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Developing *Artemia* Enriched Herbal Diet for Producing Quality Larvae in *Penaeus monodon*, Fabricius

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Abstract

Post larvae (PL1– 30) of *Penaeus monodon* were fed five different herbal medicinal diets namely MD1, MD2, MD3, MD4 and MD5, prepared using *Hygrophila spinosa, Withania somnifera, Zingiber officinalis, Solanum trilobatum, Andrographis paniculata, Psoralea corylifolia* and cod-liver oil. *Artemia franciscana* nauplii and pre-adults were enriched with the above five diets and fed to the larvae of *P. monodon*. Survival, bioenergetics and specific growth rate were studied. To evaluate the quality of post larvae, they were subjected to salinity (0 and 50‰), pH (6 and 10) and formalin stress (80 and 160 ppm) shocks. Post larvae fed the herbal medicine enriched *Artemia* survived to a maximum of 95% in the MD1 group whereas the unenriched *Artemia* fed group showed only 89% survival. The unenriched *Artemia* fed group consumed 103.78±0.93 mg·animal·30 days food whereas the herbal medicinal diets helped to increase the food consumption significantly ($P<0.05$) and the MD1 enriched groups consumed the maximum (121.68±1.84 mg·animal·30 days) food. A similar pattern was also noticed in absorption, production and metabolism. The average absorption efficiency (86.17%) was not significant ($P>0.05$). The unenriched *Artemia* fed post larvae had a conversion efficiency of 17.47±0.21% whereas in the herbal medicinal diets enriched *Artemia* fed groups, efficiency increased significantly ($P<0.05$) to a maximum of 20.29± 0.23% in the MD1 fed group. The same pattern was also observed in net production efficiency. Specific growth rate also increased from that of the unenriched group. Among the five different herbal medicinal diets enriched *Artemia* and unenriched *Artemia* fed groups, when subjected to stress test, the MD1 group exhibited the highest resistance followed by MD3, MD5, MD4 and MD2 enriched *Artemia* fed groups.

Introduction

Shrimp culture is considered as one of the lucrative industries due to the high market price of shrimp and the unlimited demand for it in the international market. The world market of shrimp has expanded rapidly in recent years reaching about US $6.5 million, 7% of which is India's contribution. By virtue of its geographical location in the Indian Ocean, India possesses a rich shrimp ground in the sea and offers immense potential for shrimp farming (Varghese 1995). Anticipating a target production of 200,000 mt by year 2010, the Marine Product Export Development Authority (MPEDA), has envisioned the hatchery production of quality shrimp seed of 24.0 billion post larvae (PL–20). For a sustained growth of the aquaculture industry, regular supply of adequate quantities of quality seeds is one of the prerequisites. Quality seeds are those that ensure high growth rate, low mortality and can withstand stress during culture (Santhanakrishnan and Visvakumar 1995).

To produce quality shrimp, broodstock selection is very important, while sound management during the larval rearing activities is necessary to produce quality shrimp fry. A reduction in the use of chemicals and drugs or addition of hormones would increase the natural immunity of shrimp larvae (Sorgeloos 1992), though providing sufficient nutrients to the larvae and preventing bacterial infections are still the most important.

Major impacts could be documented on improved larviculture outputs, not only in terms of survival, growth and success of metamorphosis, but also with regard to their quality, e.g. reduced malformations, improved pigmentation and stress resistance (Sorgeloos 1994). Although hormones have positive effects on the growth of prawn (Sambhu 1996) these cannot be recommended in commercial aquaculture operations due to their residual effects in the muscle of prawn.

Outbreaks of bacterial diseases are also taken into account in shrimp larvae through the application of antibiotics to cure the diseases. But it is not economical and advisable because it needs continuous and large volume of water exchange for the toxic effect on fish to subside. Sparks (1981) explained that drug resistance may be due to preexisting factors in the microorganisms, or it may be due to some acquired factor(s). Due to the residual effect and developing resistance in the use of antibiotics, hormones, drugs and vitamins, a search for an alternative source of natural herbal origin is necessary. Though this will increase the production cost, India's vast and inexhaustible resource of drugs of plant origin can be utilized to address the above said need. The systematic investigation of these drugs used in indigenous medicine on modern scientific lines was started more than thirty years ago and much has been accomplished during this short period of time (Zafer 1994).

