SEAMEO SEARCA

*A Professorial Chair Lecture on:*

# THE USE OF ALGAE IN THE FEED FORMULATION FOR AQUACULTURE SPECIES

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*SEARCA Professorial Chair Awardee*
*(April 2015-March 2016)*

**Wednesday, March 30, 2016**
**10:00 - 11:30 AM**
**Conference Room, CFOS Faculty Center**

# Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) Professorial Chair Lecture

Augusto E. Serrano, Jr.

# The use of seaweeds in the feed formulation for aquaculture species

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University of the Philippines Visayas

# Unutilized, nuisance

Hundred Islands,
Alaminos, Pangasinan

# Unutilized, nuisance

Boracay Island, Aklan

# Unutilized, nuisance

Underground River,
Puerto Princesa, Palawan

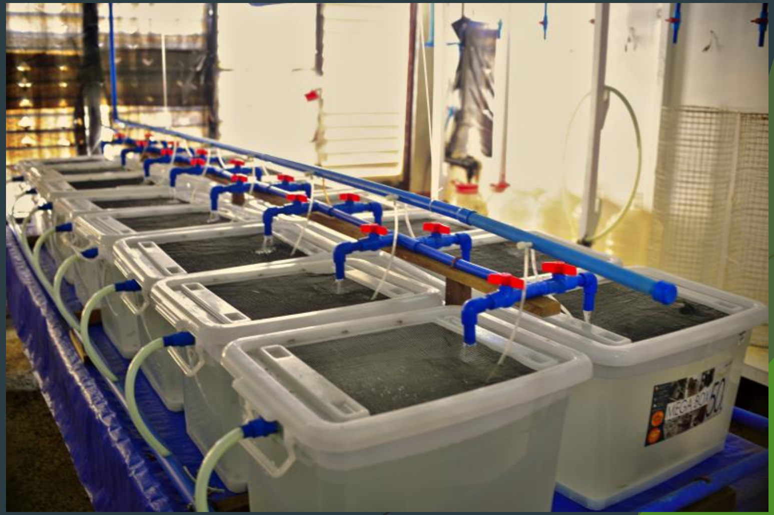
# Nuisance

# Could be used as ingredient in aquafeeds for shrimps

# Rhizoclonium spp. grows in any idle fishpond

# Rhizoclonium riparium at Dagupan, Pangasinan

# DOST-PCAARD and UP Visayas ( 3 years)

# Aquafeeds Program

## ISP Interventions, Deliverable Potential Impacts

### Seaweeds

| Industry Problems | S & T Gaps | S & T Interventions | Deliverables | Potential Impact |
|---|---|---|---|---|
| • High cost of imported ingredients. Volatile prices of raw materials | • Cheap, locally available feed ingredients | • Utilize macroalgae i*Ulva lactuca, Enteromorpha (Ulva) intestinalis, Sargassum* and *Rhizoclonium* as feed ingredient | • Information on nutritive value of PC and raw meal of seaweeds (proximate analysis, amino acid profile, digestibility)<br>• Biological value of raw meal and PC of seaweeds to shrimp and tilapia<br>• Feed formula for shrimp and tilapia | Reduce cost of the feeds for tilapia and shrimp<br>Reduce the cost of marketable sized tilapia and shrimp |

# Selected seaweeds

*Ulva lactuca*

*Rhizoclonium riparium var implexum*

*Enteromorpha intestinalis*

# Characterization as ingredient

## Biochemical

- Proximate analyses
  - Meal or Protein concentrate (PC)
- Amino acid profile
  - Meal or PC

## Biological (lab)

- *In vivo* digestibility
- Growth performance
- Feed efficiency
- Body composition
- Immunological responses

*Penaeus monodon* or *Litopenaeus vannamei*

# Objective

replace

# Feeding trial facilities

# Source and preparation

- Sources
  - Enteromorpha intestinalis – Arevalo and Dumangas
  - Ulva lactuca – Zamboanga
- Preparation
  - Meal
    - Cleaning (debris, other animals)
    - Shade-dried, oven-dried
    - pulverized
  - Protein concentrate (PC)
    - Juiced
    - Acidified
    - Precipitate oven dried, pulverized

