EVALUATION OF THE PHYSICAL PROPERTIES OF SHRIMP FEEDS

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"EVALUATION OF THE PHYSICAL PROPERTIES OF SHRIMP FEEDS"

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Abstract

Physical properties such as water stability and feed attractability could affect the rate of feed consumption of shrimps, their nutritional intake and growth. *"Poor physical property would result to minimum feed intake, thus diminishing nutrient consumption of shrimps".*

This study evaluated the physical properties of three established commercial shrimp feeds. The physical properties considered are water stability, sinking rate, attractability, bulk density, color, size and shape. The feeds were submerged in water for a certain period of time, dried, weighed and the DML (Dry Matter Loss) was calculated. As for sinking time, the time it took for the all the feeds to reach the bottom of the cylinder was measured. Shrimps were placed in aluminum tanks and the time it took for them to be attracted to the feeds were measured. The weight of the beaker without feeds was measured and then subtracted to the weight of the beaker filled with feeds. As for color, size and shape, the feeds were placed in a tray and were observed and measured.

The results show that Oversea feeds has the least percent change in water stability, has the least recorded shrimp travel time in the attractability test, least minimum sinking time, and the highest bulk density. The SEAFDEC feeds have the least maximum sinking time and SEAFDEC feeds also exhibit the darkest color among the three. In conclusion, It was found that Oversea feeds is the most water stable, most attractive to *P. monodon,* has the least minimum sinking time, and has the highest bulk density. SEAFDEC feeds has the least maximum sinking time, and has the darkest color among the three

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CHAPTER I

Introduction

A. Background of the Study

Farmed shrimp contributed to 27% of total world shrimp production in 1995 with a volume of 712 000 tonnes. Undoubtedly, the shrimp culture industry earns valuable foreign exchange for developing countries and generates jobs across the industry from fry gatherers to growers and processors. However, grave socio-economic consequences including conversion, expropriation and privatization of mangroves and other lands; salinization of water and soil; decline in food security; marginalization of coastal communities, unemployment and urban migration; and social conflicts have followed in the wake of shrimp farm development in the Philippines and other tropical countries. (Primavera, 1997)

Penaeus monodon mature and breed only in tropical marine habitats and spend their larval, juvenile, adolescent and sub-adult stages in coastal estuaries, lagoons or mangrove areas. In the wild, they show marked nocturnal activity, burrowing into the bottom substratum during the day and emerging at night to search for food as benthic feeders (FAO Fisheries and Aquaculture Department 2005).

As shrimp farms evolve from low to high stocking densities, the quality of feeds become very important. Other extensive farms use small amounts of feed and fertilizer to stimulate a natural food chain. On semi-intensive farms, with many more shrimp scouring the bottom of the ponds, most of the feed is consumed by the shrimp and less is available to serve as stimulant to the natural food web. Therefore, the quality of the feed is more important because, the shrimp get the most of their nutrition from it.

The quality of shrimp diets is determined not only by their nutritional make-up but also by their physical properties (Lim-Cuzon, 1994).

The physical properties are water stability, sinking rate, feed attractability, feed microscopy, bulk density, color, size, shape and shelf life. Water stability denotes on how long the feed is made available to the consumer. Sinking rate is the speed at which the feed can reach the bottom. Feed attractability denotes the ability of a feed to attract its consumer. Feed microscopy shows how well a feed is mixed and if there are unwanted materials during the mixing process. Bulk density affects the energy the feed gives and an indicator if the feed was adulterated or not. Color indicates if the feed was properly mixed or not and an indicator of feed composition. Size denotes if the feed has been properly mixed. Shape affects the water stability. Shelf life denotes on how the feed stays unspoiled for a length of time.

However, the focus of most research and development is in the nutritional value of feeds. Physical property of the feeds is often neglected. Poor physical property would result to minimum feed intake, thus diminishing nutrient consumption of shrimps.

The study is about the evaluation of the physical properties of shrimp feeds. Through this, it may be assessed if the current shrimp feeds possess the ideal physical properties.

B. Statement of the Problem

This study evaluated the physical properties of shrimp feeds of three established feed manufacturers.

C. Objective of the Study

This study evaluated the shrimp feeds of established feed manufacturers based on physical properties, in terms of:

- water stability
- sinking rate
- attractability
- bulk density
- color
- size
- shape

D. Significance of the Study

Meeting the nutritional needs of shrimps is the most important quality of a feed (Coloso, 2009). However, physical property should also be a priority of feed manufacturers to ensure maximum consumption of these nutrients.

Through this research we may assess if the feeds that are used today in shrimp farming possess the ideal physical properties for shrimp feed. Shrimp feed manufacturers may use our study as a reference for feed development. The results of our study may also help shrimp farmers choose the feed that suits their preference.

E. Scope and Delimitation

This study was limited to only three shrimp feed brands. The study was conducted in SEAFDEC from July 2009 to December 2009. The parameters for physical properties tested were *only*: water stability, sinking rate, feed attractability, bulk density, color, size, and shape. The test for shelf life was no longer conducted because the feeds already have an assigned expiration date. Due to the lack of knowledge in interpreting the data, feed microscopy test was no longer included. The ingredients of the feeds were also unknown due to it being unavailable to the public.

F. Definition of Terms:

Attractability - This is the property of the feed to attract the consumer. In this study the attractability was determined by the time it takes for the prawn to reach the feed.

Bulk Density - This is the property that determines the presence of contaminants and adulterants. It is calculated as weight of sample per litre. In this study bulk density was the mass of the feeds divided by the volume of the container.

Feed Microscopy – This is property that helps determine whether the feed has been adulterated. In this study feed microscopy is the appearance of the feeds under the microscope.

Sinking Rate - It is the rate at which a pellet sinks. In this study, sinking rate was determined by taking the sinking time of the feeds.

Water Stability- This is the property of the feed to maintain its form in water. In this study, the stability of the pellets in water was determined by the percent change in weight of the pellet.

