Effects of phytase, cellulase, and lactic acid fermentation on phosphorus, protein, NDF-ADF, and organic matter digestibilities of rapeseed meal and soybean meal in rainbow trout

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Abstract:

Improving digestibilities of dietary nutrients is important for fish growth and for environmental protection. Major sources of pollution associated with aquaculture management are phosphorus (P), nitrogen (N) and organic matter (OM) in fish feeds. Using cheap, easily available ingredients is of economical importance. Thus, we studied effects of digestive enzymes and fermentation to improve digestibilities of P, N, and OM using practical ingredients.

Two ingredients (rapeseed meal or RS, and soybean meal or SB) were tested. They were both processed as follows (Table 1), and mixed with a casein-gelatin basal diet at a 4:6 ratio to prepare test diets for digestibility measurements. Rainbow trout (1-year old) were fed with one of the test diets or the basal diet for two weeks, and fecal samples were collected by stripping. The diet and fecal samples were analyzed for total P, crude protein (CP), ash, OM, neutral detergent fiber (NDF), acid detergent fiber (ADF), and chromic oxide that was used as an inert indicator to determine the apparent digestibilities.

Digestibility of P increased from 73% (Tr1) to 89% (Tr5) or 97% (Tr6) in RS, and from 65% (Tr1) to 100% (Tr5, 6) in SB. Other treatments showed no apparent effect on P digestibility. Digestibility of CP was 76-83% (RS) and 98% (SB), but no treatment effect was observed on CP digestibility. Digestibility of OM in RS (60-77%) did not increase with any of the above treatments. In SB, however, OM digestibility tended to increase from 90% (Tr1) to 96% (Tr5,6). Dry matter digestibility of RS showed similar values (65-78%) regardless of the treatments. However, in SB, dry matter digestibility tended to be higher for Tr5-6 (96%) than Tr1-4 (88-91%). Digestibilities of NDF and ADF did not show any pattern for both RS and SB. However, incubation of RS and SB with fermented rice paste and cellulase decreased slightly, but significantly, the content of NDF and ADF in these ingredients (Fig.1).

The present results confirmed marked effects of phytase supplementation on P digestibility. However, the effect of cellulase was not large enough to increase OM digestibility to any significant extent. Further research will be required to explore the optimum treatment methods and conditions that can increase OM digestibility of these and other low-cost feed ingredients for fish feeds.

Fish meal-based feed
Major pollutants: Phosphorus, Nitrogen

Global trend

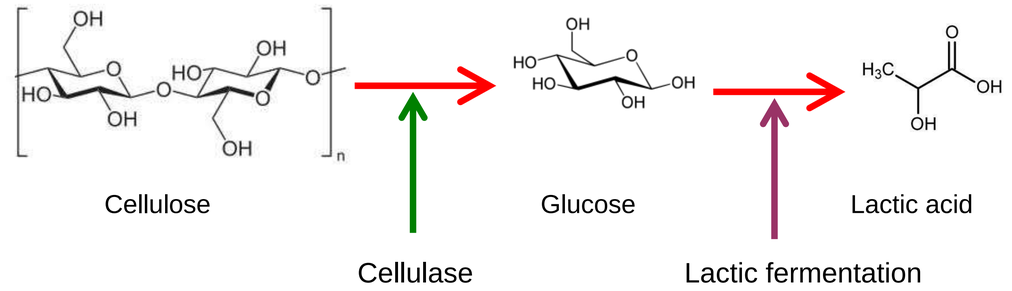
Sustainable change

Plant-based feed
Major pollutants: Phosphorus, Nitrogen, Cellulose (organic matter)