# Meal


# Protein concentrate


# Formulae

- **Weight gain, WG (g) = FABW - IABW**
- Where FABW = final average body weight (g); and IABW = initial average body weight (g)
- **SGR (Specific Growth Rate, % body weight day$^{-1}$) = 100*(ln FABW - ln IABW) / D**
- Where D = days of culture
- **FCE (Feed Conversion Efficiency, %) = 100*(FI /WG)**
- Where FI= total feed intake of individual fish
- **FCR (feed conversion ratio) = WG/FI**

- **PER = WG / (FI*feed protein (in decimal))**
- 
- PR (Protein Retention, %) = 100*(% final carcass CP in decimal x FABW (g)) – (% initial carcass CP in decimal x IABW (g)) /(FI*diet CP in decimal (g))
- 
- LR (Lipid Retention, %) = 100*(% final carcass body CL in decimal x FABW (g)) – (% initial carcass CL in decimal x IABW (g)) /(FI*diet CL in decimal (g)
- 
- PG (Protein gained, g) = FABW*initial body CP in decimal – IABW*final body CP
- 
- Survival (%) = 100*Final number of fish replicate container$^{-1}$/Initial number of fish replicate container$^{-1}$
- 

- The following generalized quadratic equation was used:
- 
- $R = a + bI + cI^2$
- Where: $R$ = measured response (i.e. WG or SGR), $I$ = dietary nutrient concentration, and $a$ , $b$ , and $c$ are constants that are calculated to provide the best fit of the data. The value of $I$ that produces the maximum response (i.e. $I_{max}$) is calculated as follows:
- 
- $I_{max} = -0.5\ (b/c)$

# Biochemical evaluation

# *Proximate analysis*

| Seaweed | CP | CL | Fiber | Ash | NFE |
|---|---|---|---|---|---|
| *Ulva intestinalis* (meal) | 9.9 | 0.1 | 5.9 | 33.1 | 51.0 |
| (PC) | 31.6 | 27.6 | 1.37 | 31.4 | 8.0 |
| *Ulva lactuca* (meal) | 14.5 | 0.5 | 4.4 | 31.7 | 48.9 |
| (PC) | 43.9 | 22.3 | 3.2 | 16.8 | 13.8 |
| *Sargassum* spp. (meal) | 11.0 | 0.4 | 11.0 | 34.7 | 42.9 |
| *Rhizoclonium riparium var implexum* (meal) | 18.8 | 0.2 | 21.35 | 38.6 | 21.05 |
| (PC) | 25.4 | 0.22 | 2.4 | 48.8 | 23.18 |

# Amino acid profile- *Rhizoclonium* spp.

Table 4

Essential amino acid index (EAAI), chemical score (CS) and A/E ratios of *Rhizoclonium* meal collected from Arevalo, Iloilo and EAA requirement levels for the Nile tilapia and the tiger prawn

| *Specification* | *Rhizoclonium* *1 | *Penaeid req.* *3 | *A/E*4* | | *(A/E Rhizoclonium)/(A/E req.) (%)* |
|---|---|---|---|---|---|
| | *AA (% CP)* | | *Rhizoclonium meal* | *Penaeid shrimp* | *Penaeid shrimp* |
| Arginine | 5.54 | 5.8 | 11.47 | 14.08 | 81.5 |
| Histidine | 1.89 | 2.1 | 3.91 | 5.10 | 76.7 |
| Isoleucine | 5.30 | 3.5 | 10.97 | 8.50 | 99.7 |
| Leucine | 8.53 | 5.4 | 17.65 | 13.11 | 134.6 |
| Lysine | 5.68 | 5.3 | 11.76 | 12.86 | 91.5 |
| Phenylalanine | 6.20 | 7.1 | 12.83 | 17.23 | 74.5 |
| Methionine | 1.77 | 3.6 | 3.66 | 8.74 | 41.9 |
| Threonine | 5.05 | 3.6 | 10.45 | 8.74 | 119.6 |
| Tryptophan | 0.94 | 0.8 | 1.95 | 1.94 | 100.5 |
| Valine | 7.42 | 4.0 | 15.36 | 9.71 | 158.2 |
| Total | 48.32 | 41.2 | - | - | - |
| EAAI | - | - | - | 0.92 | - |
| CS | - | - | - | 41.9 | - |

*1 Values are averages of the EAA of *Rhizoclonium* sp. collected from the two sites
*2 Santiago & Lovell (1988)
*3 Akiyama (1992)
*4 A/E is the ratio of a given essential amino acid to the total essential amino acids
AA – amino acid
CP – crude proteine

