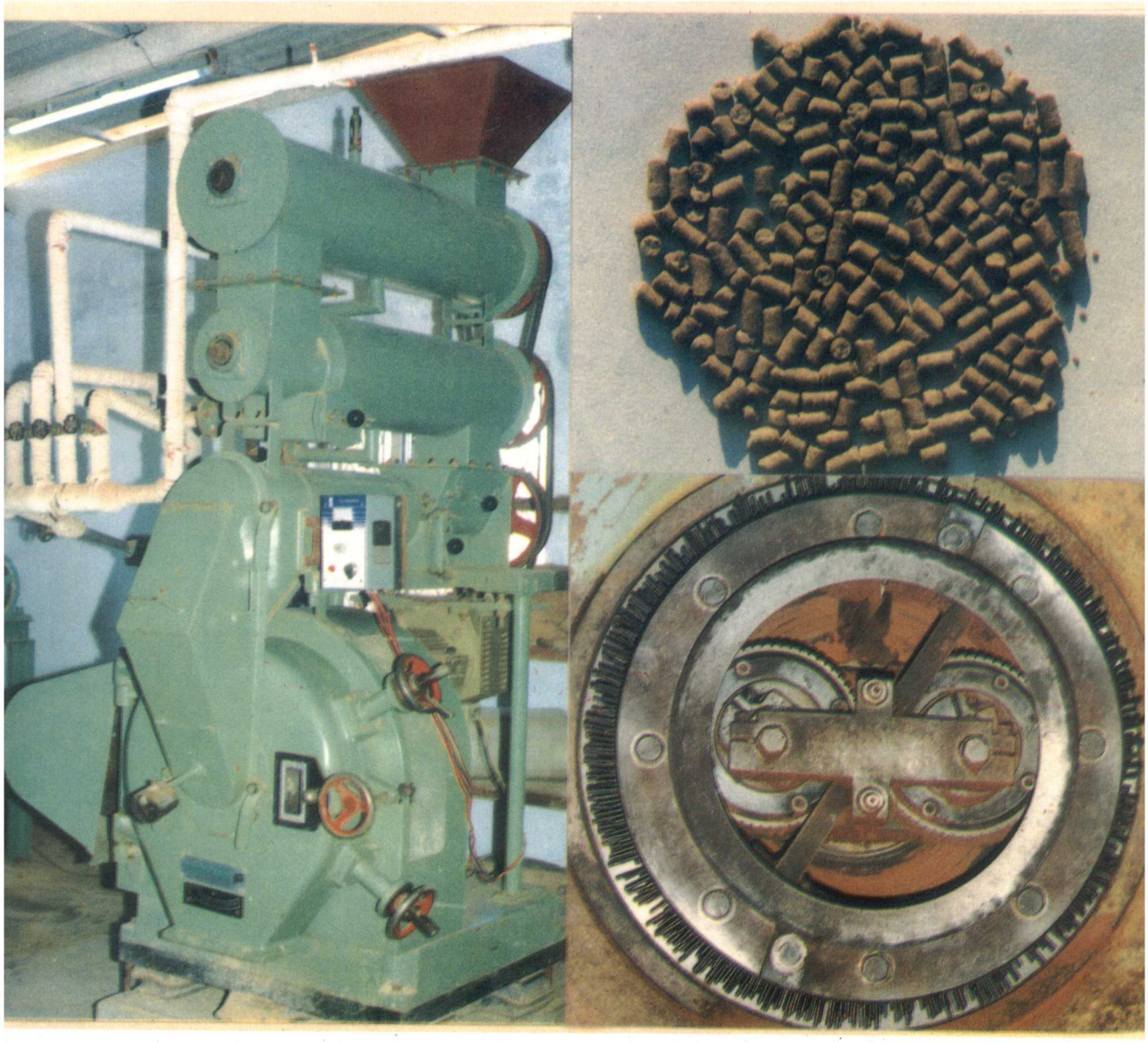
SHRIMP FEED PROCESSING AND PRODUCTION TECHNOLOGY



CIBA BULLETIN No. 13
MARCH 2000

केन्द्रीय खारापानी जलजन्तु पालन संस्थान
(भारतीय कृषि अनुसंधान परिषद)
नं १०१–बी, महालिंगपुरम मेन रोड़, चेन्नै–६०० ०३४.
CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE
(Indian Council of Agricultural Research)
101-B, MAHALINGAPURAM MAIN ROAD, CHENNAI - 600 034.

SHRIMP FEED PROCESSING AND PRODUCTION TECHNOLOGY

S. AHAMAD ALI, C. GOPAL AND J.V. RAMANA

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CHENNAI-600 034

Restricted Circulation

Published by : **Dr. G. R. M. Rao**
Director
Central Institute of Brackishwater Aquaculture
Chennai - 600 034.

Edited by : **Shri S. Srinivasagam,**
Shri M. Kathirvel &
Dr. (Smt.) Munawar Sultana,
Senior Scientists

Cover Photos: A Ring-Die pellet mill (left)
Shrimp feed pellets (top right)
Pellets extrusion from the Die (bottom right)

Back cover : Wet laboratory for shrimp feed evaluation

Printed at: **M/s. KJ Grapharts**
5, Alagar Perumal Koil First Street
Vadapalani, Chennai - 600 026.

PREFACE

Feed is one of the important and major inputs in shrimp aquaculture. Availability of good quality feeds at competitive prices to the shrimp farmers is essential for shrimp culture development in the country. The important shrimp feeds available in India are very expensive. It is in this context that the Central Institute of Brackishwater Aquaculture had come forward to undertake a Research and Development project for the development of feed technology for semi-intensive culture of tiger shrimp and the Indian white shrimp with the financial assistance from the Department of Biotechnology, Govt. of India, New Delhi. The project was successfully completed resulting in the development of indigenous shrimp feed processing and production technology. The Technology Bulletin is brought out based on the information generated and experience gained in the project. It is hoped that this feed technology will be utilized for commercial production of indigenous shrimp feeds in India and makes them available to the shrimp farmers at a competitive price.

