presented higher CVW (heterogeneous group) and CR, when larvae fed with Gemma and D5 showed the lower (homogeneous groups). This was on the same line with Baras *et al.* (1999) [9] who reported that homogeneity of larval size greatly reduces cannibalism. In the present study, cannibalism rate increased with time, and was correlated to evolution of body weight during the rearing period. The same result was obtained in vundu catfish (*Heterobranchus longifilis*) rearing, where cannibalism started four days after hatching and decreased when a mean weight of 30 g was reached (Baras *et al*., 1999) [9]. There were no significant differences between batches fed with Gemma and those fed with diets containing different levels of CBM regarding whole body protein, lipid and moisture. This result is a major factor because it reflects the quality of formulated diet based on byproducts locally available. Although previous work (Lim *et al*., 2000; Nyina-wamwiza *et al*., 2007) [17, 20] showed a correlation between dietary lipid level and whole body lipid level in *Clarias gariepinus*, no significant change in body lipid were observed in relation to the increase of CBM incorporation rate. This lack of increase body lipid indicates that almost of the energy generated for growth is directed towards the production of muscle tissue, which is very interesting in terms of valuation of formulated diets. The decreasing of ash of larvae's whole body with the inclusion of CBM might be due to the lowering of ash in diets and to the

Table 7: Proximate whole body composition (% wet weight) of *C. gariepinus* larvae

	Initial	**Gemma**	**D1**	**D2**	**D3**	**D4**	**D5**
Moisture (%)	79.66	74.28 ± 0.25^{a}	74.6 ± 0.22^{a}	74.53 ± 0.77^{a}	74.28 ± 0.83^{a}	74.34 ± 0.28^{a}	73.80 ± 0.14^{a}
Protein (%)	12.04	15.27 ± 0.55^{a}	15.32 ± 0.04^{a}	14.99 ± 0.31^{a}	15.12 ± 0.27^{a}	14.93 ± 0.09^{a}	14.90 ± 0.16^{a}
Lipid (%)	3.99	5.50 ± 0.40^{a}	4.98 ± 0.25^{a}	5.27 ± 0.36^{a}	5.40 ± 0.50^{a}	5.39 ± 0.16^{a}	5.51 ± 0.20^{a}
Ash (%)	2.03	3.50 ± 0.23^{a}	3.53 ± 0.27^{a}	3.21 ± 0.11^{a}	2.86 ± 0.07^{bc}	2.71 ± 0.07^{bc}	2.44 ± 0.9^{c}

Data are mean values ± SD (n=3); means in the same row with the same superscript were not significantly different (P>0.05).

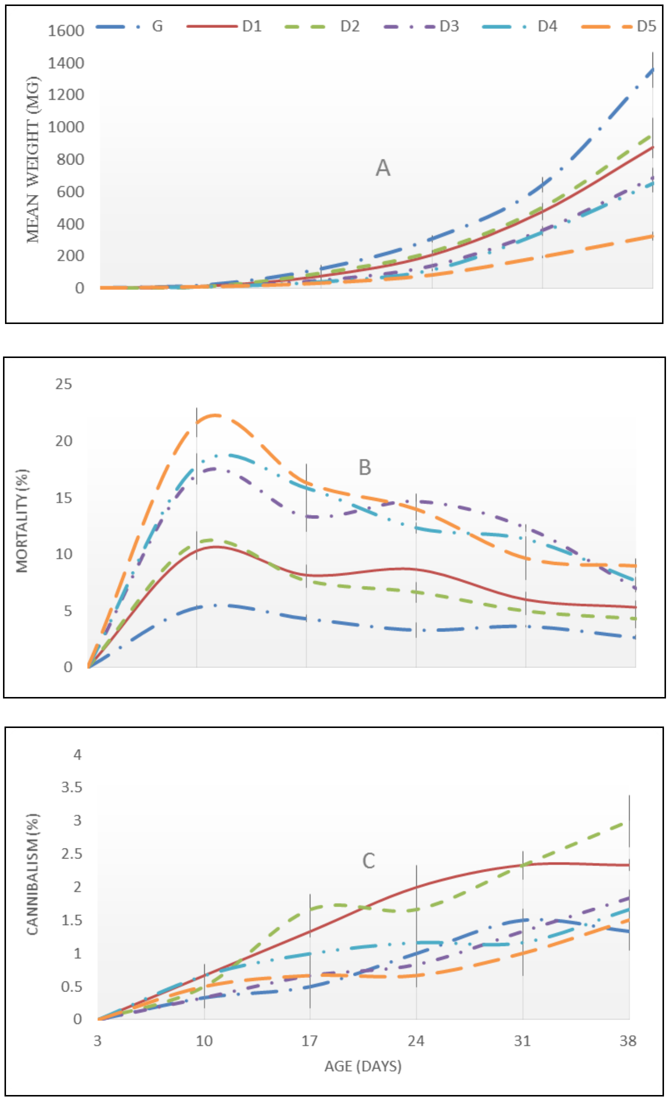

Fig 1: Effect of experimental diets on weight (A), Mortality (B) and Cannibalism (C) during *C. gariepinus* larval rearing. G: gemma

increasing of fiber content which interferes in minerals absorption (Ward & Reichert, 1986) [34].

Commercial feed (Gemma) certainly gave the best results in terms of growth performances, however a loss of 51.29 € was recorded due to its high cost (110 €/Kg). Furthermore, D2 has allowed making the biggest profit margin (1.28 €). It is therefore economically more profitable.

5. Conclusion

The results of this study showed that CBM has a potential to supplement fish meal in diets for *C. gariepinus* larvae. They demonstrate that 25% inclusion level of CBM in *C. gariepinus* larvae diet improves growth performances for a profitable feed for catfish larvae. Nevertheless, subsequent research should evaluate anti-nutritionals factors in CBM. Furthermore, CBM might be tested in diet for *C. gariepinus* fingerlings.

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7. References

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