# Amino acid profile - *Rhizoclonium* spp.

| | (A/E Ingredient)/(A/E req.)(%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | RM | RM (Leganes) | PCRM | PCRM | RM (Arevalo) | RM | PCRM | PCRM (Leganes) |
| | Nile tilapia | | | | Penaeid shrimp | | | |
| Arginine | 108.1 | 135.3 | 352.1 | 134.43 | 81.4 | 101.9 | 265.1 | 101.4 |
| Histidine | 93.1 | 109.1 | 222.26 | 314.52 | 89.8 | 89.8 | 183.3 | 259.0 |
| Isoleucine | 99.8 | 99.8 | 102.6 | 73.09 | 129.2 | 129.2 | 71.2 | 94.6 |
| Leucine | 117.4 | 114.6 | 114.6 | 87.99 | 134.6 | 133.9 | 69.8 | 103.4 |
| Lysine | 96.2 | 96.2 | 51.6 | 67.54 | 91.3 | 78.4 | 48.9 | 64.1 |
| Phenylalanine | 128.5 | 114.3 | 128.5 | 98.50 | 74.6 | 66.3 | 36.7 | 57.2 |
| Methionine | 62.2 | 74.7 | 139.3 | 173.22 | 42.0 | 50.5 | 94.1 | 116.9 |
| Threonine | 117.3 | 72.9 | 78.3 | 104.61 | 119.5 | 74.3 | 79.7 | 106.5 |
| Tryptophan | 74.6 | 63.1 | 68.1 | 93.08 | 100.0 | 84.5 | 91.2 | 124.7 |
| Valine | 129.2 | 133.1 | 71.9 | 91.76 | 158.3 | 163.1 | 88.1 | 112.5 |
| Total | 1385.6 | 1013.1 | 1329.3 | 1238.75 | 1020.7 | 971.9 | 1028.1 | 1140.3 |
| EAAI*5 | 100.0 | 98.4 | 112.5 | 111 | 68.8 | 91.8 | 87.4 | 105.0 |
| CS*6 | 62 | 63 | 52 | 68 | 42 | 51 | 49 | 64 |
| Limiting AA | Met | Tryp | Lys | Lys | Met | Met | Lys | Lys |

# Biological evaluation

A. Apparent Digestibility Coefficients

# Dry matter Digestibility

| Seaweed | *P. monodon/P. vannamei* |
|---|---|
| *Ulva lactuca* (meal) | 71.5 (P.m.) |
| *Ulva lactuca* (PC) | 88.8 (P.m.) |
| *Sargassum* spp. meal | 84.8 (P.v.) |
| *Rhizoclonium* (meal) | 60.0 (p.v.) |

# Biological evaluation

Feeding/growth trials

# Experiment 1

Table 1. Composition and proximate analysis of diets used in Experiment 1 which contained graded amounts of *Enteromorpha intestinalis* meal (EIM) fed to the Nile tilapia *Oreochromis niloticus* juvenile replacing soybean meal (g $kg^{-1}$) (Aquino et al 2014)

| % EIM inclusion | 0 | 3.9 | 7.8 |
|---|---|---|---|
| % SBM replacement | 0 | 15 | 30 |
| Fish meal (sardine) | 310.0 | 310.0 | 310.0 |
| Soybean meal | 260.0 | 221.0 | 182.0 |
| EIM | 0.0 | 39.0 | 78.0 |
| Copra meal | 74.8 | 74.8 | 74.8 |
| Rice bran | 120.9 | 120.9 | 120.9 |
| *Leucaena* meal (leaf) | 101.0 | 101.0 | 101.0 |
| Cod liver oil | 30.0 | 30.0 | 30.0 |
| Vegetable oil | 20.0 | 20.0 | 20.0 |
| Vitamin mix | 21.7 | 21.7 | 21.7 |
| Mineral mix | 21.6 | 21.6 | 21.6 |
| Cornstarch | 30.0 | 30.0 | 30.0 |
| Carboxymethylcellulose | 10.0 | 10.0 | 10.0 |
| TOTAL | 1000.0 | 1000.0 | 1000.0 |
| Proximate composition (dry basis) | | | |
| DM | 949.2 | 945.3 | 944.1 |
| CP | 400.2 | 388.1 | 374.9 |
| CL | 99.4 | 94.3 | 94.1 |
| Crude fiber | 64.7 | 61.8 | 63.7 |
| Ash | 140.5 | 149.1 | 156.7 |
| NFE | 295.2 | 306.8 | 310.8 |