Plants are the storehouses and rich sources of safe and cheap chemicals. These plant products have been reported to have various activities like anti stress, growth promoters, appetizer, tonic, immunostimulants and antimicrobials. They are highly promising for utilization in the aquaculture industry in producing quality seed. In the present work, herbs such as *H. spinosa, W. somnifera, Z. officinalis, S. trilobatum, A. paniculata and P. corylifolia* having

the above mentioned characteristics were fed to *A. franciscana* along with cod-liver oil because of its versatile characteristic of encapsulating any product without discriminating its chemical nature.

Materials and Methods

Mysis stage of *P. monodon* purchased from the Trisea Shrimp Hatchery, Chettikulam, Tamilnadu, India, were acclimatized to laboratory conditions and reared till they reached the post larval stage (PL1). Before starting the experiment they were starved for 12 h. The length as well as the weight were measured.

The above mentioned herbal medicines were selected based on their biological effects. All these products were processed as micronized particles (<50 µm). The detailed descriptions of the herbal products are given in table 1. With the help of the six micronized herbals five different diets were prepared. Diets 4 and 5 were further enriched with cod-liver oil (Table 2).

A. franciscana nauplii (San Francisco Bay brand) were hatched out from the cysts. These nauplii were reared in laboratory conditions and fed with rice bran juice. After four days they are ready for enrichment. The 4-day old nauplii (for feeding to the earlier post larval stages) and pre-adults *A. franciscana* (for feeding to the late post larval stages) were enriched with five different herbal medicinal diets at a concentration of 400 mg·l (Citarasu 2000). This is the optimal concentration for herbal micronized powder. Enrichment was carried out for 48 h afterwhich, the enriched *Artemia* were fed to the post larvae. Average leaching was calculated by analyzing the nutrient contents of

Table 1. Detailed description of the herbal medicinal ingredients.

Sl. no.	Botanical Name	Family	Distribution	Useful parts	Active Principles	Biological effect
1	*Hygrophila spinosa*	Acanthaceae	India and Ceylon	Whole herb	Astrol I to IV Asteracanthine and Asteracan thicine	Growth promo ter, tonic, nut ritive, aphrodi-siac, etc.
2.	*Withania somnifera*	Solanaceae	Western India and Bengal	Roots, fruits. seeds, leaves	Withanine Withananine and Somniferine, etc.	Immunostimu lant, nervine tonic, alterna-tive, aphrodi siac, etc.
3.	*Zingiber officinalis*	Zingiberaceae	India and Bengal	Rhizome	Zingiberene Gingerol and Camphene, etc.	Appetizer, sti-mulant, diges-tive, etc.
4.	*Solanam trilobatum*	Solanaceae	India	Leaves, flower, roots, bolls	Solanine	Antibacterial, cardiac tonic, expectorant, etc.
5.	*Andrographis paniculata*	Acanthaceae	India and Bengal	Whole herb	Andrographolid	Antiviral, ant-helmintic, alte rative, antipy-retic, etc.
6.	*Psoralea corilifolia*	Papilonaceae	India	Seeds	Psoralen Psoralidin and Raffinose, etc.	Antifungal, antibiotic, ant helmintic, etc.

suspended enriching herbal products in regular intervals such as 0, 20, 40 and 60 mins. During these time intervals, changes in nutrients composition were analyzed. The average values derived from the above three time intervals revealed the leaching rate. The feed particle consumed by the enriching organisms will have a particular nutrient value in relation to the enriching time. The biochemical composition such as protein lipid and carbohydrate were analyzed following the method of AOAC (1990).

Two types of feeding experiments were carried out. Experiment I was performed mainly to assess the survival and resistance to stress. The first experiment was conducted in a continuous flow system. The culture troughs (10 l capacity having 100 PL's) received filtered water from the upper reservoir tank through a regular drop flow via a small aerator tube at the rate of 5 ml·min. When the water level in the troughs rises, excess water passes out through the filter let-outs and collects in the effluent tank via a standpipe filter. Healthy and quality post larvae were stocked in the culture tanks at a density of 10 l and five replicates were maintained for all types of diets. Mild aeration was given continuously to maintain the O_2 level. The mean salinity (30.9±0.80‰), temperature (24.65±0.66ºc), pH (8.15±0.12), dissolved oxygen (4.77±0.23 mg·l) and ammonia (0.077±0.01 mg·l $NH4^{-N}$) were recorded during the culture period. The post larvae of *P. monodon* (PL30) from Experiment I (after the end of the experiment) were challenged to salinity (0 and 50‰), pH (6 and 10) and formalin (80 and 160 ppm) stress following the method of Tackaert et al. (1989).

