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[Hok - Bighead Catfish]

Fish Innovation Lab

Final Technical Report [Start Date: August 01st,2020– End Date: July 31st, 2023]

Cooperative Agreement 7200AA18CA0030

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[Development of Bighead Catfish *(Clarias macrocephalus)* Culture for Sustainable Aquaculture in Cambodia]

Final Technical Report

[Project Start Date: August 01st, 2020 – End Date: July 31st, 2023]

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Abbreviations and Acronyms

ADCdiet	Apparent Digestibility Coefficient Diet
ADCE	Apparent Digestibility Coefficient Energy
ADCP	Apparent Digestibility Coefficient Protein
BC	Bighead Catfish
BCC	Bighead Catfish Culture
CAST	Commercialization of Aquaculture for Sustainable Trade
CCF	Capture and Culture Fisheries
CTU	Can Tho University
CE SAIN	Center of Excellence on Sustainable Agricultural Intensification and Nutrition
FCR	Feed Conversion Ratio
FILC	Fish Innovation Lab Cambodia
FFA	Faculty of Fisheries and Aquaculture
FM	Fish Meal
HCC	Hybrid Catfish Culture
HC	Hybrid Catfish
IFReDI	Inland Fisheries Research and Development Institute
I#	Investigation number
KSU	Kansas State University
MD	Mekong Delta
MDR	Mekong Delta Region
NARDI	National Research and Aquaculture Development Institute
PER	Protein Efficiency Ratio
RUA	Royal University of Agriculture
RUPP	Royal University of Phnom Penh
SBM	Soybean Meal
SEA	Southeast Asia
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture
SGR	Specific Growth Rate
TAMU	Texas A&M University, USA
UBB	University of Battambang
URF	Under Rated Fish (‘trash’ fish). In this proposal, it will not be called ‘trash’ because it connotes fish that has no value which is not true. The URF are valuable to the ecosystem balance and food chain.
WF	WorldFish
CP	Crude Protein
D.O	Dissolve Oxygen
FR	Feeding Rate
DWG	Daily Weight Gain
^{0}C	Celsius

mg/L)	Miligram per litre
d^0KH	drop of Alkalinity test
d^0GH	drop of Hardness test
SGR	Specific Growth Rate
VSI	Viscerosomatic index
HIS	Hepatosomatic index
GSI	Gonadosomatic index
NS	Non-significant

Glossary

N/A

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Abstract

Bighead catfish (BC) or *Clarias macrocephalus* is a favorite fish for Cambodians, but the farming of this species is limited, and most of the production comes from wild catch. The market demand for BC has been increasing strongly in recent years, promoting research and culture in the Mekong Delta Region (MDR). However, research on nutrition, feed formulation, and feeding practices for BC has received little attention (Hien et al. 2018). Moreover, capacity building of RUA's Faculty of Fisheries and Aquaculture is important to sustain the previous initiatives of USAID and CE SAIN, which included pond renovations in three CE SAIN Agricultural Technology Parks located in Kampong Thom, Battambang, and Phnom Penh. The project involved nine undergraduate interns (three of whom were females) who served as project research assistants, and two Graduate Research Assistants who actively engaged in the technical implementation of the activities. Through hands-on research and teaching activities, students and interns have gained improved knowledge about feed formulation for the sustainable culture of bighead catfish in Cambodia.

Introduction

Over the past 20 years, the aquaculture sector in Cambodia had an average annual growth of over 10%, and over the past 10 years, it has routinely exceeded 18% growth. In 2014, total national output topped at 112,000 tonnes when marine and freshwater production are included (O. Joffre et al., 2016). In Cambodia, aquaculture is highly critical sector to meet rural employment needs, yet it has faced challenges to achieve goals in this area (O. M. Joffre et al., 2021).

Bighead catfish (*Clarias macrocephalus*) is a native species in Cambodia (So et al., 2018). In aquaculture, it is used to produce hybrid catfish (*Clarias macrocephalus x Clarias gariepinus)* (Avillanosa et al., 2019), which Cambodians like to raise because it is fast growing. Bighead catfish is cultured in Thailand, Vietnam, and the Philippines; it can be harvested at a market size of 80-200 g per fish (Coniza et al., 2003). Bighead catfish is also a highly economical and popular fish in Cambodia, but most bighead catfish are wild caught. In this context, due to the high market demand (Coniza et al., 2008) and high market price (around US$2.35–2.94 per kg) (Na-Nakorn & Brummett, 2009), bighead catfish has significant potential to be promoted for farming.

