Aquaculture Research Spotlight

June 28, 2023

Soy Aquaculture Alliance

Welcome!

Easton Kuboushek

Executive Director

Soy Aquaculture Alliance

Housekeeping

- Attendees are muted
- The webinar will be recorded and available at soyaquaculture.org
- For questions, please use the Q&A Function

Agenda

1. Housekeeping
2. Acknowledgments
3. Introductions
4. Research Review by USB
5. Research Updates from Auburn University and the University of Idaho
6. Q&A

Goals for Today:

- Review research projects related exploring the value of soy in aquafeed

- Discuss “What next?” and What if?” research priorities for U.S. aquaculture

Audience

- Qualified State Soybean Boards (QSSBs)
- Academic
- Aquaculture Industry
- Agriculture
- Feed Companies
- Media

85+ Registrations!

Soy Aquaculture Alliance

Thank you, members!

Soy Aquaculture Alliance

Thank you, SAA Members!

Illinois Soybean Association

Iowa Soybean Association

Kansas Soybean Commission

Kentucky Soybean Board

Michigan Soybean Committee

Missouri Soybeans

Nebraska Soybean Board

Ohio Soybean Council

South Dakota Soybean Checkoff

tn soybean promotion board

VSB Virginia Soybean Board

Soy Aquaculture Alliance

US SOY

+

AQUACULTURE

USSEC
U.S. SOYBEAN EXPORT COUNCIL

UNITED SOYBEAN BOARD

Soy Aquaculture Alliance™

ASA
American Soybean Association

WISHH
WORLD INITIATIVE FOR SOY IN HUMAN HEALTH

Introductions

Soy Aquaculture Alliance

Introductions

Erica Curles

Science Communicator for
Smithbucklin
(United Soybean Board)

Soy Aquaculture Alliance

Introductions

Dr. Allen Davis

Professor for the School of Fisheries, Aquaculture and Aquatic Sciences at Auburn University

Soy Aquaculture Alliance

Introductions

Dr. Vikas Kumar

Assistant Professor of Research for Fish Nutrition & Nutrigenomics at the University of Idaho

Soy Aquaculture Alliance

SAA Update

Easton Kuboushek

Soy Aquaculture Alliance

About SAA

Mission:

Expand domestic aquaculture and the value of U.S. Soy in aquafeed.

About SAA

2023 Strategic Programs

1. Aquaculture Research
2. Aquaculture Industry Relations
3. Soybean Industry Relations
4. Market Analysis and Development
5. Advocacy (Non-Checkoff)

SAA Updates | Research

- Quarterly Research Report available next month!
- 2 project reports wrapped up in the last month, expecting final reports soon
- Looking ahead: 2024 RFP will open in October

Other SAA Updates

- Attending 39th Annual Meeting of Fish Feed and Nutrition Workshop in July
- Thank you for reading The Fish Feed and following LinkedIn

Aquaculture Research Review

Erica Curles

June 28, 2023

Soy Aquaculture Alliance

UNITED SOYBEAN BOARD


From beginning…
…to end.


Soybean Meal in Aquaculture
UNITED SOYBEAN BOARD

The Latest in Soybean Meal Inclusion

- **Successes of SBM**
  - Tilapia – SBM as main protein source[1]
  - Spotted knifejaw – 25% FM replacement by SBM[2]
  - Golden pompano – 25% FM replacement SBM[3]
  - Largemouth bass – Nutritional programming – SBM in live feed[4]
  - Zebrafish – SBM in live feed advanced gut development and led to longer body length[5]
  - Artemia – Best performance with SBM as protein source[6]
  - Humpback grouper – 67% of FM protein replacement by SPI, PM, and hemoglobin powder blend[7]
  - Hybrid striped bass – SBM of different varieties, ADM SBM did best[8]
  - Redlip mullet – 50% replacement of FM without impacts[9]
  - Yellow catfish – SBM as main protein source improved egg production, diameter, and hatching rate[10]

The Latest in Soybean Meal Inclusion

- **Fermented SBM**
  - African catfish – 40% FM replacement[1], 50% FM replacement by fermented soy pulp/okara[2, 3]
  - Goldfish – 32% FM replacement[4]
  - Rainbow trout – 40% FM replacement[5]
    - *40% SBM has also been achieved through breeding[6]*
  - Mitten crab – 15% FM replacement improved growth and protein content[7*]
  - Chinese perch – 30% FM replacement + 2.27% hydroxyproline – mitigate negative impacts of SBM on growth and improve texture[8]
  - Sea cucumber – attractive, ↓FCR, ↑SGR and weight gain[9]
  - White shrimp – 75-100% replacement of FM[10]
  - Coho salmon – 40% FM replacement, ↓ FCR, ↑ final weight, SGR[11]

The Latest in Soybean Meal Inclusion

- **Enzyme-treated SBM**
  - Turbot – 40% FM replacement by eSBM[1]
  - Channel catfish – 100% FM and PM replacement, ↓FCR and ↑SGR[2]
  - Abalone – 75% FM replacement with no negative effects[3]

Photo: United Soybean Board

The Latest in Soybean Meal Inclusion

- **Functional Ingredients**
  - Sodium acetate – Turbot, 45% FM replacement[1]
  - Green tea and olive extracts – largemouth bass, 31% SBM[2]
  - Prebiotics – improved growth in yellowtail with 25% FM replacement[3]
  - *Bacillus subtilis* – Phytase-producing reduced inflammatory response in zebrafish[4], improved protein ADC and gut health in bullfrogs[5], improved all parameters in red sea bream[6]
  - Aloe vera – reduced gut damage/inflammation markers and susceptibility to bacterial infection in zebrafish[7] and Atlantic salmon[8]
  - Butyrate – glyceride maintained healthy gut in black sea bream[9], NaB preserved growth and gut morphology (33% SBM) in rice eel[10], tributyrin mitigated negative effects in shrimp (44% SBM)[11]
  - Betaine – bullfrog (with GAA)[12], tilapia[13] and rainbow trout[14]


Soy Lipids in Aquaculture
UNITED SOYBEAN BOARD

Soybean Oil, Lecithin, and More

Lipid

- **Fish Oil Substitution**
  - Red drum – 50% FO replacement with SBM or SPC outperformed FM with FO/SO[1]
  - Yellow drum – 80% FM replacement increased fillet yield[2]
- **Benefits of Soy Lecithin**
  - Largemouth bass – 4% SL increased weight gain, SGR, and crude protein[3,4]

Soybean Oil, Lecithin, and More

- **Successful Supplements**
  - Glycerol Monolaurate 0.04% – full FO replacement in yellow croaker[1]
  - Soybean oil-based polymer can protect phytase in pelleted diets[2]
  - Tilapia – diet restricted by 25%, 0.6% SBO prevented growth reduction, improved FCR, restriction reduced suspended solids[3]; finisher diet – 45 g/kg SBO improved growth performance and PUFA[4]
  - Tributyrin – 2-4 g/kg in yellow croaker, 75% FO replacement[5]
- **New Species**
  - Red claw crayfish – optimal lipid level of 10%, 100% SO[6]


Soy Carbohydrates in Aquaculture
UNITED SOYBEAN BOARD

Is there opportunity for soy carbohydrates in aquafeeds?

- **Soybean oligosaccharides replacing 1-5% of glucose in a biofloc system growing crucian carp[1]:**
  - Increased:
    - *Floc volume*
    - *Weight gain*
    - *Specific growth rate*
    - *Chao index of intestinal microbial species richness*
  - Decreased:
    - *FCR*
    - *Pseudomonas and Vibrio*

Other Uses of Soy in Aquafeeds

Non-Nutritional Benefits

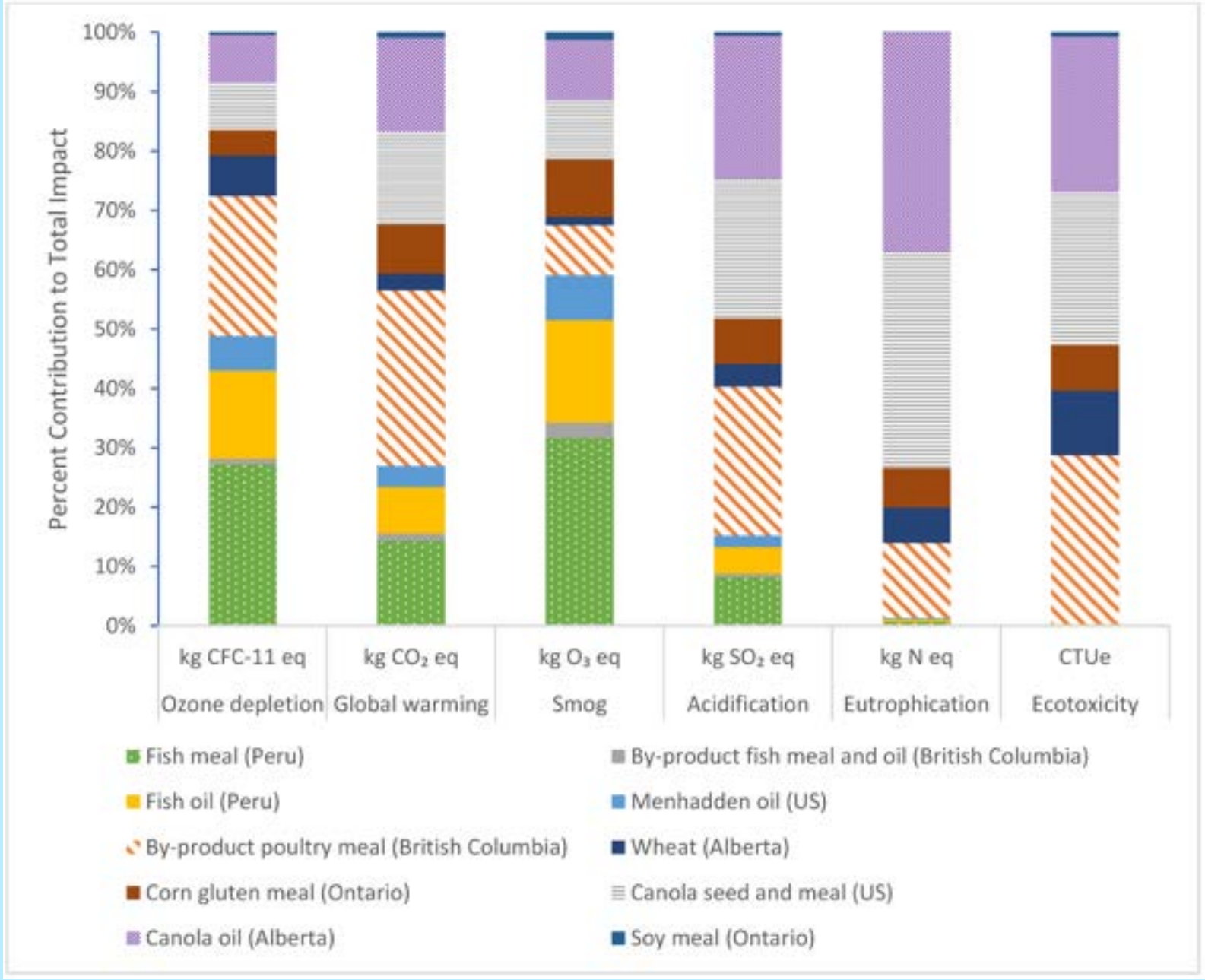
Non-Nutritive

- **Soy isoflavones**
  - 1-5 g/kg diet of genistein leads to 80%+ female Japanese eels vs 90% males in the control group[1]
  - 500 mg/kg soy isoflavones improve survival of challenged grass carp[2]
  - Daidzein at 40 mg/kg in 40% SBM diets preserved growth performance and gut health of turbot[3, 4]
- **Soybean phospholipid in the water reduces mortality of white shrimp under cold stress[5]**
- **If U.S. soybeans are used in grass carp diets – reduced carbon footprint of feed by 15% compared to Brazilian soybeans[6]**

Highlighted Studies

Meta-Analysis of Factors Causing Enteritis

- **Impact of several variables on enteritis severity**
  - Raised in freshwater vs seawater
  - SBM inclusion level
  - Year the study took place
  - Water temperature
- **They found…**
  - Seawater and low water temperatures made enteritis more severe
  - Increasing SBM inclusion level did not lead to more severe enteritis
    - *Could be due to variety of sources*
  - Enteritis from SBM-based diets has decreased in severity over time



Life Cycle Assessment of Aquaculture Stewardship Council Certified Atlantic Salmon

Sherry and Koester, 2020

Soybean meal-induced enteritis in Atlantic salmon (*Salmo salar)* and Chinook salmon (*Oncorhynchus tshawytscha*) but not in pink salmon (*O. gorbuscha*)


Erica Curles
ecurles@smithbucklin.com
THANK YOU
UNITED SOYBEAN BOARD™
UNITEDSOYBEAN.ORG


Soybean Industry
Practical soy-based diets for Florida pompano and Pacific white shrimp.
AUBURN UNIVERSITY
Soy Aquaculture Alliance
Aquaculture Industry

INTRODUCTION

High protein

Diverse cultivars

Differently processed products

Suitable for many species

Readily available

Soybean

INTRODUCTION

Intestinal morphology changes

High protein

Differently processed products

ANFs

Trypsin inhibitor

Soybean

Diverse cultivars

Health risk factor

Immunity impairment

Readily available

Suitable for many species

Soy in Aquatic Animal Feeds

- Very tolerant species – very high use
  - Pacific white shrimp - > 50% Soybean meal
  - Catfish & tilapia
- Tolerant but Require 10-15% animal protein
  - Florida pompano – 47% soybean meal
  - California Yellowtail (HSWRI) – 30% SBM + 15%SPC
  - White Sea Bass (HSWRI) – 30 % SBM + 8% SPC

- Lower tolerance -
  - Salmonids (primarily “allergic” response, often 20%)

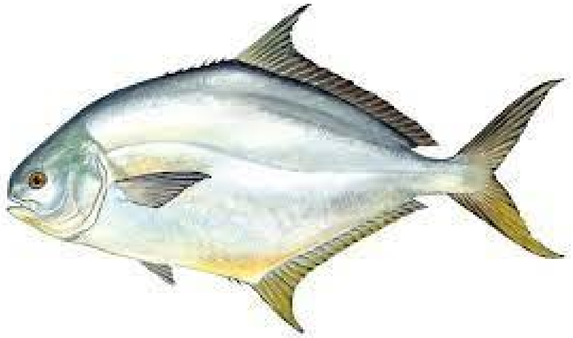
    Can utilize highly processed soy products

Objective:
Improve commercial feeds.

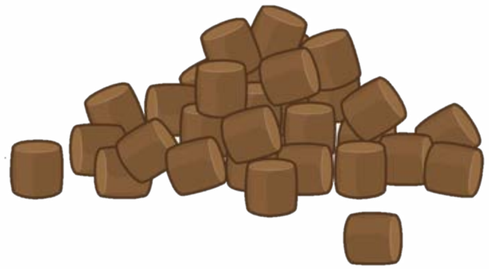
Florida pompano & Shrimp

- **Benchmark practical open feed formulations with commercial diet.**
- **Evaluate and optimize the use of advanced soy products in fish and shrimp feed formulations.**

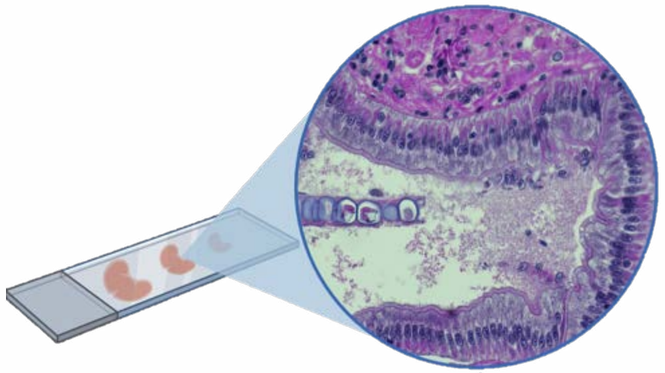
OBJECTIVES: FLORIDA POMPANO



Growth performance



Feed utilization efficiency



Intestine histomorphology

Table 1. Dietary composition of high soy grow out diet formulated to 40% protein and 10% lipid.

