Soy-in-Aquaculture: Managed Research Program

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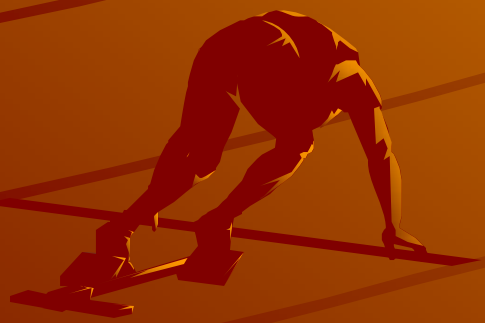
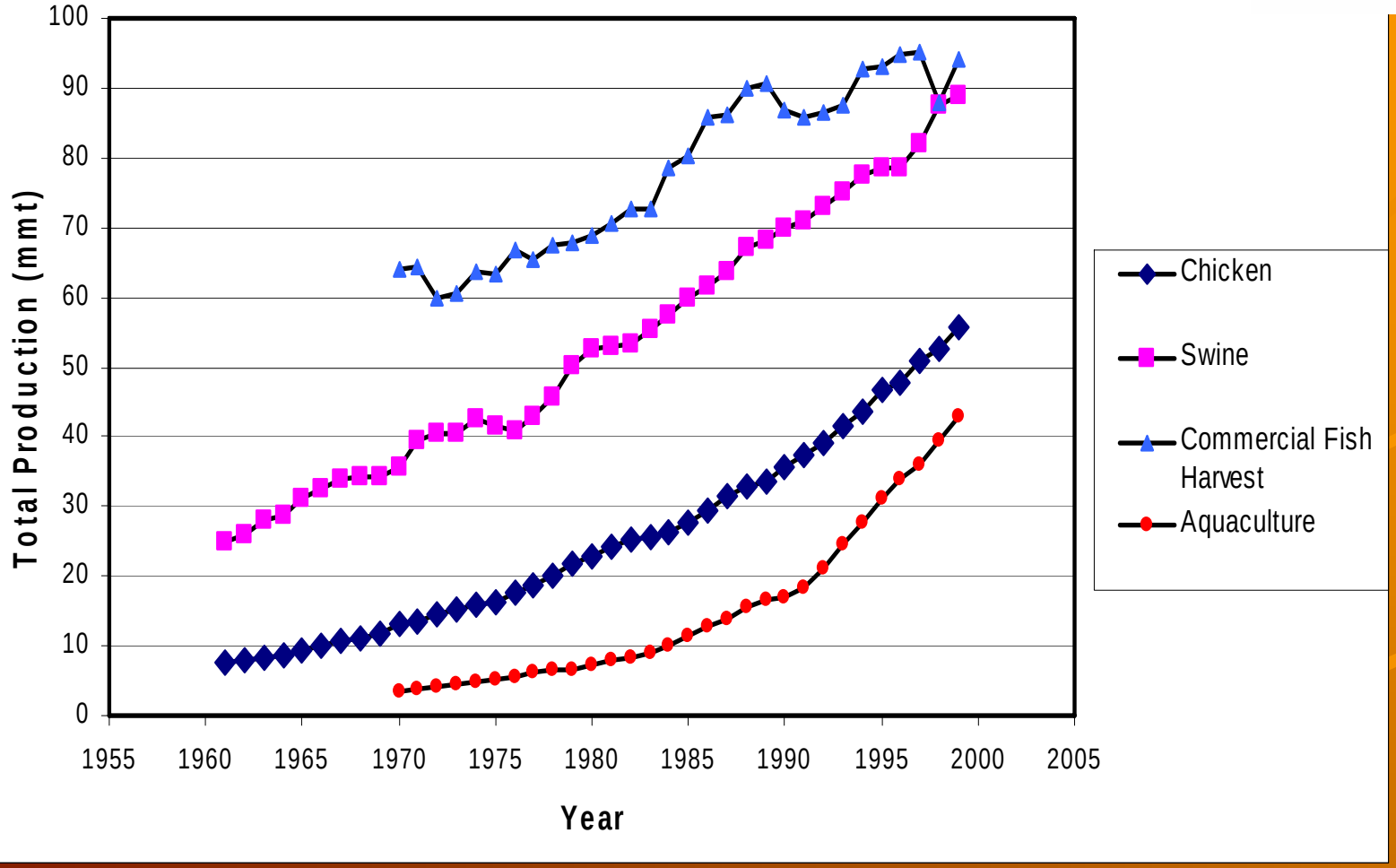



Total Production (mmt)
100
90
80
70
60
50
40
30
20
10
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year
Chicken
Swine
Commercial Fish Harvest
Aquaculture

Challenge

- 25,000 – 30,000 species
- UNFAO -- Commercial harvest records maintained for 1,173 species
- 358 species cultured
- 54 have been fed soybeans (in 2000, 17 had been fed soybeans)
- Lysine and methionine requirements quantified for ~12 species

Major Aquaculture Groups

- Carps
- Salmonids
- Tilapias

- Shrimp

New's 1997 article

- Demand for seafood in next 40 years (1995-2035) 60-120 mmt over current levels
  - 60 mmt assumes only increases in world population
  - 120 mmt assumes increases in population plus 1%/yr increase in per capita consumption
- Global production (1995) of soybean meal 120 mmt, swine 83 mmt, chickens 46 mmt
- Raises several interesting questions/challenges

