STUDIES IN THE USE OF ALGAE IN FISH NUTRITION

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Biography

- Dr. Peter Perschbacher is an Associate Professor in Water Quality at University of Arkansas, Pine Bluff. He completed his research from texas A&M University, majoring in Fisheries biology. since then he has been a part of Aquaculture in various institutes and played an active key role in every aspect. His interests mailnly include Palm Society, Nature Conservancy and Arkansas Native Plant Society. He is a professional member of various governing bodies in his area of study. To name a few we have American Fisheries Society (Life member), Asian Fisheries Society etc.

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- Based on his dedication of working and commitments towards his nature of course, he has been honoured with numerous awards and honors like Whos Who in the world 2000, Whos Who in America 2002 etc.

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Research Interests

- Mutually beneficial or reciprocating polycultures especially with tilapias
- Use of algae - fresh or dried as replacements for fish meal and oil
- Alligator gar propagation and ecology
- Herbicide effects on pond phytoplankton
- Saltwater bait production.

Publications

- Peter W Perschbacher (2013) A Green Revolution in Cultured Fish and Livestock Diets? J Fisheries Livest Prod 1:1

Outline

- Aquaculture vs. Agriculture
- Current Production and Uses of Microalgae
- Diets of Cultured Fish/Shrimp/Bivalves
- Need for Fishmeal, Fish Oil Replacement
- Fishmeal, Fish Oil Replacement Studies
- Potential

Farming the Waters

- Animal vs. grain/oilseeds production
- More efficient and less damaging to the environment than animal production, such as beef and pork
- Crustaceans and filter-feeding fish/bivalves major animal crops, with no agriculture equivalent (insects?)
- Carnivores highest value crop-no agriculture equivalents
- Major animal protein source in the developing world
- Research focusing on reducing fishmeal/oil and grain/oil seed feed use – higher trophic level and biofuels competition, and health issues.

Microalgae Production = 7250t

Approximately 50% Spirulina, followed by:

Approximately 25% Chlorella

20 % Dunaliella

And Haematococcus and Crypthecodinium

Velo Mitrovich (2011)

Value and Uses of Microalgae

Velo Mitrovich (2011)

- Spirulina - $48/kg, health food and specialty feed supplements, cosmetics
- Chlorella - $48/kg, health food and specialty feed supplements, cosmetics
- Dunaliella - $286 - $2856/kg, health food supplements, cosmetics, beta carotene
- Haematococcus - $9530/kg, antioxidant, pigment additive (astaxanthin)
- Crypthecodinium/Schizochytrium - $57/g, DHA Oil

Nutrition of Tilapia, Shrimp, Bivalves

- 90% of all cultured larvae require microalgae.
- Tilapia, shrimp and bivalves – aquaculture groups with fastest market growth (>15%/yr) and highest production (>3 mmt).
- By nature – consume high % microbe and microalgae. Bivalves are cultured exclusively on natural microbes and microalgae
- Commercial diets – replace microbe/microalgal essential fatty acids (EPA-20:5-3 and DHA-22:6-3) and attractants-stimulants with fishmeal (FM) and oil (FO).
- FM is also a major source of protein for shrimp, whereas soybean is for tilapia.

FM/FO in Aquaculture

- FM in commercial diets

  -3-6% in omnivorous species (catfish, tilapia, carps)

  -30-45% in carnivorous species (salmon, trout, bass)

  -25% in shrimp feeds

- FO is added at 2%
- 2000 FM/FO demand for aquaculture = 2.1 mmt/0.55 mmt, 33% and 45% of supply respectively
- 2010 est. FM and FO = 2.8 mmt/1.0 mmt, 66% and 75% of total supply respectively.

FM/FO Issues

- FM and FO supply constant at best, with high sensitivity to climate change and El Minos.
- Cost increasing with demand, and supply fluctuations.
- Utilize planktivorous fish species at the base of the marine food chain, potentially affecting higher trophic level marine life (e.g. penguins) and perhaps increasing harmful algal blooms (HABs).
- FM, FO may contain unacceptable levels (EU) of bioaccumulated toxins, such as methyl mercury, dioxins and PCBs.

