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Inclusion of cocoa shell flour (Theobroma cacao L) in the diet of (Oreochromis spp)

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***Abstract*---**The research was carried out at the Socio Tilapia fish farm facilities; via Quevedo, Santo Domingo, Los Ríos province, at an altitude of 100 meters above sea level, to determine the inclusion of cocoa shell flour in the fish farming process (*Theobroma cacao L*) as an alternative protein source in intensive tilapia farming *(Oreochromis spp)*. The sample size consisted of 128 fish, with 8 experimental units per cage, fed for 42 days, with the inclusion of cocoa shell meal levels (0, 4, 8, and 12%), in four treatments and four replicates, with commercial pelleted concentrate as control; an experimental design (DCA) was used, with multiple comparison measures according to Tukey's test (P < 0.05). The results in all variables had a better performance in the T3 treatment (12% cocoa shell meal), without affecting any parameter, obtaining better results for feed conversion (1.45%), weight gain (24.05%), feed consumption (675.06 g) and total length with an average of (1 cm) corresponding to the days of investigation of the 32 experimental units. It was established that in fillet yield and carcass yield there is a usable value, 47.49 %, and 95.42 %, while a lower value in the by-products, 54.65 %, respectively. Therefore, it is recommended to include up to 12% of cocoa husk meal in the diets of tilapia in the fattening phase, as an alternative to lower feed costs, an option to provide a value chain to cocoa and producers in fish breeding.

***Keywords*---**captivity, cocoa, cage, lipids, nutrients, husk.

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Introduction

Aquaculture is the fastest growing major food production sector, currently accounting for almost 50% of the world's fish products destined for food (FAO, 2012). Approximately, 600 aquatic species are farmed in a confined way, most of them with different systems and culture facilities with varying degrees of use of inputs and technologies. In the current decade, Tilapia (*Oreochromis Spp*) has been introduced in all countries susceptible to its cultivation (Vega-Villavisante *et al.*, 2010). It is considered the fourth most cultivated species worldwide, after shrimp and salmonids (FAO, 2012; Scorvo *et al.*, 2010). It is one of the most important species in intensive aquaculture, with rapid growth development and excellent yield.

Cocoa is one of the most valuable agricultural commodities in international trade and therefore an essential source of foreign exchange for cocoa-producing countries (Ideas, 2005). The contribution of cocoa trade in many countries to foreign exchange is variable due to price fluctuations but has been as high as 54% of export earnings in Ghana, 40% in Côte d'Ivoire, and 30% in Cameroon. A study was conducted on the inclusion of cocoa husk in tilapia fattening, being a by-product resulting from the roasting of the grain, which is lost without any other use, whose residues often end up on the riverbanks or worse, are incinerated polluting the environment; fish farmers are unaware of its use for feeding tilapia, with the lowest possible cost. Therefore, the objective of the study was to determine the inclusion of cocoa shell meal (*Theobroma cacao L*) as an alternative protein source for fattening intensively reared tilapia (*Oreochromis spp*) and its productive yield.

Materials and Methods

The experimental design used was a complete randomized design (CRD), which allowed obtaining the experimental results using the free version of the Infostat statistical package; in addition, the Tukey test was applied to establish differences between the multiple comparison measures ($P \leq 0{,}05$).

Table 1. Distribution of experimental units

Treatments	T.U. E	Number of repetitions	Total fish
T0 without cocoa shell meal and 100% commercially balanced	8	4	32
T1 with 4% of cocoa shell meal + 96% commercial feed	8	4	32
T2 with 8% of cocoa shell meal + 92% commercial feed	8	4	32
T3 with 12% of cocoa shell meal + 88% commercial feed	8	4	32
Total		16	128

Parameters evaluated in the research

The fish were measured in length (cm), with an ichthyometer and their weight gain (g), with an OHAUS digital table scale with a capacity of 5 kg every 7 days, 8 fish per experimental unit were used for data recording, which were later tabulated to obtain the results. The variables that were evaluated for statistical analysis of the research were as follows:

Determination of weight gain (g)

The weight increase (g) of the fish in each experimental unit was evaluated, taking the initial weight as a reference. For this purpose, an OHAUS digital table scale with a capacity of 5 kg was used.

$$GP = PF(g) - PI(g)$$

Where:
GP: Weight gain
PF(g): Final weight in grams
PI (g): Initial weight in grams

Food Consumption (g)

The amount of fish feed was weighed in (g). before offering per treatment unit, considering the expected feeding rate of 3% of the live weight, with a digital table scale OHAUS brand with a capacity of 5 kg
Where:
Food consumption (DC)= (Biomass x feed rate) /100
Total consumption (CT)= Daily food consumption x time

Feed conversion factor (FCA)

It is defined as the weight gain achieved from one unit weight of feed; a value of 1 indicates perfect utilization of feed to produce one unit of body biomass.