I wish to record my appreciation to Dr. S.A. Ali, Principal Scientist, Dr. C. Gopal, Scientist (senior scale), Dr. J.V. Ramana, Scientist and all others who were associated with the project for bringing out this publication.

Chennai - 34.
20th March, 2000

Dr. G.R.M. RAO
Director

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1

INTRODUCTION

In India shrimp farming has emerged as a commercial enterprise as a result of the phenomenal growth during the last decade. Parallel to this growth the feed industry also developed in India and has become the central focal point in shrimp aquaculture. Both imported as well as indigenous feeds are marketed in the country. Since the imported feeds are expensive inspite of the duty reliefs given by the government, the indigenous feed industry mainly caters to the needs of farmers in producing the supplementary feeds, using empirical formulations. As development of nutritionally balanced feeds is one of the major contributing factors for growth of shrimp farming, the Central Institute of Brackishwater Aquaculture undertook a mission-oriented research project on nutritional studies of candidate species, namely, Tiger shrimp (*Penaeus monodon)* and Indian white shrimp (*P. indicus)*, identification and evaluation of suitable feed materials, formulation of balanced feeds and development of processing and production technologies using indigenously available raw materials and machinery. The Institute has developed shrimp feed technology for processing and production of different grades (Starter, Grower and Finisher) of pelleted shrimp feeds for semi-intensive culture of both tiger and Indian white shrimps.

The feeds were tested in yard experiments and also in grow-out ponds, which gave appreciable growth and feed conversion ratio (FCR). It is expected that indigenous shrimp feed technology developed by this Institute would help in producing quality and cost effective feeds for shrimp culture and become substitute for imported feeds and help in saving valuable foreign exchange for the country.

2

DIETARY REQUIREMENTS OF PENAEID SHRIMP

Understanding the nutritional requirements of candidate species of shrimp is essential before formulatig balanced feeds. Shrimp feed should have adequate energy for growth and survival, which is contributed by the three major nutrients, namely, protein, fat and carbohydrate. The feeds should have vitamins and minerals to avoid their deficiencies. Based on the available information, the dietary requirements of tiger and Indian white shrimps are summarised in Table 1.

Table 1. Dietary requiremnts of *P. monodon* and *P. indicus*

Nutrients	*Penaeus monodon*	*Penaeus indicus*
PROTEIN (%)	35 - 46	30 - 42
Essentail aminoacids (%)		
Arginine	3.71	3.06
Histidine	0.69	1.52
Isoleucine	0.61	1.55
Leucine	1.03	2.98
Lysine	3.16	2.40
Methionine	1.24	1.05
Phenylalanine	1.70	1.64
Threonine	1.61	1.47
Tyrosine	0.51	0.51
Valin	2.06	2.78
LIPID (%)	3.5 - 8.0	6.0 - 9.0
Essential fatty acids (%)		
Linoleic acid (18:2n-6)	0.05	--
Linolenic acid (18:3n-3)	0.10	--
Eicosapentaenoic acid(20:5n-3)	0.01	--
Docosa hexaenoic acid (22:6n-3)	0.005	--
Lecithin (%%	0.1 - 2.0	0.5 - 2.0
Cholesterol (%)	0.5	0.5
TOTAL ENERGY(kcal/100g)	280 - 370	350 - 400

Table 1. (Contd.)

Nutrients	*Penaeus monodon*	*Penaeus indicus*
MINERALS		
Calcium (%)	2.0 - 2.5	0.5 - 0.6
Phosphorus (%)	1.2 - 1.4	1.05
Potassium (%)	0.7 - 0.9	1.26
Magnesium (%)	0.08 - 0.15	Trace
Iron (mg/kg)	60 - 80	--
Zinc (mg/kg)	80 - 100	240
Manganese (mg/kg)	40 - 50	Trace
Copper (mg/kg)	8 - 10	13.6
Cobalt (mg/kg)	0.8 - 1.0	--
Iodine (mg/kg)	4.0 - 5.0	--
Chromium (mg/kg)	0.6 - 0.8	--
Selenium (mg/kg)	0.17 - 0.21	
VITAMINS (mg/kg)		
Riboflavin	40	80
Thiamine	120	100
Pyridoxine	120	200
Pantothenic acid	100	75
Niacin	150	250
Folic acid	5	--
Biotin	1.0	--
Vitamin B12	<0.1	--
Choline chloride	600	625
Inositol	2000	3000
Vitamin C plain	261.5	4000
Vitamin C protected	40.25	--
Vitamin D	0.025-0.05	--
Vitamin E	200	--
Vitamin K	40	--
Vitamin A	3-6	--

Source : Alagarswami and Ali (1999 - 2000).

3

FEED RAW MATERIALS

Identification and selection of raw materials is essential for formulating successful feeds. The indigenous animal and plant raw materials, which were analysed and tested for tiger and white shrimp are given in Table 2. Protein is the essential component of feed. The animal protein is indispensable for balancing the essential amino acids. The proportion of protein sources of animal origin is carefully fixed along with the plant protein sources in the feeds. Suitable carbohydrate sources, lipids rich in poly unsaturated fatty acids (PUFA), phospholipid and cholesterol, vitamin and minerals are identified and incorporated in the feed formulations.

A list of feed raw material suppliers is given in Annexure I.