Feed plays an important role in aquaculture, contributing up to 70-90% of total production costs. Fish feed is an important input to promote successful fish farming (Lazard, 2014). Fish feed formulation from locally available raw materials is important to sustain local intensive aquaculture. The only local

feed mill was established in Cambodia in 2020, and this local feed mill produces floating pellets. Most other floating pellet feeds available are costly due to being imported from Vietnam and Thailand (O. M. Joffre et al., 2021). It is anticipated that the production of local feeds, using local ingredients, would increase the fish feed availability and reduce the cost in Cambodia. However, before developing new, local fish feed formulations, it is important to assess the quality of the feeds that are available on the market. The objective of the Feed the Future Innovation Lab for Fish study was to compare the effects of two brands of feed available in the market in Cambodia, examining different protein levels, fish growth, feed conversion ratio (FCR), somatic indexes, and proximate composition in BC.

Research Methods

I. Commercial Aquafeed Evaluation for Bighead Catfish Culture in Recirculation Aquaculture System (RAS System)

a) Experimental Design (Trial 1)

The experiment aimed to assess the effect of various commercial feed brands with different protein contents on the growth of bighead catfish using a 2 x 2 factorial experimental design with 4 treatments and a total of 16 experimental tanks. The experimental factor was the protein content of the commercial feed. Two protein levels (30% and 35% crude protein) were evaluated in a 12 week experiment. The two commercial feed brands were selected from locally available feeds that are available for use by commercial aquaculture producers.

Table 1: Experimental design

Treatment	Replicate	Feed Company	Feed Brand	Protein (%)	Size (mm)
Ocialis 30%	4	APSARA AGRI SUPPLIES	Ocialis	30	3
Dollar 30%	4	LY HONG CHHOY TRADING CO., LTD	Dollar	30	3
Ocialis 35%	4	APSARA AGRI SUPPLIES	Ocialis	35	2
Dollar 35%	4	LY HONG CHHOY TRADING CO., LTD	Dollar	35	3

b) Bighead Catfish Selection

Bighead catfish fingerlings were obtained and transported from Freshwater Aquaculture Research and Development Center (FARDEC) when weight was around 6-7 g. The fish rearing time in RUA

aquaculture farm is 4 months. Thirty fish for the experiment were stocked at a weight of 84.12-86.85 g of initial size, with final weight ranging from 96.25g -126.65g at 12 weeks.

c) Feed and Feeding

Experimental feed was bought from two feed companies with two different percentages of protein content. Fish were fed two times per day (7-8 am and 3-4 pm). The feed was stored in bags inside plastic bins. The feed was weighed before and after fish feeding to calculate the daily amount of feed used. Fish were fed to satiation. Any uneaten feed was calculated by pellet counting after feeding for 15 minutes.

d) Fish Sampling

The fish were weighed weekly by removing all fish from aquaria at 7 am before feeding, and final individual fish length-weight was measured for all fish at the experiment's conclusion. In addition, 19 fish were sampled from each treatment at the experiment's conclusion, weighed, and dissected to collect gonad, liver, and viscera weight for calculating the final hepatosomatic index, gonadosomatic index, and viscerosomatic index. Tissues from the 19 fish were also collected for proximate analysis to determine crude protein, crude lipid, crude fiber, ash, and dry matter. During the experiment, dead fish were replaced with similar sized fish within 12 hours.

e) Feed Proximate Composition Analysis

Proximate analysis was conducted on 350 g samples of each feed by the Science, Technology and Innovation National Laboratory to determine crude protein, crude fat, crude fiber, ash, and dry weight.

f) Water Quality Monitoring

Water quality monitoring was conducted daily on five randomized fish tanks, water from the sand filter and bio-filter, and water from the sump tank. Daily parameters measured were temperature, pH, and dissolved oxygen (DO). Total ammonia nitrogen (TAN), nitrite, nitrate, hardness, and alkalinity were monitored weekly. The DO and temperature were measured by Eco-Sense DO 200A. pH, TAN, nitrite, nitrate, hardness, and alkalinity were measured colorimetrically by sera test kit.

g) Sensorial Tests

Sampled fish were decapitated, eviscerated, and frozen at -20 ^{0}C. After thawing, sampled fish were filleted and cooked for 10-15 minutes. Fifty-eight people participated in a test exercise that evaluated appearance, odor, flavor, and consistency using a questionnaire provided by the team.

h) Data Analysis

All data collected was entered in Microsoft Excel and used to calculate the daily weight gain (DWG), feed conversion ratio (FCR), hepatosomatic index, gonadosomatic index, and viscerosomatic index. The data was analyzed with ANOVA and LSD test using R statistical software.