1. $$FCA = \frac{Pa}{Pg}$$

Where:
= weight of feed ingested
= Fresh weight gained by the fish.
IC= kg feed ingested /increase in biomass.

Survival rate (SUP)

It is an indicator of the organisms' resistance to handling and confinement, expressed as a percentage.

$$SUP = \frac{Nt}{Ni} \times 100$$

Where:
= Number of live fish at time t
= Number of initial fish.

Specific growth rate (TCE)

Express the percentage increase in weight of the organism per day according to the expression:

$$(TCE) = [("In\ Wx – In\ Wi")] / "t" \times 100$$

Where:
Wx: is the final weight (g),
Wi: is the initial weight (g)
T= is the time of the experiment.

Table No. 2. Experimental measurements for weight

Fish weight	Weight of by-products
Total weight (1)	Scale weight (6)
Gutted fish weight (2)	Fins weight (7)
Fillet weight with skin (3)	Head weight (8)
Gutted fish yield (4)	Visor weight (9)
Fillet yield (5)	Skeleton weight (10)
	R. By-products (11)

Source: Medina & Yépez, 2021

Total weight (1) corresponds to the weight of the whole fish just caught from the pool; Gutted fish weight (2), the fish was opened by the abdomen without viscera; Fillet weight with skin (3), fish without head, scales, fins, viscera and skeleton; Gutted yield (4), the weight of the gutted fish was calculated over the total weight per hundred; Fillet yield (5), calculation of the fillet weight with skin over the total weight per hundred.

Scale weight (6), separation of all fish scales and weighing; Fins weight (7), separation of dorsal pectoral, caudal anal, and pelvic fins; Head weight (8), from the mouth to the end of the gills; Guts weight (9), from the organs and gills of the fish extracted for the weight of eviscerated fish; Skeleton weight (10), by separating the fillet, head, and other by-products; R. By-products (11), are the calculations of the total weight of all by-products on the total weight per hundred.

Experimental handling

The study began by obtaining 128 tilapia (Oreochromis spp) with homogeneous weights of 80 to 90 g from the Piscícola Socio Tilapia production center. They were placed in the pool and 16 floating mesh cages of 1 cm in diameter were placed inside the pool, with a radius or circumference of 60 cm by 1. 90 m, each one had its base and cover with the same metallic mesh, at a distance of 30 cm from each other, containing 8 experimental units, chosen at random their treatments and repetitions. Their identifications were assigned according to a draw, air diffuser hoses were provided for oxygenation in each one of them.

The concentrate was prepared every two days and consisted of mixing the percentage of commercial feed, analyzed and calculated according to zootechnical production parameters, plus cocoa shell meal. According to the proposed study, the volume of water plus the appropriate weight of the Aquacc Natural Bind+ binder or additive. Depending on the weight of the fish each week and so on for the 7 weeks of field work. The cocoa shell flour (0, 4, 8, 12%) was obtained by pre-drying the beans in the sun at 24°C for two days, then placing them in cellophane paper and placing them in an oven at 45°C for three days, after which the cocoa bean shells were milled.

Bromatological and proximate analyses of protein, fat, moisture, ash, and fiber content were carried out at the laboratories of the Universidad Técnica Estatal de Quevedo, Ecuador. Carcass and fillet yields, as well as by-product yields, were taken at the end of the experimental trial at the fish sample slaughtering, to obtain the results.

Results and Discussion

Inclusion levels of cocoa shell flour *(Theobroma cacao L)* (0- 4 – 8 – 12%) on the production parameters of the *(Oreochromis Spp).*

Weight Gain (g)

In this variable studied, weights were taken as a base, related to the treatments with the established densities and their respective replications; weights were taken weekly and final. There were no statistical differences, but there was a numerical difference, observing that T3 (inclusion of 12% cocoa shell meal) generated higher biomass with a weight gain of 24.50 g. According to Aguinaga (2019), in his research on partial inclusion of guava seed and pulp-based meal in the feed of black tilapia in the fattening stage, T1 with 15% inclusion of guava seed and pulp-based meal obtained a higher result than the other treatments at the level of this variable, reaching a final weight of 175.10 g/fish, that is, T1 ended with an average weight gain of 30.97g. However, Peters et al. (2009), in their experimental work presented results for weight gain lower than those obtained in the research, there is a lower average weight gain in fish fed with 25% inclusion of meal (14.589 g.).