Table 2. Proximate composition of selected feed ingredients

Ingredient	Percent on dry weight basis					
	Moisture	Crude Protien	Crude Fat	Crude Fiber	NFE	Ash
Fish meal	10.80	55.02	5.40	1.73	3.27	23.78
Prawn head meal	9.91	39.83	9.60	16.34	4.14	20.18
Squid meal	8.40	66.50	4.40	3.98	5.91	10.81
Mantis shrimp meal	10.70	44.23	4.40	5.69	4.34	30.64
Clam meat meal	10.10	49.96	8.66	Trace	23.53	7.75
Soybean meal	10.45	51.50	1.00	8.85	19.70	8.50
Ground nut cake	13.05	46.93	5.00	8.90	18.03	8.09
Sunflower cake	7.00	26.69	2.04	30.13	26.44	7.70
Gingelly cake	9.76	38.71	6.00	10.69	15.82	19.02
Wheat flour	12.50	12.50	2.00	1.75	70.00	1.25
Rice flour	12.50	8.07	0.33	Trace	78.64	0.46
Maida flour	12.26	11.07	0.33	Trace	75.19	1.15
Corn starch	13.20	1.78	0.40	1.00	82.62	1.00
Tapiocca flour	8.50	2.00	0.50	3.50	83.10	2.40
Yeast	1.40	56.10	2.14	0.33	30.18	9.85
Spirulina	7.80	60.89	9.00	7.53	1.78	13.00

4

FEED FORMULATIONS

The raw materials selected for feed formulations are proportioned in such a way that the protein, lipid and energy requirements of shrimp are met with. Generally, three grades of feeds are formulated to suit the growing stages of shrimp, namely post-larvae, juveniles and adults (marketable size). These grades are Starter, Grower and Finisher. Fish meal, squid meal, prawn head meal and mantis shrimp meal are selected as animal protein sources. Besides having representative levels of essential amino acids, these materials possess good attractant properties for shrimp. Shrimps are attracted to feed through chemoreceptors, which are distributed all over their body. Substances like free aminoacids present in feed act as attractants for shrimp. Such attractants and flavours are needed in shrimp feed for quick consumption and effective utilisation of feed.

Among the plant protein sources, soybean meal is one of the superior ingredients. Gingelly cake and sunflower cake are sparingly used along with soybean meal to balance the protein levels and also the essential amino acid profiles. Fish oil and lecithin (soya) are used to meet the PUFA and phospholipid needs respectively. Wheat flour and tapioca starch used are good sources of carbohydrate. Vitamin and mineral mixtures are prepared by mixing individual vitamins and minerals and homogenising them or commercial products are procured and used. Binders may be selected from among guargum, wheat gluten and polymethylocarbamide.

To prevent oxidation of fat in feed, antioxidants such as Butylated hydroxyamisole (BHA) (0.01 - 0.02% of fat content) or Butylated hydroxy-toluene (BTA) (0.01 - 0.02% of fat content) or Ethoxyquin (150 mg/kg of feed) are used. Mould inhibitors such as Sodium or Calcium Propionate at the rate of 0.2 to 0.5% of the feed are added.

The required nutrient levels for the different grades of feeds for tiger shrimp and white shrimp are given in Table 3.

Table 3. Required nutrient levels in different grades of shrimp feeds for semi-intensive farming

Nutrient	Tiger shrimp			White shrimp		
	Starter	Grower	Finisher	Starter	Grower	Finisher
Crude protein (%)	40-45	38-40	35-38	40-42	35-38	32-35
Lipid (%)	6-8	8-10	8-10	6-8	8-10	8-10
Carbohydrate (%)	10-16	15-20	20-25	10-15	15-25	20-30
Crude fibre (%)	1-2	1-3	2-4	1-2	2-4	3-5
Ash (%)	10-12	10-15	12-18	10-15	10-16	10-18
Energy (kcal/100g)	350-400	380-420	380-420	350-400	350-400	350-400
Vitamin mix (mg/kg)	0.5-2	0.5-2	0.5-2	0.5-2	0.5-2	0.5-2
Mineral mix (g/kg)	2-5	2-5	2-5	2-5	2-5	2-5

5

PROCESSING AND PRODUCTION OF FEED

The feed production involves grinding of raw materials, mixing, steam conditioning, pelletization, grading and packing, which contribute to the production of good quality feeds.

A list of suppliers of feed mill machineries is given in Annexure II.

5.1. Grinding of raw materials

Grinding of dry solid raw materials to a specific particle size is essential. Materials like dry fish, squid, prawn head etc. are individually powdered in two stages. In the first stage, these materials are passed through a hammer mill fixed with a 5 mm sieve for size reduction. In the second stage, the coarse material is powdered in a micropulverizer and passed through a sieve to a particle size of not more than 300 microns. Larger particles are recycled.

5.2. Mixing

The powdered ingredients are mixed as per the desired feed formulation and homogenized in a horizontal ribbon mixer. Required quantity of vitamin premix and mineral premix are also added and blended for 20-30 minutes. Liquid ingredients such as fish oil, lecithin and water (if required) are added at this stage for obtaining a homogenous feed mix. Binder also is added for uniform distribution.