-Daily Weight Gain (g/day) = final weight (g) - initial weight (g)/culture period (day)

-Specific Growth Rate (%/day) = final weight (g) - initial weight (g)/culture period (day) x100

-Feed Conversion Ratio = total dry feed intake (g)/total final weight (g) - total initial weight (g)

-Feeding Rate (%/BW) = total dry feed intake (g)/total live body weight x100

- Gonadosomatic index (%) = gonad weight (g)/live fish weight (g) x100

- Hepatosomatic index (%) = liver weight (g)/live fish weight (g) x100

- Viscerosomatic index (%) = fat weight (g)/live fish weight (g) x100

II. Commercial Aquafeed Evaluation for Bighead Catfish Culture in Pond Net Cage System

a) Rearing Facility

The second experiment was conducted in pond net cages (hapas). The pond size was approximately 540 m^2 with net cage size of 1x1x1.3 m. The freeboard of the net cage was 0.30 m, and each net cage was covered. The net cages were installed in two lines with 1 m between net cages. The hapa nets were cleaned every two weeks.

b) Experimental Design

This experiment aimed to determine the effect of different commercial feed brands with different protein levels on the growth of bighead catfish using a 2 x 2 factorial experimental design with 4 treatments and a total of 16 experimental hapas. The experimental factor was protein content and commercial feed brand, with two protein levels (30% or 35% crude protein) and two brands. The experiment was conducted for 14 weeks. The two commercial feed brands selected are both available for local commercial aquaculture.

Table 2. Commercial Feed Experiment Design

Treatment	Replicate	Feed Company	Feed brand	Protein (%)	Size (mm)
Ocialis 30%	4	APSARA AGRI SUPPLIES	Ocialis	30	2
Dollar 30%	4	LY HONG CHHOY TRADING CO.,LTD	Dollar	30	2
Ocialis 35%	4	APSARA AGRI SUPPLIES	Ocialis	35	2

Dollar 35%	4	LY HONG CHHOY TRADING CO.,LTD	Dollar	35	2

c) Bighead Catfish Selection

Bighead catfish fingerlings were purchased from the Freshwater Aquaculture Research and Development Center. The fingerlings were acclimated in fiberglass tanks. The fish were stocked at 29.36-31.89 g of initial size with 30 fish per net cage. Final weights reached 64.04-77.70 g after 14 weeks.

d) Feed and Feeding

Experimental feed was bought from two feed companies with two protein levels. Fish were fed three times per day (7-8 am, 12-1 pm, and 4-5 pm). The feed was stored in bags inside plastic bins. Feed was weighed before and after fish feeding. Fish were fed to satiation, and uneaten feed was calculated by pellet counting after feeding 15 minutes.

e) Fish Sampling

The fish were sampled twice weekly and weighed by removing all fish from net cages at 7 am before feeding. Final individual fish length-weight was measured for all fish at the experiment's conclusion. Ten fish were collected from each treatment at the experiment's conclusion, weighed, and dissected to collect gonad, liver, and viscera weights for calculation of the final hepatosomatic index, gonadosomatic index, and viscerosomatic index.

f) Feed Proximate Composition Analysis

Proximate composition analysis was conducted on 350g of each feed by the Science, Technology and Innovation National Laboratory to determine crude protein, crude fat, crude fiber, ash, and dry weight.

g) Fish Proximate Composition Analysis

Proximate composition analysis was conducted on 350 g of harvested fish from the 16 net cages at the experiment's conclusion. Analysis was done by the Science, Technology and Innovation National Laboratory to determine crude protein, crude fat, crude fiber, ash, and dry weight.

h) Water Quality Monitoring

Water quality was conducted twice daily on five randomized net cages and pond water to monitor, temperature, pH, and DO. Once per week, TAN, nitrite, nitrate, hardness, and alkalinity were measured. DO and temperature were measured by Eco-Sense DO 200A, and pH, TAN, nitrite, nitrate, hardness, and alkalinity were measured colorimetrically by sera test kit. Water turbidity was measured by Secchi disk.

i) Data Analysis

All data was entered into Microsoft Excel to calculate daily growth rate (DWG), feed conversion ratio (FCR), hepatosomatic index, gonadosomatic index, and viscerosomatic index. Data was analyzed using two-way ANOVA using R statistical software.