Composition	
Poultry meal	8.00
Soybean meal	55.20
CPC - Empyreal 75	10.00
Menhaden fish oil	8.16
Lecithin (soy)	0.50
Whole wheat	14.49
Mineral premix	0.25
Vitamin premix	0.50
Choline chloride	0.20
Rovimix Stay-C 35%	0.10
CaP-dibasic	2.00
Methionine	0.10
Taurine	0.50

Bench marking

Trial 1 (n=6)	Biomass (g)	Weight (g)	Weight Gain (%)	TGC	FCR	Survival (%)
Zeigler 40/10	886.9	60.45	**160.0**	**0.087**	**1.86**	97.78
AU diet	780.9	55.17	**138.8**	**0.078**	**2.05**	94.44
P Value	0.0260	0.0758	**0.0057**	**0.0034**	**0.0153**	0.0924
Trial 2 (n=3)						
Zeigler 40/10	3357.3	137.95	269.2	0.11	1.89	97.3
AU diet	2852.7	125.56	226.1	0.10	2.05	90.7
P Value	0.1919	0.3318	0.2836	0.4353	0.5769	0.2524

INGREDIENTS

Solvent-extracted soybean meal (SBM)

Bright Day
Solvent-extracted soybean meal; low oligosaccharide (SBM-LO)

Soycomil PE
Soy protein concentrate (SPC)

Hamlet HP300
Fermented soybean meal (FerSBM)

Modified expeller-pressed soybean meal (EPSBM)

INGREDIENTS PROXIMATE & AMINO ACIDS PROFILE

	SBM	SBM-LO	SPC	FerSBM	EPSBM	FM	PBM
Proximate Composition (g 100 g^{-1})							
Crude protein	43.28	53.36	55.26	61.56	43.20	64.75	67.06
Moisture	13.32	10.59	7.21	6.48	7.12	6.28	5.33
Crude fat	0.26	0.00	1.36	0.00	5.57	9.09	12.50
Crude fiber	3.65	2.93	4.16	6.31	5.03	0.66	0.93
Ash	5.92	6.24	6.87	6.19	6.80	19.77	9.97
Amino acids Composition (g 100 g^{-1})							
Histidine	1.12	1.39	1.43	1.62	1.11	1.66	1.34
Isoleucine	2.05	2.61	2.71	2.99	1.94	2.56	2.57
Leucine	3.41	4.12	4.23	4.75	3.29	4.31	4.70
Lysine	2.81	3.34	3.25	3.97	2.41	4.89	4.14
Methionine	0.60	0.73	0.74	0.83	0.58	1.69	1.32
Phenylalanine	2.27	2.80	2.81	3.14	2.13	2.45	2.81
Threonine	1.63	2.01	2.11	2.40	1.63	2.50	2.62
Tryptophan	0.55	0.71	0.71	0.79	0.46	0.65	0.69
Valine	2.13	2.65	2.77	3.09	2.12	2.97	3.05

SBM: solvent-extracted soybean meal (Bunge)

SBM-LO: SBM low oligosaccharide (Bright Day)

SPC: soy protein concentrate (Soycomil PE)

FerSBM: fermented SBM meal (Hamlet HP300)

EPSBM: expeller-pressed soybean meal (All Sustained)

FM: fish meal

PBM: poultry by-product meal

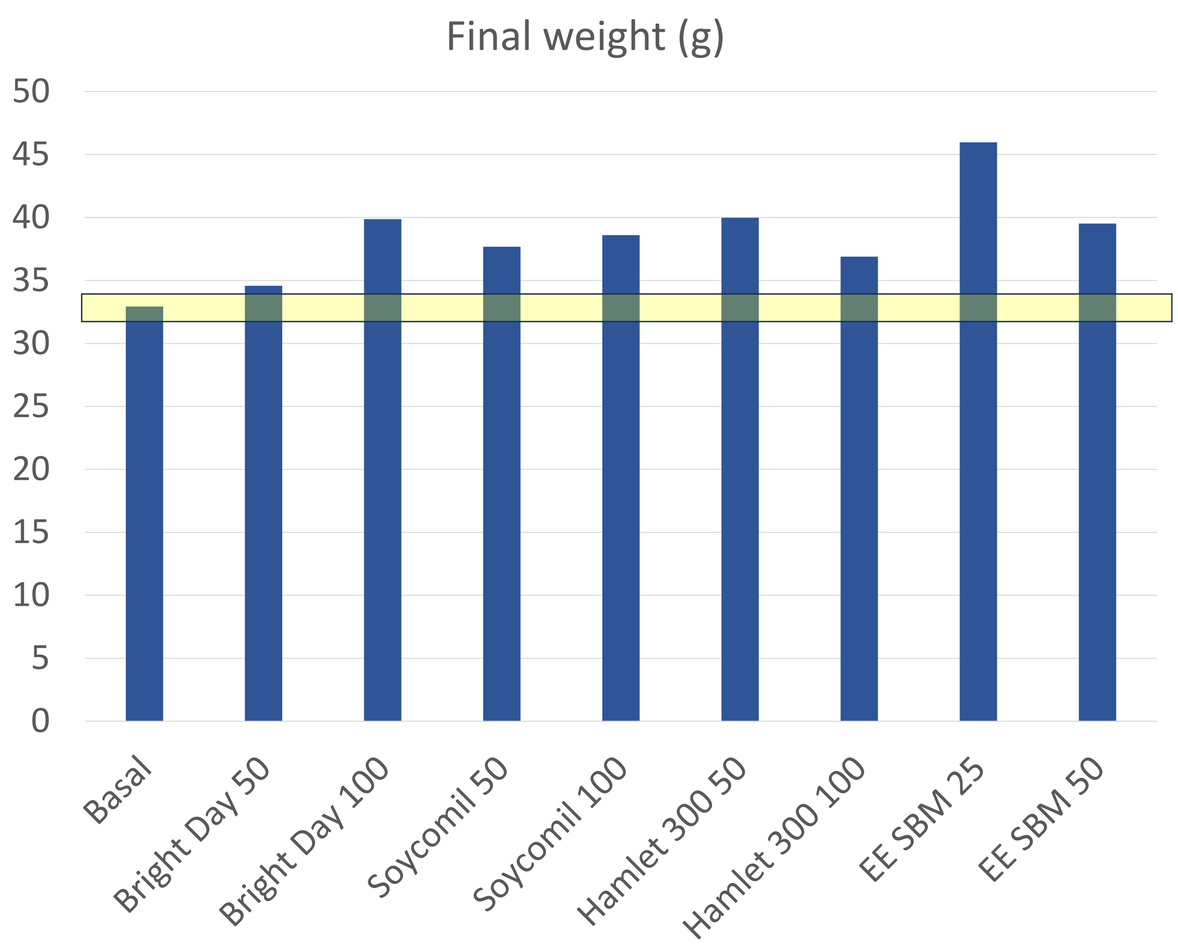
Florida pompano diets formulated to contain 40% protein and 10% lipid.

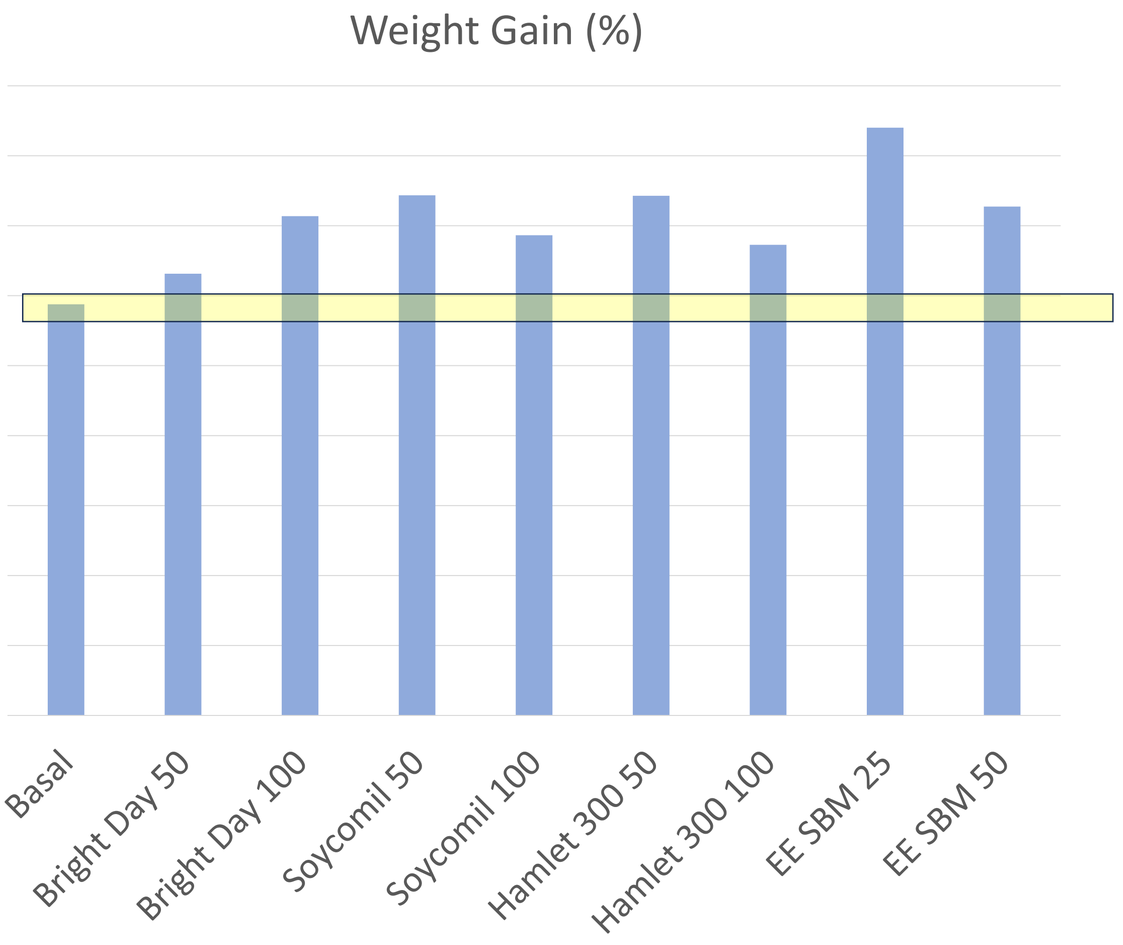
	Basal	BrightDay 50%	BrightDay 100%	Soycomil 50%	Soycomil 100%	Hamlet 50%	Hamlet 100%	Expeller SBM 25	Expeller SBM 50
Poultry meal	**14.00**	**14.00**	**14.00**	**14.00**	**14.00**	**14.00**	**14.00**	**14.00**	**14.00**
SE Soybean meal	**49.97**	**24.99**	**0.00**	**24.99**	**0.00**	**24.99**	**0.00**	**36.49**	**24.99**
Bright Day		**21.00**	**42.00**						
SPC Soycomil PE				**18.55**	**36.95**				
Hamlet HP 300						**20.55**	**40.90**		
Expeller-extruded SBM								**12.18**	**24.36**
CPC	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75
Menhaden fish oil	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42
Soy oil	1.82	1.89	1.95	1.89	1.95	1.61	1.40	1.01	0.19
Lecithin	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Corn Starch	0.13	4.05	7.98	6.60	13.13	4.89	9.73	2.23	2.37
Whole wheat	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Premix	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
CaP-dibasic	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Methionine	0.11	0.10	0.10	0.01	0.00	0.00	0.00	0.12	0.13
Taurine	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Aquaria trial

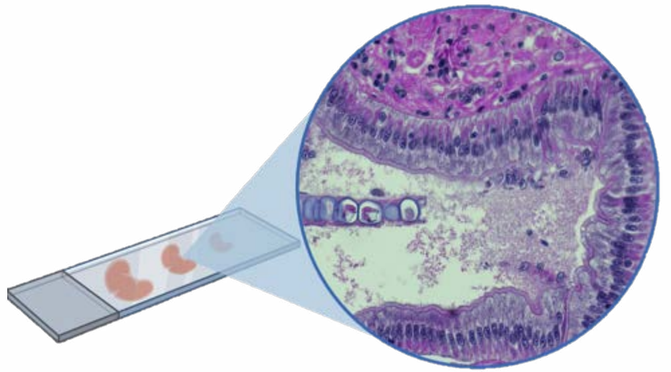
Response of juvenile pompano (4.8 g initial weight) to various soy sources over a 76-day culture period.

Diets	Final Biomass (g)	Final Ind. Weight (g)	Weight Gain (g)	P-Gain (%)	FCR	Survival
Basal	306.93	32.93	27.67	587.67	2.12	95.00
Bright Day 50%	315.40	34.58	29.79	631.35	2.19	92.50
Bright Day 100%	367.95	39.87	34.93	713.68	2.12	92.50
Soycomil 50%	329.83	37.68	33.22	743.46	2.33	86.67
Soycomil 100%	357.33	38.6	33.67	686.43	2.12	92.50
Hamlet 300 50%	389.78	39.98	35.19	742.80	2.09	97.50
Hamlet 300 100%	351.35	36.89	32.07	672.67	2.08	95.00
EP SBM 25%	413.65	45.97	41.06	840.07	1.88	90.00
EP SBM 50%	383.95	39.52	39.52	727.41	2.12	97.50
P-value	0.4572	0.4927	0.5227	0.7179	0.8741	0.9246
PSE[2]	36.31185	3.469595	4.5	84.2645	0.13065	6.0381


Final weight (g)
50
45
40
35
30
25
20
15
10
5
0
Basal
Bright Day 50
Bright Day 100
Soycomil 50
Soycomil 100
Hamlet 300 50
Hamlet 300 100
EE SBM 25
EE SBM 50


Weight Gain (%)
900
800
700
600
500
400
300
200
100
0
Basal
Bright Day 50
Bright Day 100
Soycomil 50
Soycomil 100
Hamlet 300 50
Hamlet 300 100
EE SBM 25
EE SBM 50

Growth trial is completed working on histology and other measures.