CHAPTER II

Review of Related Literature

A. *Penaeus monodon*

At the post larval stage they ingest small crustaceans like crabs and shrimps and mollusks, fish, polychaetes, ophiuroids, and even debris, sand and silt. Crustaceans seem to be their staple food though mollusks are also eaten in large amounts (Pascual, 1989). They catch foods with pereiopods, take to their bucal cavity and nibble slowly. They are omnivores but cannibalize if food is scarce or of poor quality. They are also scavengers, feeding on any kind of decaying matter available in the habitat (F.P. Pascual, n.d.).

P.monodon juveniles prefer seagrass and weed beds (Chen, 1990) They live by themselves and feed on decaying plantmaterial, plankton, and small bottom organisms. The shrimp use their antenna and the first pairs of leg to trace food. Food is picked up by the first pairs of legs and pushed into the mouth opening. Most shrimp feed 24 hours per day, with a peak during the dark hours. Shrimp are selective slow eaters (Lim-Cuzon, 1994). Due to its benthic life, shrimp are bottom feeders. (Coloso, 2009).

B. Feeds

B.1. Feed Types

As the shrimp grow, consumption increase and natural food in the pond becomes insufficient. Thus, many shrimp farmers provide supplemental feeds (F.P. Pascual, n.d.).

One type of feed is the moist or wet feed. These are freshly prepared feeds using locally available ingredients. The feeds should be given fresh immediately after preparation. However, these could also be frozen and thawed when needed (Kungvankij and others, n.d.).

Another type of feed is the dry pelleted feed. Pelleted feeds are available commercially to be used as supplementary or full feeds of shrimps. These are also prepared using locally available ingredients. A good pellet should not only meet all the nutritional requirements of shrimp but also stable in water for a certain period of time.

The feeds should have also longer shelf-life. Usually, commercial pellets are bought in bulk and should be properly stored in storage room with low humidity to minimize fungi occurrence and insect infestation. It is advisable to ensure rapid turn over feed supply (Kungvankij and others, n.d.).

B.2. Established Shrimp Feed Manufacturers

Shrimp industry has been in existence for more than two decades as well as shrimp feed production business Joint efforts of the government, academes, research institutions and businessmen kept the industry thriving through the years, despite the challenges it faced.

Santeh Feeds, Oversea Feed Corporation and the Southeast Asian Fisheries Development Center (SEAFDEC) have been part of the industry for years. These commercial feed manufacturers are backed with studies, research and development. Some have their own division which handles the responsibility, while others rely on collaborative ventures with noted aquaculture research institutions and fisheries schools like the University of the Philippines in the Visayas.

Santeh Feeds Corporation has been one of the few aquaculture companies open for innovations. By striving to improve their products through extensive research and development, it has become a great help for small-scale fish farmers. (Fontanilla, n.d.). We can rely on Santeh to be in the forefront assisting farmer groups, NGOs and associations involved in aquaculture development holding seminars, exhibits and other marine promoting activities (Yap, n.d.). The company's continuing commitment is to improve their products' quality to be acceptable economically, socially and environmentally in the fisheries sector (Cagauan, n.d.).

SEAFDEC was established in 1967, and its Aquaculture Department (AQD) started operations in 1973. Thru its Research Division's Nutrition Section, SEAFDEC/AQD produces its own feeds which are both used internally and available to outside consumers. As a research institution SEAFDEC is noted for research backed technology generation.

With more vigorous and institutionalized focus to reach out to stakeholders, rich and poor, the AQD has not forgotten its primary mandate of research, which is the backbone of technology generation (Toledo, 2007).

As with Santeh and SEAFDEC, Oversea Feeds has been in business for years. Oversea Feeds Corporation is an aquatic feed manufacturing company, previously known as Oversea Agri-aqua International Development Corporation. It produces quality pelleted feeds for prawn and fish. Founded on June of 1988, it was established to meet the growing demand of aquatic growers in the region. The plant is presently located at Barrio Balud, San Fernando, Cebu that is 28 kilometers from Cebu City.

Oversea Feeds Corporation is committed to produce the best aquatic feeds to the highest quality standards, thus, enhancing optimum growth to aquatic animals, satisfying growers' demand and employees' benefits (Co, 2009).

Presently, it supplies feeds to many fish pond operators in Luzon and the Visayas, particularly the islands of Cebu.

B.3. Physical Properties

B.3.1 Water Stability

Feeds should be stable in water for a certain period to increase their availability to aquatic animals. The feed has to maintain its integrity in the water so that the entire feed is consumed. This is especially true if the species to be fed are slow feeders such as crustaceans. If feeds are not water stable, they disintegrate rapidly losing much of the nutrient content and resulting in feed wastage and degradation of water quality. The use of efficient binders and processing techniques, such as steaming and extrusions, produces a more stable pellet. A simple test to determine whether a feed is water stable or not is by crumbling the pellet by hand or checking for rough edges. Another method for testing water stability is by determining weight loss of pellet after it is placed in water for specific period. Correct interpretation of the results is necessary in testing other binders to improve water stability. Proper processing condition for the formulated diet and the binders used are equally important in achieving a water stable pellet. The higher the percentage of the pellet disintegration at a given time, the higher the weight loss, and the lower the pellet stability (Millamena and others, 2002).

B.3.2 Sinking rate

The rate at which the pellet sinks to the bottom of the container. The faster the pellet sinks, the better it is. According to an interview with Dr. Coloso of SEAFDEC, there is no ideal sinking rate. But it is best if the pellet sinks immediately after it is distributed.

B.3.3 Attractability

Attractants are important components in any feed formulation since they determine how fast and how much of a feed will be taken in by the aquatic animal. A well formulated feed will be useless if the animal does not accept it. Attractability tests are carried out with a single animal and effectiveness is measured usually with a stopwatch based on how fast the animal is attracted to the pellet (Millamena and others, 2002).

B.3.4 Feed Microscopy

The microscope identifies the physical composition of a feedstuff or feed ingredient that either confirms or denies the presence of unwanted materials. A high powered microscope can detect even the finest ground adulterants in a sample. This method is more accurate than the use of the senses in checking adulteration in feeds and feed ingredients (Millamena and others, 2002).