Experiment II was performed to assess the bioenergetics. Post larvae (2 PL's/l) were reared in a glass aquaria (5 replicates of each) containing 1 l of seawater. Enriched and unenriched *Artemia* of mean weight (2.05±0.15 of nauplli and 6.05±0.39) were given *ad libitum* to both experiments. In the earlier post larval stages about 100 *Artemia* nauplii were fed and later stages (PL10 and above) about 7 to 9 pre-adult *Artemia* were fed by the post larvae. The following bioenergetics parameters were estimated using the formula of Marian and Murugadass (1991).

Table 2. Ingredients and percentage composition of different herbal medicinal diets (MD).

Ingredients	Composition (%)				
	MD1	MD2	MD3	MD4	MD5
Hygrophila spinosa	50	40	30	25	40
Withania somnifera	25	20	30	25	25
Zingiber officinalis	10	10	10	10	10
Solanum trilobatum	5	10	10	10	5
Andrographis Paniculata	5	10	10	10	5
Psoralia corylifolia	5	10	10	10	5
Cod liver oil	Nil	Nil	Nil	10	10

· Consumption(C)

Food consumed = Weight of food given – Unfed

· Absorption (A)

Food absorbed = Food consumed – Faeces

· Absorption efficiency (Ae)

$$= \frac{\text{Absorption}}{\text{Consumption}} \times 100$$

· Metabolism (M)

Food absorbed – production

· Production (P)

Final body weight–Initial body weight (dry)

· Gross conversion efficiency (K_1)

$$= \frac{\text{Production}}{\text{Consumption}} \times 100$$

· Net conversion efficiency (K_2)

$$= \frac{\text{Production}}{\text{Absorption}} \times 100$$

· Specific growth rate

$$= \frac{(\ln W_2 - \ln W_1)}{(t_2 - t_1)} \times 100$$

Where

ln = Logarithmic number

W_2 = Final weight at time t_2

W_1 = Initial weight at time t_1

The data obtained were statistically analyzed using Student Newman Keuls (SNK) test and one-way ANOVA following Zar (1974).

Results

The average nutrient leaching rate was calculated up to 60 mins and is given in table 3. Among the different diets, a 3 to 8%, 7 to 15% and 9 to 12% leaching were noticed in protein, lipid and carbohydrate respectively.

Post larvae of *P. monodon* showed 89% survival when no herbal enrichment was given in the live feed. The same survival was also observed in the MD2 group. Survival was increased to 90, 92, 93 and 95% in the MD4, MD3, MD5 and MD1 enriched *Artemia* fed post larvae respectively (Fig.1).

Consumption of 103.78±0.93 mg·animal·30 days was observed when the post larvae were fed with unenriched *Artemia*. The herbal medicinal diets enriched *Artemia* fed groups increased the consumption significantly ($P<0.05$). The MD1 enriched *Artemia* fed groups achieved the maximum consumption (121.68±1.84 mg·animal·30days) which is 17.24% higher than the unenriched

Artemia fed group. The same trend was also observed in absorption. The lowest food absorption was 90.16 mg·animal·30 days noticed in the unenriched *Artemia* fed group. The highest absorption of 104.41±1.48 mg·animal·30 days was evidenced in MD1 enriched *Artemia* fed group. The absorption did show significant ($P<0.05$) difference.

The post larvae fed on unenriched *Artemia* had a production of 18.14±0.30 mg·animal·30 days. This was significantly increased ($P<0.05$) to 21.49±0.31, 22.540.62, 23.12±0.66, 23.86±0.10 and 24.7±0.14 mg·animal·30 days in MD2, MD4, MD5, MD3 and MD1 enriched *Artemia* fed groups respectively. A 36.16% increase in production was observed in the MD1 enriched *Artemia* fed groups than in the unenriched group. Metabolism also revealed that the herbal medicinal diets enriched *Artemia* fed groups varied significantly ($P<0.05$) from the unenriched groups. In the unenriched *Artemia* fed group, the conversion efficiency was 17.47±0.21%. This efficiency was significantly increased ($P<0.05$) in the enriched *Artemia* fed groups and little variation occurs among the enriched groups. The net production efficiency (K_2) reflects the same pattern as that of gross conversion efficiency (K_1). The efficiency was 19.51±1.28% observed in the unenriched *Artemia* fed