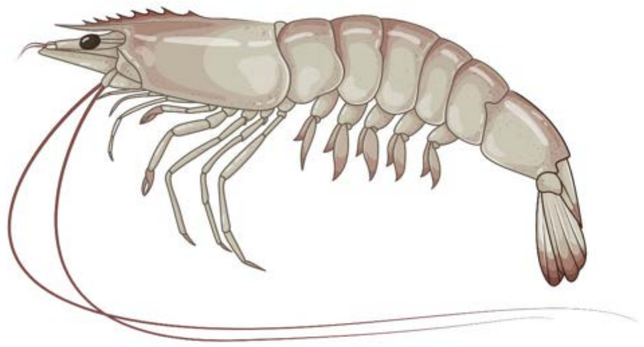
Intestine histomorphology

Next step

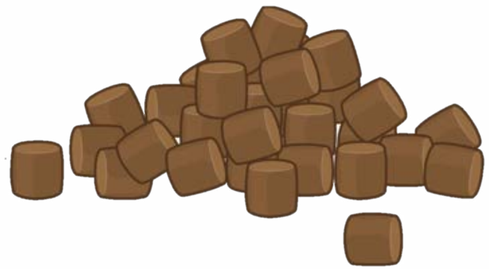
- Looking at dose response to

		Bright Day (low oligosaccharide)				Hamlet HP300 (fermented)			
Diet name	15% PM	40	60	80	100	40	60	80	100
Poultry meal	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
SE Soybean meal	50.00	30.00	20.00	10.00	0.00	30.00	20.00	10.00	0.00
Bright Day	0.00	16.85	25.25	33.65	42.00				0.00
HP 300						16.30	24.40	32.50	40.65
CPC	6.77	6.77	6.77	6.77	6.77	6.77	6.77	6.77	6.77
Menhaden fish oil	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42
Soy oil	1.82	1.87	1.90	1.93	1.95	1.65	1.57	1.48	1.40
Lecithin (soy)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Corn Starch	0.09	3.19	4.76	6.33	7.96	3.96	5.94	7.93	9.86
Whole wheat	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Premix	1.05	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
CaP-dibasic	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Taurine	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

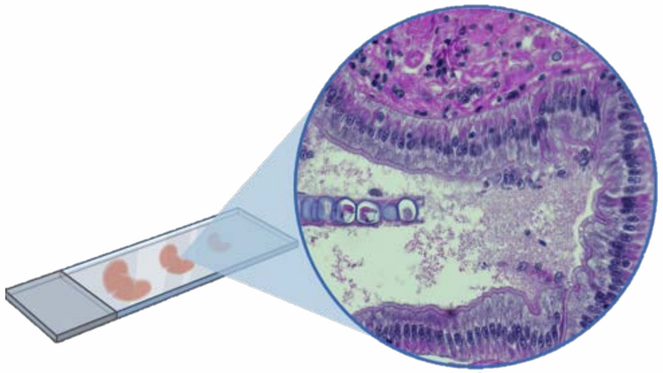
OBJECTIVES PACIFIC WHITE SHRIMP



Growth performance



Feed utilization efficiency



Intestine histomorphology

Physiological gene expression

INGREDIENTS

Plant-based
Soybean meals

BUNGE

Solvent-extracted soybean meal (SBM)

BENSON HILL

Bright Day
Solvent-extracted soybean meal; low oligosaccharide (SBM-LO)

ADM

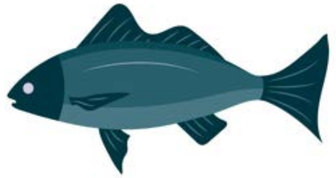
Soycomil PE
Soy protein concentrate (SPC)

HAMLET PROTEIN

Hamlet HP300
Fermented soybean meal (FerSBM)

ALL SUSTAINED

Modified expeller-pressed soybean meal (EPSBM)



Animal-based
Fishmeal + Poultry by-product meal

RIVER VALLEY INGREDIENTS

Poultry by-product meal

OMEGA PROTEIN®
Healthy Products for a Healthy World®

Special Select
Fishmeal

DIET FORMULATION

Composition	Basal	SBM-LO 50%	SBM-LO 100%	SPC 50%	SPC 100%	FerSBM 50%	FerSBM 100%	EPSBM 100%	Animal
Fishmeal	60	60	60	60	60	60	60	60	177
Poultry by-product meal									177
Soybean meal	480	240		240		240			
SBM-Low Oligosaccharide		202	404.5						
Soy protein concentrate				179.5	359.5				
Fermented SBM						199	398		
Enzyme treated SBM								477.5	
Other ingredients	460	498	535.5	520.5	580.5	501	542	462.5	646

SBM: solvent-extracted soybean meal (Bunge)

SBM-LO: SBM low oligosaccharide (Bright Day)

SPC: soy protein concentrate (Soycomil PE)

FerSBM: fermented SBM meal (Hamlet HP300)

EPSBM: expeller-pressed soybean meal (All Sustained)

FM: fish meal

PBM: poultry by-product meal

GROWTH PERFORMANCE

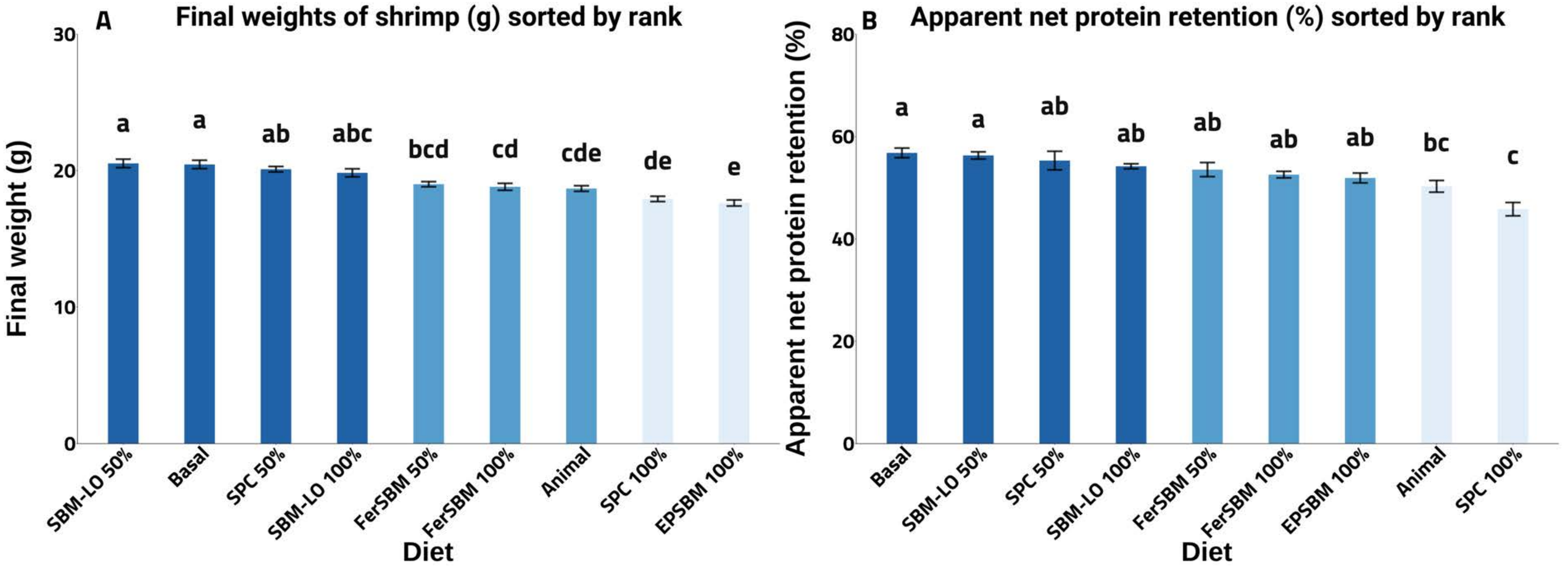


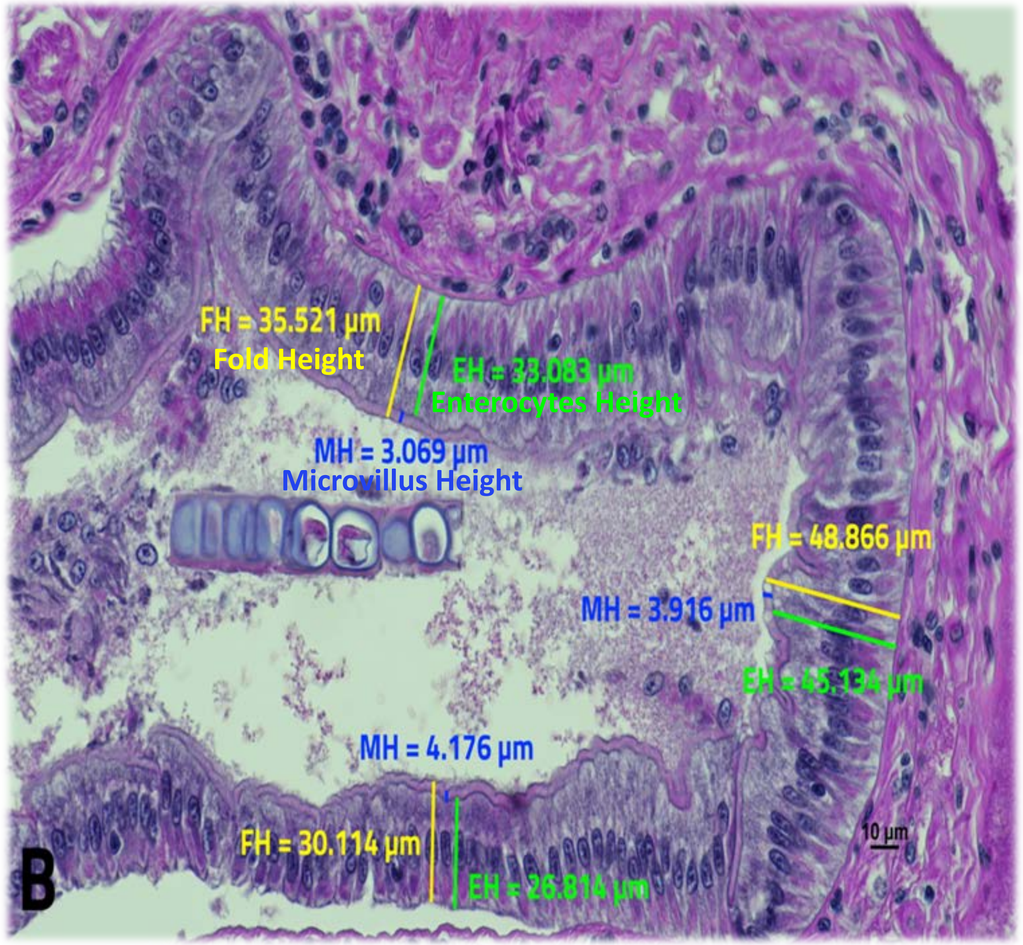
Figure 4. Final weight and net protein retention sorted by rank of Pacific white shrimp (*L. vannamei)* cultured in green water recirculating system for eight weeks fed basal (n = 3), FerSBM 100% (n = 4), SBM 100% (n = 3), FrSBM 100% (n = 4), EPSBM 100% (n = 4), and Animal (n = 4) diets. Bar graphs presented as mean and standard error of the mean as error bar.

HISTOMORPHOLOGY

Parameters	Basal[a]	SBM-LO 50%[b]	SBM-LO 100%[b]	SPC 50%[b]	SPC 100%[a]	FerSBM 50%[b]	FerSBM 100%[b]	EPSBM 100%[b]	Animal[b]	*P*-value
Fold height (µm)	19.74	19.51	20.80	20.55	17.81	25.79	22.04	21.94	22.70	0.859
Enterocytes height (µm)	18.11	17.51	19.30	18.77	16.54	24.00	20.36	20.14	21.05	0.850
Microvillus height (µm)	1.68	2.22	1.44	2.04	1.32	1.99	1.88	1.85	1.68	0.726

Note: Values represent the mean of three replicates ([a]) and four replicates ([b]) of each diet. *Non-parametric Kruskal-Wallis analysis

Means not sharing any letter are significantly different by the Tukey's HSD-test (parametric ANOVA) or Dunn's test (non-parametric Kruskal-Wallis) at the 5% level of significance.



SBM: solvent-extracted soybean meal (Bunge)

SBM-LO: SBM low oligosaccharide (Bright Day)

SPC: soy protein concentrate (Soycomil PE)

FerSBM: fermented SBM meal (Hamlet HP300)

EPSBM: expeller-pressed soybean meal (All Sustained)

FM: fish meal

PBM: poultry by-product meal

GENE EXPRESSION

tnf-a

Pro-inflammation

tgf-ß1

Anti-inflammation

proPO & SOD

Innate immune

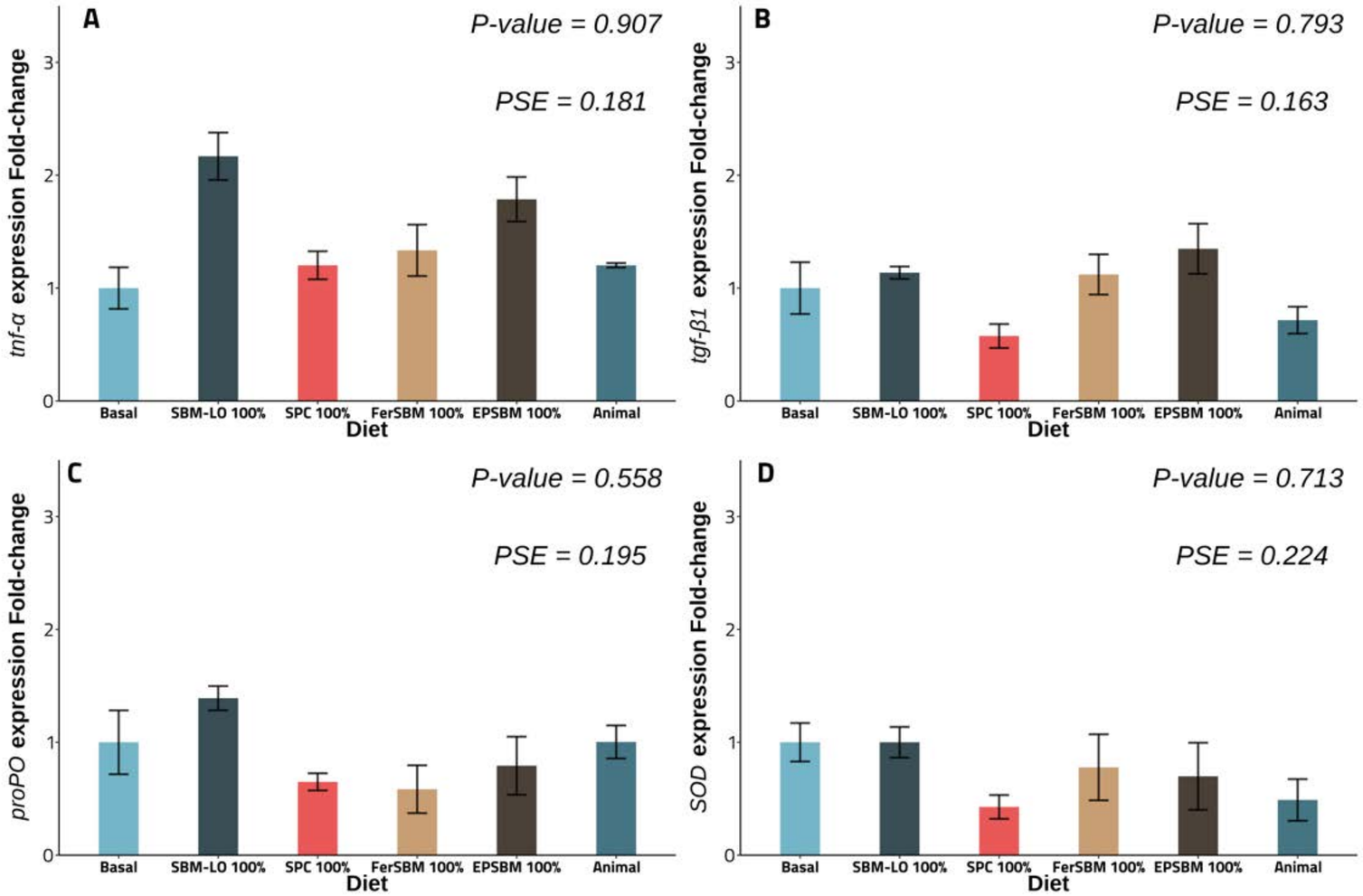


Figure 5. Gene expression of Pacific white shrimp (*L. vannamei*) cultured in green water recirculating system for eight weeks fed basal (n = 3), FerSBM 100% (n = 4), SBM 100% (n = 3), FrSBM 100% (n = 4), EPSBM 100% (n = 4), and Animal (n = 4) diets. Bar graphs presented as mean and standard error of the mean as error bar.