B.3.5 Bulk Density

The bulk density of the sample is compared with that of a pure feedstuff. If contaminants or adulterants are present, the bulk density will either be higher or lower than the values of the pure feedstuffs. The use of bulky feed ingredients in a feed mixture instead of heavier ones lowers the total digestible nitrogen of the mixture. Bulky feed yields low biologically available energy. The bulk density is computed as weight of samples in gram per liter after the sample has been placed and poured off in a 1 L cylinder (Millamena and others, 2002).

B.3.6 Shelf Life

The shelf life is the time it takes for the feed to spoil. According to Dr. Coloso, a usual feed's shelf life is three months. In an interview with doctor Coloso of SEAFDEC, it was learned that an indicator is the rancid smell and the appearance with white or black molds.

B.3.7 Color

Color is an indicator of ingredient composition and the quality of processing. Usually feed is the color of dark coffee due to the ingredients used and the production process. Coloring should be uniform, because variations indicate an inadequate milling and mixing of ingredients, variations in cooking, bad water distribution during the pellet production, or of oil in the finished product (Cruz-Suarez and others, n.d.).

B.3.8 Size

The size of the particle is important because the shrimp may segregate the larger feed particles and thus obtain nutrients in an unbalanced way. Most ingredients are ground to a size of at least 500 um. Feed with well ground particles improve their physical and binding capacity in the production process. A feed with uneven sized particles indicates a bad milling process, and the degree to which ingredients are ground affects the uniformity of the mix, its compacting capacity, gelatin properties and performance (digestibility, conversion rate and growth rate). A well processed does not have fractures and its superficial appearance is uniform. Fractures are generated by defects during the production process, are due to inadequate particle size or fast cooling amongst other factors.

Fractures may allow water to penetrate the pellet and reduce its hydro-stability (Cruz-Suarez and others, n.d.).

The size for the feed for shrimps is not related to the size of the shrimp's mouth, but the organism does need to carry the feed as it eats, and often moves around with it, for which reason the pellet should be sufficiently small to allow this (Cruz-Suarez and others, n.d.).

Measuring pellets is a simple way of monitoring the quality of feed during its production or its destruction during handling. A great variation in the lengths of pellets indicates a bad cutting process or inadequate handling (Cruz-Suarez and others, n.d.).

C. Related Studies

In the study of Cruz-Suarez and others entitled "Review of Certain Physical Characteristics and Quality Control of Commercial Feed for Shrimp Farming in Mexico", they tested the different physical properties of pellets. In their study they measured pellets using an electric vernier. In assessing the hydrostability of the feeds, they submerged the feeds in water, the feeds were then drained, dried, weighed, and the percentage of dry mass loss was calculated in comparison to the feeds original weight. They discussed the ideal physical characteristics for a shrimp feed. An ideal feed should have a uniform color that of dark coffee, is free of fractures, and should be stable in water for about 4-6 hours.

In Lim and Cuzon's study entitled "Water Stability of Shrimp Pellet: A Review", they discussed the factors that affects feeds water stability. Factors that affect water stability are: composition of diets, feed manufacturing process, and binders. Their paper reviews information on the various factors which affect the water stability of pellets for shrimp. These include composition of the diet, method of manufacturing, and binders. Problems associated with the methods used for evaluation of water stability, and factors affecting the length of water stability required are also discussed.

CHAPTER III

Methodology

I. Materials:

- Brackish water
- Commercial shrimp feeds

Tools:

-Beaker/ Fiberglass Tank

-Countdown timer

-Scientific calculator

-Digital weighing scale

-Stop watch

-Nylon sack bags

-Microscope

-1'x1.5' Laboratory tray

-3"x5"x0.5" Screen wire baskets (9)

- 1 L transparent glass container/
1 L Volumetric Flask (3)

-500mL beaker (3)

II. Procedures

A. Acquisition of Materials and Feeds

The shrimp feeds for testing and comparison were sample feeds given by the manufacturers. SEAFDEC/AQD feeds were provided by Mr. EstebanGaribay with permission from Dr. Fe Estepa. Oversea feeds were given by Mr. Pablo Carbo, sales representative of Oversea feeds Corporation. Santeh feeds with office at Lapus, Iloilo City, also provided their sample feeds.

SEAFDEC/AQD laboratory instruments such as microscope, beakers and digital weighing scale will be used in some research activities, the same when the researchers conducted their preliminary feed processing activity. Dr. Evelyn Grace Ayson, approved the use of some SEAFDEC facilities in support of the researchers.

Aluminum wires were bought and made into wire baskets to be used in water stability test. Sack bags for storage can be bought at dry good stores or public markets. The researchers already have scientific calculators and countdown timers/stopwatches. Brackish water can be prepared using a mixture of sea water and fresh water both of which are available in the coastal towns of Iloilo.

B. Water stability

Five grams of each feed was distributed and placed inside three 3"x5"x0.5" different wire basket and then submerged in brackish water for designated times of 2, 4, 6 and 8 hours. It was drained, dried, weighed and the percentage of dry mass loss was calculated in comparison to its original weight. The result was expressed in a percentage of retention or of dry matter loss (DML). The values obtained made it possible to estimate the quantity of dry matter truly ingested and thus, the feeding conversion rate (Cruz-Suarez and others, n.d.).

C. Sinking time

Five grams of each shrimp feed were dropped in a one liter transparent container filled with brackish water. Sinking time was recorded using a stopwatch starting from the moments the feeds were dropped. The time when the first pellet and the last pellet reached the bottom of the container were recorded (Mallare, 2009).

D. Attractability

The aerators were turned off during each attractability test to avoid possible extraneous variables. On one end of the tank 5 grams of each of the pellets were placed just below the opening of the polyvinylchloride (PVC) pipe. The PVC pipe prevented the pellets from floating away, as well as stopped its odor from spreading. The pellets were submerged for one minute before the shrimps were placed inside the aquarium. Three different shrimps were placed in each aquarium. Each shrimp was placed in a PVC pipe.

The timer started when the shrimps were released from their PVC pipes found on the side of the tank opposite the PVC pipe filled with the pellets.

The time it took for the shrimp to move across the aquarium towards the attractant and touch the pellet, from the time they were released into the tank was recorded using a stopwatch. Each shrimp was timed until the time the feed was reached.