# Experiment 1 Results

Table 2

*Oreochromis niloticus*

*Enteromorpha intestinalis* meal (EIM)

| % EIM incl. | 0 | 3.9 | 7.8 |
|---|---|---|---|
| % SBM repl. | 0 | 15 | 30 |
| IABW | 0.03 | 0.03 | 0.03 |
| FABW | 6.97[a] | 8.25[a] | 4.54[b] |
| WG | 7.00 [a] | 8.28 [a] | 4.57 [b] |
| SGR | 6.79[a] | 6.99[a] | 6.29 [b] |
| FCR | 1.00 | 1.06 | 1.10 |
| Survival | 95.6 | 93.3 | 93.3 |
| PR | 29.6 | 29.7 | 26.7 |
| LR | 9.59[a] | 7.45[b] | 6.87[b] |

# Experiment 1

- Increasing the inclusion level of EIM beyond 3.9% (15% SBM replacement) resulted in significantly poorer WG, SGR and FI but resulted in statistically similar FCR and survival rate

| | |
|---|---|
| (Hasan and Chakrabarti 2009) | -progressive decrease in performance when 15%-20% algal meal was added to the diet |
| (Azzaza et al 2008) | -*Ulva rigida* as SBM replacement up to 20 % in the diet of Nile tilapia did not affect growth performance and feed efficiency |
| Guroy et al (2007) | - 10-15% *Ulva rigida* meal to the diet of the Nile tilapia was optimum for growth performance |
| Ergun et al (2008) | - 5% *Ulva rigida* meal was optimum for the Nile tilapia |
| Diler et al (2007) | 15% *Ulva rigida* meal optimally replaced wheat meal in *Cyprinus carpio* |
| Mustafa & Nakagawa (1995) | 5% - 15% *Ulva rigida* in the diets of black sea bream (*Acanthopagrus schlegeli*), red sea bream (*Pagrus major* ), rainbow trout (*Oncorhynchus mykiss* ) improves the growth performance |

# Experiment 1

- Why only 3.9%
  - higher inclusion of EIM could have resulted in a considerable increase in phenolic compounds causing poor digestibility of dietary protein.
  - could be due to high carbohydrate and ash contents in EIM.

***Conclusion of Experiment 1.***

EIM could replace 15 % of the SBM in the diet of Nile tilapia without exhibiting adverse effect on WG, SGR, FCR, PR and survival rate.

Experiment 2

Table 3

Composition and proximate analysis of diets used in Experiment 2 containing graded levels the protein concentrate of *Enteromorpha intestinalis* (EIPC) fed to the Nile tilapia *Oreochromis niloticus* juvenile replacing soybean meal (g $kg^{-1}$) (Serrano Jr. and Aquino 2014)

| % EIPC inclusion | 0 | 3.9 | 7.8 | 11.7 |
|---|---|---|---|---|
| % SBM replacement | 0 | 15 | 30 | 45 |
| Fish meal (sardine) | 310.0 | 310.0 | 310.0 | 310.0 |
| Soybean meal | 260.0 | 221.0 | 182.0 | 143.0 |
| EIPC | 0.0 | 39.0 | 78.0 | 117.0 |
| Copra Meal | 74.8 | 74.8 | 74.8 | 74.8 |
| Rice Bran | 120.9 | 120.9 | 120.9 | 120.9 |
| *Leucaena* leaf meal | 101.0 | 101.0 | 101.0 | 101.0 |
| Cod liver oil | 30.0 | 30.0 | 30.0 | 30.0 |
| Vegetable oil | 20.0 | 20.0 | 20.0 | 20.0 |
| Vitamins | 21.7 | 21.7 | 21.7 | 21.7 |
| Minerals | 21.6 | 21.6 | 21.6 | 21.6 |
| Cornstarch | 30.0 | 30.0 | 30.0 | 30.0 |
| Carboxymentylcellulose | 10.0 | 10.0 | 10.0 | 10.0 |
| TOTAL | 1000.0 | 1000.0 | 1000.0 | 1000.0 |
| Proximate composition *(dry basis)* | | | | |
| DM | 949.2 | 950.7 | 949.8 | 947.4 |
| CP | 400.2 | 375.1 | 375.3 | 382.2 |
| CL | 99.4 | 98.5 | 96.3 | 95.5 |
| Crude Fiber | 64.7 | 62.4 | 61.5 | 62.7 |
| Ash | 140.5 | 150.2 | 164.0 | 183.2 |
| NFE | 295.2 | 313.9 | 302.8 | 276.3 |