Food consumption (g)

In feed consumption, there were no significant differences between the different treatments of fish fed with inclusion levels of 4%, 8%, and 12%. These results are similar to those obtained by Olvera *et al.* (1988) when they partially replaced the fish meal with seed meal of the legume Sesbania grandiflora; and when they partially replaced the fish meal with feather hydrolysate meal, both in feed for tilapia, using experimental diets with fish oil and fish meal in their composition (Olvera *et al.*, 1988).

Feed Conversion

This represents the best way to evaluate the quality of fish feed. In the different inclusion levels of 4%, 8%, and 12%, there were no significant differences. These results were superior to those presented by Bairagi *et al.* (2002), in their studies with Indian carp fry, where they formulated diets with fermented and unfermented Lemna meal (*Lemna polyrhiza*), at inclusion levels of 10, 20, 20, 30, and 40%, respectively; 20, 30 and 40%, respectively, whose values were 2.68; 2.79; 2.87; 3.01; 2.73; 2.56; 2.55; 2.66.

Total length cm

The results of the total length were observed, an increase in all treatments from week 1 that began the experiment until week 7 (42 days), noting that each week the treatments gained cm both T1 (4% cocoa shell flour), T2 (8% cocoa shell flour) and T3 (12% cocoa shell flour), therefore, it can be seen that the T3 obtained a greater gain in cm for the 42 days of research.

Absolute growth rate (TCA)

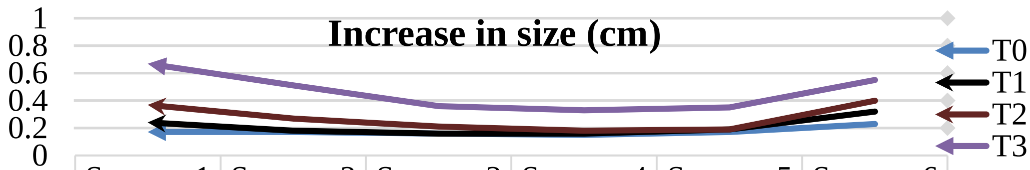
Regarding the variable studied specific growth rate, no significant differences (P≤0.05) were obtained between T1 (4% cocoa shell meal) and T2 (8% cocoa shell meal), in the treatments T0 (commercially balanced) and T3 (12% cocoa shell meal) there were significant differences, obtaining the T3 a greater numerical difference and with higher TCA with 3.20 g in the 42 days of investigation.

Specific growth rate (TCE)

There was no significant difference between T1 and T2, both showed similar results, while there were significant differences (P≤0.05) between treatments T0 and T3 (12% cocoa shell meal) obtained a higher TCE with 0.98% during the 42 days of the research.

Survival (%)

This variable was not influenced by the inclusion of 0%, 4%, 8%, and 12% cocoa shell meal in diets for tilapia in the fattening phase, thus obtaining 100% survival for all treatments. From week 5 onwards, there was a survival rate of 88% in treatments 0 and 2, respectively. These values are similar to those of Pouomogne *et al.* (1997), in their evaluation of the inclusion of cocoa shell meal in pelleted diets for the feeding of tilapia in the fry stage, they found no statistical differences (p>0.05).



	Semana 1	Semana 2	Semana 3	Semana 4	Semana 5	Semana 6
T0	0.17	0.17	0.16	0.15	0.17	0.23
T1	0.24	0.18	0.16	0.16	0.19	0.32
T2	0.37	0.27	0.21	0.18	0.19	0.4
T3	0.67	0.51	0.36	0.33	0.35	0.55

Figure 1: Weekly size increase in 42 days of the experiment.

Biochemical characteristics (protein, moisture, ash, ethereal extract, crude fiber) of cocoa shell meal (Theobroma cacao L) in cocoa meal diet

Table 3 shows the values obtained from the bromatological analysis of the cocoa shell meal (Theobroma cacao L). This analysis corresponded to protein 14.67%, fat 15.44%, moisture 10.32%, ash 4.77%, and fiber 14.60%.