E. Bulk Density

A 500-mL beaker was weighed. It was then filled with feeds up to the 500-mL mark. The container filled with feeds was weighed. The weight of the container filled with feeds was subtracted with the weight of the weight of the container. The unit of bulk density is grams per litre (Coloso, 2009).

F. Color

Each commercial shrimp feed was placed in a tray. The color of each shrimp feed was observed. The judging of color was based on researcher's perception. The observations were recorded (Cruz-Suarez and others, n.d.).

G. Size and Shape

Each commercial shrimp was placed on a tray. The size of each feed was measured and observed if it fell in the ideal pellet size for juvenile shrimp. The shape of each feed was then observed. All observations were recorded (Cruz-Suarez and others, n.d.).

CHAPTER IV

Results and Discussion

This study evaluated the physical properties of shrimp feeds of chosen established feed manufacturers, namely: SEAFDEC, SANTEH Corporation and Oversea Corporation. The physical properties which were evaluated were water stability, sinking rate, attractability, bulk density, color and size.

Results

The table below shows that Oversea feeds has the least percent change in water stability. It can also be seen that Oversea feeds has the least recorded shrimp travel time in the attractability test, least minimum sinking time, and the highest bulk density. The SEAFDEC feeds have the least maximum sinking time and SEAFDEC feeds also exhibit the darkest color among the three.

Table 1. Table of physical evaluation for the three feeds.

	Water Stability (% change in weight)	Feed Attractability (min)	Sinking Time		Bulk Density (g/mL)	Color	Size (mm)
			Min (s)	Max (s)			
SEAFDEC	17.2	3.46	3.83	27.06	0.557	Dark Brown	1-2
SANTEH	24.7	6.25	7.37	29.38	0.456	Caramel Brown	1-2
Oversea	16.1	2.89	3.25	161.09	0.650	Light Brown	1-2

It was found that all the pellets exhibited a cylindrical shape. The length of the pellet was taken, however; the other dimensions of the pellets were not taken.

Discussion

It was observed that the Oversea feeds was the best in terms of water stability because it displayed the least amount of weight loss after submerging it in water for 8 hours. According to

Millamena and others, feeds should be stable in water for a certain period to increase their availability to aquatic animals, the lower the percentage of weight loss, the more stable the feed is. Thus, Oversea feeds, with the least amount of weight loss can be considered as the best in terms of water stability.

The Oversea feeds were observed to be the best in terms of feed attractability because it took the shrimps the least amount of time to reach the feeds. According to Millamena and others, attractability tests are important because they determine how fast and how much of a feed will be taken in by the aquatic animal. The shorter the time taken for the shrimp to get attracted and consume the feed, the better the feed is in terms of attractability.

The Oversea feed was the best in terms of minimum sinking time because one of its feed pellets was the first to reach the bottom. The SEAFDEC feed is the best in terms of maximum sinking time as the last feed pellet of SEAFDEC reached the bottom the fastest. Oversea has the highest maximum sinking time because some of the pellets that already reached the bottom, after a few seconds, would then go up again. A floating object is stable if it tends to restore itself to an equilibrium position after a small displacement. For example, floating objects will generally have vertical stability, as if the object is pushed down slightly, this will create a greater buoyant force, which, unbalanced against the weight force will push the object back up. As a floating object rises or falls, the forces external to it change and, as all objects are compressible to some extent or another, so does the object's volume. Buoyancy depends on volume and so an object's buoyancy reduces if it is compressed and increases if it expands. If an object at equilibrium has a compressibility less than that of the surrounding fluid, the object's equilibrium is stable and it remains at rest. If, however, its compressibility is greater, its equilibrium is then unstable, and it rises and expands on the slightest upward perturbation, or falls and compresses on the slightest downward perturbation. The sinking rate could not be determined, thus we measured the sinking time of the first feed to reach the bottom and of the last feed to reach the bottom. According to Coloso, the faster the pellet sinks, the better the pellet is because shrimps are generally bottom feeders, and would rather eat at the bottom than at the surface.

The Oversea feed performed best in terms of bulk density. Bulk density is measured by computing the weight of the samples in grams per liter. Due to lack of equipment, grams per milliliter was used. According to Millamena and others, bulky feeds will yield low biologically available energy. Thus, the less bulky the feed is, the better it is.

The SEAFDEC feed was best in terms of color. According to Cruz-Suarez and others, color is an important indication of proper quality composition and ingredient composition. The color of feed pellets should be a uniform color of dark coffee. Thus, a different colored feed indicates lower quality composition and inadequate mixture of feed pellets.

All feed pellets were observed to be equal in size. According to Cruz-Suarez and others, the size of a feed particle is important because shrimps may segregate larger feed particles and obtain nutrients in an unbalanced way. Size indicates how much the feed ingredients are well ground and mixed together. Uneven sized feeds may contain fractures and instabilities in structure. Thus, size must be uniform all throughout. The size of pellets for juvenile prawns ranges from 1-2mm.

CHAPTER V

Summary of Findings, Conclusion, Recommendations

This study evaluated the physical properties of shrimp feeds of three established feed manufacturers; namely: SEAFDEC, Santeh, Oversea.

This study evaluated the shrimp feeds of based on physical properties, in terms of:

- water stability
- sinking rate
- attractability
- bulk density
- color
- size
- shape.

Summary of Findings

- Oversea feeds has the least percent change of weight, has the least minimum sinking time, has the least travel time in the attractability test, and the highest bulk density.
- SEAFDEC feeds has the least maximum sinking time, and exhibits the darkest color among the three.
- Santeh feeds has the least bulk density.

Conclusion

It was found that Oversea feeds is the most water stable, most attractive to *P. monodon,* has the least minimum sinking time, and has the highest bulk density. SEAFDEC feeds has the least maximum sinking time, and has the darkest color among the three.

Recommendations

The study could further be improved by the following:

- Conduct a study on the chemical properties of the shrimp feeds for a better evaluation of the feed.
- Search a more accurate method in measuring sinking rate for more accurate results.
- Compare feeds of a different life stage of a prawn. Feeds for other life stages may have varied results.