Experiment 2

Table 4

*Oreochromis niloticus*
X
*Enteromorpha intestinalis* protein concentrate (EIPC)

| % EIPC incl. | 0 | 3.9 | 7.8 | 11.7 |
|---|---|---|---|---|
| % SBM rep. | 0 | 15 | 30 | 45 |
| WG | 7.00[a] | 5.37[ab] | 4.67[b] | 4.20[b] |
| SGR | 6.79[a] | 6.48[ab] | 6.30[b] | 6.18[b] |
| FCR | 1.00 | 1.05 | 1.01 | 1.02 |
| Survival | 95.6 | 88.9 | 91.1 | 91.1 |
| PR | 29.6 | 29.6 | 29.0 | 28.2 |
| LR | 9.59[a] | 7.36[b] | 7.58[b] | 7.52[b] |

# Experiment 2

- Tilapia fed 3.9% (15% SBM replacement) exhibited statistically similar WG and SGR with those fed the control diet

- ‘unpalatable’ components might have also been concentrated.
  - Azaza et al (2008) 30 % *Ulva rigida* meal contains on a dry weight basis 2.65% saponins, 0.22% tannins and 0.61% phytic acid; lower digestible energy
  - Serrano (2013) - may not necessarily result in the negative performance as we have shown in the common carp previously

- There is no available data with which to compare the results of Experiment 2.

- Feed efficiency (i.e. FCR), survival and PR were not affected by the dietary treatments.

# Experiment 2

- ***Conclusion of Experiment 2.***
- EIPC produced from the combined procedures of acidification and heat treatment could be included at 3.9% (i.e. 15% SBM replacement) of the diet without adversely affecting SGR, feed and nutrient efficiencies and survival but with possible slight reduction in body CL.

Experiment 3

Table 5

Composition and proximate analysis of diets used in Experiment 3 containing graded levels of *Enteromorpha intestinalis* meal (EIM) fed to the black tiger shrimp *Penaeus monodon* postlarvae replacing soybean meal (g kg$^{-1}$) (Serrano Jr. and Tumbokon 2015)

| % EIM incl. | 0 | 5.25 | 10.5 | 15.75 | 21 |
|---|---|---|---|---|---|
| % SBM repl. | 0 | 15 | 30 | 45 | 60 |
| Fish meal (Danish) | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 |
| Squid Meal | 29.0 | 29.0 | 29.0 | 29.0 | 29 |
| Carboxymet hylcellulose | 80.5 | 80.5 | 80.5 | 80.5 | 80.5 |
| Lignobond | 15.0 | 15.0 | 15.0 | 15.0 | 15 |
| Vitamins | 10.0 | 10.0 | 10.0 | 10.0 | 10 |
| Minerals | 10.0 | 10.0 | 10.0 | 10.0 | 10 |
| DicalPhos | 20.0 | 20.0 | 20.0 | 20.0 | 20 |
| BHT | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Bread flour | 11.7 | 11.7 | 11.7 | 11.7 | 11.7 |
| Cod liver oil | 63.0 | 63.0 | 63.0 | 63.0 | 63 |
| Lecithin | 5.0 | 5.0 | 5.0 | 5.0 | 5 |
| Soybean meal | 350.0 | 297.5 | 245.0 | 192.5 | 142.5 |
| EIM | 0.0 | 52.5 | 105.0 | 157.5 | 210 |
| TOTAL | 1000.0 | 1000.0 | 1000.0 | 1000.0 | 1000 |
| Proximate analysis (%, dry basis) | | | | | |
| DM | 89.6 | 91.6 | 91.9 | 92.1 | 92.4 |
| CP | 45.8 | 43.3 | 40.59 | 38.1 | 35.7 |
| CL | 11.6 | 10.9 | 10.1 | 10.1 | 10.7 |
| Crude fiber | 2.8 | 2.6 | 2.6 | 2.6 | 2.6 |
| NFE | 27.9 | 29.4 | 33.0 | 33.0 | 33.6 |
| Ash | 11.0 | 12.6 | 13.9 | 14.9 | 16.0 |