Conclusions (shrimp and pompano)

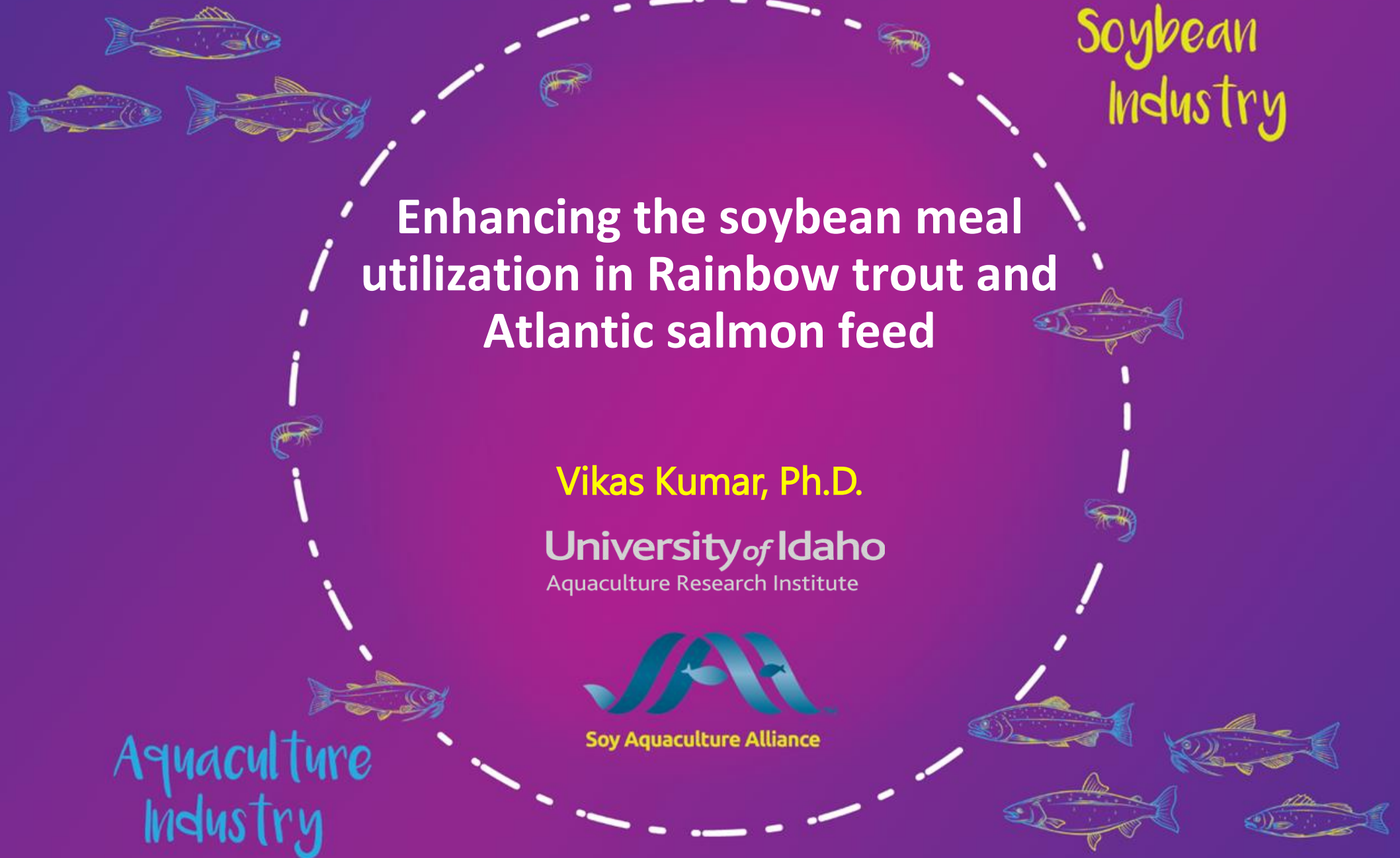
- **Species difference to the response to soy products.**
- **Origin/processing of the soybean meal** largely **contributes to the quality of soybean meal products. High inclusion is not appropriate for all types of soy**.
- Various meal can improve digestibility, nutrient retention (P), as well as growth performance.
- **Reduced performance** may reflect **palatability and nutrients issue rather than anti-nutrients factors**

Dr. D. Allen Davis

Trenton Corby, Khanh Quoc Nguyen, Trinh Ngo, Stephanie Velasquez

& Dr. Timothy Bruce

Soy Aquaculture Alliance



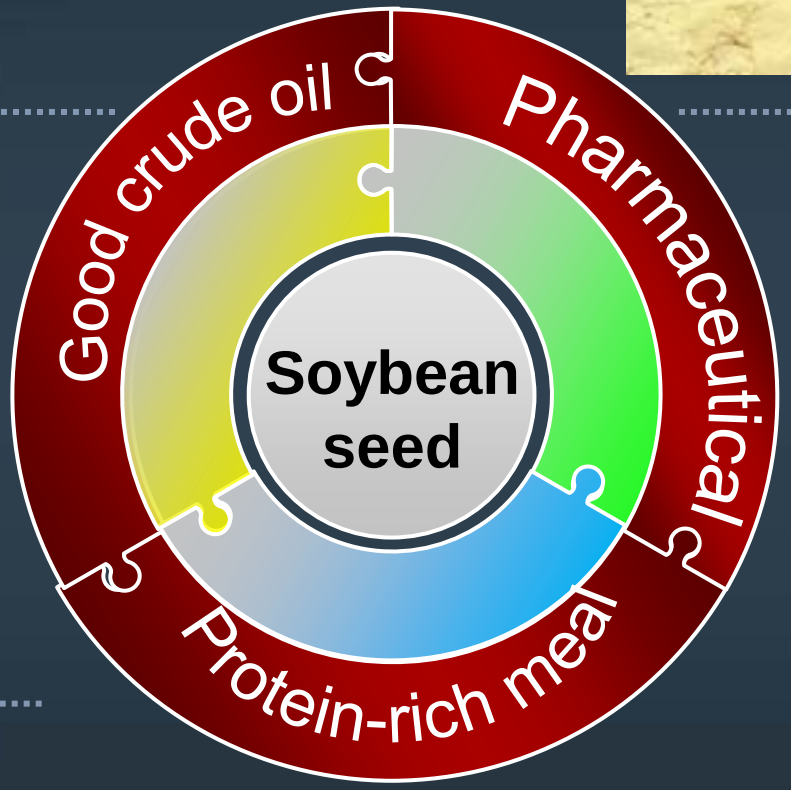
Enhancing the soybean meal utilization in Rainbow trout and Atlantic salmon feed

Vikas Kumar, Ph.D.

University of Idaho
Aquaculture Research Institute

Soy Aquaculture Alliance

Soybean Seed



Examples:

Good quality of oil:

- Soybean seed = 20-25%
- Human food
- Animal and fish feed

(Source: Kumar, 2010a,b; 2011a,b,c)

Examples:

- *Isoflavones*
- *Steroid hormones*
- *Glyceollins*

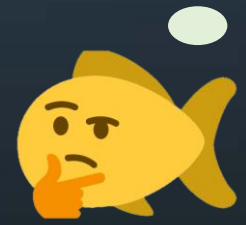
(*Source: Sacks* et al., *2006; Kim* et al., *2010*)

Examples

- Crude protein: **40-48%,** vitamins and minerals

(Source : Kumar, 2010a,b; 2011a,b,c)

Antinutrients!

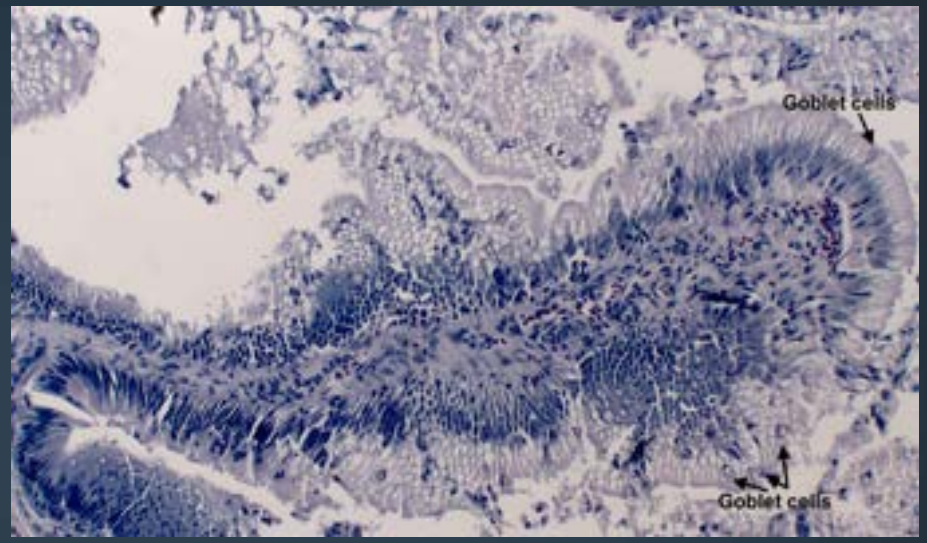


Distal Intestinal Morphology – Rainbow trout

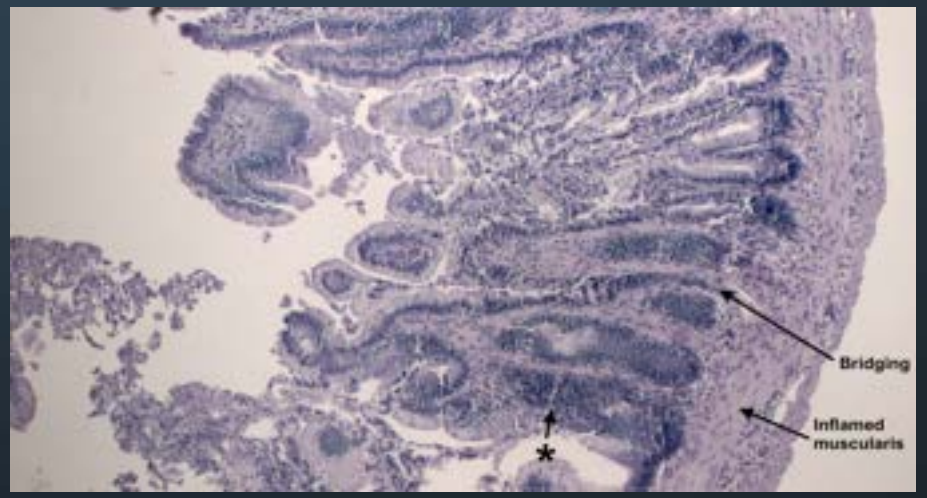
Fish meal

Soybean meal

40X



20X



Kumar et al., *(Unpublished)*

AQUAFEED
Soybean is a major ingredient
Not alternative ingredient

Goal and Projects

Overall goal to increase the inclusion of soy in salmonids diets

Project 1: Improving **”Feed Efficiency”** of soy diets in selected rainbow trout

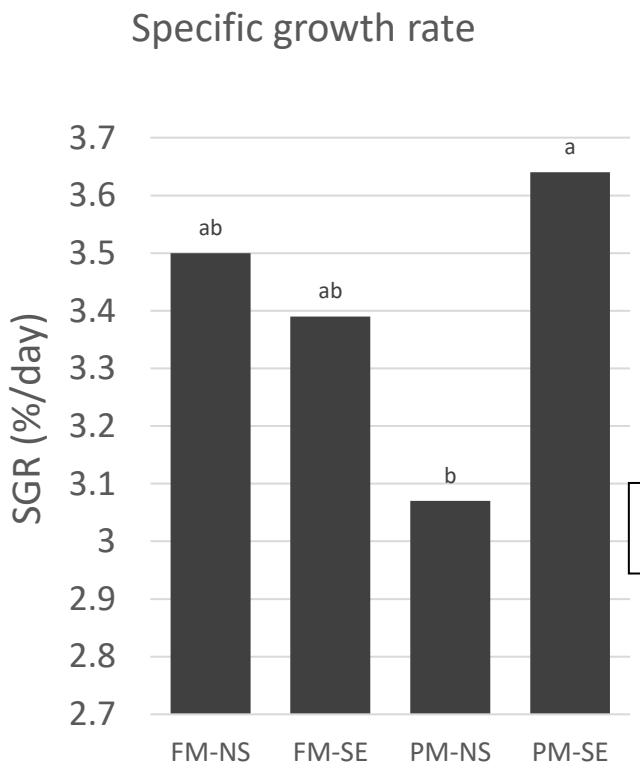
Project 2: Enhancing the soybean meal utilization in Rainbow trout *via* black soldier fly larvae

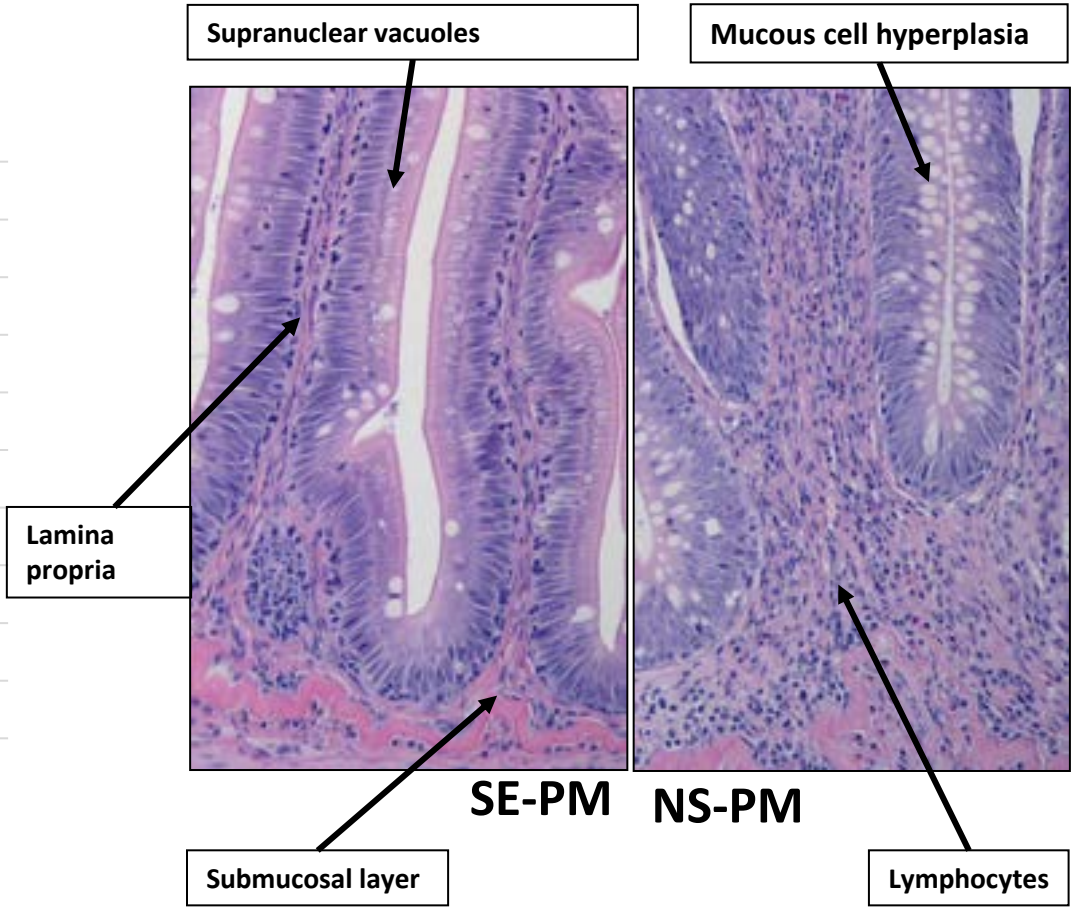
Project 3: Improving the soybean meal utilization in Atlantic salmon *via* black soldier fly larvae