Feeds for Projected Growth

- Simple model
  - 60-120 mmt tons of aquatic animals reared intensively, 1:1 FCR, feed needs are 60-120 mmt
  - 10% incorporation of fish meal = 6-12 mmt of new demand for fish meal
  - Global supply of fish meal is ~6.8 mmt

Simple model – Alternative Proteins

- 60-120 mmt tons of aquatic animals reared intensively, 1:1 FCR, feed needs are 60-120 mmt
- 40% incorporation of soybean meal = 24 -48 mmt of new demand for soybean meal

Global oilseed supply, metric tons

Crop	Total Harvest	Cake
Soybeans	189,523,638	123,327,242
Oil, palm fruit	139,148,600	3,727,703
Seed cotton	56,969,044	12,388,472
Coconuts	50,227,217	1,902,410
Ground nuts in shell	37,057,652	7,416,247
Rapeseed	35,931,652	17,760,805
Sunflower	26,085,901	9,267,370
Dry beans	18,886,344	N/A
Sesame	2,765,419	736,057
Linseed	2,054,195	861,863
Lupins	1,596,444	N/A
Castor beans	1,153,768	N/A
Safflower	731,425	318,700

How do we facilitate increases in aquacultural production given the apparent ingredient limitation?

- Efficient lines of research designed to develop diets for new culture species.
- Targeted lines of research focused on defining limitations in alternative protein sources

United Soybean Board

- Domestic Marketing Committee, moved to New Uses Committee last year
- Strategic planning meeting held in Baton Rouge, LA
- Topics and species prioritized
- Goals of USB – movement of soy products into large aquaculture industries and those underutilizing soybean protein, use of USB funds as seed money, short-term focus, yet complete evaluation.
- Initial targets – Salmonids and extensive industries in Asia

Initial Project

- Research – rainbow trout and Atlantic salmon
- Marketing – builds on ASA-China program by expanding on-farm trials to Philippines, Indonesia, Malaysia and India

Research component

- Systematic evaluation of antinutritional factors
  - Lectins, trout and salmon, Purdue
  - Saponins, trout and salmon, Ohio State
  - Trypsin inhibitor, trout, Univ. Idaho
  - Trypsin inhibitor, salmon, Michigan State
- Antigenic proteins and oligosaccharides not addressed

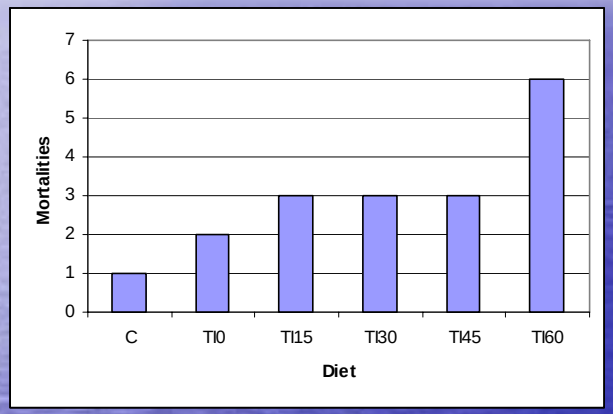
Research – Seed money

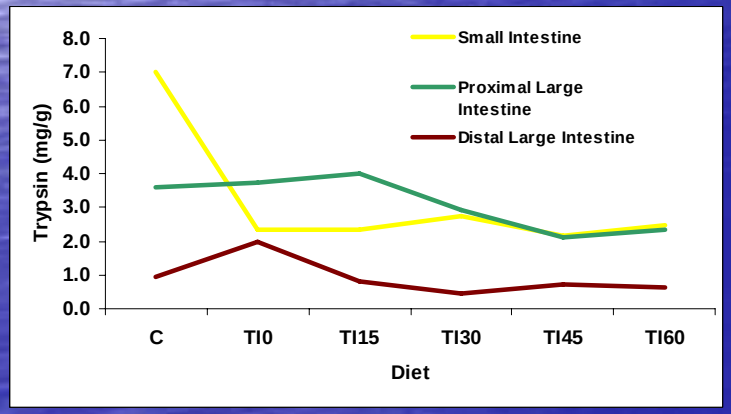
- Genistein, trout, Univ. Wisconsin and Maine