## Experiment 3

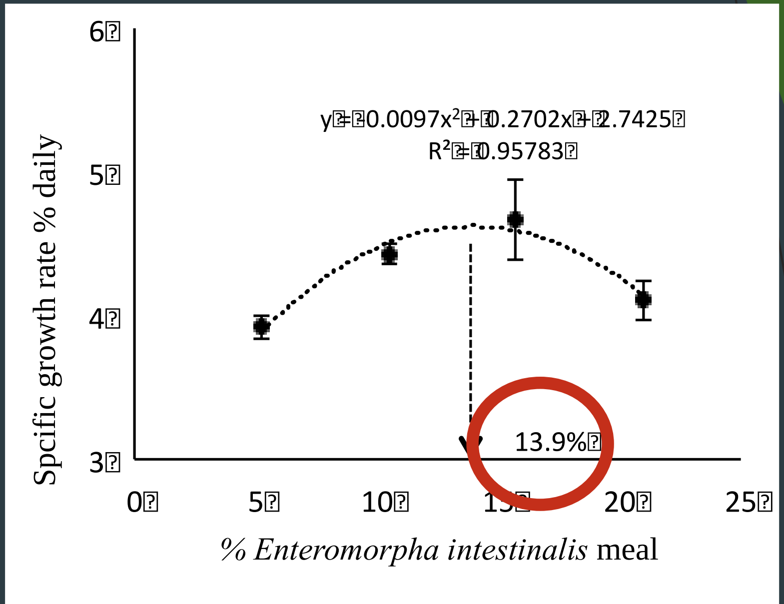
### Table 6

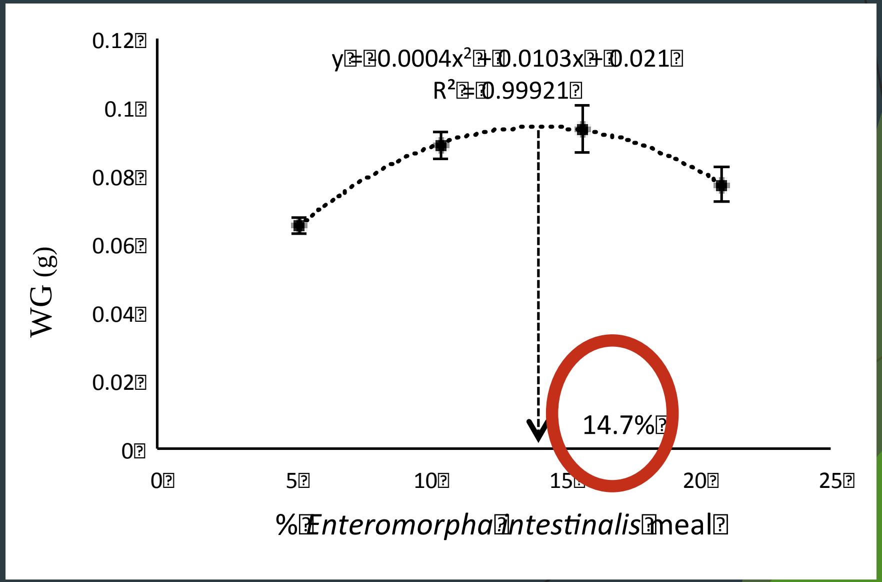
***Penaeus monodon***
X
***Enteromorpha intestinalis* meal (EIM)**

| % EIM incl. | 0 | 5.25 | 10.5 | 15.8 | 21.0 |
|---|---|---|---|---|---|
| % SBM rep. | 0 | 15 | 30 | 45 | 60 |
| IABW | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| FABW | $0.14^{ab}$ | $0.11^{a}$ | $0.14^{ab}$ | $0.16^{b}$ | $0.12^{ab}$ |
| WG | 0.08 | 0.07 | 0.09 | 0.09 | 0.08 |
| SGR | $4.78^{ab}$ | $4.48^{b}$ | $5.09^{ab}$ | $5.19^{a}$ | $4.80^{ab}$ |
| Survival | 84.4 | 75.6 | 84.5 | 77.8 | 91.1 |
| FCR | 1.46 | 1.47 | 1.54 | 1.24 | 1.35 |
| PER | 1.56 | 1.59 | 1.60 | 2.12 | 2.08 |

Experiment 3

Figure 1. Responses of the shrimp to varying levels of dietary EIM fitted into a quadratic model.