Analytical composition* of rapeseed meal and soybean meal

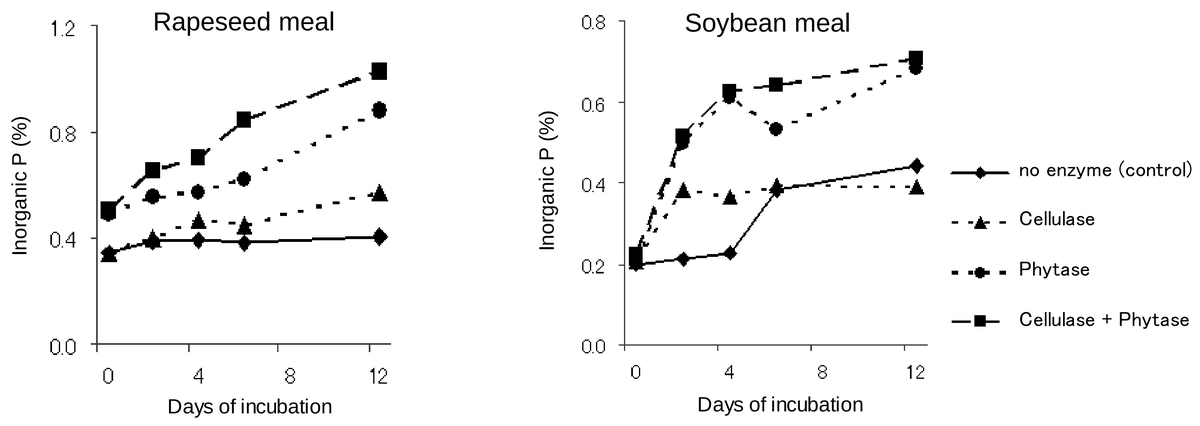
	Rapeseed meal	Soybean meal
Crude protein (%)	36.5	47.5
Organic matter (%)	42.0	41.9
NDF (%)	24.9	7.3
ADF (%)	19.7	6.1
Ash (%)	6.87	6.68
Phosphorus (%)	1.12	0.75