5.3. Steam conditioning

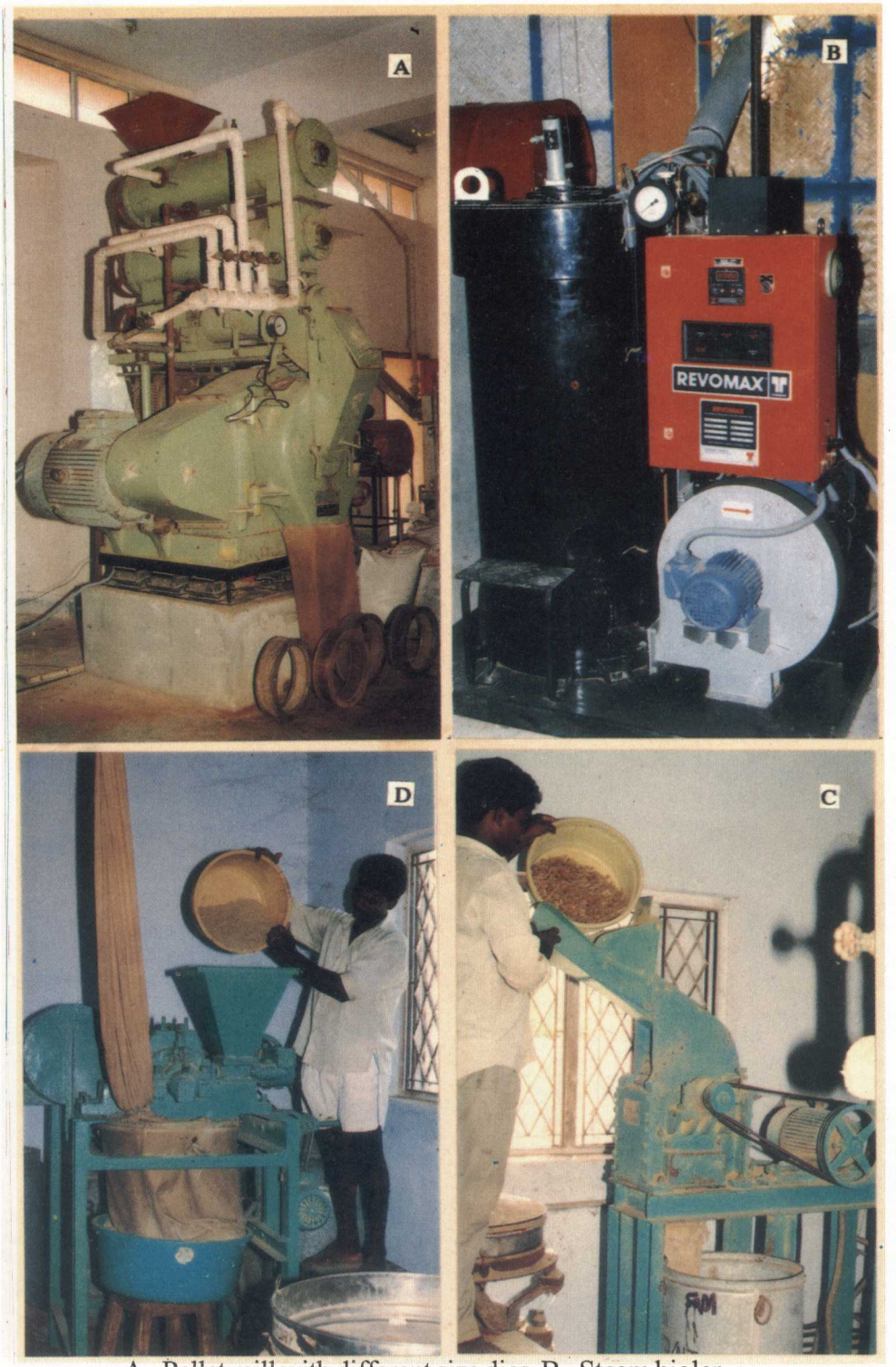
The homogenized feed mixture is steam conditioned by passing through steam chambers in three stages for gaining moisture, binder-raw material interaction, gelatinization of starch and finally sterilization of feed. Steaming of feed also facilitates lubrication of feed material to pass through the pelleting die. The steam conditioning chambers are generally attached to the pellet mill itself. These can also be separately installed so that the process is completed before the feed mix enters the pelleting die.

5.4. Pelletization

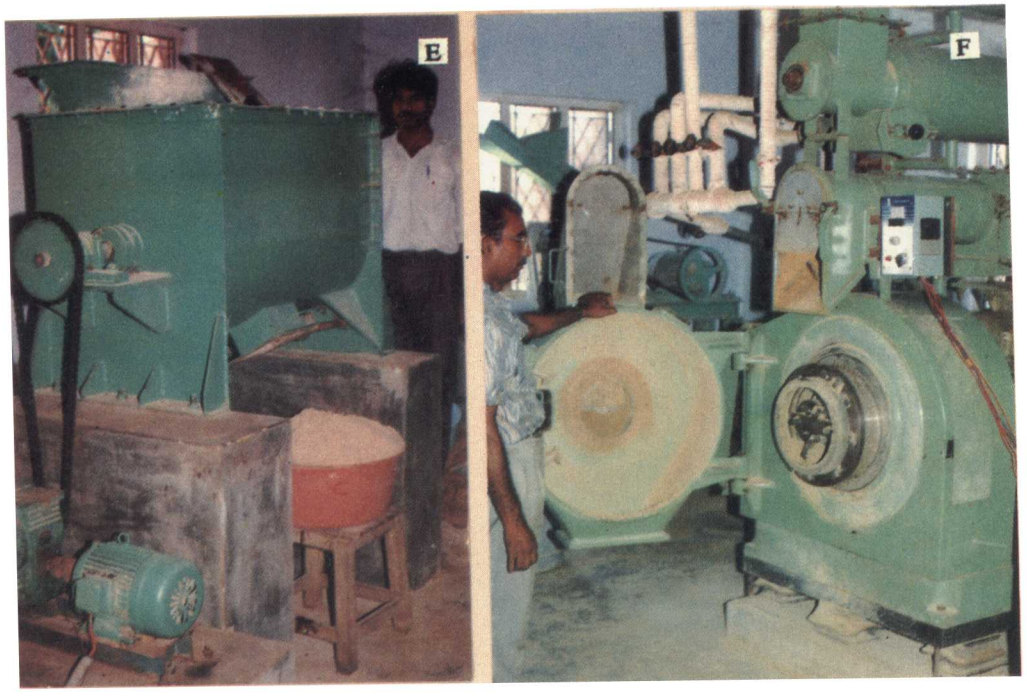
Shrimp feeds are produced in pellet form. Ring-die pellet mill is used for commercial production of shrimp feed. The feed production technology described here is based on the ring-die pellet mill, which is indigenously available. It has three steam conditioning chambers attached to it. The feed mixture after passing through the steam conditioning chambers enters the pelleting chamber which has a rotating die and two rollers. The feed mixture with adequate level of moisture (16-17%) is compacted into pellets as it passes through the die. The pellets are cut with an attached knife assembly. The length of the pellet can be regulated by adjusting the knife. The smooth working of the pelleting machine and the quality of feed pellets depend on the moisture level in the feed just before it enters the pelleting chamber, temperature and consistency of the feed mixture. Moisture levels from 15 to 18% are found to work satisfactorily. Higher moisture levels make the feed lumpy and choke the pelleting die. Similarly, the lower moisture levels also choke the die due to insufficient lubrication for the material to pass through.