# Experiment 3

- CP did not affect growth (see PER) probably due to the compensatory increased in FI.
- Probably there was a balanced amino acid similar to another chlorophyte, *Rhizoclonium riparium  var implexum* which exhibited essential amino acid index (EAAI) for the shrimp *Penaeus monodon*  of 0.97 (Bunda et al. 2015)

# Experiment 3

- ***Conclusion of Experiment 3.***

- The optimum inclusion level of EIM in the diet of the black tiger shrimp ranged from 13.9 to 14.7% or its equivalent range of 39.7% to 42% SBM replacement. However, the highest inclusion of 21.0% or 60% replacement of SBM in the diet could be used without deleterious effects on the growth performance and feed efficiency of the shrimp.

## Experiment 4

Table 7
Composition and proximate analysis of diets used in Experiment 4 containing graded levels of *Enteromorpha intestinalis* meal (EIM) fed to the black tiger shrimp *Penaeus monodon* postlarvae replacing soybean meal (g $kg^{-1}$) (Serrano Jr. et al 2015)

| % ULPC incl. | 0 | 5.2 | 10.5 | 15.8 |
|---|---|---|---|---|
| % SBM repl. | 0 | 15 | 30 | 45 |
| Fish meal (Danish) | 380.0 | 380.0 | 380.0 | 380.0 |
| Squid Meal | 29.0 | 29.0 | 29.0 | 29.0 |
| Soybean Meal | 350.0 | 298.0 | 245.0 | 193.0 |
| Bread flour | 80.0 | 80.0 | 80.0 | 80.0 |
| Cod Liver Oil | 63.0 | 63.0 | 63.0 | 63.0 |
| Lecithin | 5.0 | 5.0 | 5.0 | 5.0 |
| Carboxymethylcellulose | 37.5 | 37.5 | 37.5 | 37.5 |
| Lignobond | 15.0 | 15.0 | 15.0 | 15.0 |
| Vitamins | 10.0 | 10.0 | 10.0 | 10.0 |
| Minerals | 10.0 | 10.0 | 10.0 | 10.0 |
| Dicalcium phosphate | 20.0 | 20.0 | 20.0 | 20.0 |
| BHT | 0.5 | 0.5 | 0.5 | 0.5 |
| ULPC | 0.0 | 52.0 | 105.0 | 158.0 |
| TOTAL | 1000.0 | 1000.0 | 1000.0 | 1000.0 |
| Proximate Analysis (%, dry basis) | | | | |
| DM | 95.8 | 96.0 | 95.2 | 95.1 |
| CP | 41.3 | 41.4 | 40.7 | 40.1 |
| CL | 10.8 | 10.7 | 10.4 | 10.2 |
| Crude Fiber | 2.5 | 2.0 | 2.9 | 2.9 |
| Ash | 15.3 | 15.1 | 15.9 | 15.4 |
| NFE | 26.0 | 26.9 | 25.3 | 26.4 |

## Experiment 4

Table 8

*Penaeus monodon*
X
*Ulva lactuca* meal
(ULM)

| % ULM inclusion | 0 | 5.2 | 10.5 |
|---|---|---|---|
| % SBM replacement | 0 | 15 | 30 |
| IABW | 0.11 | 0.11 | 0.11 |
| FABW | 1.45 | 1.22 | 1.03 |
| SGR | $3.02^{a}$ | $2.82^{ab}$ | $2.61^{b}$ |
| FCE | 0.67 | 0.65 | 0.66 |
| PG | $0.20^{a}$ | $0.17^{b}$ | $0.16^{b}$ |
| PER | 13.1 | 14.8 | 14.3 |
| Survival | 87.0 | 93 .0 | 87.0 |

# Experiment 4

- Shrimp fed with the control diet and with that containing 15% ULM resulted in significantly higher SGR than those fed with 30% ULM but FABW of those fed diet with 30% ULM were all similar
- In terms of FCE, PG, and PER, no significant differences were observed in all treatments.
- Other studies
  - Incorporating 10% seaweed to the diets of *Penaeus monodon* and *Litopenaeus vannamei* resulted in higher WG, FCR was lowered by 0.1 point, improved color of shrimp, 25% lower mortality rates, improved taste and texture of the shrimp (Ocean Harvest Technology 2010).