*values are dry basis
NDF: neutral detergent fiber;
ADF: acid detergent fiber

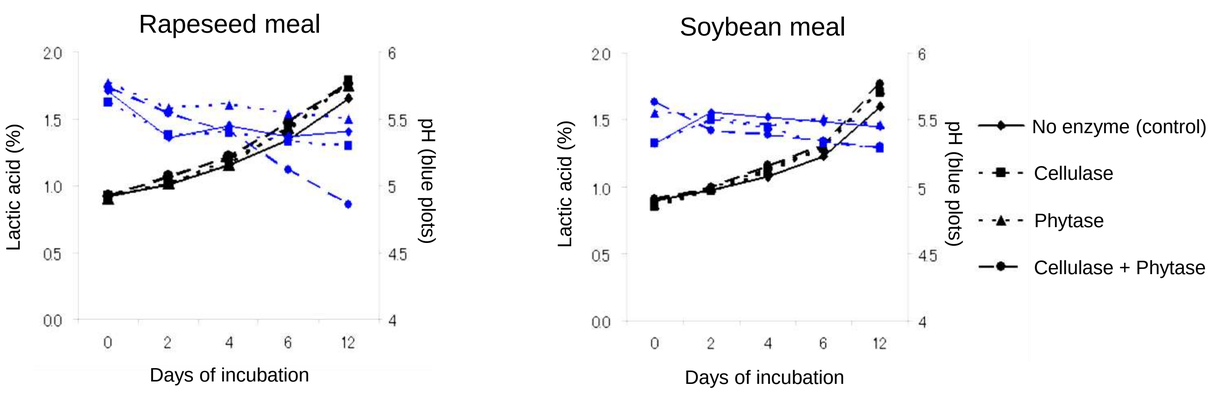


Chemical analyses

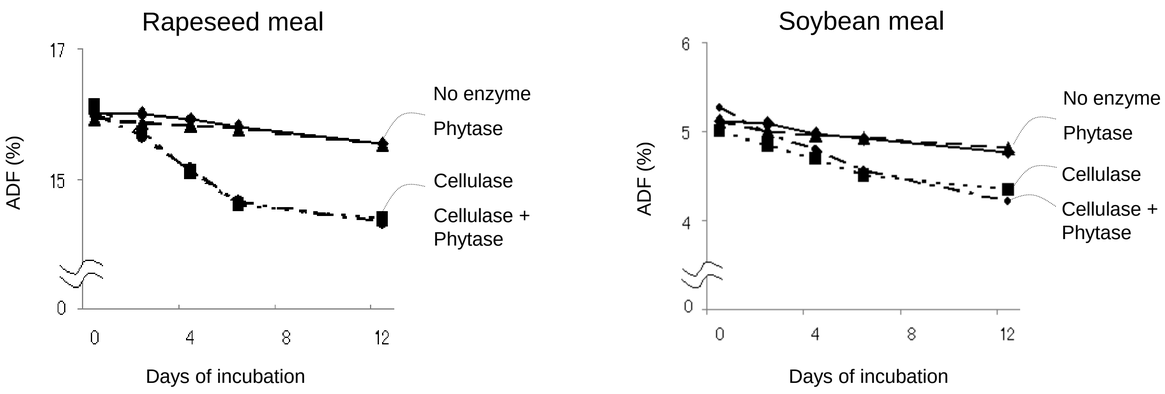
Inorganic P



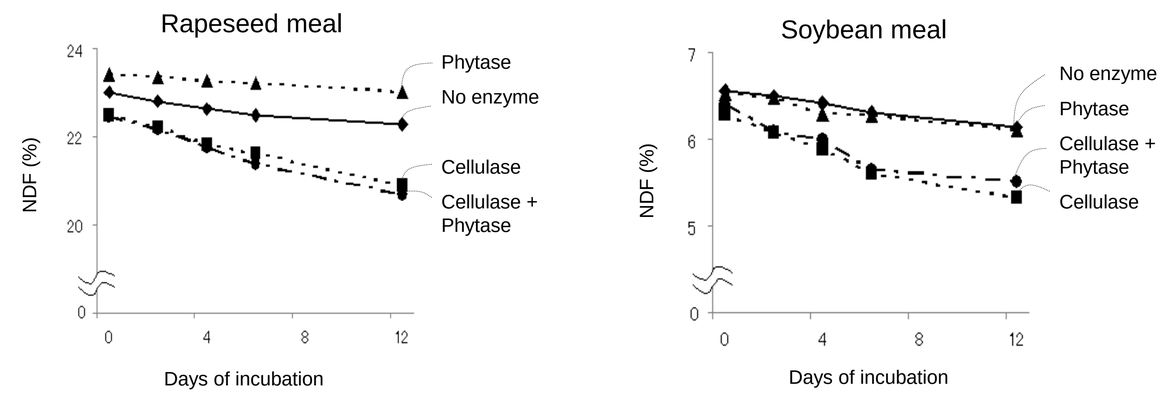
Lactic acid and pH



Acid detergent fiber (ADF)



Neutral detergent fiber (NDF)



In vivo digestibility

Composition of the basal diet for digestibility measurement

Ingredients	%
Wheat gluten*	28.0
Casein	10.0
Egg while powder	12.0
Fish oil	6.0
Cod liver oil	3.0
Wheat flour	28.0
Vitamin mix	1.0
Mineral mix**	4.0
Choline Cl (70%)	0.20
Ascorbic acid	0.20
Alpha-cellulose	7.6
sub-total	100
Trace mineral solution (ml)	*20*
Water (approx. ml)	*7*

*fortified with L-lysine HCl at 1% per gluten
**mineral mix supplied Cr_2O_3 at 0.6% per diet

Processing methods of test ingredients

# 1	No processing (control)
2	AC (autoclave)
3	LF (Lactic fermentation)
4	AC + LF
5	AC + phytase + LF
6	AC + phytase + cellulase + LF

AC: 120°C-10 min. with water (1:1, w/w).
LF: 40°C-3 days.
1-6 were added with fermented rice paste at 15% (dry basis)
Fermented rice paste is a byproduct of Funazushi.
Funazushi is an old-fashioned Sushi.

Test diets were formulated by mixing the Basal diet (60%) and one of the processed test ingredients (40%).

Fecal samples were collected by stripping.