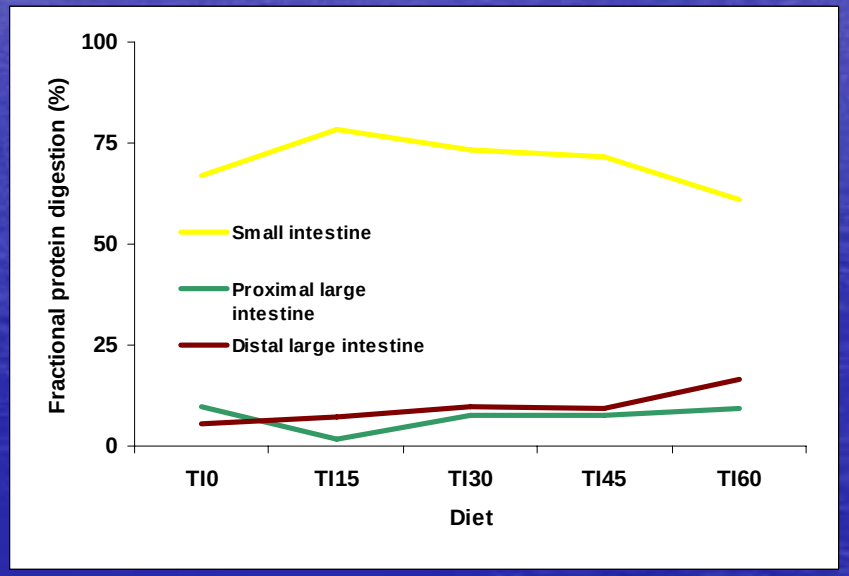
Thorough Evaluation

- Organoleptic properties, Maine
- Economics, Kentucky State University

TI – Atlantic salmon



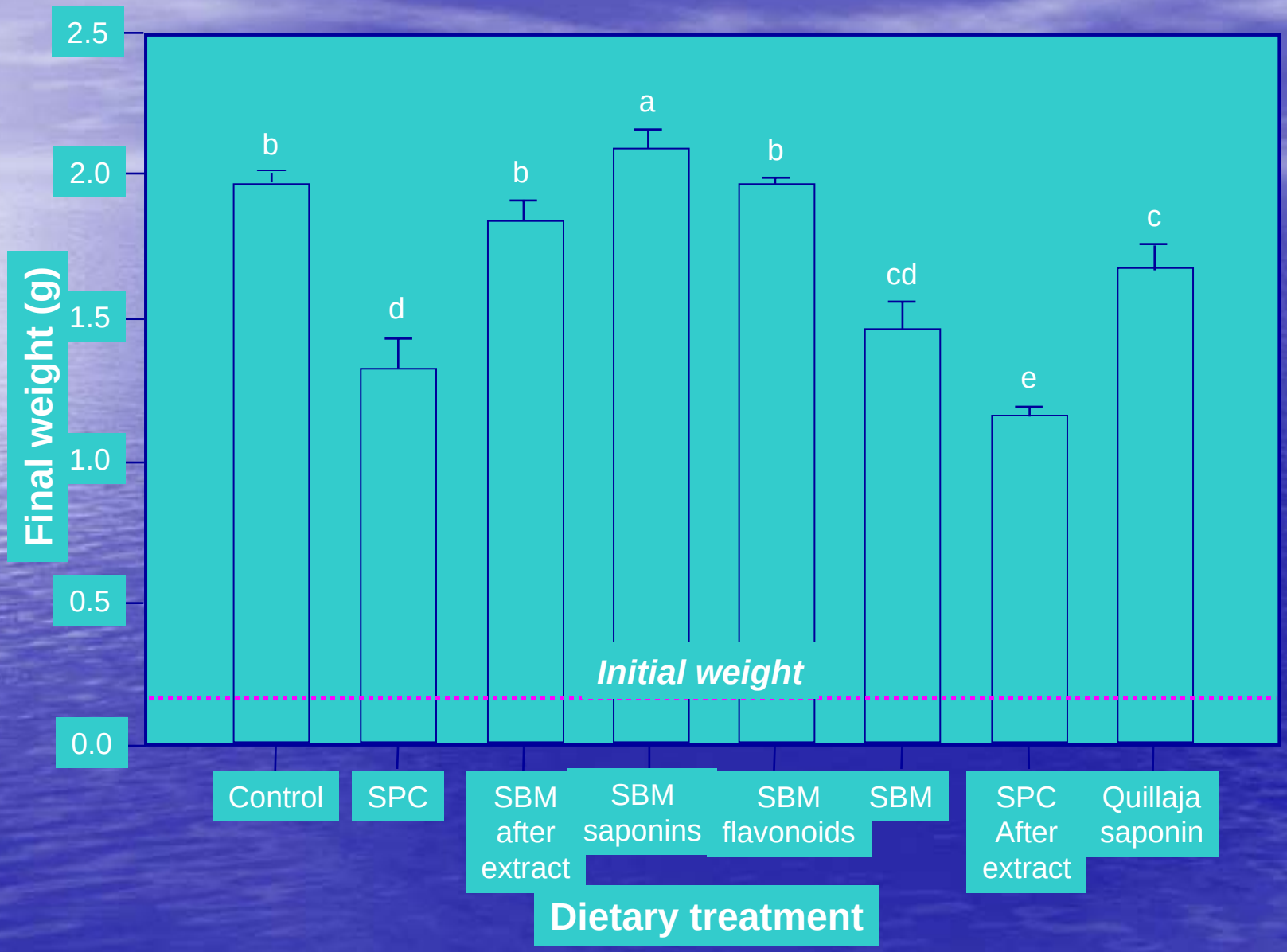




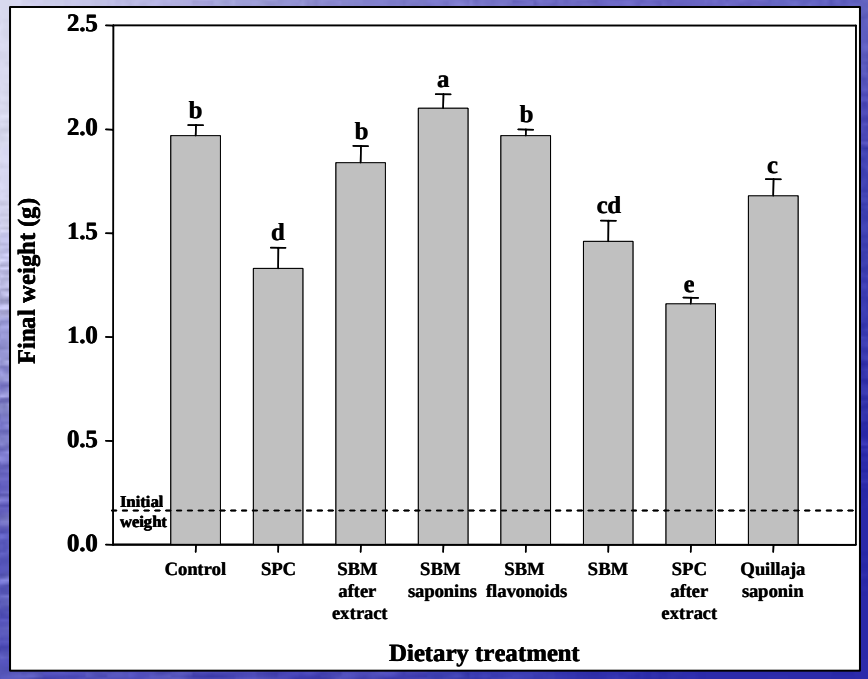
Extrusion conditions – Rainbow trout

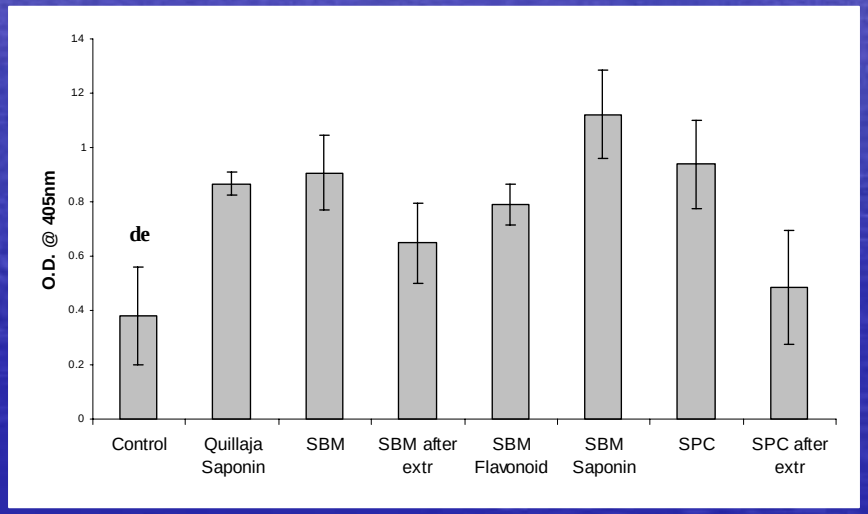
Processing conditions	Time	Temp
18 Seconds 200°F	Higher weight gain	Lower feed conversion
36 Seconds 200°F	Lower weight gain	Higher feed conversion
18 Seconds 260°F	Higher weight gain	Lower feed conversion
36 Seconds 260°F	Lower weight gain	Higher feed conversion

Weight after 8 weeks of feeding



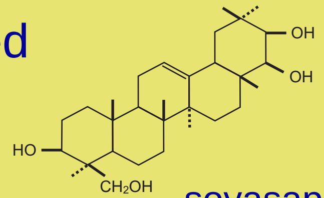
Saponins - Weight gain and antibody titers to A. salmonicida