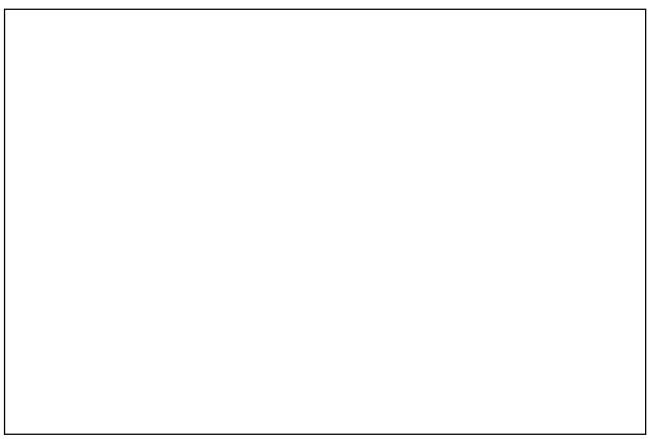


Fig. 1. Survival (%) of *Penaeus monodon* shrimp post larvae (PL1-30) fed on different herbal medicine diets enriched *Artemia franciscana*.

Table 3. Changes in the biochemical composition during leaching.

Enrichment	Protein (%)		Lipid (%)		Carbohydrate (%)	
	Before leaching	After 60 mins (Average)	Before leaching	After 60 mins (Average)	Before leaching	After 60 mins (Average)
Control	55.23 ± 2.13	55.23 ± 2.13	4.92 ± 0.38	4.92 ± 0.38	19.55 ± 0.42	19.55 ± 0.42
MD1	62.63 ± 0.44	60.63 ± 2.20	6.03 ± 0.09	5.45 ± 0.42	13.71 ± 0.69	12.41 ± 0.45
MD2	61.50 ± 2.17	58.85 ± 1.51	5.95 ± 0.42	5.34 ± 0.33	15.05 ± 0.92	13.35 ± 0.54
MD3	60.50 ± 2.17	58.30 ± 1.70	6.20 ± 0.26	5.22 ± 0.27	15.51 ± 0.50	13.51 ± 0.67
MD4	61.00 ± 2.64	57.63 ± 1.69	8.25 ± 0.43	7.67 ± 0.33	13.85 ± 0.30	12.54 ± 0.57
MD5	63.20 ± 1.47	58.14 ± 1.50	8.90 ± 1.35	8.08 ± 0.28	12.15 ± 0.36	11.24 ± 0.31

group. This was significantly increased to ($P<0.05$) 22.41±0.14, 22.75±0.44, 23.29±0.48, 23.57±0.03 and 23.65±0.25% in the MD2, MD4, MD5, MD3 and MD1 enriched *Artemia* fed groups respectively (Table 4). The specific growth rate (%) is given in table 5. The lowest specific growth rate (11.62±0.12%) was observed in the unenriched *Artemia* fed group. The herbal medicinal diets helped to increase the specific growth rate significantly ($P<0.05$) and varied slightly. The average specific growth rate in the enriched *Artemia* fed groups was 12.40%.

After 30 days of culture, marked differences in the ability of the post larvae to survive against the osmotic, pH and formalin stress were detected among the five enriched and unenriched diets. In 0‰ salinity stress, the unenriched *Artemia* fed group succumbed to death within 80 min while the enriched *Artemia* fed groups was able to tolerate it to a maximum of 140 min (Fig. 2a.). The same pattern was observed in the 50‰ salinity stress. The unenriched *Artemia* fed group tolerated it for 390 min, but in the herbal treated ones survival increased to 450, 480, 510, 540 and 570 min in MD2, MD4, MD5, MD3 and MD1 respectively (Fig 2b). The pH stress (6 and 10), is illustrated in figures 2c and 2d. In the post larvae exposed to 6 pH, maximum tolerance was observed for 600 min in the MD1 enriched *Artemia* fed group. The lowest was 350 min in the unenriched *Artemia* fed group and 72% of the tolerance increase was noted in the MD1 than in the unenriched *Artemia*. In 10 pH the MD1 and MD3 enriched *Artemia* fed groups succumbed to death at 420 min but the unenriched *Artemia* fed group tolerated it for only 300 min. When the post larvae were exposed to the lower concentration of formalin (80 ppm), the unenriched group succumbed to death within 350 min. The enriched

Table 4. Bioenergetics parameters of *Penaeus monodon* post larvae (PL 1-30) fed with different herbal medicinal diets enriched *Artemia franciscana*.