FM/FO Substitution

- Plant (e.g. soybean, corn gluten) meals and oils are potential FM, FO replacements – insufficient essential fatty acids prevent total replacement.
- Health aspects also reduced – omega 3:omega 6 ratio reduced.
- Biofuel/biodiesel, terrestrial animal feed, and human food uses of plant meals and oils will increase – reducing supply and increasing costs.

Sea Bream Fatty Acid Profiles Ceulemans et al. (2003)

- Replacement of 25% FM and 31-46% FO with soybean, wheat, corn products resulted in reduction of n-3:n-6 ratio by 69% (1.83 to 0.75)

Microalgae Nutrient Profiles

- *Spirulina* meal – 65% protein, 18% glycogen, 5% lipids (incl. 1.3% gamma linolenic acids), vitamins (23000 IU of beta carotene/10g), and minerals.
- *Haematococcus* meal – a natural source of astaxanthin for enhanced coloration.
- *Crypthecodinium/Schizochvtrium* Oil/meal – DHA for improved health of cultured species and humans.

Microalgal Nutrition Studies: Tilapia

Spirulina meal	11% of diet	11% of FM (11% of diet)	Chow & Woi (1996)
Spirulina meal	22, 40, 60, 80, 100% of FM	40% of FM (21% of diet)	Olvera-Novoa et al. (2001)
Chlorella, Scenedesmus meal	10, 25, 50, 75% of FM	50% of FM (15 – 17% of diet)	Badwy et al. (2008)
Spirulina meal	50% of diet	50% of FM (50% of diet)	Perschbacher et al. (2010

Microalgal Nutrition Studies: Shrimp

Natural greenwater	Unknown % of diet	64% of squid, 64% of FM	Sanchez et al. (2011
Diatom, *Nannochlor-opsis* meal	9% of diet	9% of FM, FO	Ju et al. (2009)
Schizochytr-ium meal	0,6% of diet	100% of FO	Patnik et al. (2006)

Microalgal Nutrition Studies: Other

Silver bream	*Spirulina* meal	25, 50, 75, 100% of FM	50% of FM (32% of diet)	El-Sayed (1994)
Sea Bass, yellowtail	*Spirulina* meal	0, 20, 20, 30% of diet	100% of FM (10/20% of diet-S/Y)	Wrobeski et al. (2011)
Channel catfish	Algal DHA oil	2% of diet	100% of FO	Faukner et al. (2011)
Channel catfish	*Schizo.* meal	0, .5, 1, 1.5, 2% of diet	40% of FO (1% of diet)	Li et al. (2009)

Conclusions

- Up to 70% dietary inclusion equal to standard control fishmeal/oil diets possible for omnivores.
- Fish feed additives is the current use for improved coloring/growth/health/carcass quality for high value species (Hasan and Chakrabarti 2009).
- Most economical large scale use by fish and bivalves filtering mixed microalgae from water (e.g. caged, unfed Nile and blue tilapia production averaged 2 tons/ac/season on the dense microalgae resulting from nutrients released from catfish feed. Perschbacher, 1995, 2001).

Future Prospects

- Aquaculture will double in 10 years to >100 mmt based on marine culture, and be the major seafood source.
- Aging populations will select seafood products with higher omega 3:omega 6 ratios, and DHA and EPA for greater health benefits.
- Fishmeal and fish oil demand and price will continue increase and acceptability decrease.
- Costs will be reduced, esp. as biodiesel/bioplastics byproducts (NOAA/USDA 2010).
- Additional microalgae species and bioengineered microalgae will be utilized.

Microalgal Potential = $1.4 trillion

Velo Mitrovich (2011)

- Over 90% in biofuels, followed by:
- Chemicals
- Feed supplements
- Food supplements

Microalgal Potential – Biofuels = $72.6 Billion

Velo Mitrovich (2011)

- Approximately 90% in chemicals
- Approximately 10% in feed supplements
- Remainder in food supplements

“U.S. women have one of the lowest DHA levels in the world”

Senanaykake and Fichtali (2006)

“A very large market for aquaculture feeds could be developed for microalgae biomass containing long chain omega-3 fatty acids to replace fish meal and oil, <u>but for this production, costs must be reduced to between $1 and $2/kg dried algal biomass.”</u> (underlining added)

Benemann (2011)

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