Rainbow Trout Selection for Plant Protein Utilization (UI-ARI and USDA)

Growth Performance And Effects Of Selection On Enteritis

Ingredient (% of total)	Plant meal (PM diet)
Soy protein concentrate	23.00
Soybean meal	25.00
Wheat gluten meal	2.24
Wheat flour	13.3
Fish oil	17



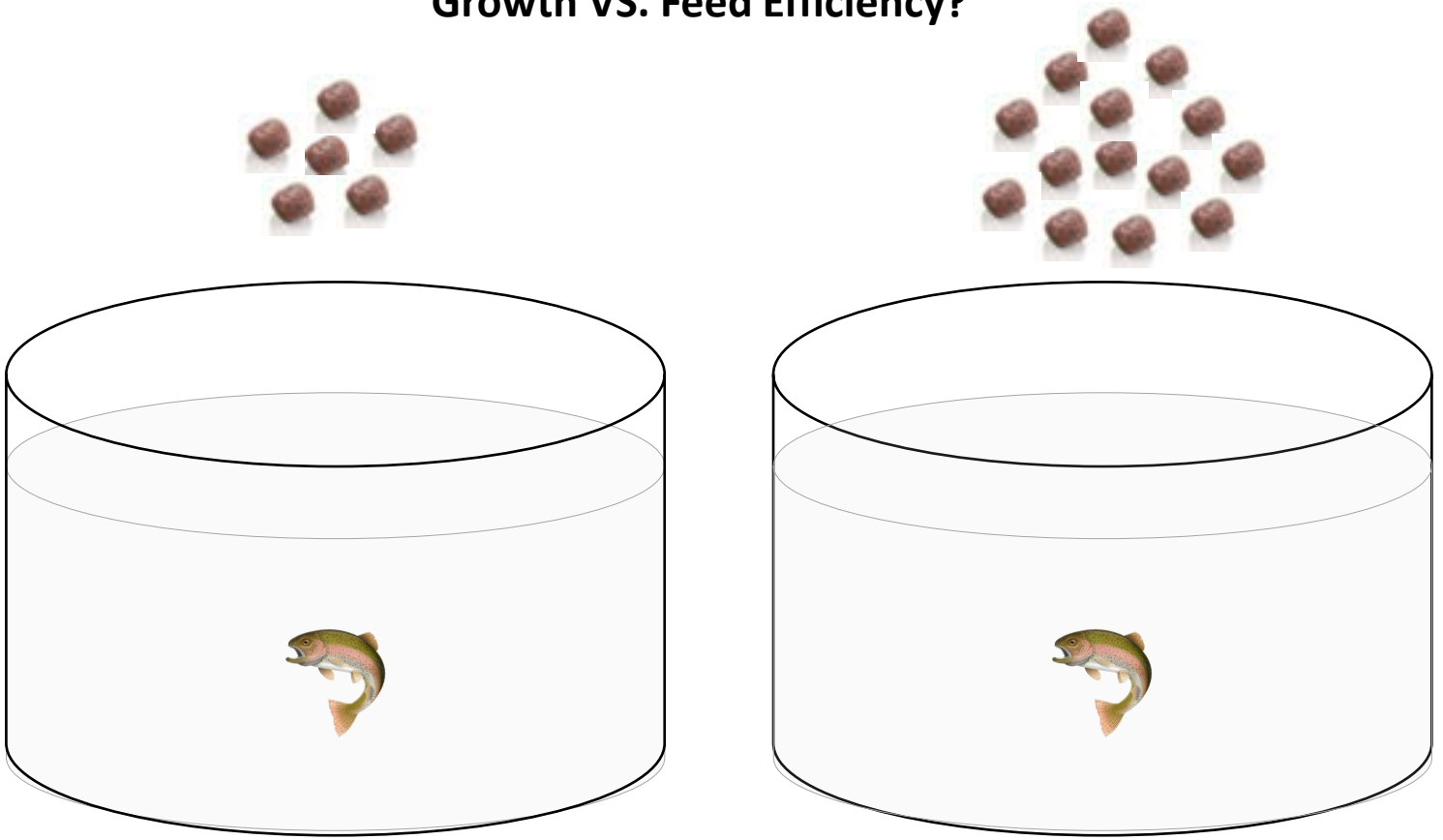


FM=Fish meal, PM=Plant meal, NS=Non-selected, SE=Selected

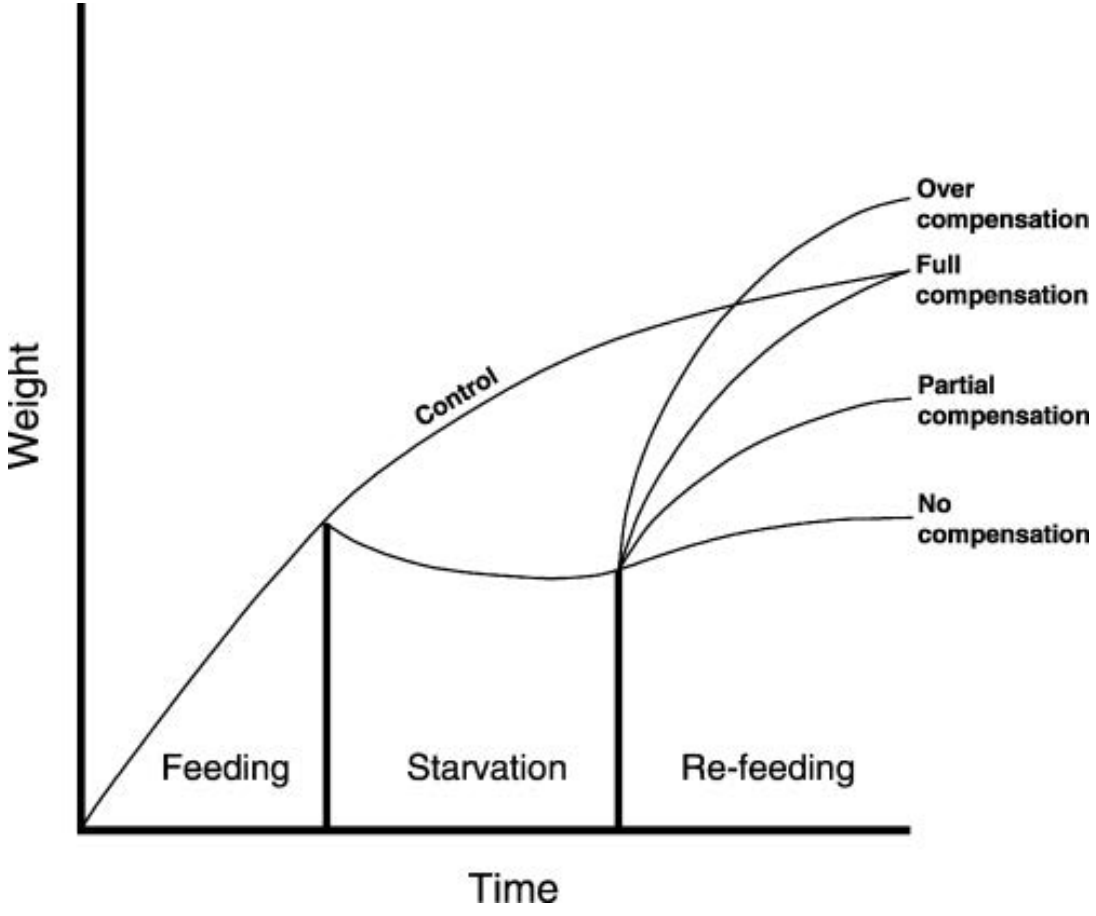
Unpublished data from ARI/USDA

Project 1: Improving ”Feed Efficiency” of soy diets in selected rainbow trout

Growth VS. Feed Efficiency?



Hypothesis: Patterns Of Growth Compensation In Fish



Jobling, 1994; Ali et al., 2003

Factors affecting compensatory growth:

- Length and intensity of deprivation
- Influence of Social Factors
- Seasonal variation
- Sexual maturation and reproduction
- Hyperphagia

FCR Varies Among the Four Groups

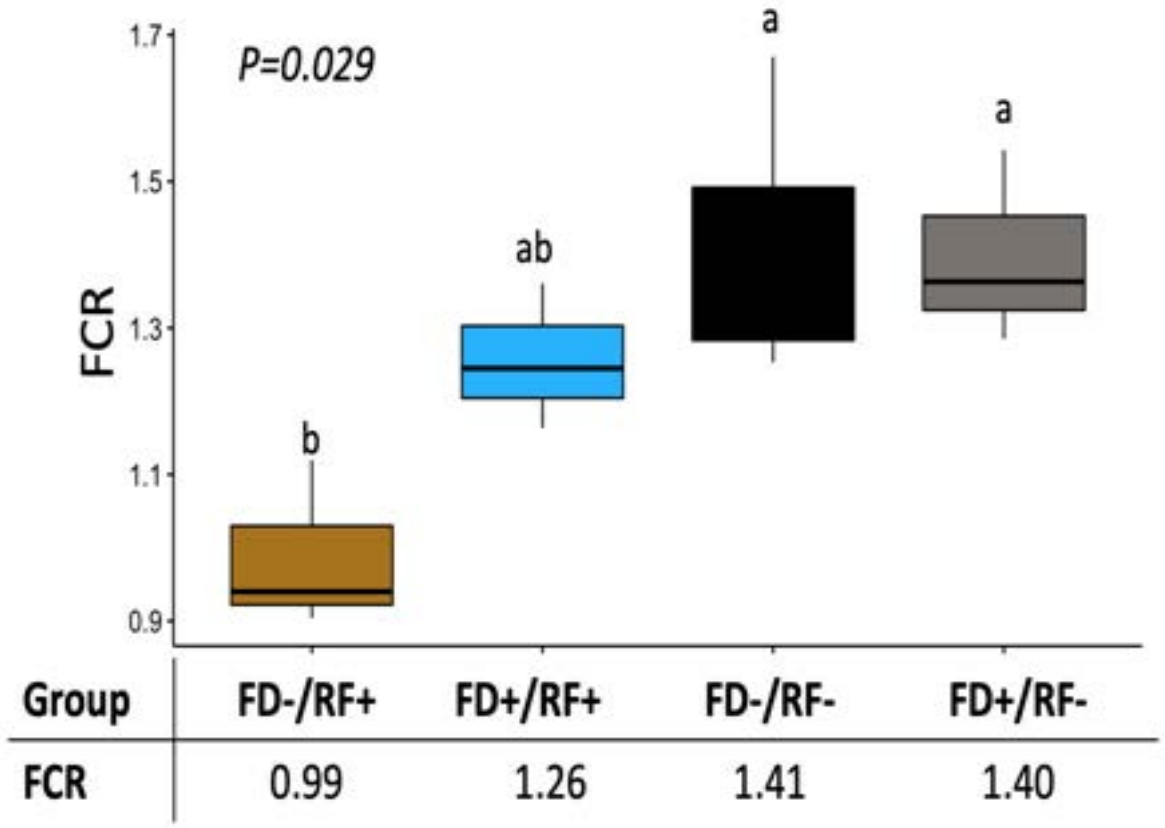
Four groups:

FD^-/RF^-: fish exhibiting loss and gain lower than the population mean

FD^+/RF^+: fish exhibiting loss and gain higher than the population mean

FD^-/RF^+: fish exhibiting loss lower and gain higher than the population mean

FD^+/RF^-: fish exhibiting loss higher and gain lower than the population mean



Group	FD-/RF+	FD+/RF+	FD-/RF-	FD+/RF-
FCR	0.99	1.26	1.41	1.40

Outcomes and Benefits

- Genetic improvement of rainbow trout for efficient SBM diet utilization
  - **10-20% increase in feed efficiency**
  - **Lower cost of production**
  - **Sustainable aquaculture**
  - **Can be applied for other commercial fish**

Need further research for breeding program: offspring for feeding trial to check their feed efficiency capacity

BREEDING/SPAWNING?

Project 2: Enhancing the soybean meal utilization in Rainbow trout via black soldier fly larvae

Pre-challenge (PHASE 1) : 70 days

- **Diets: 6** isonitrogenous (49% CP) & Isolipidic (20% lipid)
  - Fishmeal
  - Soybean meal (SBM)
  - SBM + DB 2.5%
  - SBM + DB 5%
  - SBM + WB 2.5%
  - SBM + WB 5%