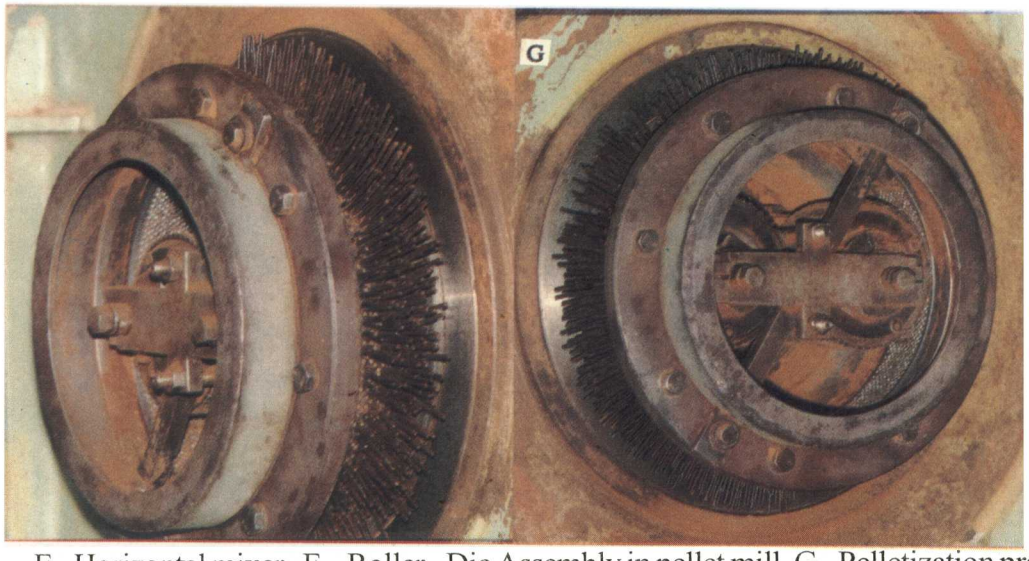
5.5. Preparation of different grades of feeds

The nutrient levels for starter, grower and finisher grade feeds for shrimp are presented in Table No. 3. The physical shape and size of feeds play an important role in feed consumption and feed efficiency by the growing shrimp.

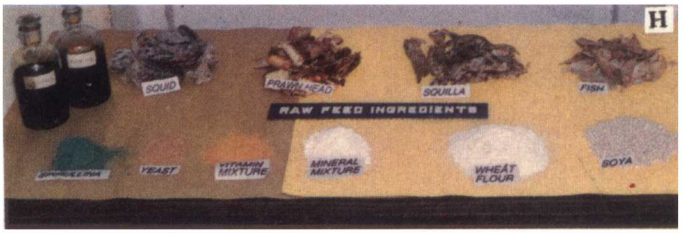


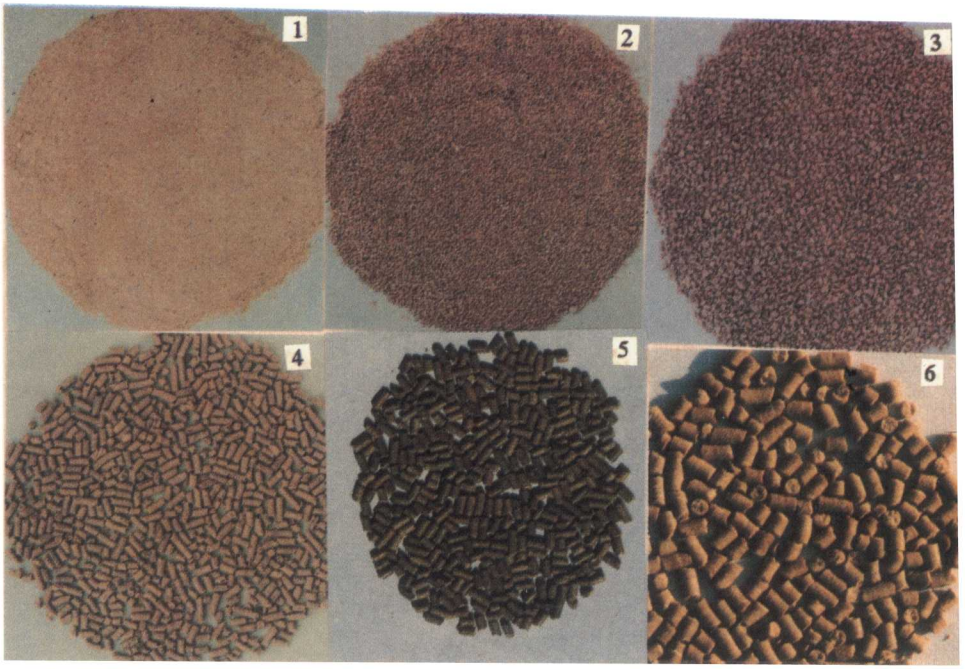
A - Pellet mill with different size dies, B - Steam bioler,
C - Hammer mill, D - Micro-pulverizer





