



October 1. 2008:

Feed for Atlantic cod (*Gadus morhua*): An overview

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Disposition



- **Introduction**
- **Nutritional needs**
 - **Macro nutrients (Protein, lipid and minerals)**
- **Formulation of feed**
 - **Raw materials**
- **General conclusions**

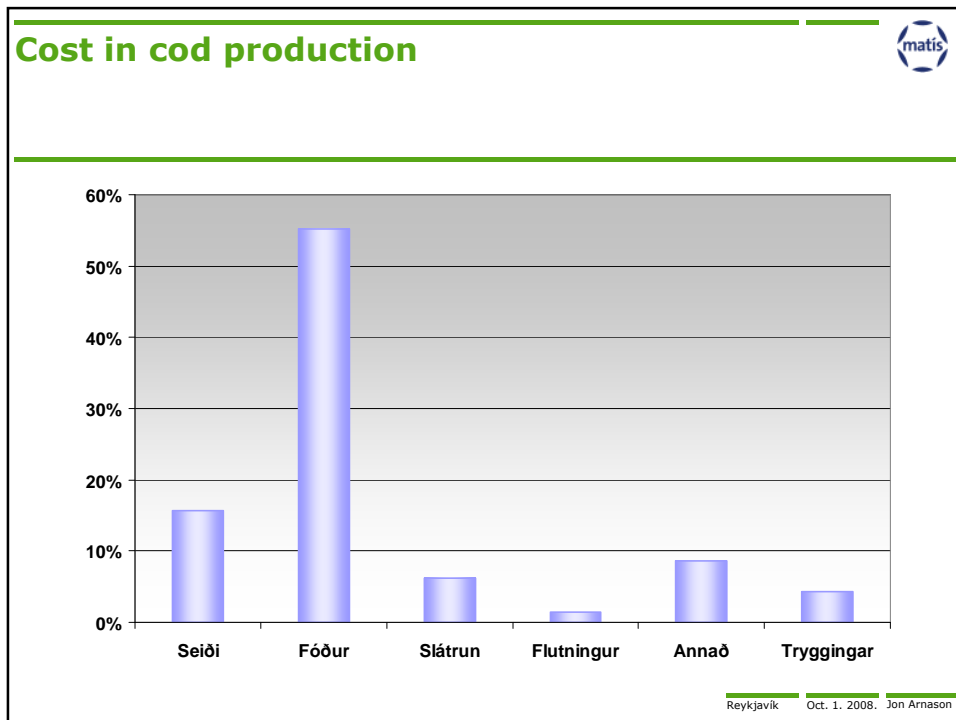
Main emphases on grower out phase

Introduction



- **Why is the feed so important?**
- **Cost**
- **Sustainability**
- **Product quality**

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Nutritional needs



- **Needs of the fish:**
 - **Nutrients for growth and maintenance:**
 - **(Protein, amino acids, fatty acids, vitamins and minerals)**
 - **Energy for the metabolic processes**
 - **No need for specific raw materials.**

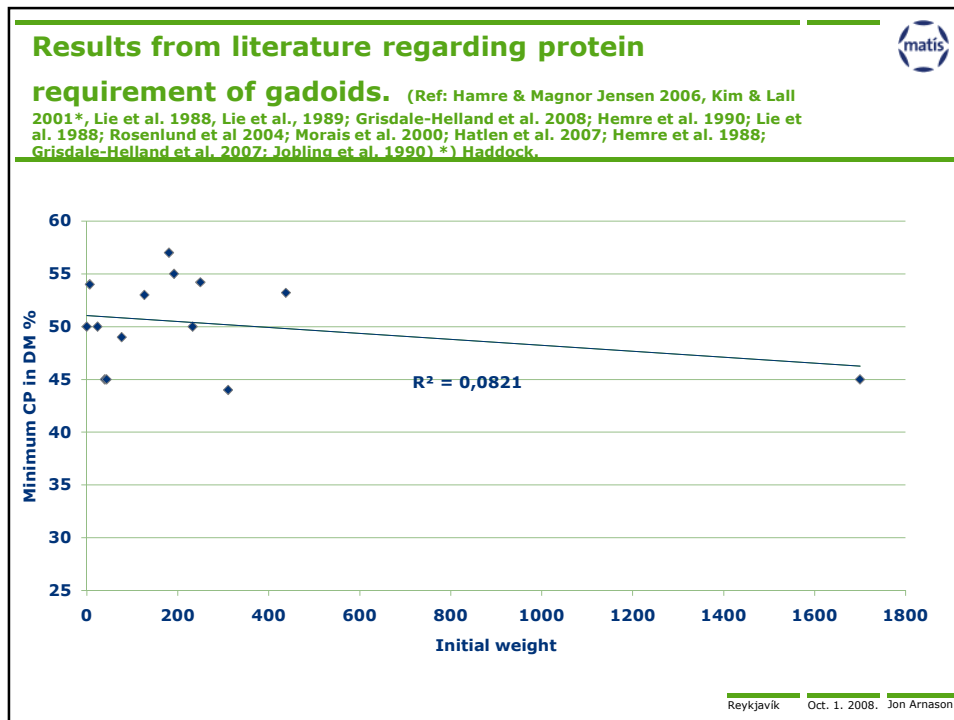
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Protein requirement