Results and Discussion

I. Commercial Aquafeed Evaluation for Bighead Catfish Culture in Recirculation Aquaculture System (RAS System)

a) Growth Performance and Somatic Index

There was no significant difference between Dollar feed and Ocialis feed, except for the 30% and 35% difference in crude protein (CP) levels on daily weight gain (DWG), specific growth rate (SGR), and feeding rate (FR) (Table 3). The 35% CP in the feed led to better fish growth than those that received the 30% CP; however, 30% CP was less consumed than the 35% CP. There was a significant interaction between the feed brand and protein level when it came to the rate at which the fish consumed the feed. The Dollar 35% CP showed a higher feeding rate than the Dollar 30%, but for Ocialis there was not a significant difference between 30% and 35% CP. In contrast, there was not a significant effect of the CP on feed conversion ratio (FCR). Dollar 35% produced the biggest fish. Male fish fed Ocialis 35% had less fat than females, but the females fed Ocialis 35% had bigger livers than females fed Dollar 35%.

In aquaculture, protein is important in feed cost and growth performance for production (Biswas et al., 2020). For catfish feed, farmers should use high quality feed for fast growth and good feed efficiency (Robinson & Li, 2015). In far eastern catfish (*Silurus asotus*), growth performance and feed conversion improved when dietary protein levels increased from 20% to 40% (Kim et al., 2012). The protein level that is suggested for African catfish (*Clarias gariepinus*) fingerlings is 35% crude protein (CP) for good growth performance, but the best FCR is achieved at 50% CP. Optimal CP content in feed for bighead catfish was found to be 46.1% (Hien et al., 2018).

Table 3. Growth performance of bighead catfish that were fed two brands of feeds with two different protein levels.

Variable	Variable	Initial weight (g)	Final Weight (g)	DWG (g/day)	SGR (%)	FCR	FR (%)
Main effect	30%	85.48	102.21^{b}	0.20^{b}	0.21^{b}	2.88	0.72^{b}
Protein	35%	86.43	123.38^{a}	0.44^{a}	0.42^{a}	1.73	0.83^{a}
Main effect	Ocialis	86.54	114.14	0.33	0.34	2.16	0.78

Feed brand	Dollar	86.37	111.45	0.31	0.32	2.04	0.77
			Interaction effect				
Ocialis	30%	86.85	108.16^{c}	0.25^{b}	0.26^{bc}	2.51	0.77^{b}
	35%	86.23	120.11^{b}	0.40^{a}	0.39^{ab}	1.74	0.79^{b}
Dollar	30%	84.12	96.25^{d}	0.14^{b}	0.16^{c}	3.52	0.67^{c}
	35%	86.62	126.65^{a}	0.48^{a}	0.45^{a}	1.72	0.87^{a}
P-Value main effect	Feed Brand	NS	NS	NS	NS	NS	NS
	Protein	NS	<0.000	<0.000	<0.000	NS	<0.000
Interaction Main effect	Feed Brand x Protein	NS	<0.000	0.064	NS	NS	<0.000

Table 4. Somatic index of bighead catfish fed two brands of feeds with two different protein levels.

Variable	Variable	Male			Female		
		GSI (%)	HIS (%)	VSI (%)	GSI (%)	HIS (%)	VSI (%)
Main effect	30%	0.32	0.43	0.29	6.81	0.36	0.07
Protein	35%	0.34	0.81	0.30	6.70	0.38	0.13
Main effect	Ocialis	0.35	0.79	0.27	7.24	0.36	0.09
Feed brand	Dollar	0.31	0.43	0.32	6.32	0.38	0.10
			Interaction effect				
Ocialis	30%	0.31	0.47	0.36^{ab}	6.82	0.38^{ab}	0.08

	35%	0.38	1.11	0.17^{c}	7.66	0.35^{ab}	0.10
Dollar	30%	0.32	0.39	0.21^{bc}	6.81	0.34^{b}	0.05
	35%	0.29	0.48	0.45^{a}	5.85	0.41^{a}	0.15
P-Value	Feed Brand	NS	NS	NS	NS	NS	NS
main effect	Protein	NS	NS	NS	NS	NS	NS
Interaction	Feed Brand	NS	NS	<0.000	NS	0.043	NS
Main effect	x Protein						

b) Water Quality

Water quality parameters were acceptable for catfish production and are shown in Table 5.