Parameters	Herbal medicinal diets					
	Control	MD1	MD2	MD3	MD4	MD5
Consumption* (mg·animal·30days)	103.78^{a} ± 0.93	121.68^{b} ± 1.84	111.02^{c} ± 0.92	117.95^{bd} ± 0.69	114.78^{ce} ± 1.33	115.64^{def} ± 1.00
Absorption* (mg·animal·30days)	90.16^{a} ± 0.89	104.41^{b} ± 1.48	95.87^{c} ± 0.97	101.23^{d} ± 0.41	99.02^{de} ± 1.12	99.34^{def} ± 0.71
Production* (mg·animal·30days)	18.14^{a} ± 0.30	24.70^{b} ± 0.14	21.49^{c} ± 0.31	23.86^{bd} ± 0.10	22.54^{e} ± 0.62	23.12^{f} ± 0.66
Metabolism* (mg·animal·30days)	72.03^{a} ± 0.76	82.94^{b} ± 3.11	74.11^{ac} ± 1.04	77.37^{cd} ± 0.30	76.48^{cde} ± 0.68	76.19^{cdef} ± 0.02
Absorption* efficiency (%)	86.87^{NS} ± 0.07	85.83^{NS} ± 0.06	86.35^{NS} ± 0.20	85.82^{NS} ± 0.15	86.26^{NS} ± 0.03	85.89^{NS} ± 0.13
Gross conversion** efficiency K_1 (%)	17.47^{a} ± 0.21	20.29^{b} ± 0.23	19.35^{b} ± 0.12	20.23^{b} ± 0.03	19.63^{b} ± 0.37	19.99^{b} ± 0.39
Net production** efficiency K_2 (%)	19.51^{a} ± 1.28	23.65^{b} ± 0.25	22.41^{b} ± 0.14	23.57^{b} ± 0.03	22.75^{b} ± 0.44	23.29^{b} ± 0.48

a, b, c, d, e and f means with the same superscript do not differ from each other ($P<0.05$)
*-SNK test, **-One way ANOVA

groups (MD1 and MD3) tolerated it up to 550 min (Fig. 2e). At 160 ppm the unenriched *Artemia* fed group tolerated it up to 120 min, whereas those fed on MD1 and MD3 enriched *Artemia* had the maximum stress resistance of 210 min.

Discussion

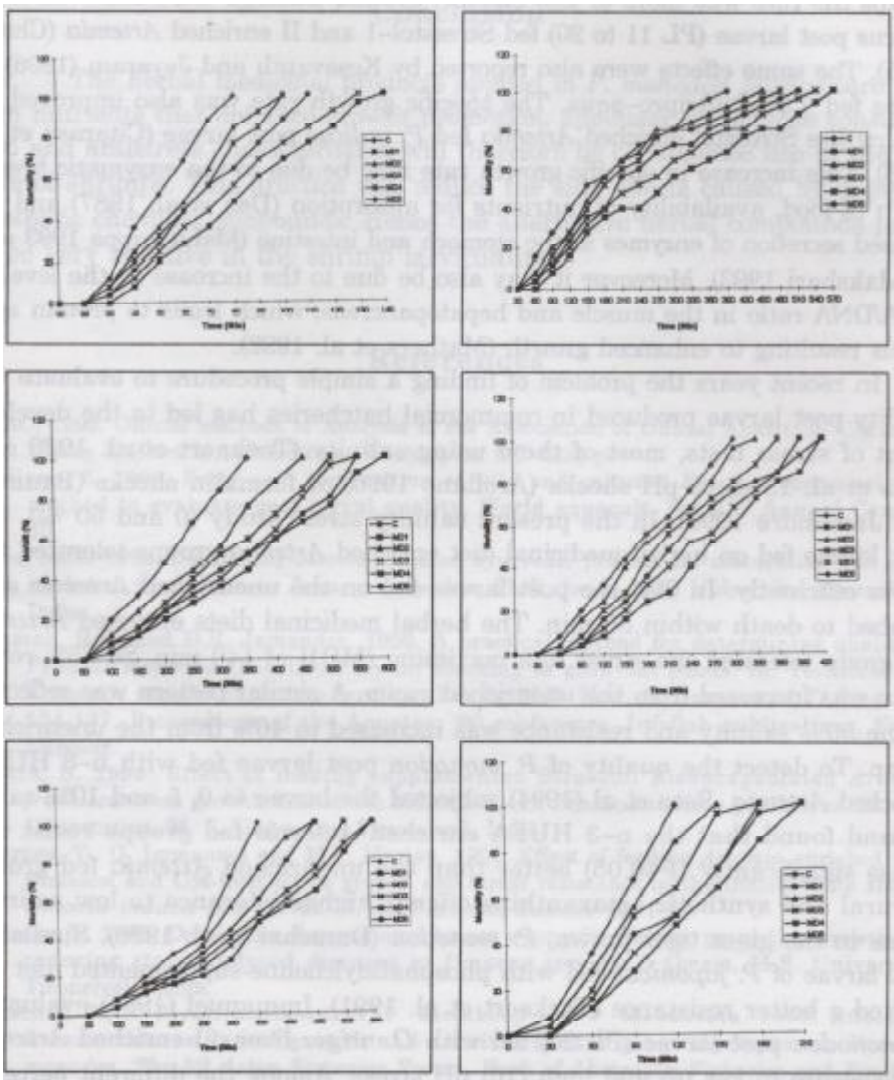
One of the main strategies in developing a larval rearing system is the establishment of a feeding regime that will result in optimal growth, survival and health of the fish larvae. Stresstol, a herbal product, from our Laboratory having several components which has a role in importing energy, giving tonic to body and resistance, infuses free energy and vigor in a system worn out due to diseases etc., has proved to increase the stress resistance in *P. indicus* post larvae 20 to 28 (Citarasu et al. 1998). In their report, the rate of growth was not increased significantly.