*__DB__- Defatted black soldier fly larvae

*__WB__- Wholebody black soldier fly larvae

- 4 tanks/treatment: 30 fish/tank
- Initial weight of 4.5g ± 0.5g

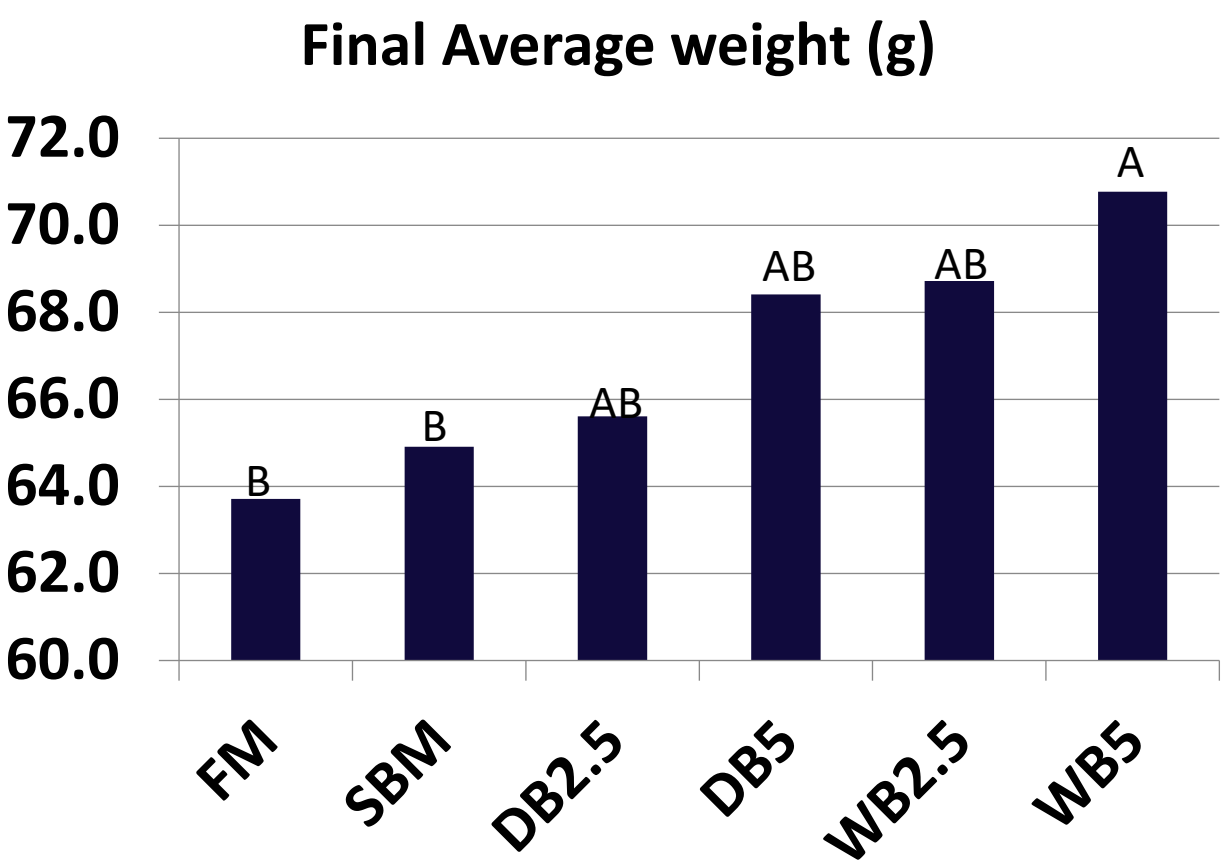
Post-challenge (PHASE 2): 28 days

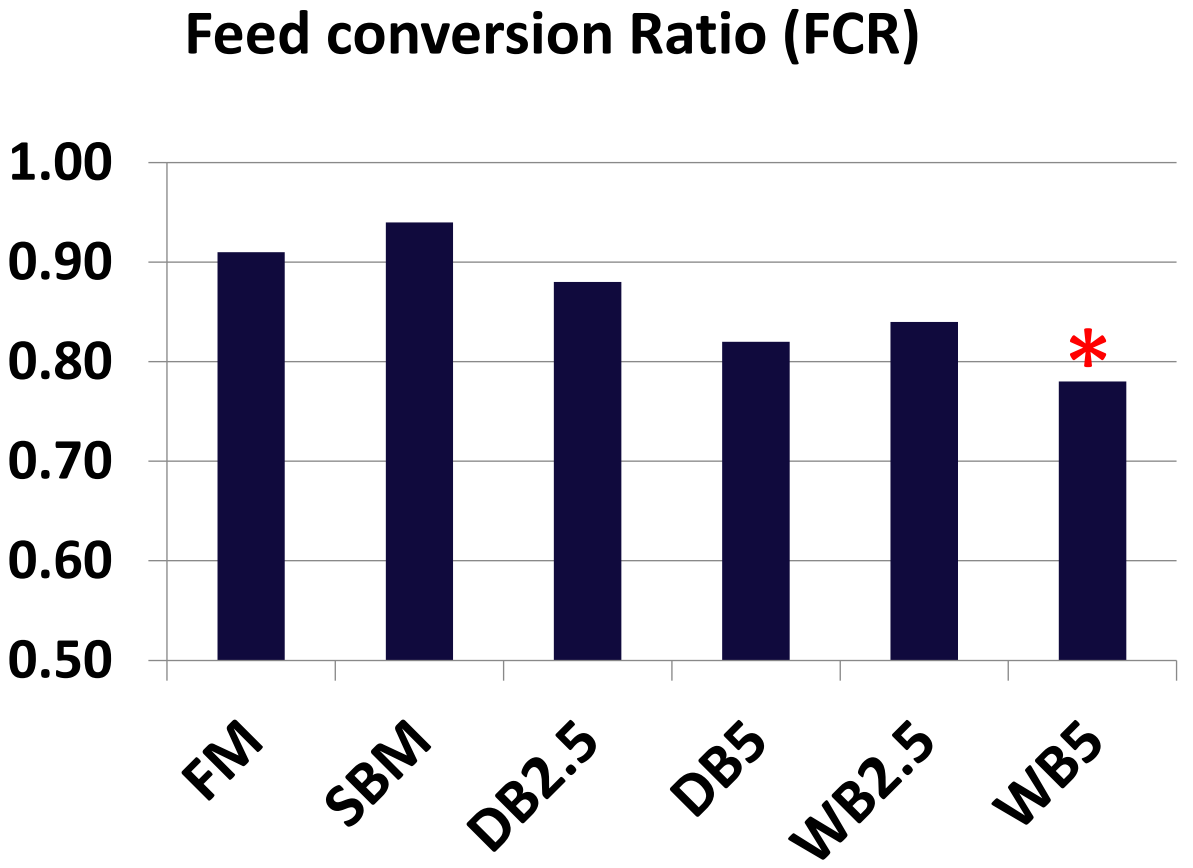
- *Flavobacterium psychrophilum*
- Dose 100 µl/fish (1.07 x 10^8 CFU/fish) given intraperitoneally.
- Initial weight of 65g ± 5g
- 1 tank/ treatment for mock (PBS placebo): 13 fish/tank
- 3 tanks/treatment for disease challenge: 13 fish/tank

DIETARY COMPOSITION % INGREDIENT INCLUSION						
	Control/FM	SBM	WB-2.5%	WB-5%	DB-2.5%	DB-5%
FM	25.00	10.00	10.00	10.00	10.00	10.00
Soybean meal	0.00	30.00	30.00	30.00	30.00	30.00
Whole BSFL (WBSFL)	0.00	0.00	**2.50**	**5.00**	0.00	0.00
Defatted BSFL (DBSFL)	0.00	0.00	0.00	0.00	**2.50**	**5.00**
Canola meal	11.50	3.00	2.70	1.60	2.60	1.60
Wheat gluten meal	4.00	4.60	4.60	4.40	4.60	4.60
Corn protein concentrate	4.00	4.50	4.50	4.30	4.50	4.50
Blood meal	12.00	12.80	12.30	12.84	12.20	12.10
Wheat flour	18.70	12.18	11.43	11.46	11.41	11.25
Poultry meal	6.40	3.00	2.70	1.60	2.60	1.60
Fish oil	15.50	16.88	16.23	15.75	16.54	16.32

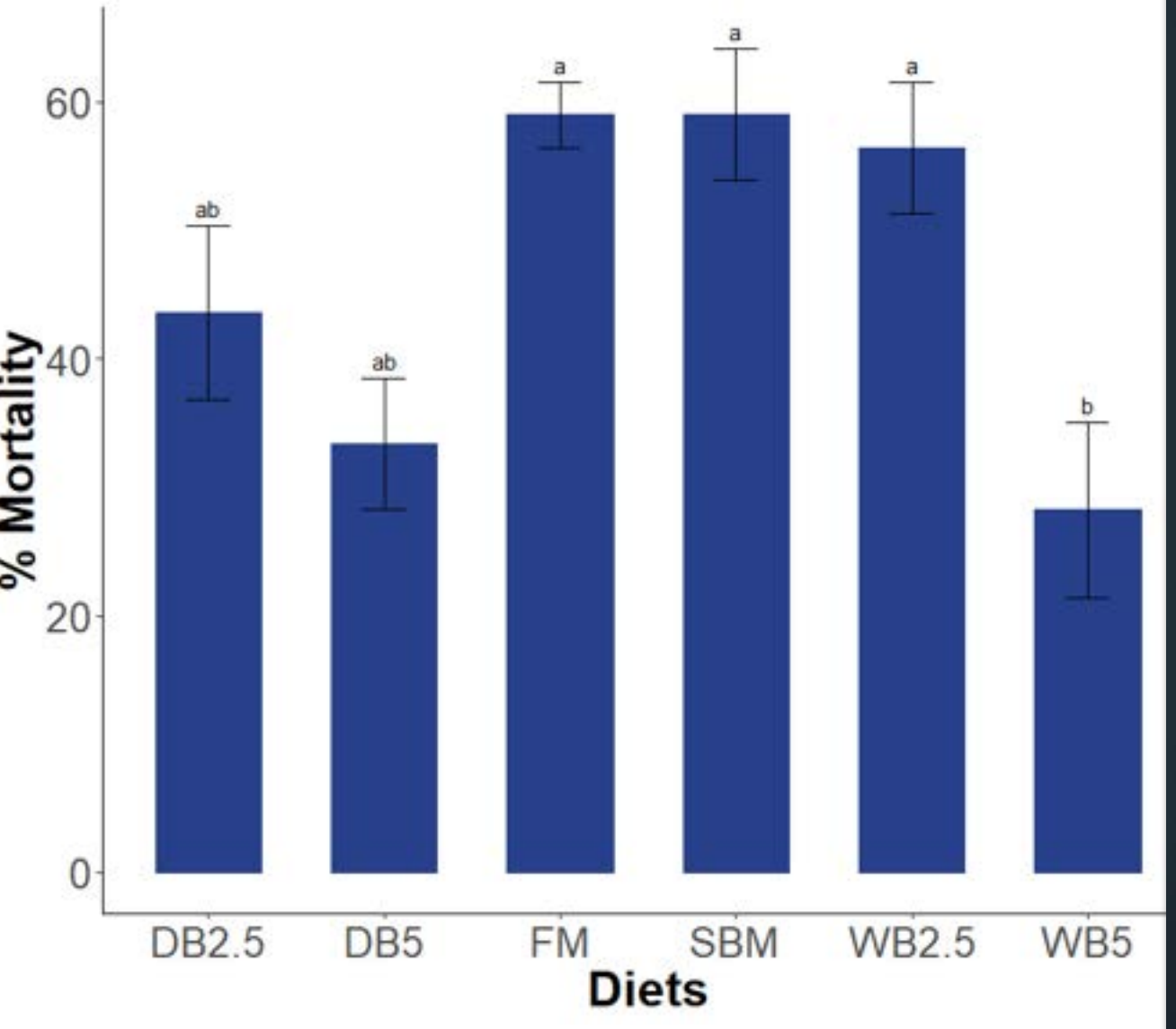
Growth performance and Feed utilization

Initial average weight: 5.2 g

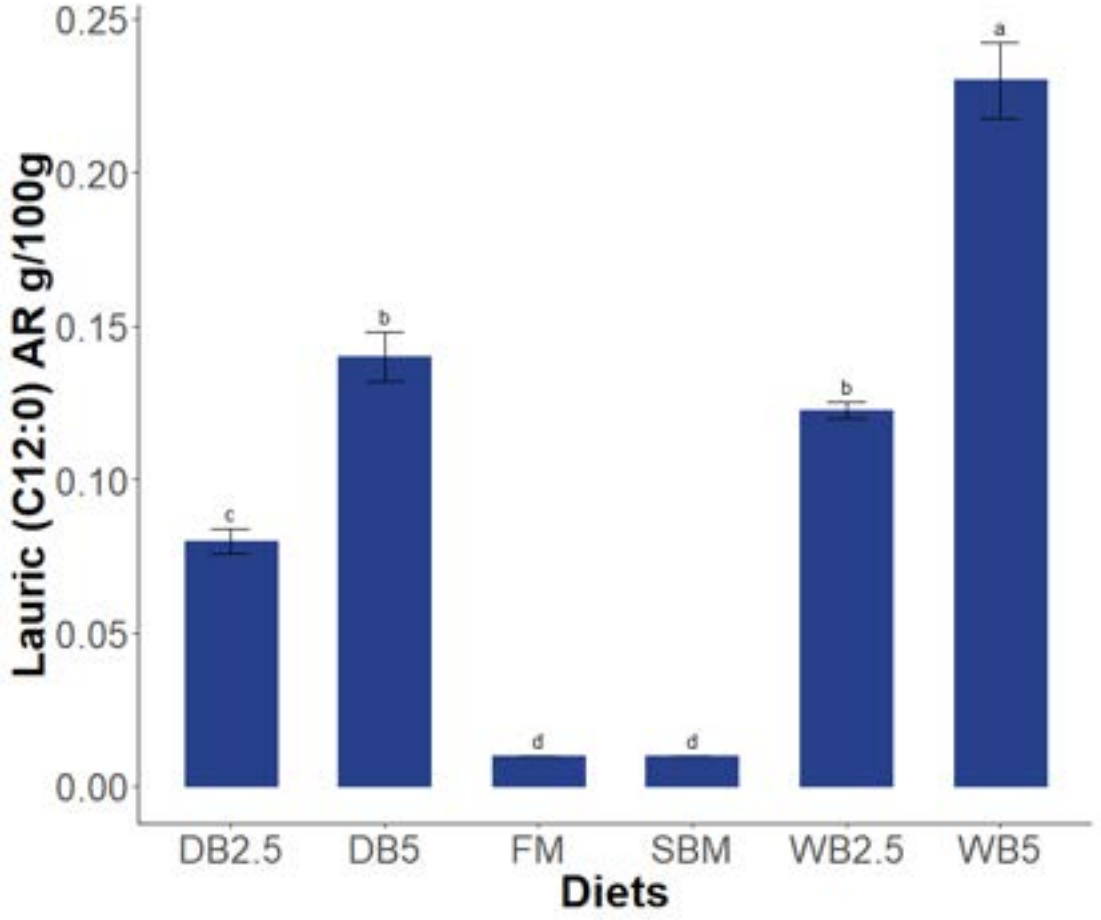




PHASE 2: Bacterial challenge (28 DAYS) -
Flavobacterium psychrophilum

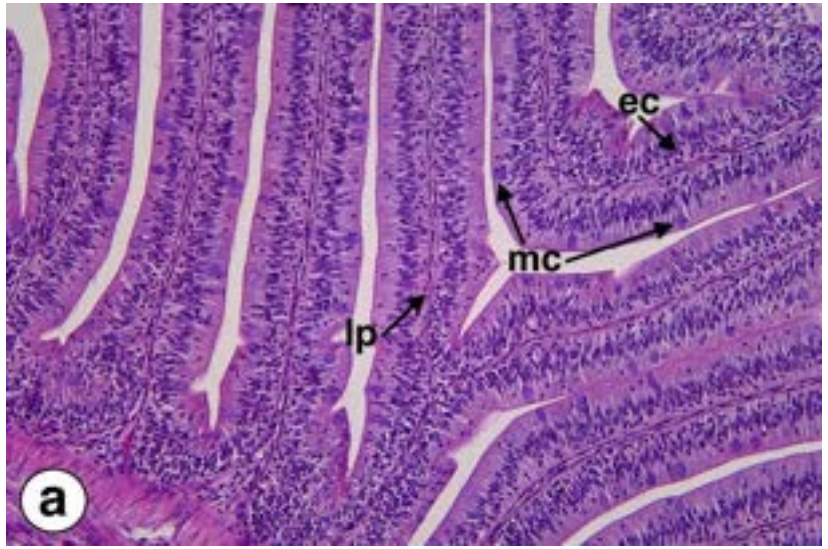


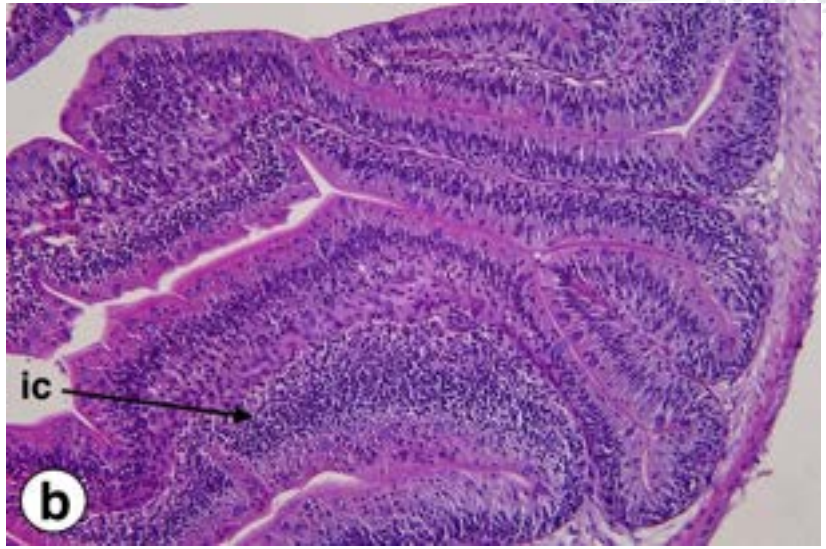
Lauric acid in the whole body (w/w)