Table 3: Bromatological composition of cocoa shell meal (*Theobroma cacao L*).

Nutritional specifications	Pisces %	Proximal analysis of the raw material under study
Protein	32,0 %	14,67%
Fat	7,0 %	15,44%
Moisture	12,0 %	10,32%
Ash	9,0 %	4,77 %
Fiber	5,0 %	14,60 %

Source: Analysis Lab. Bromatología UTEQ, 2021

These values are similar to those of Cardona et al. (2002), who, in research aimed at raw materials used in animal feed, in their analysis of cocoa hulls presented protein values of 15.60%, fat 4.4%, moisture 6.00%, ash 7.90 and dietary fiber 44%. On the other hand, research conducted by Soto (2012), based on the processing of cocoa bean husk powder intended for human consumption presented higher values in protein 18.91%, fat 1.23%, moisture 4.31%, ash 7.81%.

Carcass yield and its usable proportion (loin and fillet) as a function of the commercial merit of the fish under study

Table 4 shows that treatment 0 (commercial feed) presented a carcass yield of 94.42%, while treatment 1 (with 4% cocoa shell meal) and treatment 2 (with 8% cocoa shell meal) presented similar values in carcass yield with 94.78 and 94.77%, respectively, but treatment 3 (with 12% cocoa shell inclusion) had a better carcass yield with 95.42%.

In a study conducted by (Souza & Maranhão, 2001) on the yield of carcasses, fillets, and fillet by-products of Nile tilapia fillets fed with granulated feed, the objective was to analyze the yields of carcass, fillet, and fillet by-products, this was defined in two live weight categories. One hundred specimens, fed with 22% PB pelleted diets, were used. It was used for T1 (weights of 300-400 g) and T2 (weights of 4001-500 g), comparing these values obtained lower values for T1 in fillet yield 36.50% and in carcass yield 75.61%. T2 obtained 36.84% fillet yield and 78.18% carcass yield. Therefore, these authors obtained lower values in their results in comparison with the research proposed in this study (Nyandra & Suryasa, 2019) .

Table 4: Commercially usable proportion based on yield to the carcass and its by-products

Variables	T0. Commercial balancing		T1. 4 % of cocoa shell flour inclusion		T2. 8 % of cocoa shell flour inclusion		T3. 12 % of cocoa shell flour inclusion	
	Weight (g)	(%)	Weight (g)	(%)	Weight (g)	(%)	Weight (g)	(%)
Whole fish	174.13		188.63		186.25		200.75	
Guts	9.71	5.57	9.83	5.21	9.73	5.22	9.62	4.79
Fins	6.77	3.88	8.25	4.37	8.23	4.41	11.47	5.71
Scales	3.01	1.72	3.45	1.82	3.23	1.73	4.18	2.08
Head	46.67	26.80	47.74	25.30	47.63	25.57	49.17	24.49
Skeleton	29.67	17.03	35.85	19.00	34.83	18.70	40.58	20.21
Fillet yield	78.30	44.96	83.51	44.27	83.60	44.88	95.35	47.49
Carcass yield		94.42		94.78		94.77		95.42
By-product yield		55.63		55.70		55.63		54.65
Total		99,96		99,97		100		100

Source: Medina & Yépez, 2021.

Conclusions

- ✓ In the productive variables studied, the T3 treatment (12% cocoa shell meal), presented the best response without affecting any parameter, for feed conversion (1.45%), weight gain (24.05%), feed consumption (675.06 g), and a total length with an average of (1 cm) corresponding to the 42 days of research for the 32 experimental units, with 12% inclusion.
- ✓ From the bromatological analysis of the cocoa shell meal (*Theobroma cacao L*), the values obtained in this analysis corresponded to protein 14.67%, fat 15.44%, moisture 10.32%, ash 4.77%, and fiber 14.60%.
- ✓ Considering the results of T3 with the inclusion of 12% cocoa shell meal (Theobroma cacao L), it was established that the yield of fillet, yield to the carcass has a usable value, 47.49%; 95.42%, while a lower value was observed in the by-products, 54.65%, respectively, therefore, if it is feasible to increase production using this alternative inclusion to lower feed costs and there is already high demand in consumption of tilapia *(Oreochromis Spp).*

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