# Experiment 4

- ***Conclusion of Experiment 4.***

- All the parameters (survival rate, FCE, PR and LR) were not affected by the diet;
- Both inclusion levels of 5.2% and 10.5% (15% and 30% SBM replacement) resulted in similar growth performance (FABW and SGR)

# Experiment 5

## Table 9

Composition and proximate analysis of diets used in Experiment 5 containing graded levels of *Ulva lactuca* protein concentrate (ULPC) fed to the black tiger shrimp *Penaeus monodon* postlarvae replacing soybean meal (g $kg^{-1}$) (Serrano Jr. and Santizo 2014)

| % ULM inclusion | 0 | 5.2 | 10.5 |
|---|---|---|---|
| % SBM replacement | 0 | 15 | 30 |
| Fish meal (Danish) | 380.0 | 380.0 | 380.0 |
| Squid Meal | 29.0 | 29.0 | 29.0 |
| Soybean Meal | 350.0 | 298.0 | 245.0 |
| Bread flour | 80.0 | 80.0 | 80.0 |
| Cod Liver Oil | 63.0 | 63.0 | 63.0 |
| Lecithin | 5.0 | 5.0 | 5.0 |
| Carboxymethylcellulose | 37.5 | 37.5 | 37.5 |
| Lignobond | 15.0 | 15.0 | 15.0 |
| Vitamin | 10.0 | 10.0 | 10.0 |
| Mineral | 10.0 | 10.0 | 10.0 |
| Dicalcium phosphate | 20.0 | 20.0 | 20.0 |
| BHT | 0.5 | 0.5 | 0.5 |
| ULM | 0.0 | 52.0 | 105.0 |
| TOTAL | 1000.0 | 1000.0 | 1000.0 |
| Proximate Analysis (%, dry basis) | | | |
| DM | 95.8 | 95.1 | 95.1 |
| CP | 41.3 | 38.5 | 37.3 |
| CL | 10.8 | 10.4 | 10.2 |
| Crude Fiber | 2.5 | 2.2 | 2.7 |
| NFE | 26.0 | 29.9 | 28.9 |
| Ash | 15.3 | 14.0 | 16.1 |

## Experiment 5

Table 10

*Penaeus monodon*

X

*Ulva lactuca* protein concentrate (ULPC)

| % ULPC | 0 | 5.2 | 10.5 | 15.8 |
|---|---|---|---|---|
| % SBM rep. | 0 | 15 | 30 | 45 |
| IABW | 0.11 | 0.11 | 0.11 | 0.11 |
| FABW | 1.45[a] | 1.23[ab] | 1.16[ab] | 0.98[b] |
| SGR | 3.02[a] | 2.84[ab] | 2.76[ab] | 2.57[b] |
| FCR | 1.49 | 1.52 | 1.54 | 1.59 |
| PER | 13.12 | 14.33 | 14.60 | 13.45 |
| PG | 0.20[a] | 0.19[ab] | 0.17[ab] | 0.15[b] |
| Survival | 87 | 96 | 98 | 91 |

# Experiment 5

- only shrimps the diet containing 15.8% ULPC or 45% SBM replacement exhibited inferior FABW and SGR
- Probably due to the reduced feed intake (FI) of the shrimp, suggesting reduced palatability

| | |
|---|---|
| Rainbow trout | 100% substitution of fish meal resulted in either reduced growth (Medale et al 1998) or no negative effects (Kaushik et al 1995) |
| Other fish | Reduced growth due probably to reduced FI as a result of reduced palatability (Davis et al 1995) |
| | Due to saponins, tannins and phytic acid (Azaza et al 2008) |
| | |

# Summary & Recommendation

| | % inclusion | % SBM repl. |
|---|---|---|
| ***Enteromorpha intestinalis*** | | |
| **Meal form** | | |
| **Nile tilapia** | **3.9%** | **15%** |
| **Black tiger shrimp** | **21%** | **60%** |
| **PC form** | | |
| **Nile tilapia** | **3.9%** | **15%** |
| | | |
| ***Ulva lactuca*** | | |
| **Meal form** | | |
| **Black tiger shrimp** | **10.5%** | **30%** |
| **PC form** | | |
| **Black tiger shrimp** | **10.5%** | **30%** |

# Experiment 5

- *Conclusion of Experiment 5.*
- ULPC could be included in the diet of *Penaeus monodon* fry up to 10.5% (i.e. 30% SBM replacement) without reducing growth and PR of the black tiger shrimps;
- at 15.8% inclusion level (i.e. 45% SBM replacement), growth was reduced.

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Thank you for listening.  I am ready for questions and suggestions.