Table 5. Water quality

Description	Fish Tank	Sand filter	Bio-filter	Sump tank
D.O (mg/L)	6.15	5.92	6.71	6.15
Temperature (^{0}C)	30.54	30.82	30.76	30.81
pH	7.72	7.74	7.72	7.73
TAN (mg/L)	0.50	0.23	0.30	0.14
Nitrite (mg/L)	0.18	0.29	0.21	0.17
Nitrate (mg/L)	67.08	68.75	69.58	62.92
Hardness (d^{0}GH)	15.13	15.25	15	14.75
Alkalinity (d^{0}KH)	9.14	9.33	8.92	9.25

c) Proximate Composition

1. Feed Proximate Composition Analysis

Proximate composition analysis of the commercial feeds is shown in Table 6. Dollar 35% had higher protein content than Ocialis 35%, which correlated with the increased weight gain with Dollar 35% relative to Ocialis 35%.

Table 6. Proximate composition of feed

Feed brand	Protein	Ash (%)	Dry Weight (%)	Crude Protein (%)	Crude Fiber (%)	Crude Fat (%)

Ocialis	30	9.71	91.65	30.25	19.8	12.36
Dollar	30	7.2	91.47	30.1	14	5.71
Ocialis	35	9.22	90.39	31.81	11.4	5.48
Dollar	35	8.4	91.33	34.22	11.4	0.61

2. Fish Proximate Composition Analysis

The proximate composition of bighead catfish (Table 7) showed similar percentages of protein across brands but different crude fat and fiber. The composition of bighead catfish, including protein, lipid, moisture, and energy content, was found to be significantly affected by the diet (Noordin et al., 2019). In the current study, bighead catfish fillet composition analysis suggested that the type of feed given to the fish could impact the quality of the fillet.

Table 7. Proximate composition of bighead catfish fed two brands of feeds with two different protein levels.

Feed brand	Protein	Ash (%)	Dry Weight (%)	Crude Protein (%)	Crude Fiber (%)	Crude Fat (%)
Ocialis	30	2.30±0.30	26.47±1.18	19.38±0.72	1.99±0.61	1.14±0.37
Dollar	30	2.49±0.35	26.24±1.81	19.40±0.46	0.36±0.40	0.83±0.40
Ocialis	35	2.57±0.88	25.15±1.44	19.52±0.28	3.62±2.48	0.89±0.21
Dollar	35	2.62±0.93	25.88±0.88	18.96±0.39	0.43±0.60	0.95±0.32

d) Sensory Test

Feed composition affects growth performance, feed conversion ratio, and yields, and it also affect to flavor of the fish products (Smith et al., 1988). However, in the current study, there were not significant effects of feed brand or protein level on appearance, odor, flavor, and consistency of the experimental bighead catfish fillets.

To ensure high quality farm-raised catfish, the first quality control measure involves assessing the taste for a lack of unpleasant flavors and the presence of desirable ones. The appearance of a product is crucial as it is the first impression for a consumer, and it can influence taste perception (Delwiche, 2004). Taste, which is the final perceived sensation, could be considered as the primary sensory characteristic because it is greatly influenced by the other sensory characteristics (Martin et al., 2014). Apart from other factors that affect taste, the taste itself might contain unpleasant, organic compounds like geosmine and

methylisoborneol that impart peculiar flavors to food. These flavors can lead to customers rejecting the food and adversely impact fish farming (De Souza et al., 2012).

Table 8. Scoring of the fillets of the bighead catfish, which were fed two brands of feeds with two different protein levels.