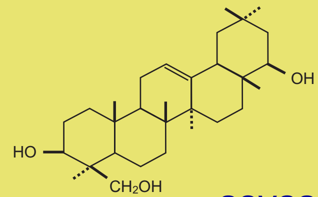


Chemical structure of soyasaponins and Quillaja saponin

Non-acetylated

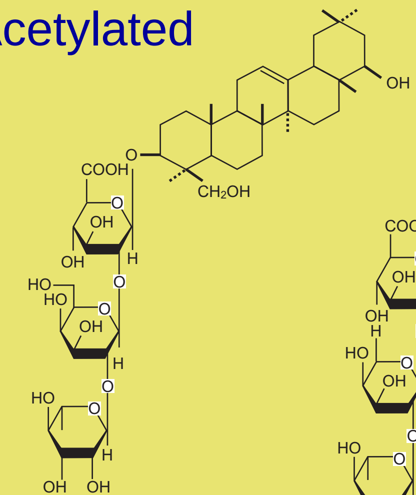


soyasapogenol A

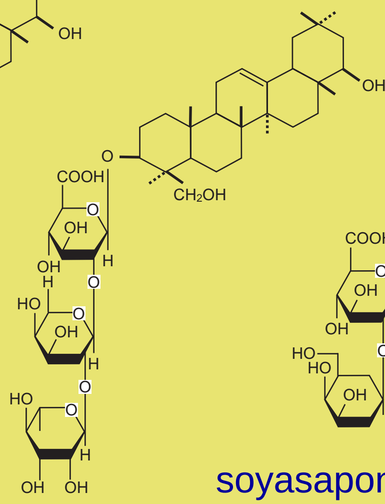


soyasapogenol B

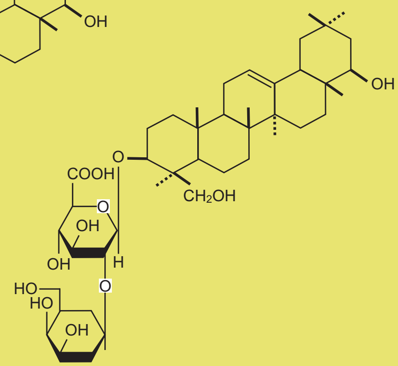
Acetylated



soyasaponih I

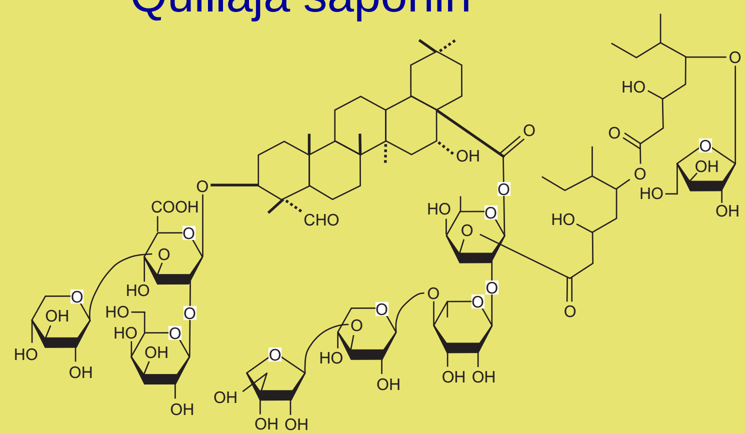


soyasaponih II



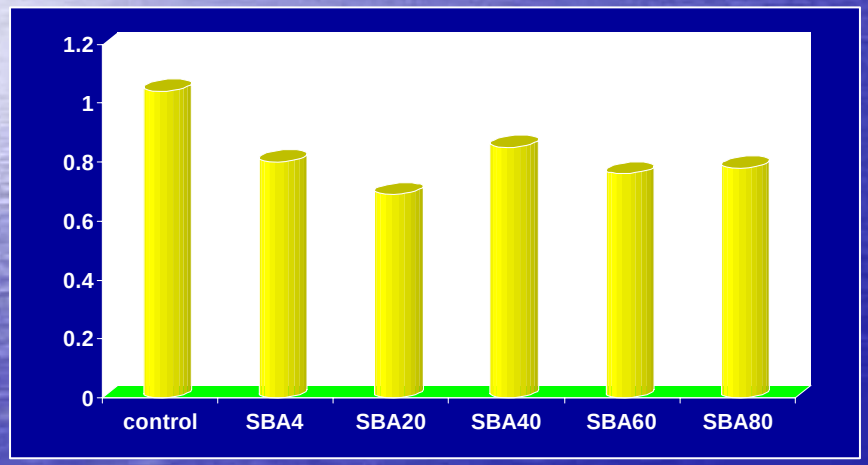
soyasaponih III

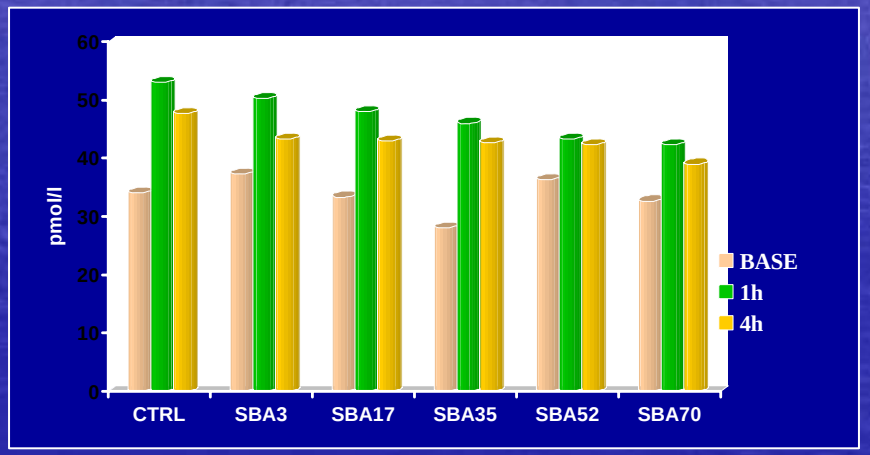
Quillaja saponin



Oda et al., 2003. *Vaccine* 21:2145.