E - Horizontal mixer, F - Roller - Die Assembly in pellet mill, G - Pelletization process

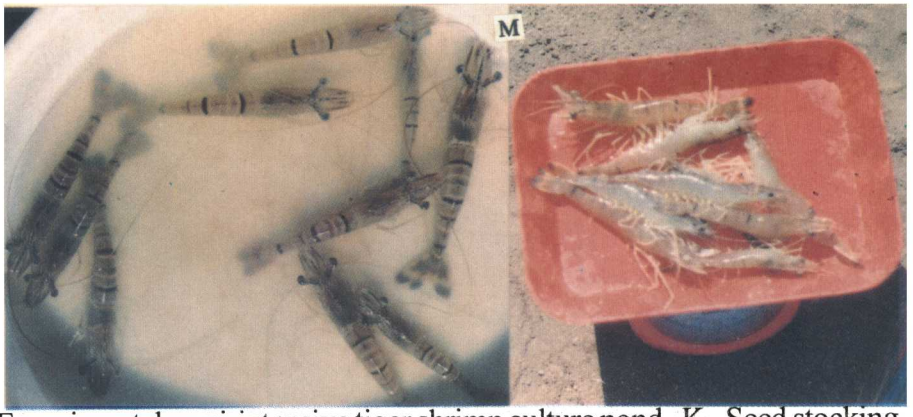




H - Feed raw materials.

Different grades of feeds : 1. Pre-starter, 2. Starter I, 3. Starter II, 4. Starter III, 5. Grower, 6. Finisher

I. Commercial packing of shrimp feeds



J - Experimental semi-intensive tiger shrimp culture pond. K - Seed stocking.
L - Feed check tray. M - Cultured shrimp grown on indigenous feed.

Soon after stocking, the post-larvae need starter feed in granular form of 200 to 500 micron size. The size of feed should be increased to 1.0 mm as the shrimps grow to 2-5 g. The shrimps require grower feed in the pellet form of 1.8 to 2 mm diameter with 3-5 mm length, when they attain a weight of 15-20 g. After that, finisher feed with pellet size of 3-5 mm in length and 2.0 - 2.5 mm in diameter is used for feeding.

The granular feeds of 200 microns, 500 microns and 1.0 mm size are prepared from the pellets by passing through a crumbler and appropriate size sieves. The finer particles are recycled. The grower and finisher grades are directly produced in pellet mill using the required size pelleting die and cutting device.

5.6. Drying

Shrimp feed pellets coming out of the ring-die pellet mill will have a moisture level of 12-14% depending upon the initial moisture. This does not require long drying of pellets. However, it is necessary to reduce the moisture below 10% for a good shelf-life of the feed. Otherwise mould (fungus) growth may develop leading to feed spoilage. The feed is therefore dried for a short period by passing through a hopper type drier/cooler, in which, the feed is passed from the top of the hopper as the dry/cool hot air rises upwards.

5.7. Feed packing and storing

Shrimp feed is packed in laminated HDP bags of 25 kg each. The feed bags should be packed properly so that the feed does not absorb moisture easily. The feed bags are stored by stacking one over the other in a well ventilated premises. Storing of feed at 10°C helps in keeping the shelf-life of the feed for long.

5.8. Flow diagram of feed processing

The processing and production of shrimp feed is summarised in a flow diagram (Fig. 1).