Variable	Variable	Appearance	Odour	Flavor	Consistency	Preference
Main effect Protein	30 %	2.68	2.72	2.58	2.56	2.61
	35 %	2.69	2.71	2.61	2.62	2.64
Main effect Feed Brand	Ocialis	2.72	2.73	2.60	2.60	2.64
	Dollar	2.66	2.71	2.60	2.58	2.62
		Interaction effect				
Ocialis	30 %	2.73	2.75	2.61	2.62	2.65
Ocialis	35 %	2.71	2.70	2.59	2.59	2.63
Dollar	30 %	2.63	2.69	2.56	2.51	2.58
Dollar	35 %	2.68	2.73	2.64	2.65	2.66
P-value main effect	Feed brand	0.271	0.797	1	0.697	0.689
	Protein	0.826	0.854	0.590	0.312	0.575
Interaction main effect	Feed brand x Protein	NS	NS	NS	NS	NS

Note: 1 = excellent, 2= very good, 3 = good, 4 =satisfactory, 5 = poor

Outputs and Conclusions

I. Commercial Aquafeed Evaluation for Bighead Catfish Culture in Recirculation Aquaculture System (RAS System)

- Feed brand (Dollar and Ocialis) does not significantly affect fish growth, FCR, somatic indexes, proximate composition, and fillet quality.

- Bighead catfish fed diets containing 35% crude protein show higher growth performance and improved (lower) FCR than those fed diets containing 30% crude protein.
- Dollar 35% had higher CP than Ocialis 35% and resulted in improved weight gain.
- Feed brand and CP content did not affect protein composition in fish fillets, but there were effects on crude fiber and crude fat. However, these did not affect sensory perception tests.

Key Beneficiaries

The development of feed formulation for sustainable culture of bighead catfish in Cambodia requires the improvement of human knowledge, capacity building, and the establishment of a research facility. Through funding from the Feed the Future Innovation Lab for Fish, CE SAIN has collaborated with RUA's Faculty of Fisheries and Aquaculture (FFA), resulting in the installation of a wet lab (RAS system) in the aquaculture facility at RUA, and the acquisition of a small floating fish feed pelletizing machine, which is also installed in the wet lab. This lab setting is fully functional and will continue to provide opportunities for hands-on research and teaching on bighead catfish nutrition for students and faculty at RUA. Highlights of the project beneficiaries include:

1. Vithun Soth directly benefited from this research activity by enrolling in a PhD program. This program provided him the opportunity to engage in hands-on research on fish fed nutrition and receive the mentorship of a WorldFish aquaculture scientist.

2. Nine interns also benefited from this work; they engaged in knowledge sharing activities from the research and technical training on the feed pelletizing machine, and they implemented feed trials.

3. Institutional capacity was developed at the RUA FFA, which received the RAS system and extruder, which were both installed at the CE SAIN farm. This farm will be used for fish nutrition research as well as other relevant research activities, and it will be used for hands-on instruction for students.

How the Scientific Results Were Disseminated

The WorldFish team worked collaboratively with the RUA, CE SAIN, and Faculty of Fisheries and Aquaculture teams to organize a closeout workshop on June 28, 2023, at the Royal University of Agriculture in Phnom Penh, Cambodia. The research team and GRA shared the scientific results of the

commercial aquafeed evaluation of bighead catfish culture in a recirculation aquaculture system. The overall purpose was to share the results of the research on bighead catfish in Cambodia and discuss the next possible steps.

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Appendices

Sensorial test questionnaire

Date:…… Questionnaire code:……
Name:……..
Age:…….
Gender:…….
Institute:……
Time:……

1. How much problem do you have with your eye in Apperance? 1.<10% 2.<20% 3. <30% 4……
2.How much problem do you have with your nose in odour? 1.<10% 2.<20% 3. <30% 4……
3. What flavor do you like? 1.spicy 2.salty 3.sweety 4…….....

+Score:
1 – excellent
2 – very good
3 – good
4 – satisfactory
5 – poor

Sample Code	Appearance	Odour	Flavor	Consistency	Preference
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Comment:……
……
……

Table 1 Proximate Composition on Feed Label

Parameter	Ocialis 30% CP	Ocialis 35% CP	Dollar 30% CP	Dollar 35% CP
Moisture (max)	11%	11%	11%	11%
Crude Protein (min)	30%	35%	30%	35%
Crude Fat (min)	5%	5%	5%	5%
Crude Fiber (max)	6%	6%	7%	6%
Phosphorus (min)	0.5%	0.5%	1%	1%
Lysin (min)	1.7%	23%	1.5%	1.8%
Ethoxyquin (max)	150 ppm	150 ppm	150 ppm	150 ppm
Methionine+Cystine (min)	-	-	0.7%	0.8 %
Calcium (min)	-	-	1%	1%