Effects of *in vitro* digestion of

rapeseed meal, soybean meal, macrophyte, and marine alga

with

cellulase, hemicellulase, multi-enzyme mix,

and

three species of white-rot fungi

evaluated based on

in vivo digestibilities of protein, fiber, organic matter, phosphorus, and trace minerals in rainbow trout

Global transition to sustainability

Limited supply Non-sustainable	Unlimited supply Sustainable
Animal sources	Plant sources
Protein Fat Ash	Protein Starch **Lignocellulose**

Most abundant organic molecule on Earth

Bioconversion
Food / Energy

in vitro digestion of

rapeseed meal, soybean meal, macrophyte, and marine alga


rapeseed meal


Egeria densa


soybean meal


Gelidium elegans

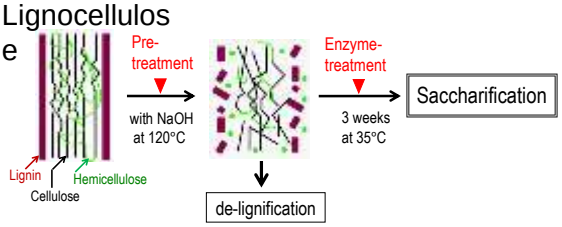
Dry & Grind

in vitro digestion by enzymes

Tr.1 Cellulase
Tr.2 Hemicellulase
Tr.3 Multi-enzyme mix
(Cellulase + Pectinase + Protease)

Commercial products

Lignocellulose



Three species of white-rot fungi


Trametes sp.


Lentinus edodes


Pleurotus sp.

Lignocellulose → (Lignocellulolytic enzyme-producing fungi; incubation) → Saccharification

in vitro digestion by fungi

Autoclaving
of plant materials

↓

Inoculation
with fungal inocula

↓

Incubation
6 weeks
at 28 or 38ºC

After incubation ……

Rapeseed meal + *Pleurotus* | Macrophyte + *Lentinus* | Soy + *Pleurotus* | Soy + *Lentinus* | Marine alga + *Pleurotus*

Feeding trials with rainbow trout

Test ingredient 30%
+ Basal diet 70%

⬇

Collection of feces by stripping

to determine *in vivo* digestibilities

Analyses of ingredients, diets, feces for

Protein (N), Organic matter (C),
⟶ CN Coder (Pregl-Dumas combustion)

Fiber,
⟶ NDF (lignin, hemicellulose, cellulose)

Phosphorus, Trace minerals
⟶ ICP-AES

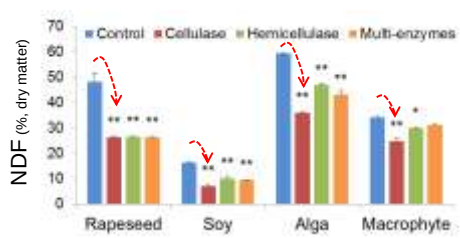
Results

Analytical composition of test ingredients

(*n*=3 analyses)

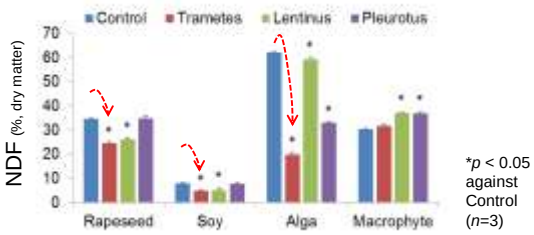
	Repeseed meal	Soybean meal	Macrophyte	Alga
CP (%)	45.9	50.8	24.3	27.3
NDF (%)	34.7	8.1	30.4	62.2
Ash (%)	8.0	7.4	21.1	8.3
Ca (%)	0.76	0.35	1.13	2.10
P (%)	1.19	0.66	0.54	0.04
Mg (%)	0.65	0.32	0.25	0.40
Fe (ppm)	0.77	0.23	244	2.37
Zn (ppm)	11.7	10.8	33.9	22.1
Mn (ppm)	7.68	3.31	265	1.88
Cu (ppm)	1.95	3.97	2.77	9.50

Effects of cellulase, hemicellulase, and multi-enzyme mix on NDF (fiber) content of plant ingredients

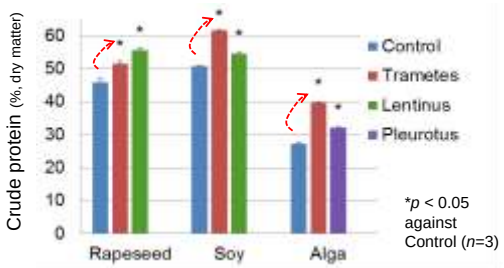


*$p < 0.05$ against Control (*n*=3)

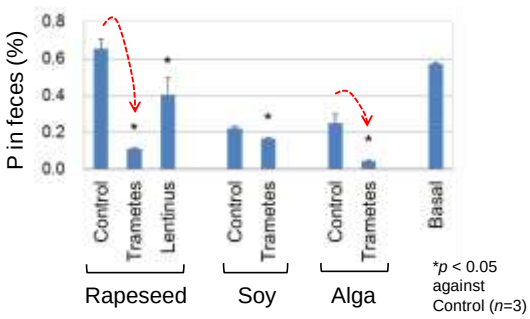
Effects of **white-rot fungi** on NDF (fiber) content of plant ingredients



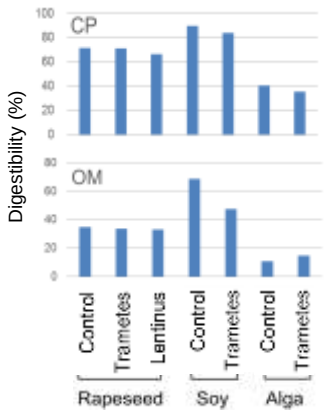
Effects of **white-rot fungi** on CP (protein) content of plant ingredients



Effects of **white-rot fungi** on Phosphorus excretion of fish



Effects of **white-rot fungi** on **Digestibility of CP** (crude protein), and **OM** (organic matter), of ingredients



Effects of **white-rot fungi** on Fecal content of minerals

mean, n=3	Rapeseed			Soy		Alga		Basal
	Control	Trametes	Lentinus	Control	Trametes	Control	Trametes	Basal
Mg	0.43	0.38	0.39	0.16	0.16	0.20	0.28	0.07
Ca	1.35	2.18	1.90	0.91	2.19	1.58	2.96	1.56
Zn	6.52	5.56	3.41	2.27	2.65	8.30	10.60	1.68
Fe	30	69	65	35	62	167	98	37
Mn	24.1	52.6	30.6	13.4	19.8	10.1	13.4	9.3
Cu	1.10	0.77	0.94	1.54	1.60	1.91	1.78	0.93