- The breeding of *P.vannemi* has recently increased. Conducting a similar study using feeds for *P.vannemi* could be done.
- Future researches could also evaluate the physical properties of other brands of feeds.

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LIST OF PLATES

Plate 1. wirebaskets labeled and used for water stability test.

Plate 2. submerging of wire baskets containing feeds.

Plate 3. wirebaskets baskets containing feeds being submerged for 4 hours.

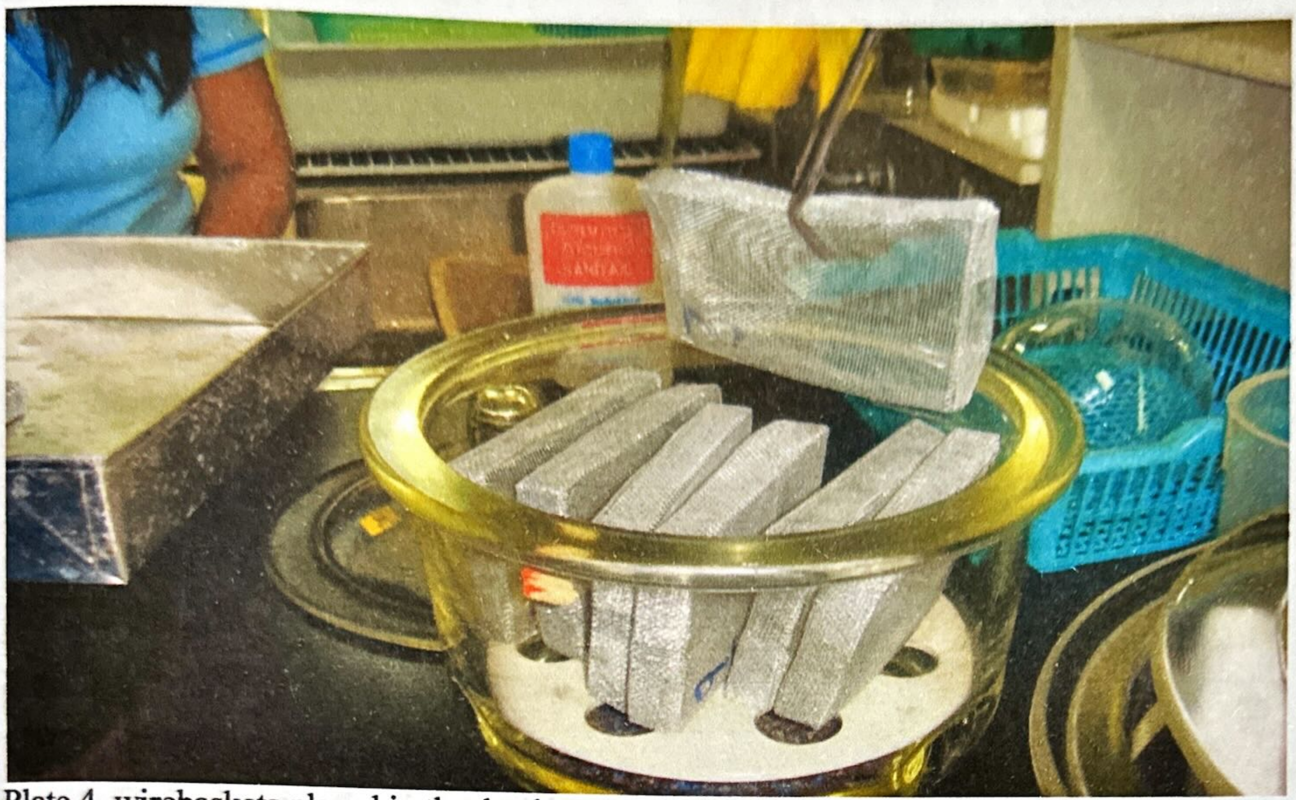


Plate 4. wirebaskets placed in the dessicator for constant weighing.