Gut Histology – Pre-challenge study

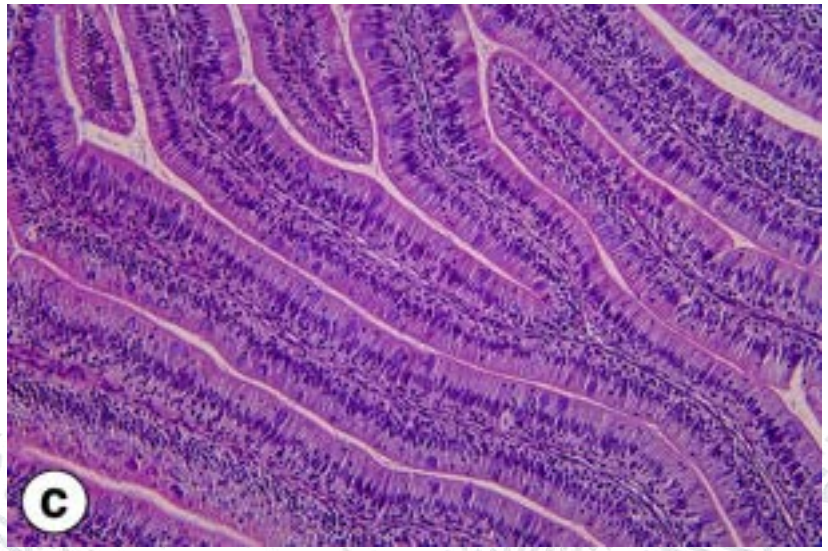
Control (Fish meal)

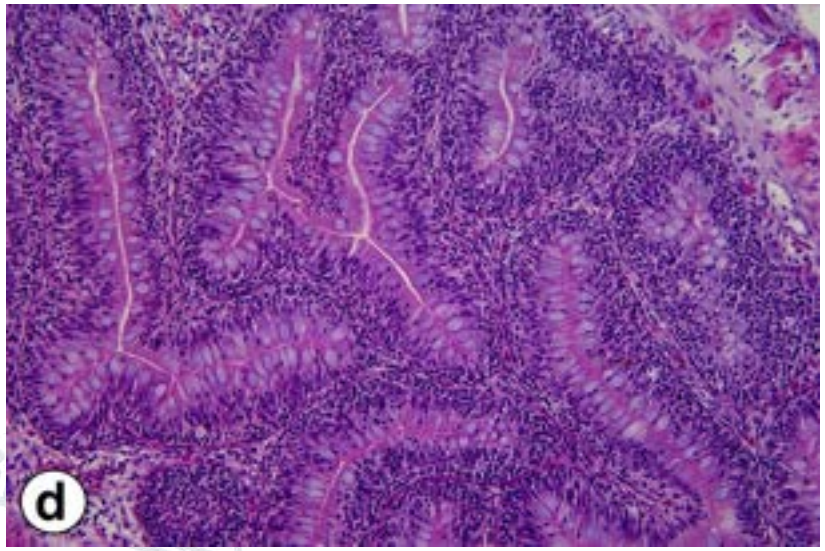




Control (Soybean meal, SBM)

SBM + Whole Insect

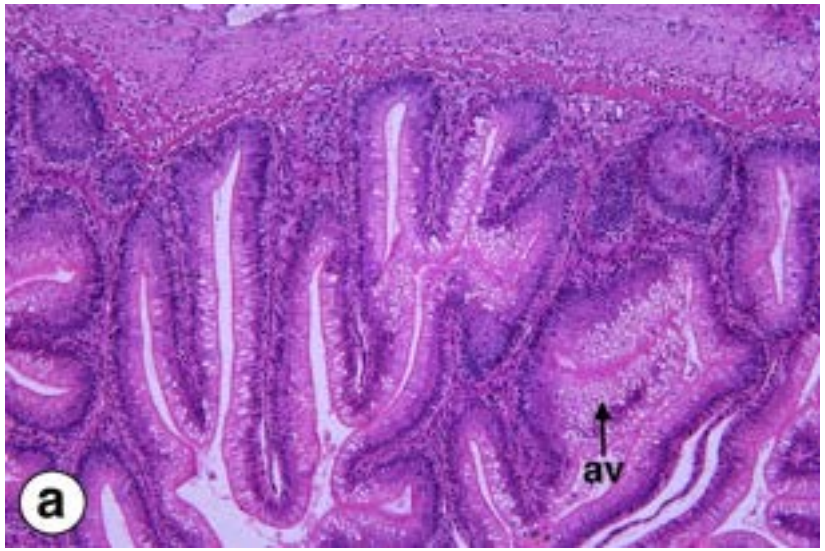


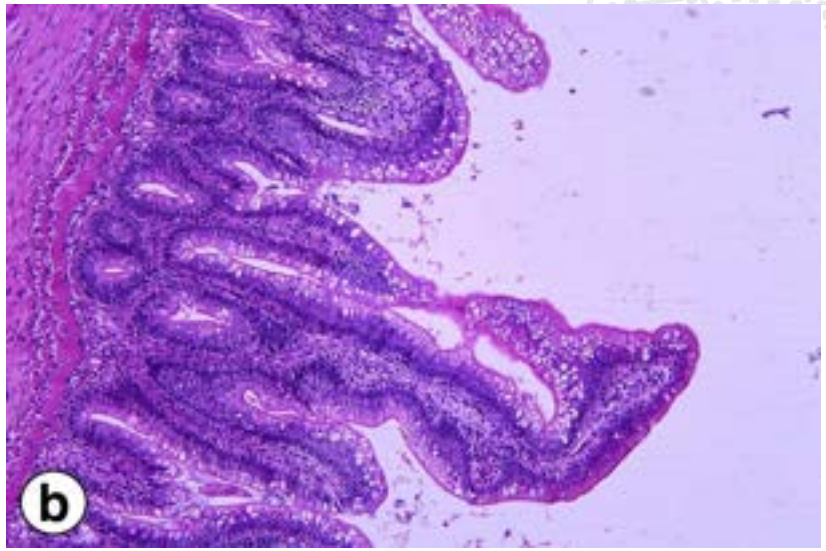


SBM + Defatted Insect

Gut Histology - Post-challenge study – Cold water disease

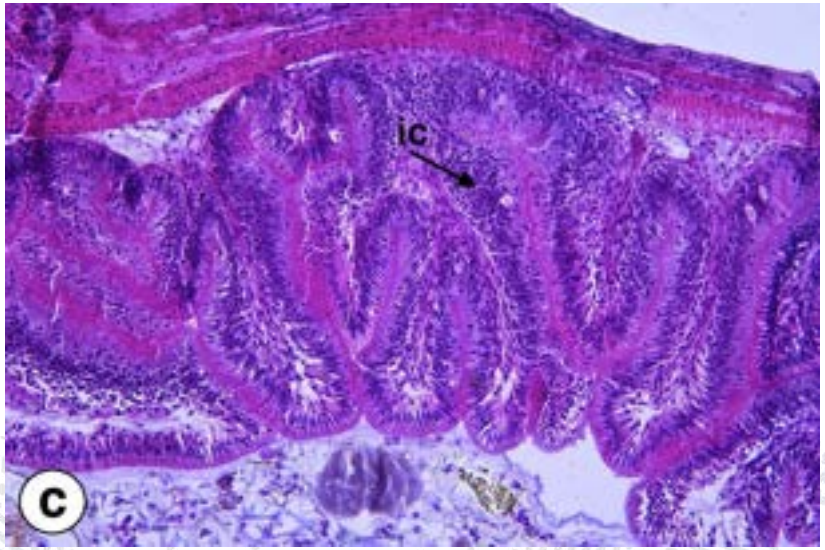
Control (Fish meal)

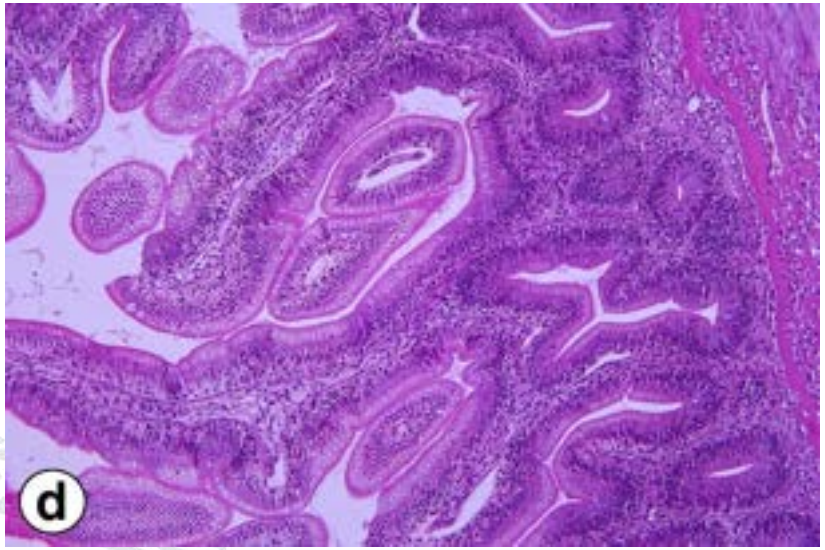




Control (Soybean meal, SBM)

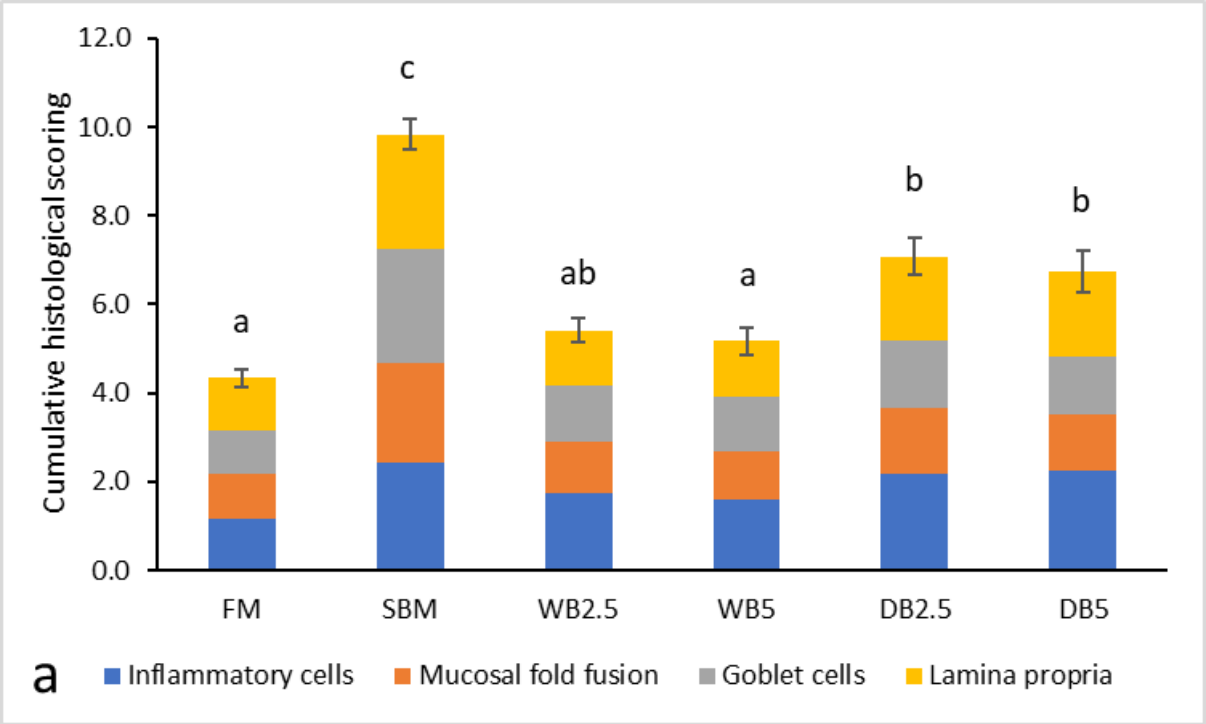
SBM + 2.5% Whole Insect

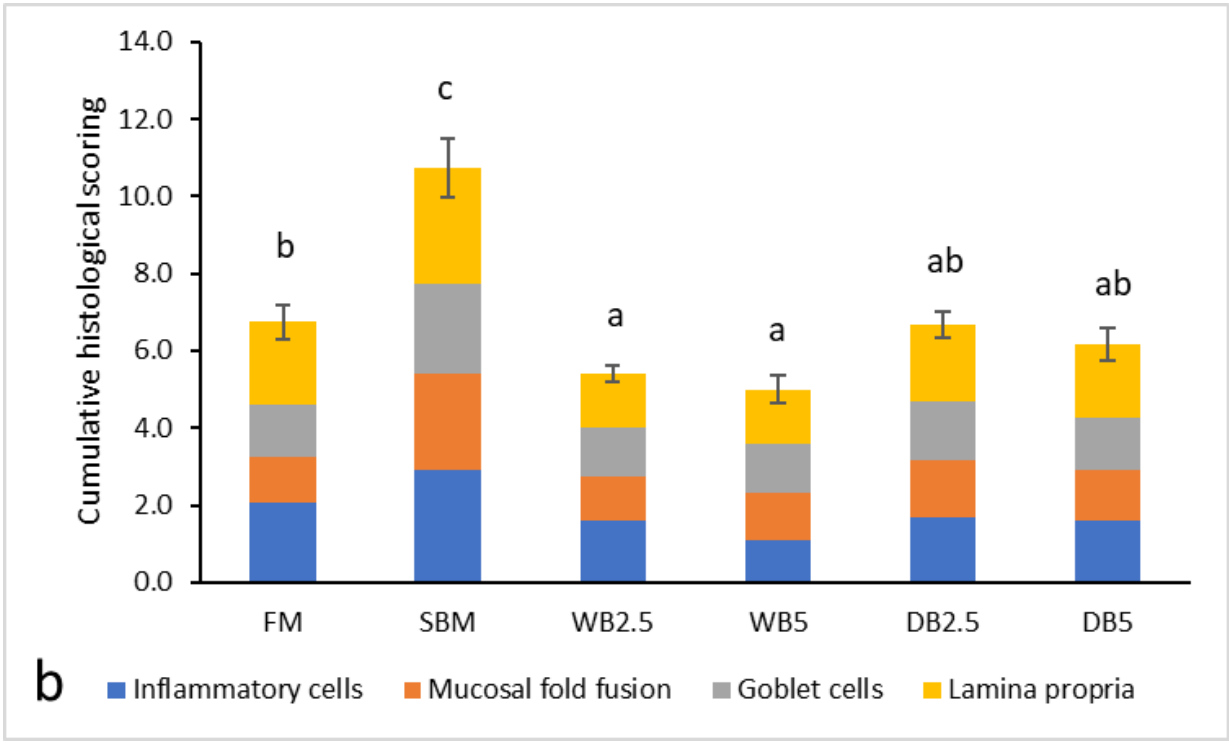




SBM + 5% Whole Insect

Cumulative histopathological scoring





Concluding remarks

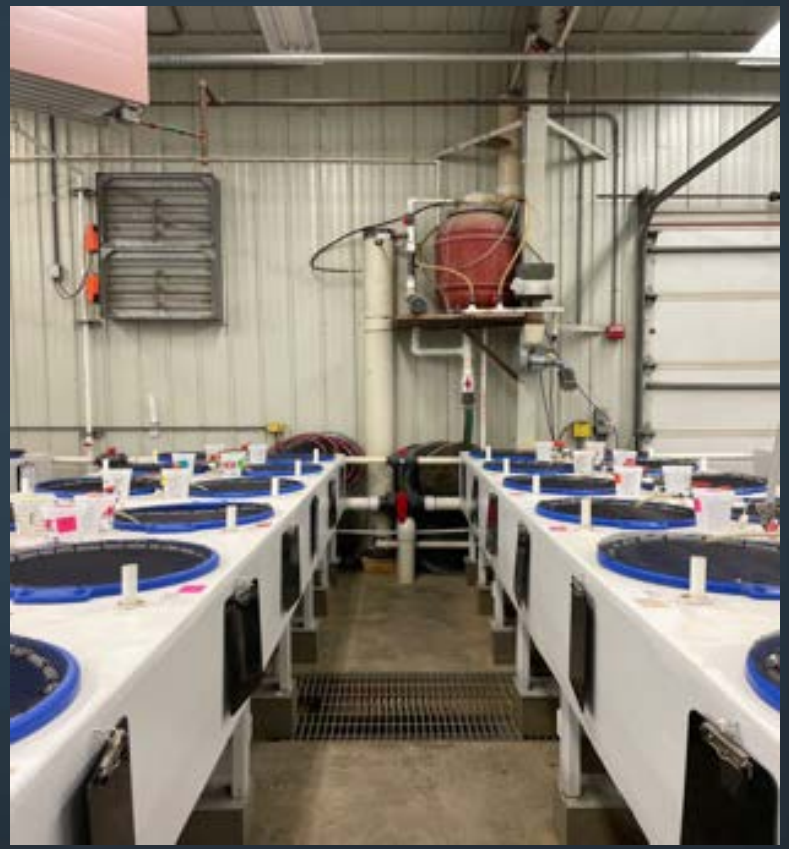
- Whole insect meal (5%) – Improved growth performance of fish
- Nutritional composition of whole body
- Cold water disease
- Insect meal – mitigate soybean meal induced enteritis
- Alternative approach to handle the practical problems in aquafeed industry