- **In nature cod has a high protein intake**
- **There is a primary need of protein for tissue growth**
- ***Protein is the most expensive macro-nutrient in feed formulation***

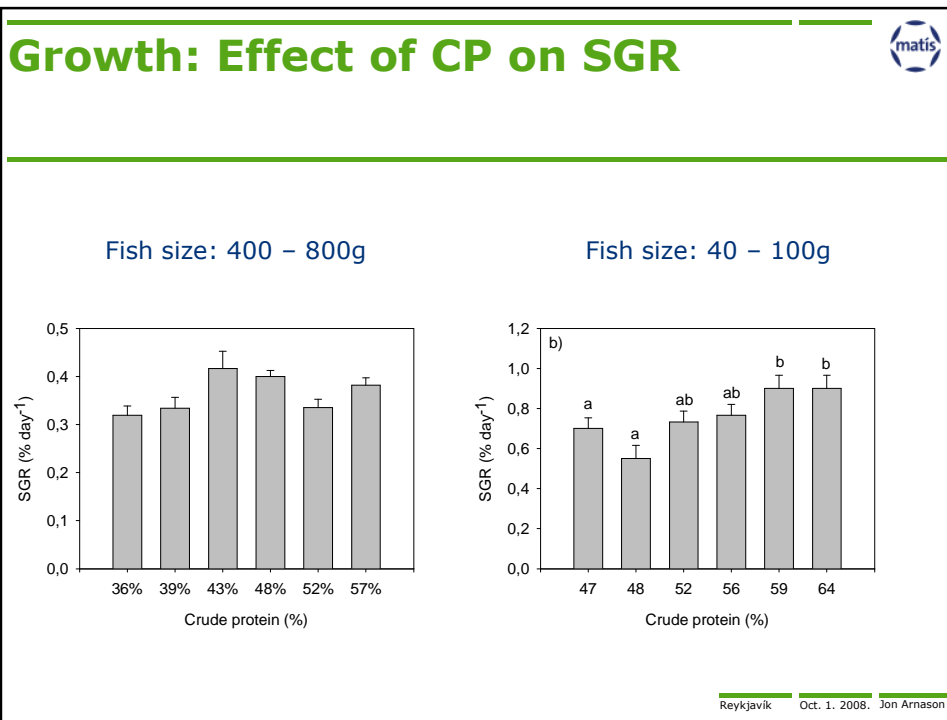
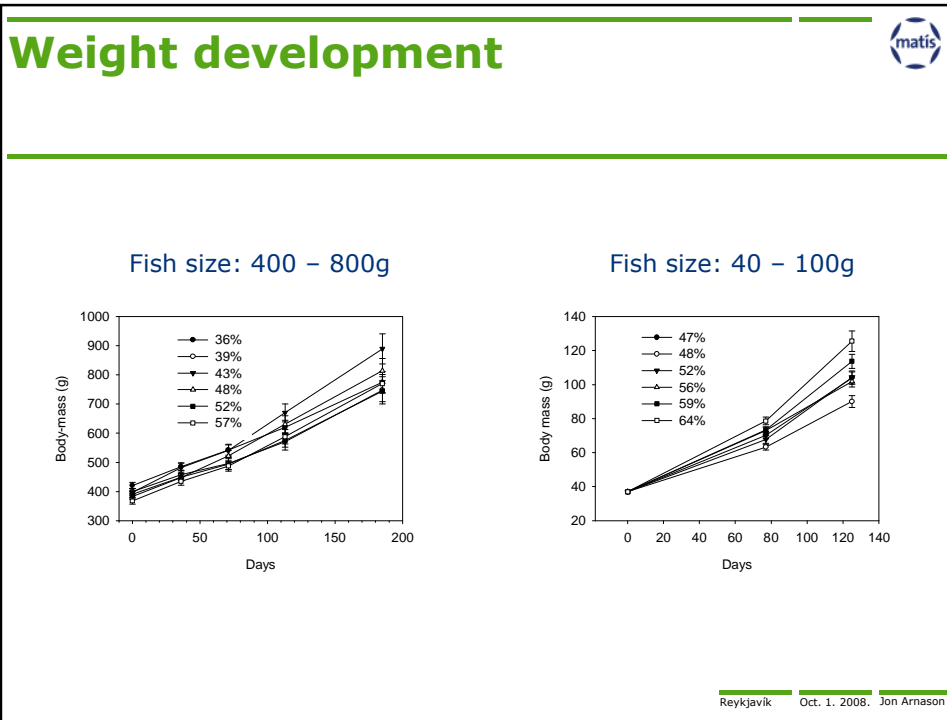
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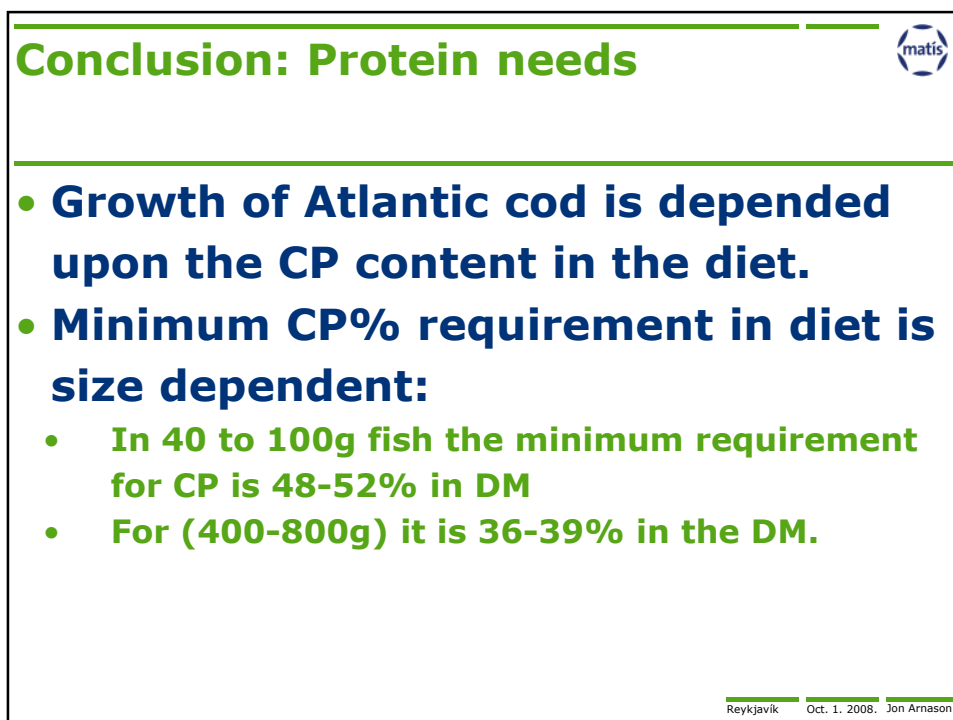
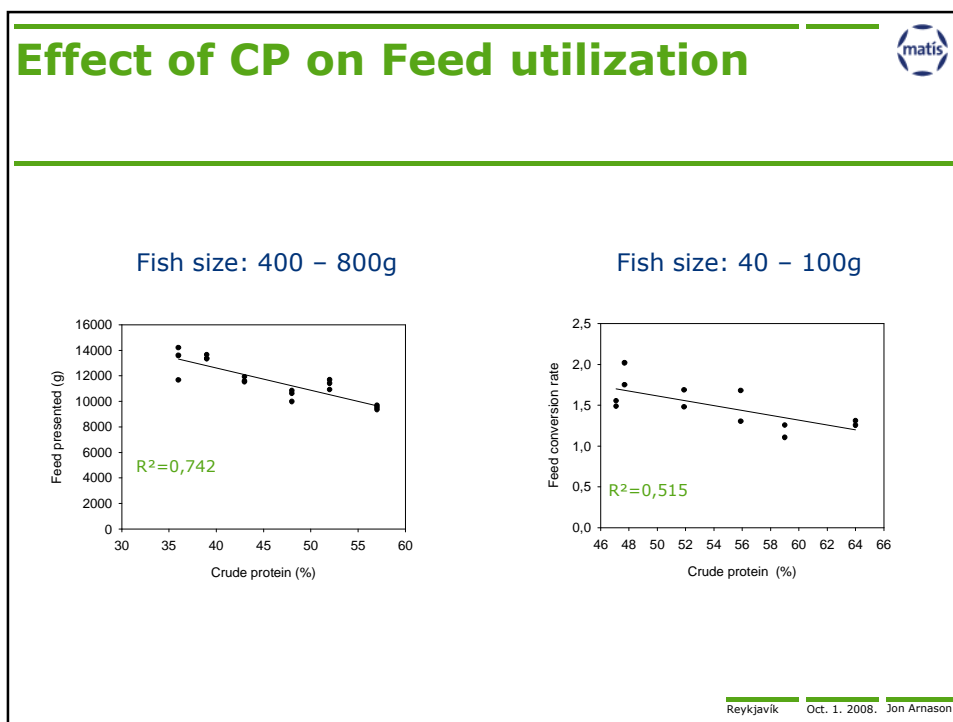