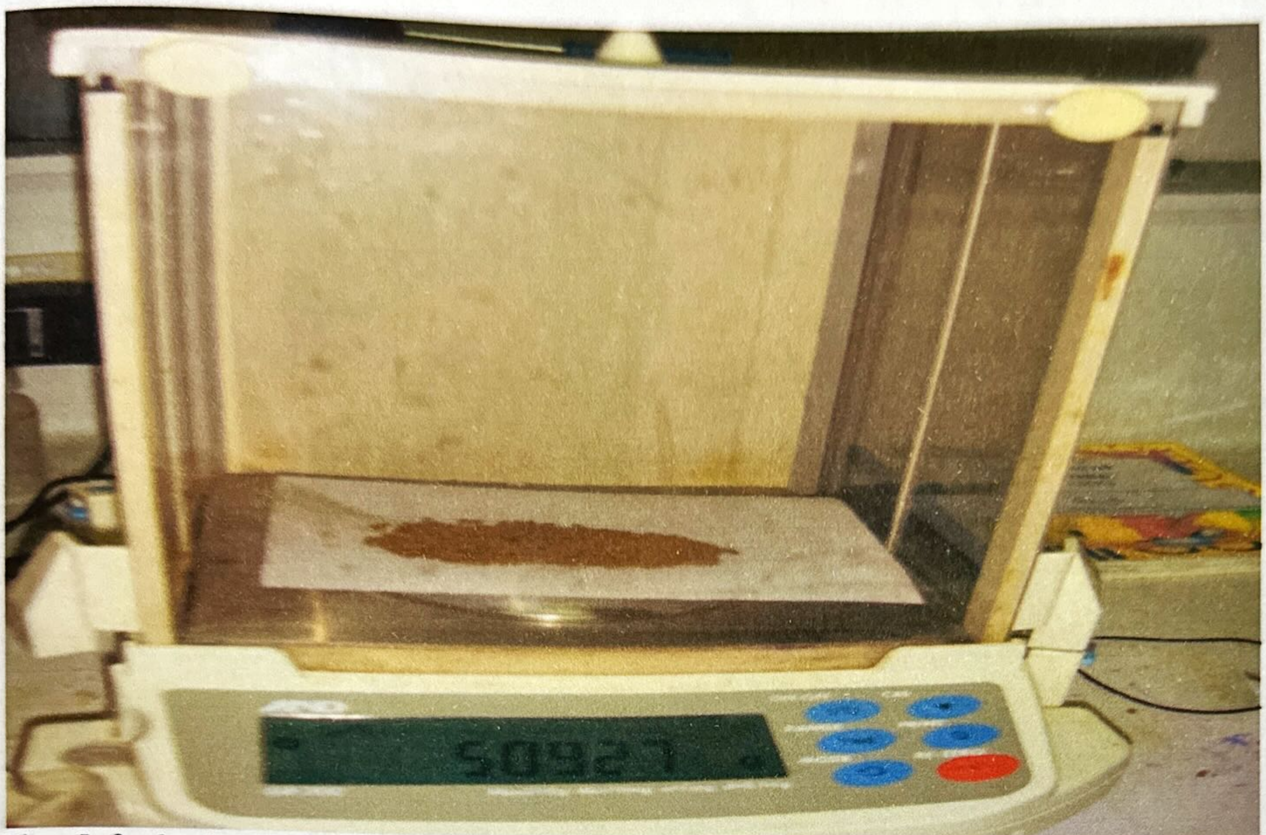


Plate 5. feeds placed in the digital weighing scale for constant weighing.

Plate 6. PVC pipes prepared for attractability test.

Plate 7. PVC pipes placed in the aluminum tank for the conduct of attractability test.

Plate 8. recording of time taken for the shrimps to get attracted to the feed.

LIST OF APPENDICES

APPENDIX A
Raw Data

Water Stability

Number	Company	Number of hours submerged	Dry Weight 1	Dry Weight 2	Dry Weight 3
1	SEAFDEC	2	13.5450	------	------
2	SEAFDEC	2	13.7582	2.4736	12.3018
3	SEAFDEC	2	13.5756	12.0905	11.6952
4	SANTEH	2	14.1551	12.8223	12.5317
5	SANTEH	2	13.6319	12.0934	11.9614
6	SANTEH	2	15.9950	12.6975	12.4179
7	OVERSEA	2	13.4623	12.5636	12.5050
8	OVERSEA	2	12.8148	12.3771	12.2778
9	OVERSEA	2	13.8525	12.9340	12.7727
10	SEAFDEC	4	13.2634	12.1996	11.9621
11	SEAFDEC	4	13.2127	12.4694	12.2935
12	SEAFDEC	4	13.6583	12.3722	12.3178
13	SANTEH	4	12.4078	12.1585	12.0647
14	SANTEH	4	13.1150	12.4372	12.3456
15	SANTEH	4	13.0862	12.4666	12.3428
16	OVERSEA	4	13.2589	12.5555	12.4608
17	OVERSEA	4	12.9429	12.3763	12.3926
18	OVERSEA	4	13.0619	12.5746	12.4444
19	SEAFDEC	6	14.3375	11.8737	------
20	SEAFDEC	6	13.1655	12.1183	------
21	SEAFDEC	6	14.5840	12.8767	------
22	SANTEH	6	14.7887	12.3589	------
23	SANTEH	6	14.2640	12.1538	------
24	SANTEH	6	12.6482	11.5578	------
25	OVERSEA	6	13.0023	12.1553	------
26	OVERSEA	6	12.5936	12.9008	------
27	OVERSEA	6	12.9008	12.5436	------
28	SEAFDEC	8	14.0084	11.9757	------
29	SEAFDEC	8	14.4171	11.8324	------
30	SEAFDEC	8	15.1928	12.1282	------
31	SANTEH	8	14.5300	11.5975	------
32	SANTEH	8	16.8430	12.2950	------
33	SANTEH	8	17.2055	12.5918	------
34	OVERSEA	8	15.6773	12.8618	------
35	OVERSEA	8	14.1889	11.7079	------
36	OVERSEA	8	14.4106	12.5715	------

APPENDEIX B
Raw Data

Attratactability Test

	Time in minutes		
SANTEH	1:03	7:37	10:35
SEAFDEC	1:14	5:22	4:03
OVERSEA	1:10	2:03	5:55