Lectins – FE and serum insulin levels in trout

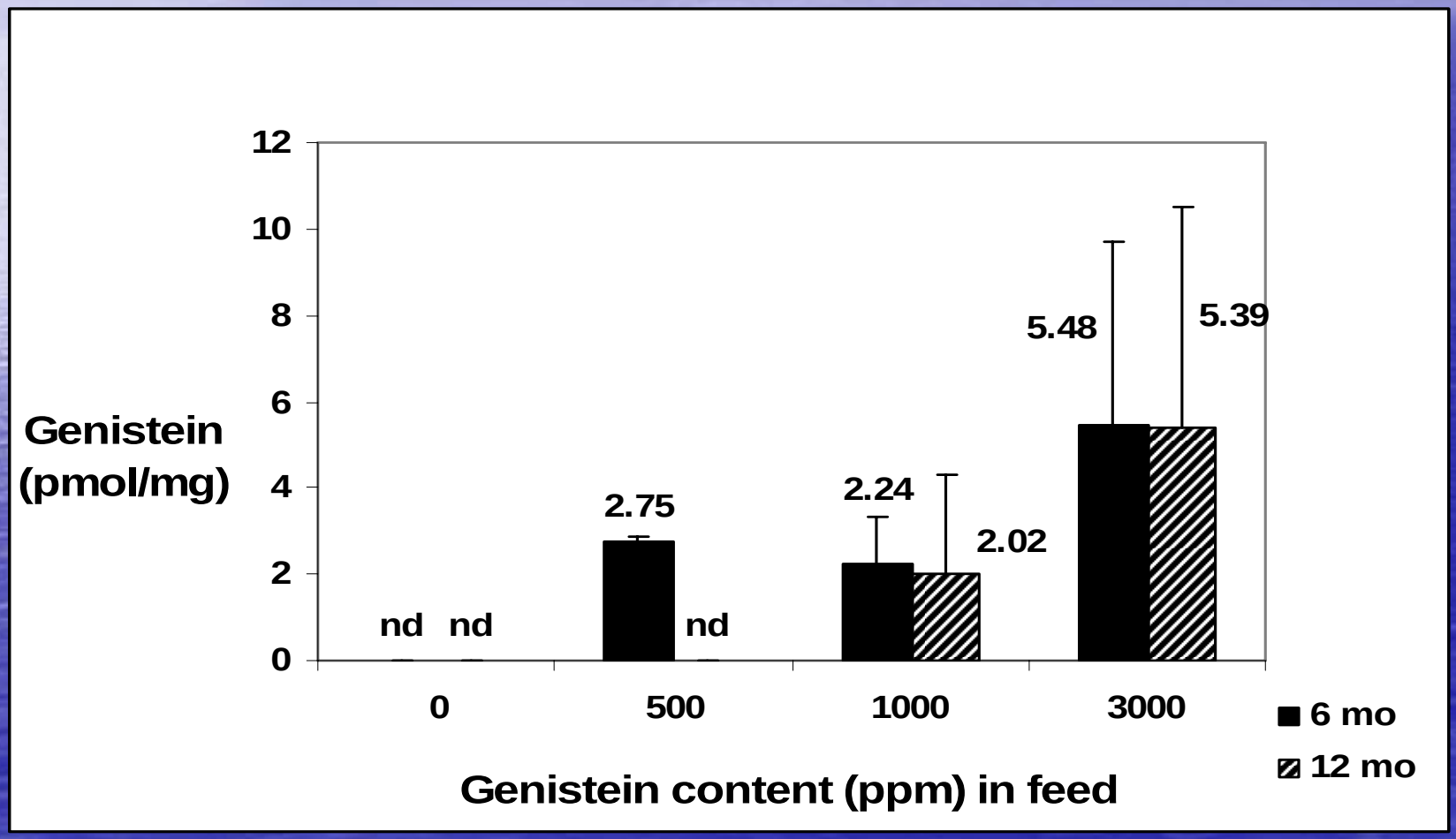




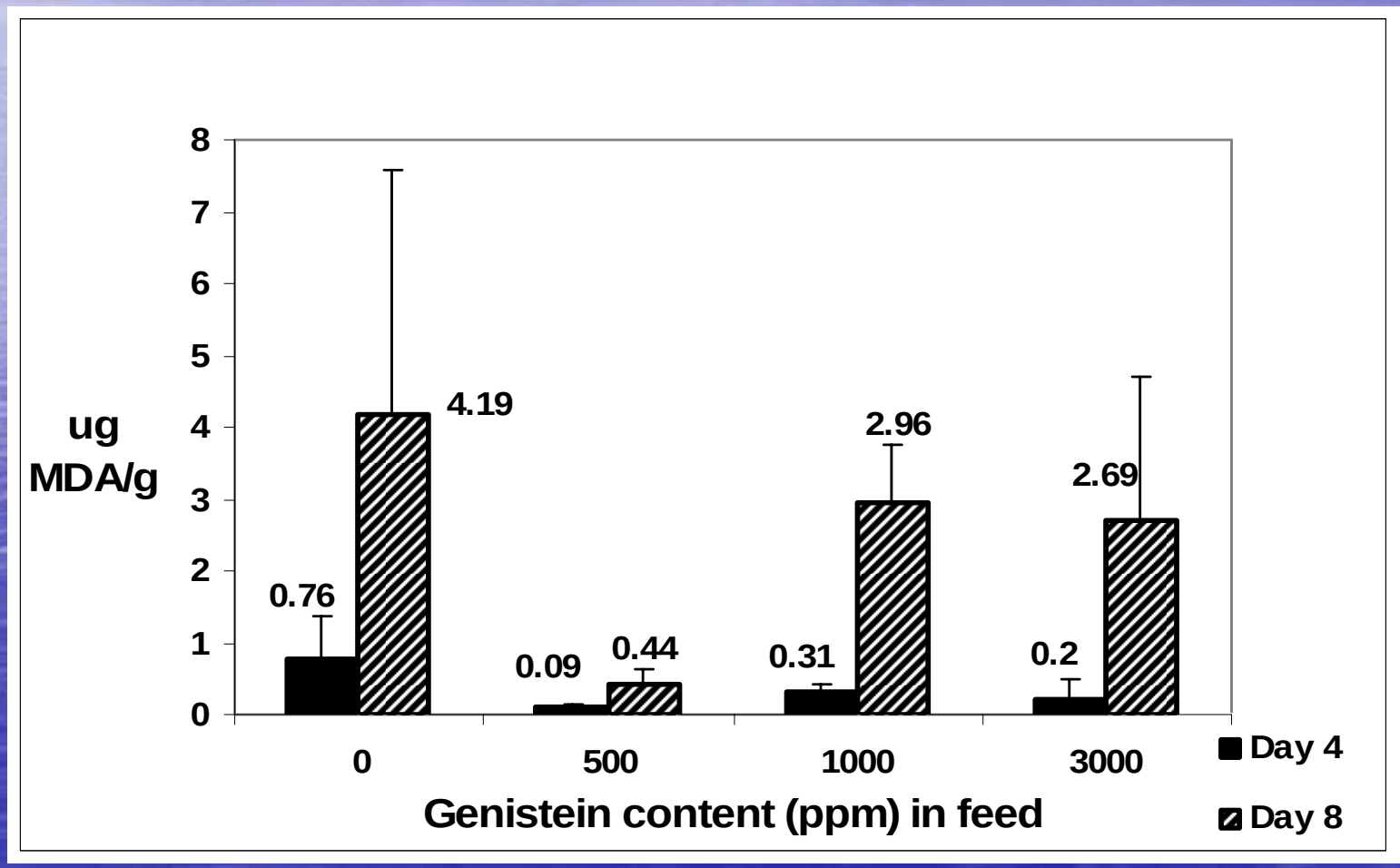
Genistein - trout

- No negative effect on weight gain
- Estrogenic activity

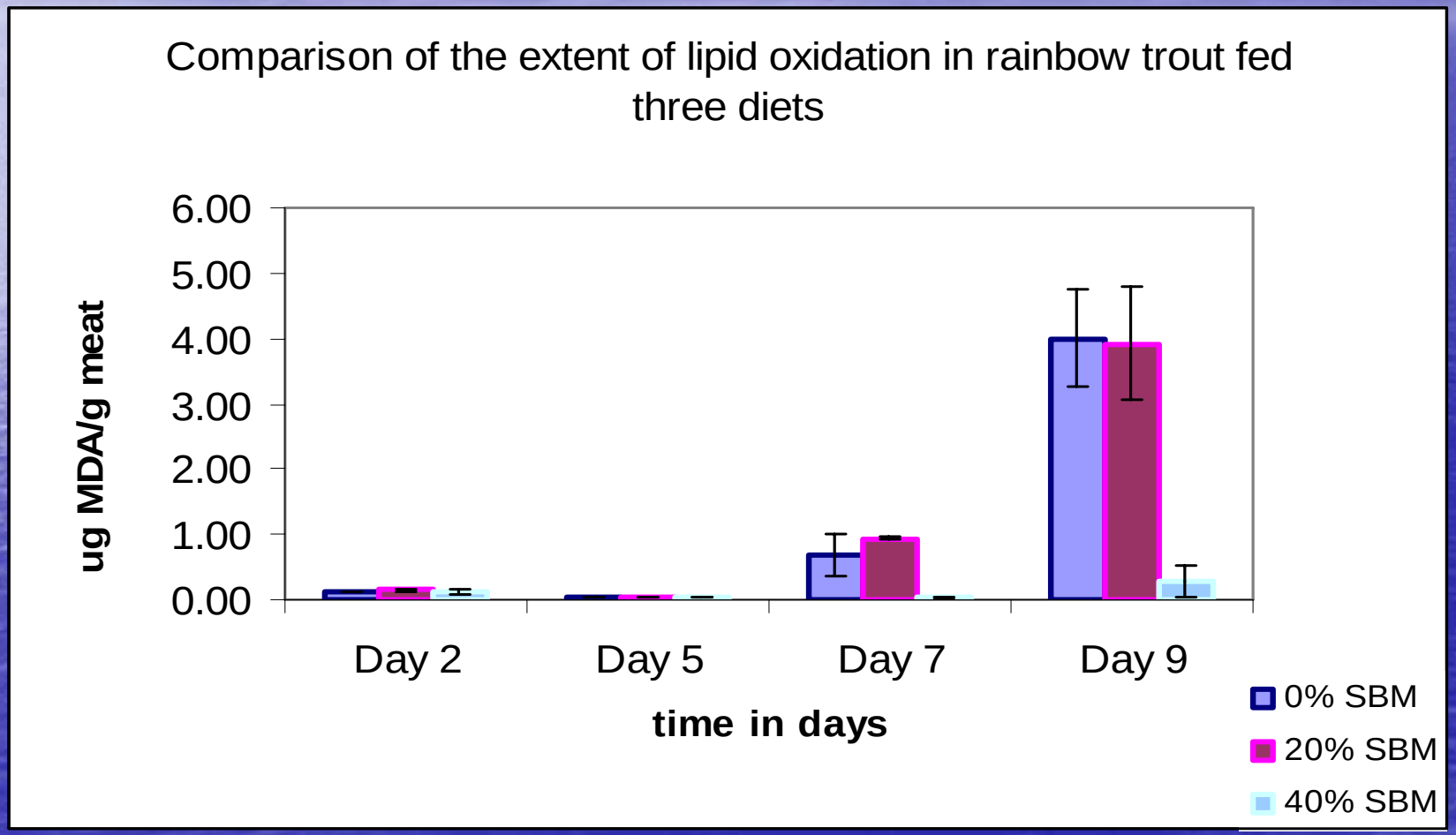
Genistein in trout muscle



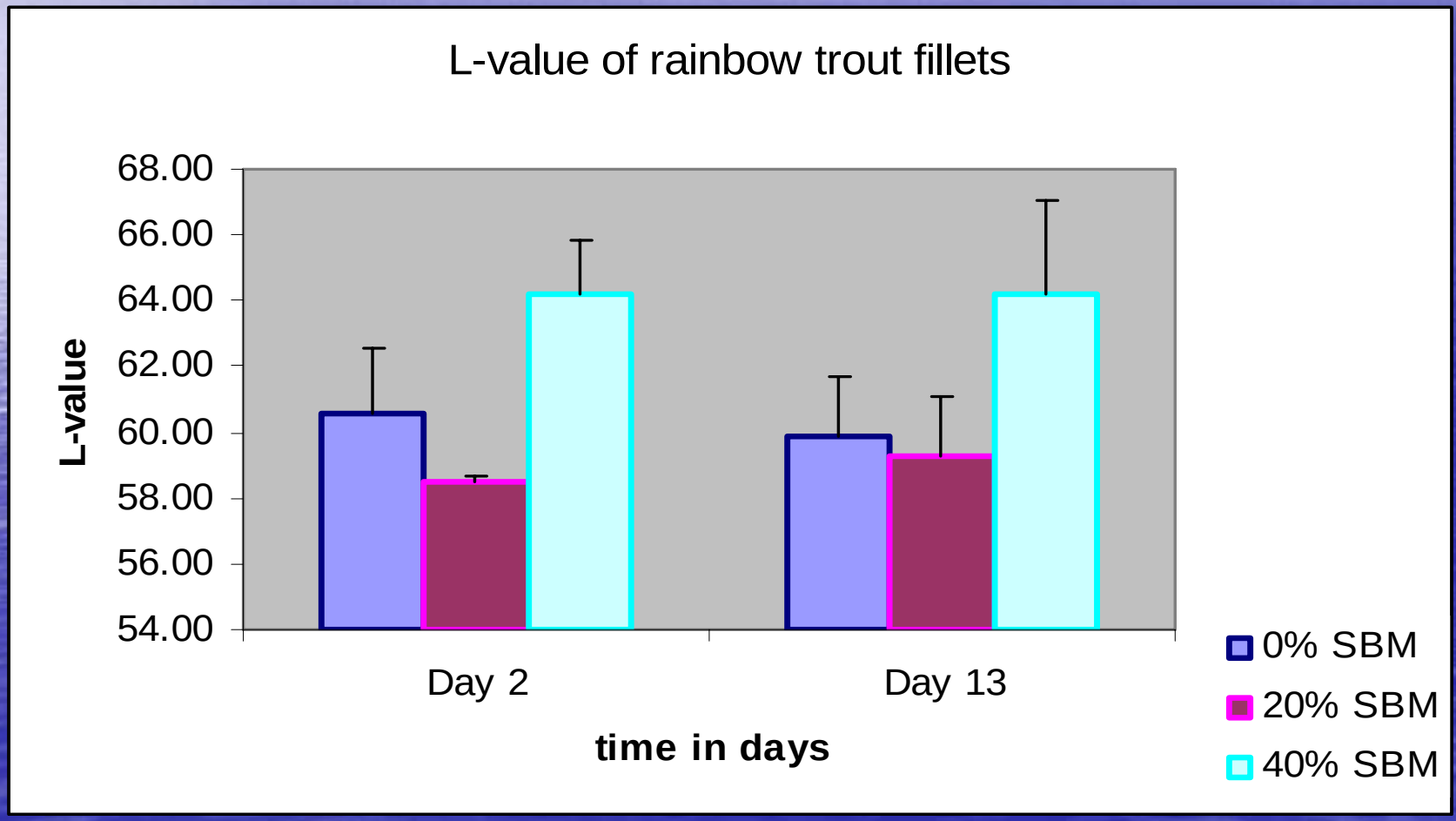
Oxidation of fillets at 4 C



Oxidation of fillets



Color of fillets



Economics

- SBM more readily incorporated into diets as dietary crude protein and energy concentrations decrease.

Purdue Aquaculture Lab

Fire – Nov. 14, 2004

Lost in the Fire.....

- Atlantic salmon study, flavor of fillets – 18 months feeding, first samples would have been collected on 11-15-04
- Rainbow trout – Interaction of soy lectins, trypsin inhibitors and oligosaccharides.

Conclusions after first 2-year project

- Lectins are part of the problem.
- Trypsin inhibitors are part of the problem.
- Saponins are not part of the problem.
- We suspect oligosaccharides are part of the problem.
- Several groups have not be able to reproduce the antigenic response seen in some labs, fish or soybean?
- Germplasm available that lack lectins, TI, phytate
- Processing can remove targeted ANFs

Conclusions

- Soy isoflavones were incorporated into fillets
- Isoflavones did not affect flavor of fillets
- Isoflavones did improve storage characteristics

Next Studies

- Field trials with trout and salmon
- Penaeid shrimp soybean evaluations
  - Supplementary nutrients needed
  - Combinations of tank and earthen pond studies, lab and commercial sites
- New marine species