The present study offers promising possibilities of using herbal products, that increase survival, consumption, growth promotion, and stress resistance. Good quality of shrimp seeds ensures high rates of survival and growth rate (Darachai et al. 1998). Comparatively the high rates of survival and growth observed in the experimental animals indicate that the quality of post larvae was improved by feeding them with herbal medicine enriched *Artemia*. Nutripro–aqua, a herbal-based diet significantly increased the growth and biomass in *M. rosenbergii* (Kesavanth and Jeyaram 1998). The growth rate promotion by Livol (IHF–100), a new growth promoter from Indian Herbs, was

Table 5. Length, weight, and specific growth rate of *Penaeus monodon* post larvae (PL 1-30) fed with different herbal medicinal diets enriched *Artemia franciscana*.

Herbal Medicinal Diets	Length (mm)		Wet weight (mg)		Specific growth rate (%)
	Initial	Final	Initial	Final	
Control	6.25 ± 0.00	27.56 ± 0.40	2.30 ± 0.05	92.74[a] ± 2.02	11.62 ± 0.12
MD1	6.33 ± 0.14	32.50 ± 0.50	2.90 ± 0.10	124.8[b] ± 0.04	12.53 ± 0.09
MD2	6.33 ± 0.14	29.00 ± 1.00	2.86 ± 0.16	109.02[c] ± 2.15	12.13 ± 0.18
MD3	6.25 ± 0.00	31.66 ± 0.28	2.86 ± 0.16	122.33[bd] ± 1.52	12.58 ± 0.14
MD4	6.25 ± 0.00	30.33 ± 0.30	2.90 ± 0.17	116.16[e] ± 1.75	12.30 ± 0.16
MD5	6.33 ± 0.28	30.93 ± 0.11	2.83 ± 0.25	120.00[df] ± 1.32	12.49 ± 0.33

a, b, c, d, e, and f means with the same superscript do not differ from each other at $P < 0.05$ (SNK test).



Figs. 2a. to 2f. Percentage mortality of *Penaeus monodon* post larvae (PL 1-30) as a function of time exposed to 0‰ salinity (2a), 50‰salinity (2b), 6pH (2c), 10pH (2d), 80 ppm Formalin (2e), and 160 ppm Formalin (2f) stress.

studied by Jayaprakas and Euphrasia (1996) and concluded that the product tested increased stimulation of appetite of prawn *P. indicus* leading to enhanced feed intake, high feed conversion efficiency and nutrient digestibility. In the present study consumption increased by 17.24% in the enriched groups than in the unenriched group. It may be due to the inclusion of 10% herbal appetizer *Z. officinalis* in the enriched diets. Absorption and production efficiencies were likewise significantly higher in the herbal diets enriched *Artemia* fed groups. Similar observations were also reported in *P. indicus* post larvae 20 to 28 fed with Stresstol by Citarasu (1998), Chirta (1995) by feeding Stresstol–I and II to *P. indicus* post larvae (PL 11 to 20) and Tefroli, a herbal product to *P. monodon* post larvae (Rani 1999).