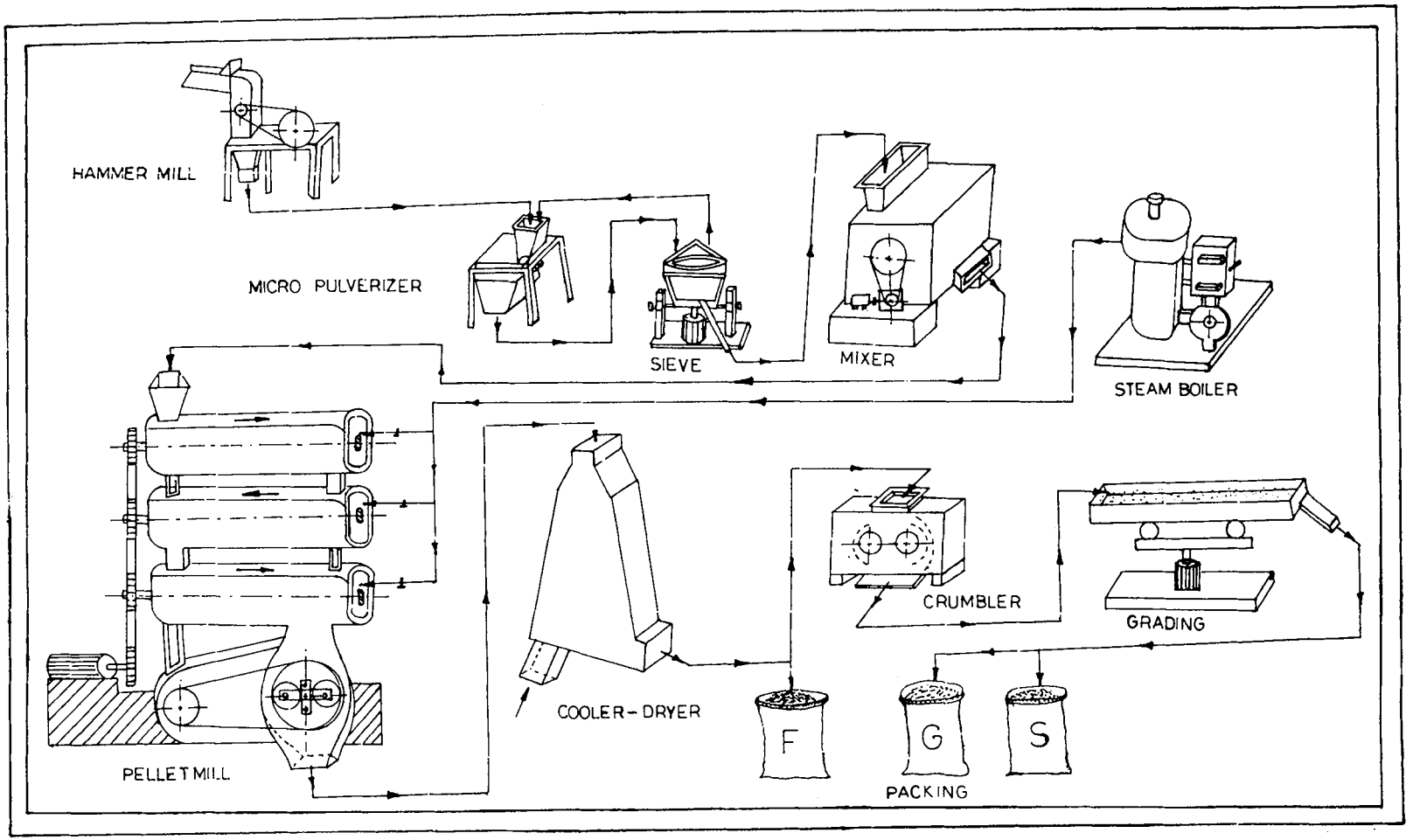


Fig. 1 : Flow diagram of shrimp feed processing and production

6

WATER STABILITY

Shrimp feed pellets should retain the shape (should not disintegrate) for a reasonable time when they are put into water column for feeding shrimp. This could be achieved by using suitable binding materials. This is known as water stability of feed. Starch present in feed formulation acts as binder if it is properly gelatinized. In ring-pellet mill the moisture level in feed is only 16-17% which is not sufficient to fully gelatinize the starch. Hence, additional binders are used, namely, guargum, wheat gluten and polymethylocarbamide (commercial name Aquastab). The feed pellets produced using these binders have a stability of 6-8 hours in water.

7

FEEDING AND FEED MANAGEMENT IN SHRIMP FARMING

The feeds developed are suitable for semi-intensive farming of *Penaeus monodon* (tiger shrimp) and *P. indicus* (white shrimp). It is recommended that the stocking densities can be between 10 to 20 / m^2 when the production levels would be around 2000 to 4000 kg/ha/crop.

Feed conversion ratio of 1.6 to 2.0 : 1 could be obtained depending upon the feed management and water quality. The recommended feeding schedules (based on results obtained in a farmer's fields) are given in Table 4.

Table 4. Rate of feeding and quantity of feed given in a semi-intensive culture of *P. monodon* with a stocking rate of 10 /m^2 ; Area: 1 ha

Culture period (Week after stocking)	Average weight of shrimp (g)	Survival (%)	Rate of feeding (% of body weight)	Quantity of feed used per week (kg)
1	0.5	90	--	14.0
2	1.0	89	--	28.0
3	2.0	88	6.0	74.2
4	2.9	87	5.5	97.3
5	3.9	85	5.0	116.3
6	5.0	84	4.8	141.4
7	6.2	84	4.6	167.3
8	7.5	83	4.4	191.8
9	9.0	82	4.0	206.5
10	11.0	80	3.8	233.8
11	14.0	78	3.4	259.7
12	16.0	76	3.2	272.3
13	18.5	75	2.8	272.3
14	20.0	74	2.7	280.0
15	22.5	73	2.5	287.0
16	25.0	72	2.3	289.8
17	28.0	71	2.1	291.9
18	31.0	70	2.0	303.8
19	33.0	70	2.0	323.4
20	35.0	70	1.9	323.4

Total feeds used: 4174 kg; Total shrimp production: 2450 kg; FCR : 1.70 : 1

8

COSTS AND RETURNS ANALYSIS

The shrimp feed mill consists of the following machinery for processing raw materials and producing feed: hammer mill and micro-pulveriser for grinding of raw materials, sieve assembly for obtaining uniform particle size for all the ingredients; horizontal ribbon mixer for preparing homogeneous feed mix; steam boiler for steam conditioning of feed mix and imparting binding; ring-die pellet mill for producing desired size feed pellets and hopper type drier - cooler for drying and cooling the feed and packing materials for packing. The capacity of feed mill and approximate costs of infrastructure and machinery are given below.

A. FIXED COSTS

(Capacity of the feed mill: 1 tonne feed per hour; Minimum production: 2000 tonnes per annum)

	Capacity & Specification	Approximate cost (Rs in lakhs)
A building with asbestos roofing	350 sq. mt	10.50
Hammer mill	1 tonne/hr. full circle	2.00
Micropulverizer	1 tonne/hr. screenless, cyclone separator, air lock, air ducting, canvas bag filter	2.50

Homogenizer (mixer)	1 tonne/batch	1.00 (Ribbon mixer)
Sieve assembly	Rotating drum type with variable mesh screen facility	1.00
Steam boiler	200 kg steam/hr. 10 kg/cm^2 pressure LDO as fuel	2.50
Ring-die pellet mill	1 tonne/hr. three steam conditioners, 3 dies (2.5 mm, 2.3 mm & 2.0 mm) 75 HP motor	6.00
Drier-cooller	1 tonne/hr. Vertical hopper type with raising hot/cool air from below	1.50
Pellet crumbler	200 kg/hr. twin-roller, adjustable gap motor driven	2.00
Ancillaries		2.00
Conveyor system		2.50
Installation charges		2.50
Total		35.00

B OPERATIOANAL COSTS (per annum)

Salaries & wages

Designation	No.	Rs	(Rs in lakhs)
Supervisor	1	0.48	2.88
Technician (Mechanical)	1	0.30	
Technician (Electrical)	1	0.30	
Skilled workers	10	1.80	