Digestibility (%) of processed test ingredients

Rapeseed meal	Processing methods					
	# 1	2	3	4	5	6
P	73.1	71.0	63.2	68.8	88.8	96.7
CP	82.7	75.9	80.3	79.3	80.5	82.0
OM	77.5	60.2	68.8	70.9	64.1	64.5
DM	78.6	64.8	73.3	74.7	68.6	70.3

Soybean meal	Processing methods					
	# 1	2	3	4	5	6
P	65.0	73.2	81.9	73.3	100	100
CP	95.7	97.4	96.5	97.8	98.7	98.3
OM	89.8	89.8	91.3	91.7	95.8	95.3
DM	88.6	88.8	90.2	90.9	96.1	95.2

P: Phosphorus; CP: Crude protein; OM: Organic matter; DM: Dry matter

For both rapeseed meal and soybean meal, the apparent digestibility of P is slightly improved by lactic fermentation and greatly improved by phytase.

Autoclaving appears to be effective for soybean meal, but not for rapeseed meal.

The apparent digestibility of CP in rapeseed meal and soybean meal has not been improved by the processing methods tested.

For both rapeseed meal and soybean meal, the apparent digestibilities of organic matter and dry matter are similar to one another regardless of the processing methods of the ingredients.

Fecal composition (% of dry matter)

Rapeseed meal	Processing methods					
	# 1	2	3	4	5	6
P	0.535	0.457	0.642	0.577	0.254	0.154
CP	9.98	9.96	9.99	10.8	10.0	10.2
OM	40.7	42.0	42.2	41.9	43.0	43.0
NDF	25.8	37.5	37.5	36.2	34.8	34.8
ADF	27.4	27.9	28.6	28.9	27.7	30.1

Soybean meal	Processing methods						
	# 1	2	3	4	5	6	Basal
P	0.568	0.499	0.402	0.546	0.168	0.158	0.189
CP	5.48	4.69	5.33	4.38	4.16	4.27	3.37
OM	39.9	40.3	40.1	40.2	41.2	40.9	41.2
NDF	27.6	32.5	28.1	27.2	31.6	30.2	27.1
ADF	19.3	21.2	22.2	19.9	25.7	24.7	23.0

P: Phosphorus; CP: Crude protein; OM: Organic matter (as C); NDF: Neutral detergent fiber; ADF: Acid detergent fiber

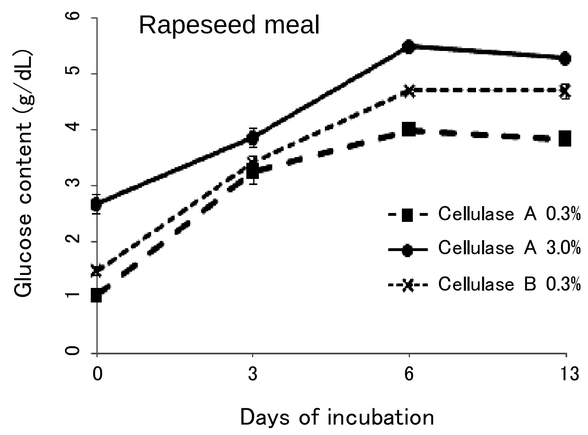
Fecal P content of fish fed phytase diets is low for both rapeseed meal and soybean meal-based diets. Other processing methods appear to have little effect on fecal P content.

Fecal CP content is similar among treatments, but is apparently higher for fish fed diets containing rapeseed meal than those fed diets containing soybean meal.

Fecal organic matter content (as C) is similar for all treatments studied.

Fecal NDF and ADF contents are similar among different processing methods, but are slightly higher for rapeseed mean than soybean meal.

Glucose



Glucose content of rapeseed meal increased as the incubation time with cellulase increased up to six days. After six days of incubation, glucose content did not increase any further.

Increasing the amount of cellulase up to 10 times the original amount did not construe as the corresponding increase of glucose.

Cellulase B (of supplier B) showed slightly higher cellulase activity compared with Cellulase A (of supplier A).

Portions of glucose produced by cellulase digestion during incubation apparently used to produce lactic acid by lactic fermentation.