Icelandic trials: Materials and methods

- Dose response trials with graded amount of protein (Semi iso energetic diets)
- Two size groups of fish
 - 40 – 100g and 400 – 800 g
- Ingredients in feed Superiour Capelin meal, Capelin oil and Wheat
- Ad libitum feeding

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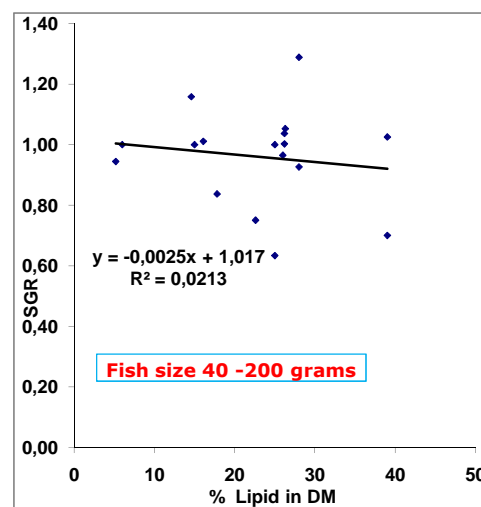
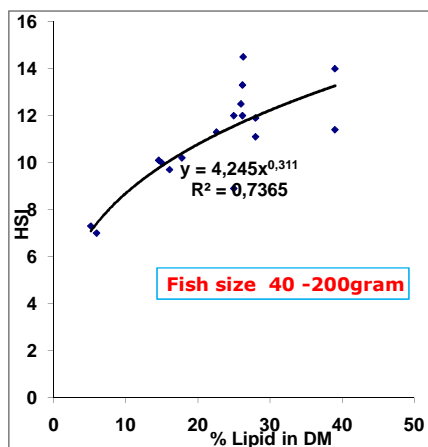
Lipids in cod diets: Tolerance or need?



- **Lipid metabolism of cod**
 - The liver is the lipid store
 - Filet lipid is very stable


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Results from older trials on effect of lipid content in diet on growth and liver size in cod (from Arnason 2004)



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Icelandic trials: Chemical composition of diets

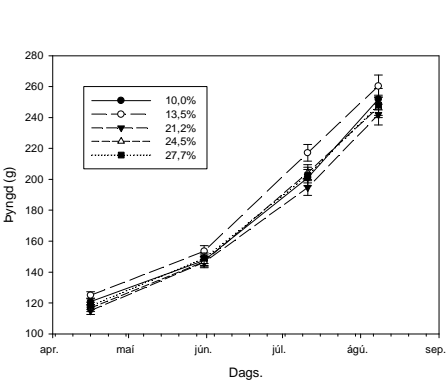


Diet	CP	Lipid	Ash
1	51,7	10,0	8,7
2	51,2	13,5	8,0
3	50,4	21,2	8,0
4	50,1	24,5	7,8
5	49,8	27,7	7,8