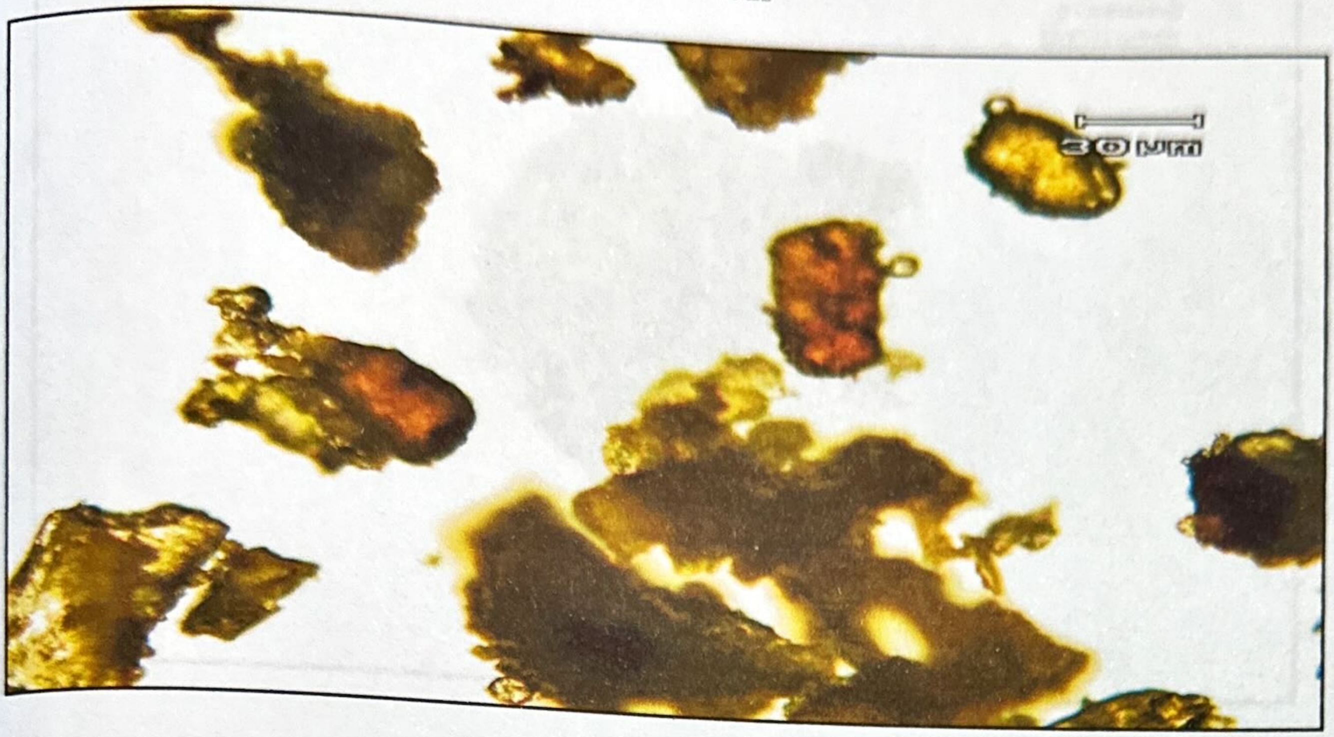
APPENDIX C
Raw Data

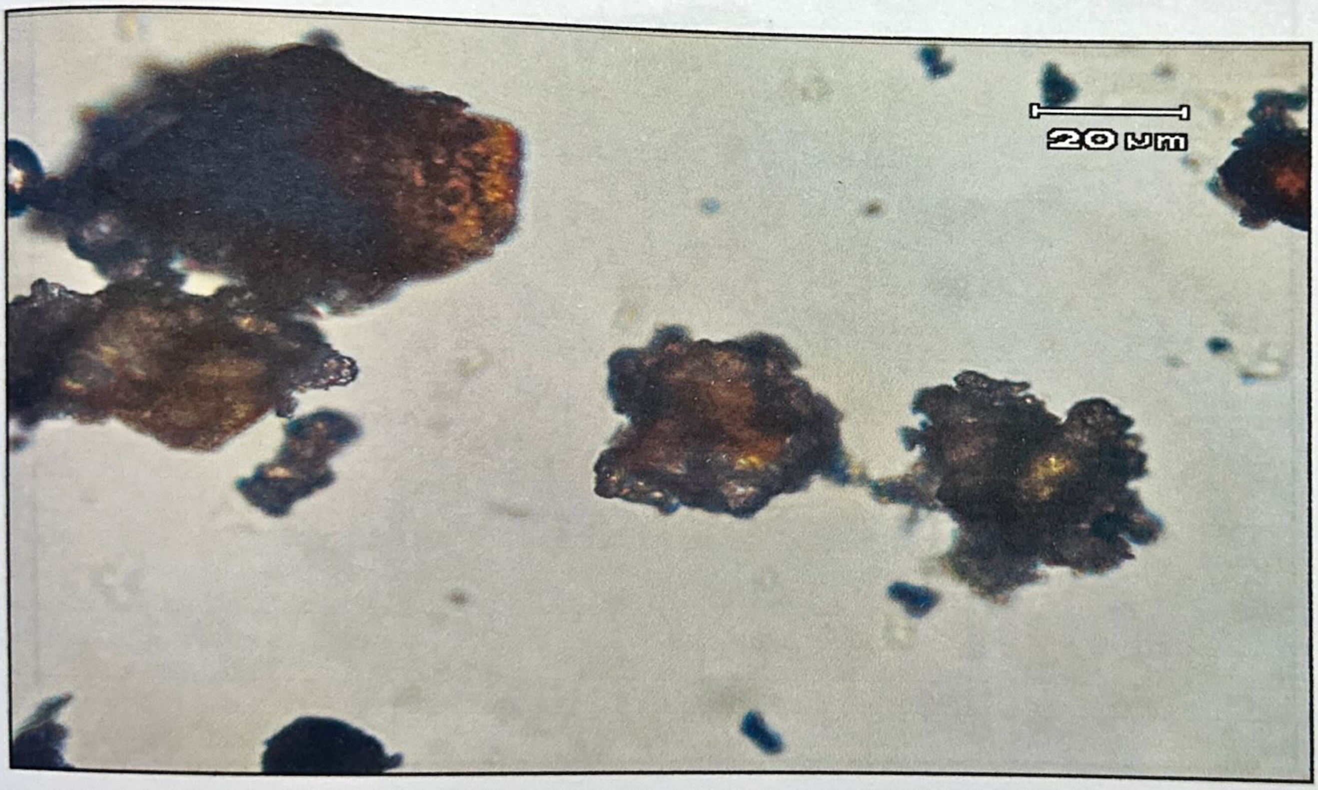
Sinking Time

Sample Number	Minimum Time (s)	Maximum Time (s)
SEAFDEC 1	4.10	24.02
SEAFDEC 2	3.47	33.27
SEAFDEC 3	3.93	23.67
SANTEH 1	7.06	33.23
SANTEH 2	7.95	29.52
SANTEH 3	7.09	26.00
OVERSEA 1	3.43	1:16.89
OVERSEA 2	3.10	58.62
OVERSEA 3	3.21	5:47.77