Specific growth rate significantly ($P < 0.05$) increased from unenriched *Artemia* fed group to enriched *Artemia* fed groups and among the enriched groups the rate was more or less similar. Similar findings were observed in *P. indicus* post larvae (PL 11 to 20) fed Stresstol–1 and II enriched *Artemia* (Chitra 1995). The same effects were also reported by Kesavanth and Jeyaram (1998) in fishes fed 7.5% Nutripro–aqua. The specific growth rate was also improved by feeding the Stresstol enriched *Artemia* fed *P. indicus* post larvae (Citarasu et al. 1998). This increase in specific growth rate may be due to the enzymatic breakdown of food, availability of nutrients for absorption (Das et al. 1987) and increased secretion of enzymes in the stomach and intestine (Maheshappa 1993 and Shadakshari 1993). Moreover it may also be due to the increase in the level of RNA/DNA ratio in the muscle and hepatopancreas which leads to protein synthesis resulting to enhanced growth (Mathers et al. 1992).

In recent years the problem of finding a simple procedure to evaluate the quality post larvae produced in commercial hatcheries has led to the development of stress tests, most of them using salinity (Tackaert et al. 1989 and Rees et al. 1994) or pH shocks (Arellano 1990) or formalin shocks (Bauman and Jamandre 1990). In the present salinity stress study (0 and 50 ‰), the post larvae fed on herbal medicinal diet enriched *Artemia* groups tolerated the stress efficiently. In 0‰, the post larvae fed on the unenriched *Artemia* succumbed to death within 80 min. The herbal medicinal diets enriched *Artemia* fed group tolerated the stress to a maximum (MD1) of 140 min. So 75% resistance was increased from the unenriched group. A similar pattern was reflected in the 50‰ salinity and resistance was increased to 46% from the unenriched group. To detect the quality of *P. monodon* post larvae fed with n–3 HUFA enriched *Artemia,* Rees et al (1994) subjected the larvae to 0, 5 and 10‰ salinity and found that the n–3 HUFA enriched *Artemia* fed groups resist the stress significantly ($P<0.05$) better than the unenriched *Artemia* fed group. Natural and synthetic astaxanthins offered higher tolerance to low salinity stress in the giant tiger prawn, *P. monodon* (Darachai et al. 1998). Similarly, post larvae of *P. japonicus* fed with phosphatidylcholine-supplemented diet exhibited a better resistance (Tackaert et al. 1991). Immanuel (1996) evaluated *P. monodon* post larvae (PL–20) fed with *O. neiger* liver oil enriched *Artemia* by exposure to low (6) and high (10) pH stress. Among the different percentages of oil (0 to 5%), 4% is the optimal for resisting stress. In the present study the MD1 enriched *Artemia* fed post larvae exposed to low (6) pH tolerated it to a maximum of 600 min and 71% increase in resistance was noticed in the unenriched groups. Rani (1999) found out that Tefroli and Trasina, herbal products fed *P. monodon* post larvae (PL40) exhibited a better resistance to pH stress. By exposing to the formalin stress (80 and 160 ppm), the herbal diets enriched *Artemia* fed groups exhibited a better resistance when compared to the un-enriched groups. This was also supported by Rani (1999) in her work. Trasina and Tefroli fed larvae (PL40) were exposed to 50 ppm formalin and it was found out that the two products helped to increase the resistance. Babu (1999) also tested the resistance power by exposing to formalin, hyper saline and hypothermal stress of nauplii hatched from the eggs of *P.*

monodon spawners, which fed on herbal diets such as *W. somnifera, Mucuna prurita, Ferula asafoetida* and *Piper longum* and concluded that the experimental larvae exhibited the maximum resistance than the control.

Conclusion

The herbal medicinal products applied in *P. monodon* larviculture contain nutrients that enhance growth promotion, the appetizer to increase consumption and anti stress characteristics and, will therefore be of immense use in the culture of shrimps. This practice will reduce the side effects caused by applying synthetic chemical compounds. Hence the alternative herbal compounds prove to be very effective in the shrimp larviculture.

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