Project 3: Whole Insect meal as a complementary ingredients for soy – Atlantic salmon feed

Feeding Trial – 12 weeks

Diets: 7 isonitrogenous (41% CP) and isolipidic (20% CL)

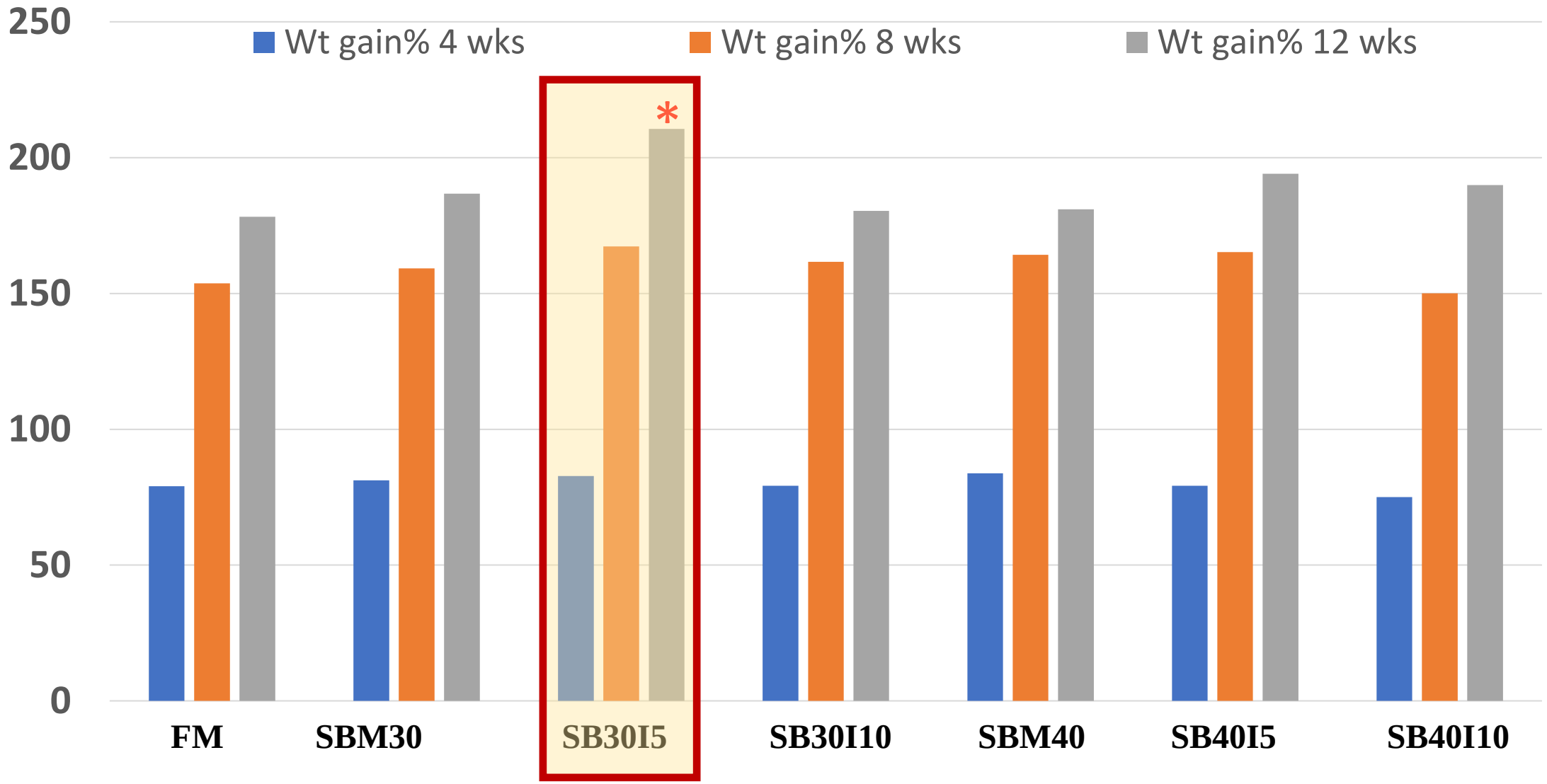
1. **Control feed - 0% SBM + 30% fishmeal (FM)**
2. **30% SBM + 10% FM**
3. **30% SBM + 10% FM + 5% BSFL**
4. **30% SBM + 10% FM + 10% BSFL**
5. **40% SBM + 10% FM**
6. **40% SBM + 10% FM + 5% BSFL**
7. **40% SBM + 10% FM + 10% BSFL**

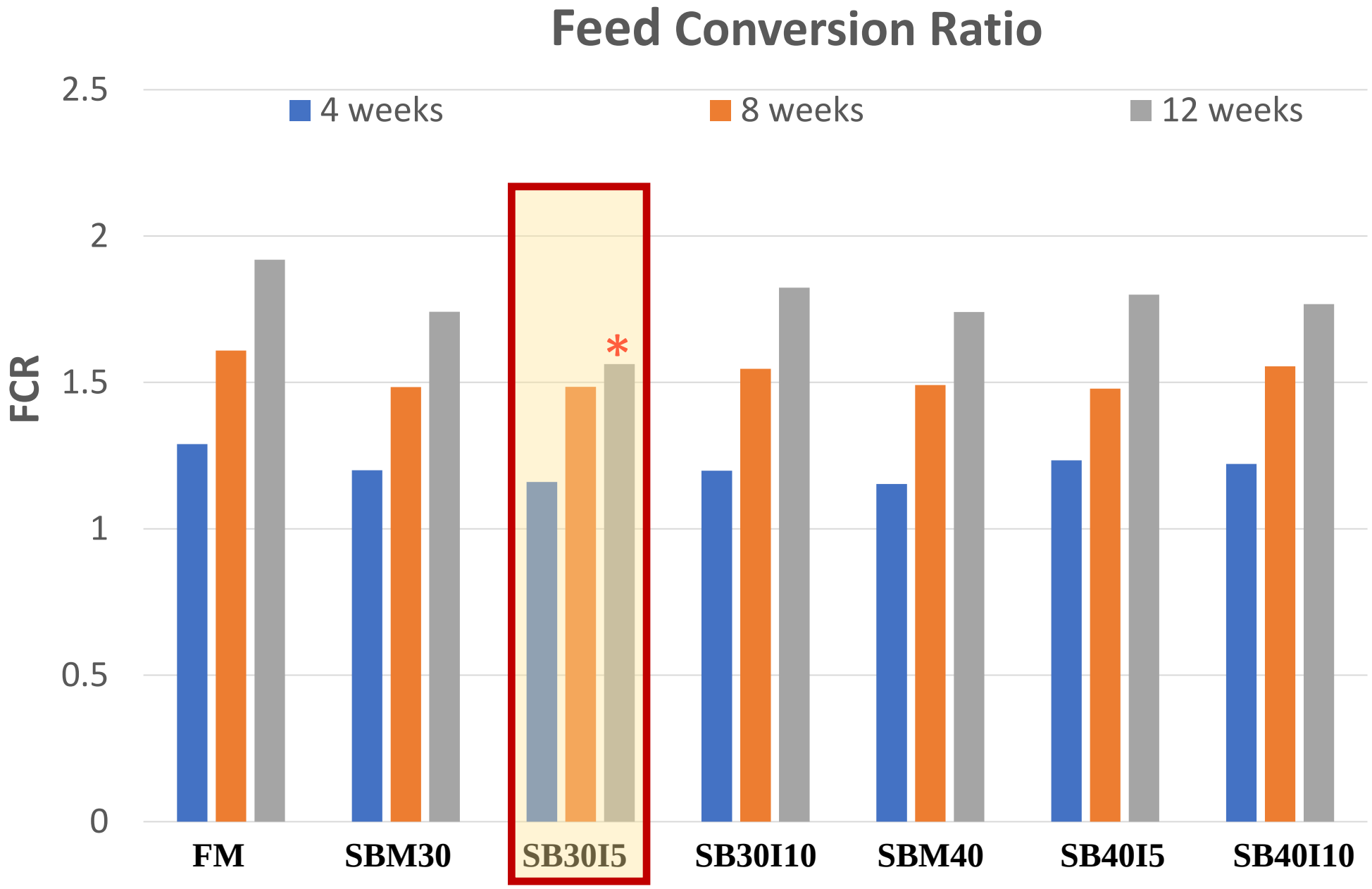


- Completely Randomized Design to assign diets to tanks

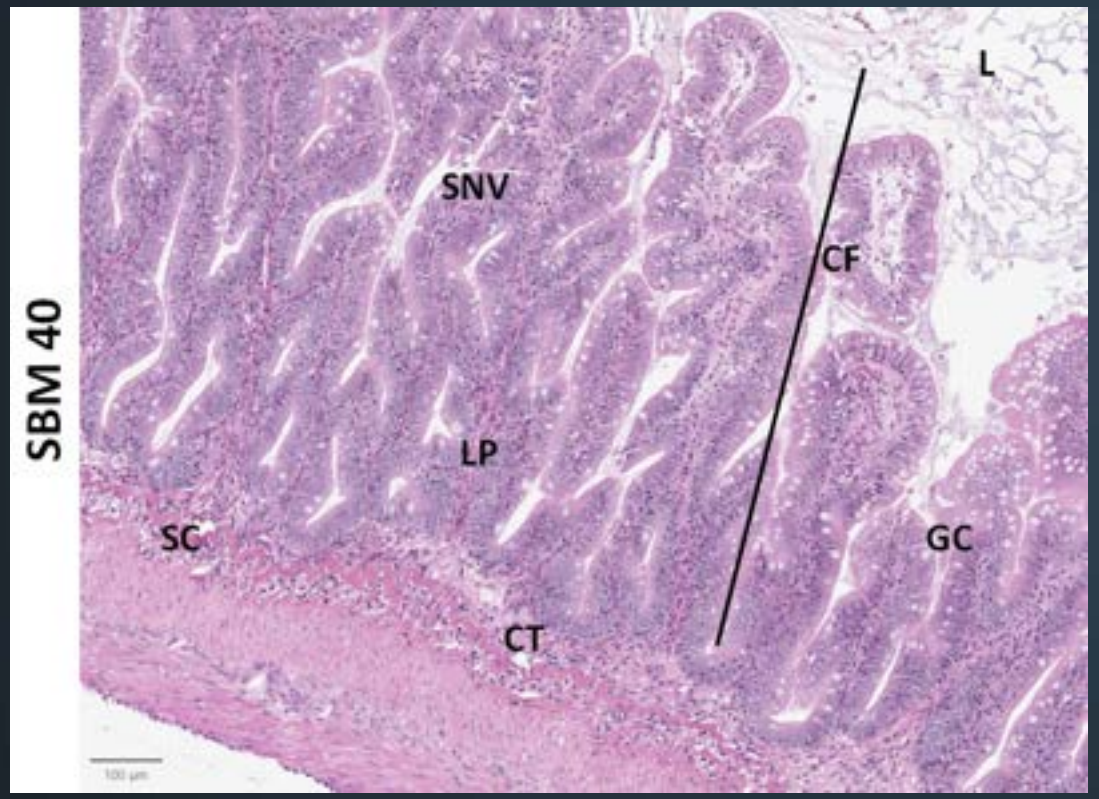
  *__BSFL__- whole insect black soldier fly larvae
- 3 tanks/treatment, 30 fish/tank

Percent Weight Gain – 12 weeks




Feed Conversion Ratio
4 weeks
8 weeks
12 weeks
FCR
2.5
2
1.5
1
0.5
0
*
FM
SBM30
SB30I5
SB30I10
SBM40
SB40I5
SB40I10

Distal Intestine - Histology



CONCLUSIONS

Dietary supplementation of whole black soldier fly larvae meal in soybean meal diets for Atlantic salmon:

- Improves growth performance
- Enhances soybean utilization
- Mitigates gut health/enteritis
- Provides an alternative dietary approach to improve utilization of feed ingredients in sustainable aquafeed

University of Idaho
Aquaculture Research Institute

Acknowledgement

ENVIROFLIGHT®

Soy Aquaculture Alliance

Feed Formulation for Atlantic salmon Project (Soy Aquaculture Alliance)

SAA Project August 2022

	D1	D2	D2	D4	D5	D6	D7
	0%	0.00%	0.00%	5% Insect	10% Insect	5% Insect	10% Insect
Ingredients	Control	SBM30	SBM40	SBM30	SBM30	SBM40	SBM40
FM	**30**	**10**	**10**	**10**	**10**	**10**	**10**
Soybean meal	**0**	**30**	**40**	**30**	**30**	**40**	**40**
Whole BSFL	0	0	0	**5**	**10**	**5**	**10**
Canola meal	12	7	3	6.5	5.2	2.7	1.5
Wheat gluten meal	3.5	4	2.4	3.5	3.1	2.7	2.4
Corn protein concentrate	3.5	4	2.4	3.5	3.1	2.3	2.1
Blood meal	3.7	4.1	3	3.5	3.3	2.4	1.8
Wheat flour	23	14.5	12.5	13.4	12.9	11.5	10.7
Poultry meal	6.4	6.4	6.4	5.8	4.8	4.2	3.5
Fish oil	15	16.3	16.3	15.1	13.9	15.2	14
Dicalcium phosphate	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Choline chloride (60%)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Vitamin premix	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Trace Mineral mixture, Trouw nutrition	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin C, Stay C-35)	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Lysine	0	0.6	0.8	0.6	0.6	0.8	0.8
Methionine	0	0.2	0.3	0.2	0.2	0.3	0.3
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Q & A

Please submit questions.

Soy Aquaculture Alliance

Question Prompts

- What emerging research are you excited about?
- What are the biggest challenges U.S. aquaculture has yet to solve?

THANK YOU!

Scan to Save Contact

Easton Kuboushek
Executive Director
easton@soyaquaculture.org
www.soyaquaalliance.com

Soy Aquaculture Alliance