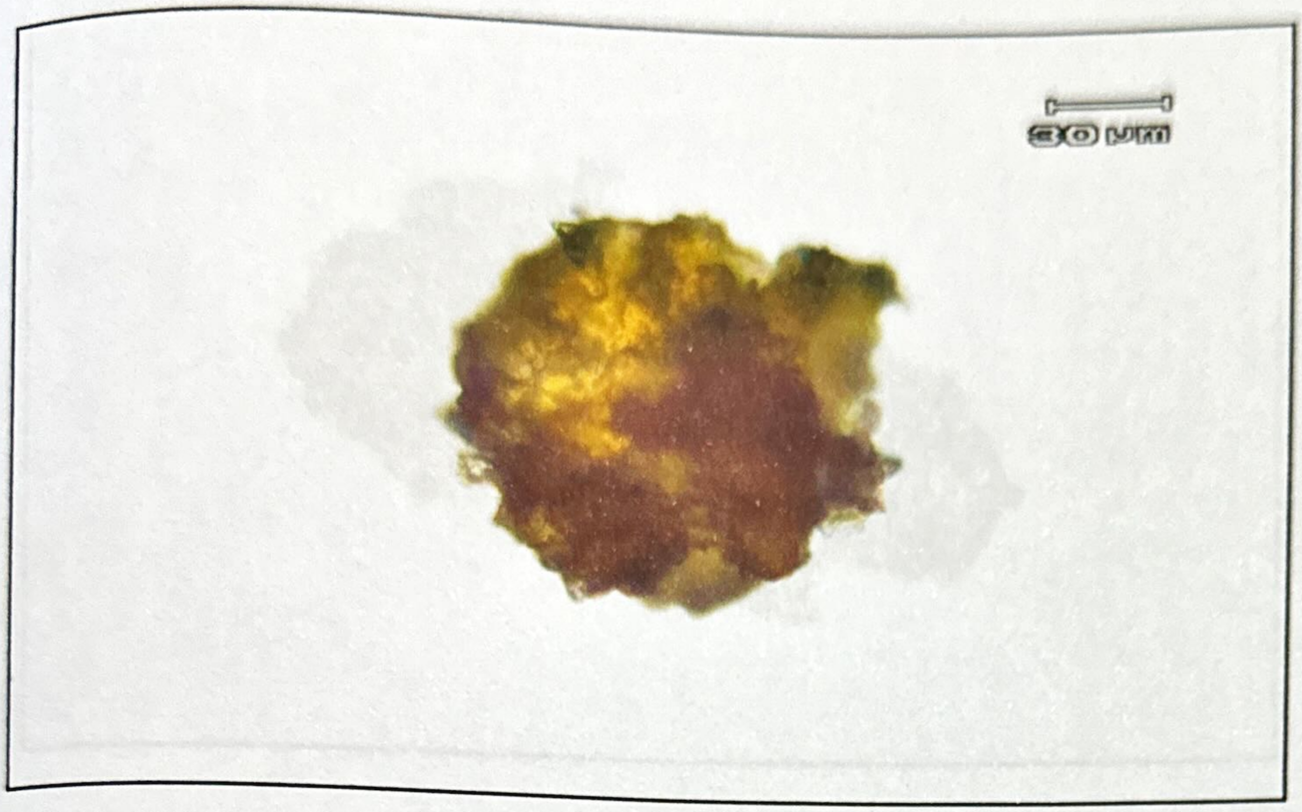
APPENDIX D
Raw Data

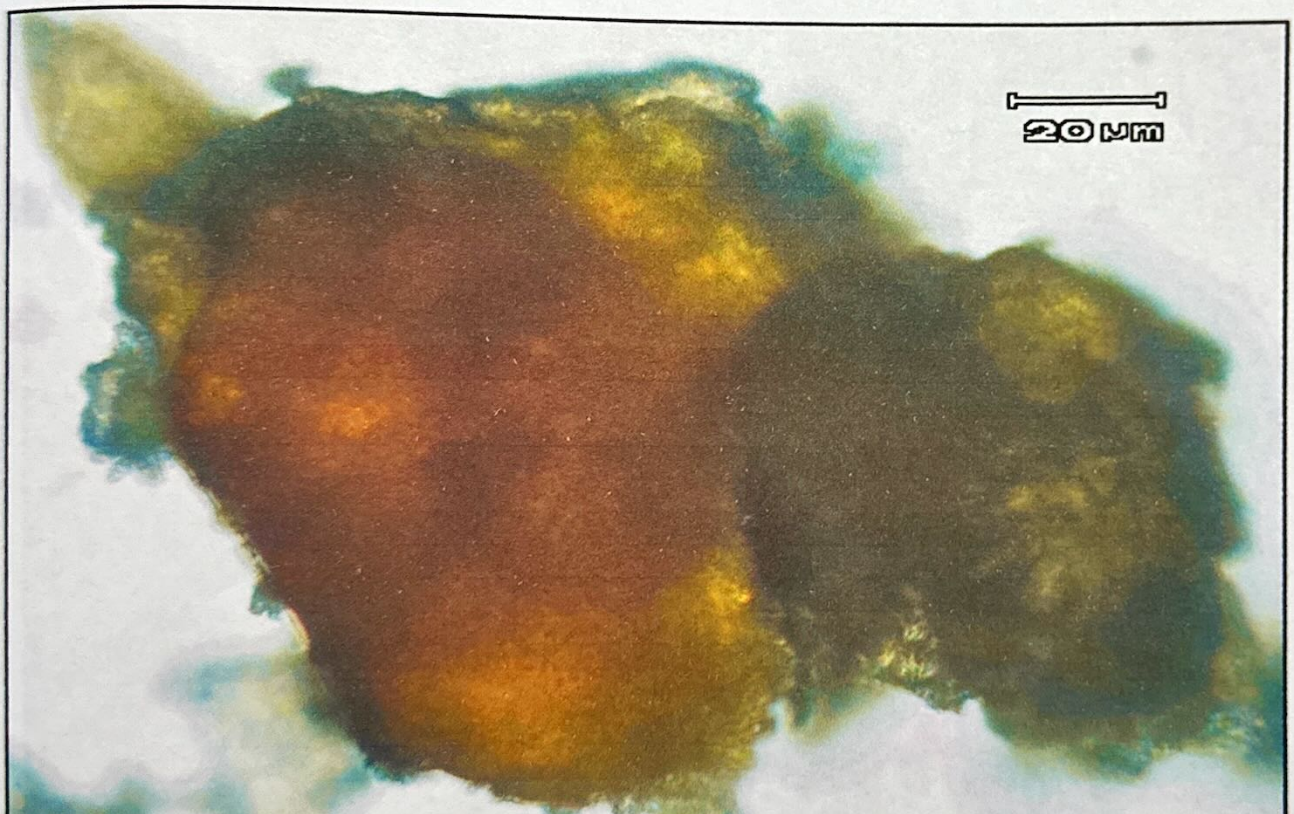
Feed Microscopy
Oversea Feeds





Santeh Feeds





SEAFDEC Feeds