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Weight development and HSI (120 – 250g)

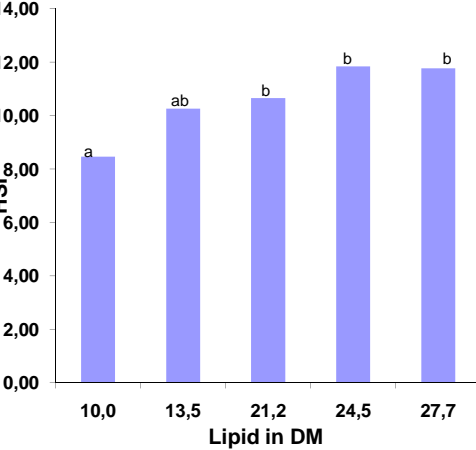




Pyngd (g)

Dags.

Legend:
 ● 10,0%
 ○ 13,5%
 ▲ 21,2%
 ◆ 24,5%
 ■ 27,7%

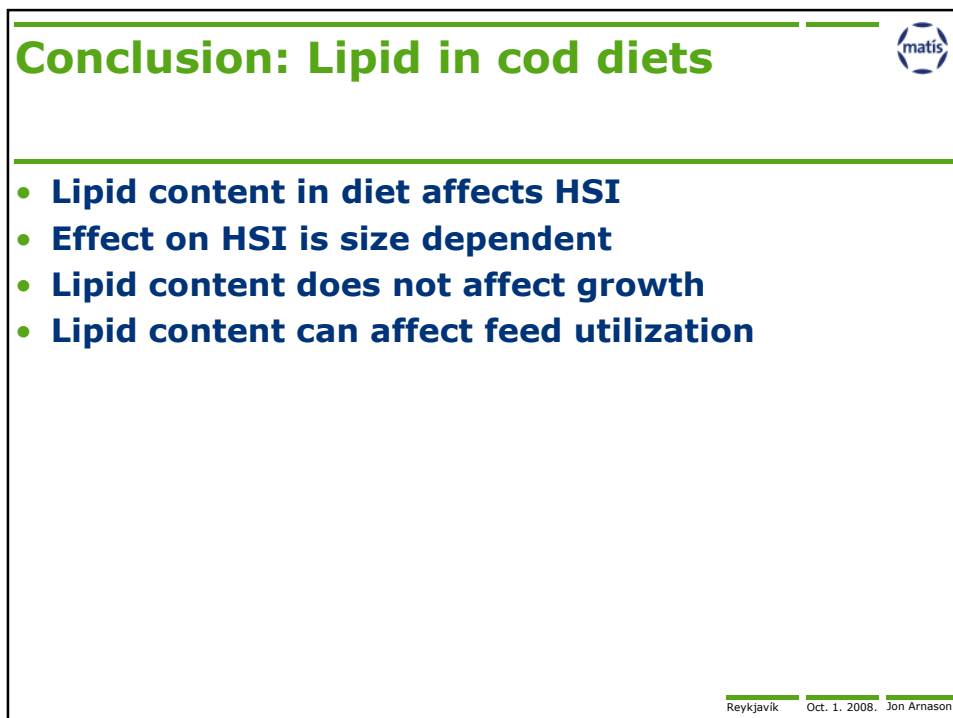
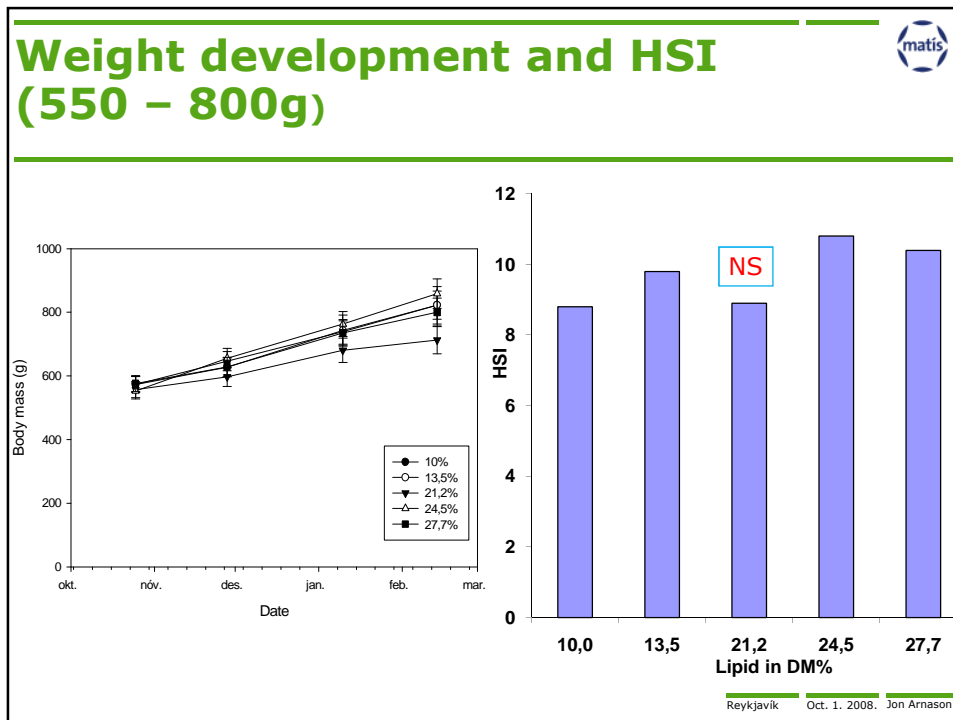