Cost of production of 2000 tonns of feed

Feed materials (@ Rs 22,000/- per ton)	440.00
Electricity & water charges	12.00
Packing cost	7.68
Maintenance cost	3.50
Contingencies	1.00
Interest on fixed cost (@ 18%)	6.30
Depreciation on machinery (@ 10%)	2.30
Total	475.66

C. RETURNS

Sale price of 2000 tonnes of feed (@ Rs. 30/- per kg)	600.00

D. GROSS PROFIT (C - B) 124.34

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ACKNOWLEDGEMENTS

The financial support received from the Department of Biotechnology, Govt. of India, New Delhi for the research Project on development of shrimp feed technology is gratefully acknowledged. The authors express their sincere thatnks to Dr. K. Alagarswami, former Director and Dr.G.R.M. Rao, present Director, Central Institute of Brackishwater Aquaculture, Chennai for their constant encouragement in carrying out the work. Thanks are due to Sri. A.R.Nazar, Smt. B. Sampoornam, Sri. Arul Vasu and Sri. T. Vaitheeswaran, Senior Research Fellows and Sri. P. Selvakumar, Technical Assistant, for their association in the project work.

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ANNEXURE -I

List of suppliers of feed raw mateials

1.	Amalgam Aquaculture Applications Ltd., Amalgam House, Bristow Road, Willingdon Island, COCHIN - 682 003, Kerala.	All marine porducts fish meal, shrimp meal, fish oil etc.
2.	Janatha Fish meal & oil products Manur Fisheries Road KOTA - 576 221, Karnataka.	Fish meal & fish oil
3.	Karnataka Fisheries Development Corporation, Fish meal plant, Baithkole, KARWAR - 581 302, Karnataka.	- do -
4.	Mukka oil and sea food Industries, Mission Street, MANGALORE - 575001, Karnataka.	- do -
5.	Noorsons Cresent Industries, 22(a), Sewree Cross, MUMBAI - 400 015, Maharashtra.	- do -
6.	Circar Marine Industries, Bhidya, VERAVAL - 382 269, Gujarat.	- do -
7.	Sakthi Soyas Limited, 180, Race Course Road, COIMBATORE - 641 018, Tamil Nadu.	Soybean meal
8.	Soya Good Rich Limited, A-3, Nehru Stadium (opposite), Jayanagr, SHIMOGA - 577 201, Karnataka.	- do -

9.	Indras Agencies (P) Ltd., 128, Wall Tax Road, CHENNAI - 600 003, Tamil Nadu.	Soybean meal & Soya lecithin
10.	S.R.V. & Co., 2, Subbaraya Street, Nungambakkam, CHENNAI - 600 034, Tamil Nadu.	Feed binders
11.	Southern India Aquaculturist, No.8, Giri Road, T.Nagar, CHENNAI - 600 017, Tamil Nadu.	All feed materials
12.	Bharat Starch Industries, 12, DLF Industrial Area, 13/7 Mathura Road, FARIDABAD - 121003, Uttar Pradesh.	Gel starch (binder) & Corn gluten
13.	Bharat Starch Industries, 205, Thambu Chetty Street, CHENNAI - 600 001, Tamil Nadu.	- do -
14.	Punjab Maize Products Ltd., A-8, DLF Industrial Estate, FARIDABAD - 121 003, Uttar Pradesh.	Wheat gluten (binder)
15	Om Muruga Energy Feeds, SP 122, Industrial Estate, 3rd Main Road , (opp. Telephone Exchange), Ambattur, CHENNAI-600 058, Tamil Nadu.	Soya cake, dry fish etc.,
16.	M/s. P. A. P. Sahib & Co., Dry Fish Merchants & Commission agents, 11, Wall Tax Road, CHENNAI - 600 079, Tamil Nadu.	Dry fish, prawn head, mantis shrimp etc.,

ANNEXURE - II

List of suppliers of feed mill machinery

1.	Cremach Designs, 893/4, G.I.D.C. Industrial Estate, Makarpura, BARODA - 390 010, Gujarat.	Whole feed mill machinery & installation
2.	Precision Products, 2007, Phase IV, GIDC Estate, Vatva, AHMEDABAD - 382 445, Gujarat.	-do-
3.	Spectoms Engineers Pvt. Ltd., Purushottam Estate, Bahucharji Road, BARODA - 390 018, Gujarat.	-do-
4.	Forms and Gears, L-3, Industrial Estate, Guindy, CHENNAI - 600 032, Tamil Nadu.	Ring-die pellet mill
5.	Basic Technology Pvt. Ltd., 2/2B, Nandy Street, CALCUTTA - 700 029, West Bengal.	Pilot scale extruder only
6.	Naz Industries, Autonagar, VIJAYAWADA - 520 007, Andhra Pradesh.	Small-scale feed production units

CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

(Indian Council of Agricultural Research)

Headquarters

Director
Central Institute of Brackishwater Aquaculture
No.101-B Mahalingapuram Main Road
Chennai 600 034
Telephones:

Director	8218125
	8218126
Head of Office	8218176
Office	8218178
	8218179
Computer Room	8218171

Telegram : MONODON
Fax : 091-44-8218126, 8218176
Email: ciba@tn.nic.in

Muttukadu Experimental Station

Officer-in-Charge
Muttukadu Experimental Station of CIBA
Kovalam Post
Muttukadu 603 112
Tamil Nadu
Telephone: 91545344
04114-45344

Kakdwip Research Centre

Officer-in-charge
Kakdwip Research Centre of CIBA
Kakdwip 743 347
West Bengal
Telephone: 03210-55072

Puri Research Centre

Officer-in-charge
Puri Research Centre of CIBA
15, B.S.Nagar, Talbania,
Puri 752 002,
Orissa
Telephone: 06752-23381


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