HSI


Lipid in DM

Significance: a, ab, b, b

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Feed formulation: raw materials



- **The role of raw materials in feed formulation:**
 - Supply nutrients to fulfill nutritional needs
 - Supply energy for the metabolism
 - Minimize presence of undesired substances for fish and consumers

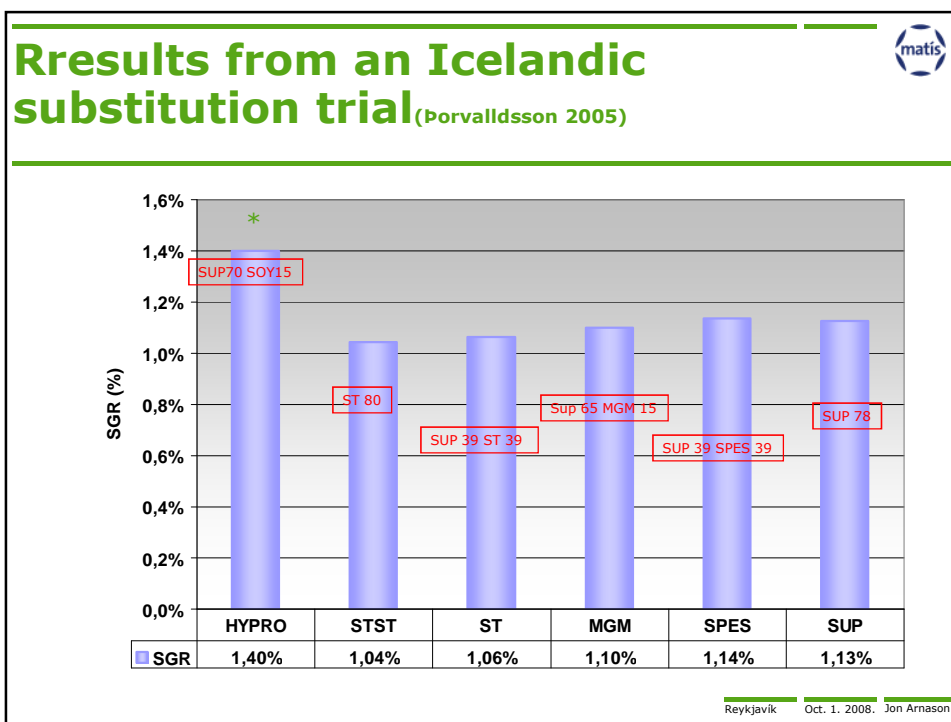
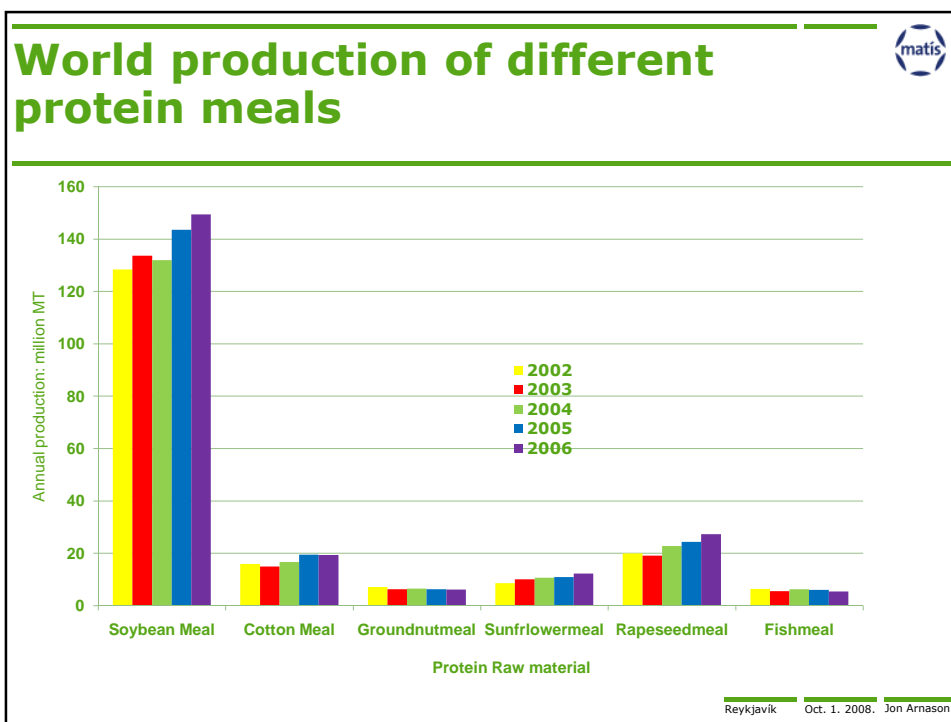
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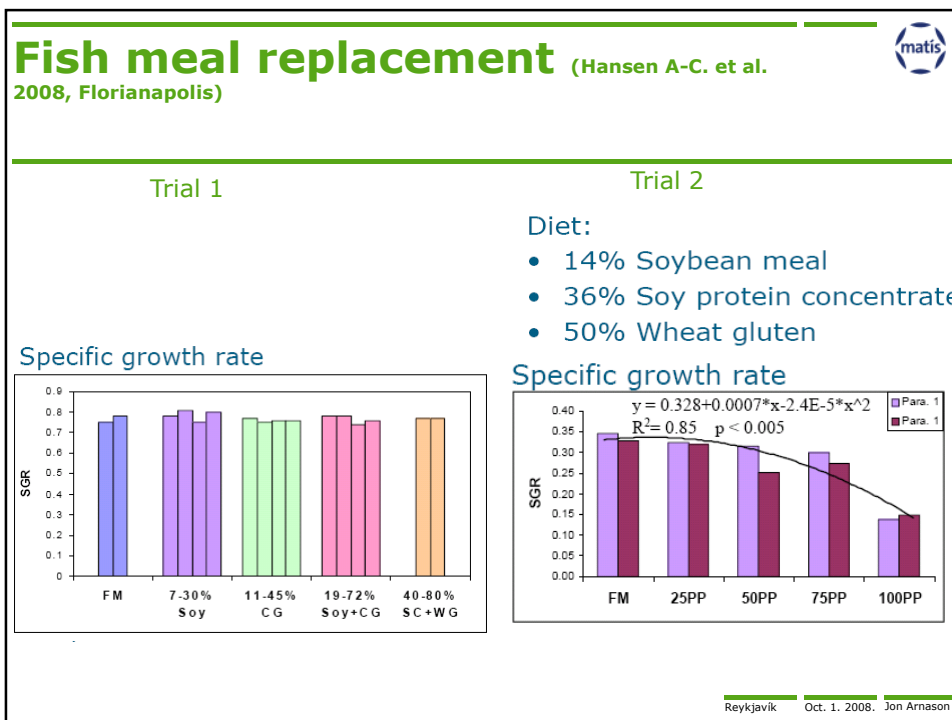
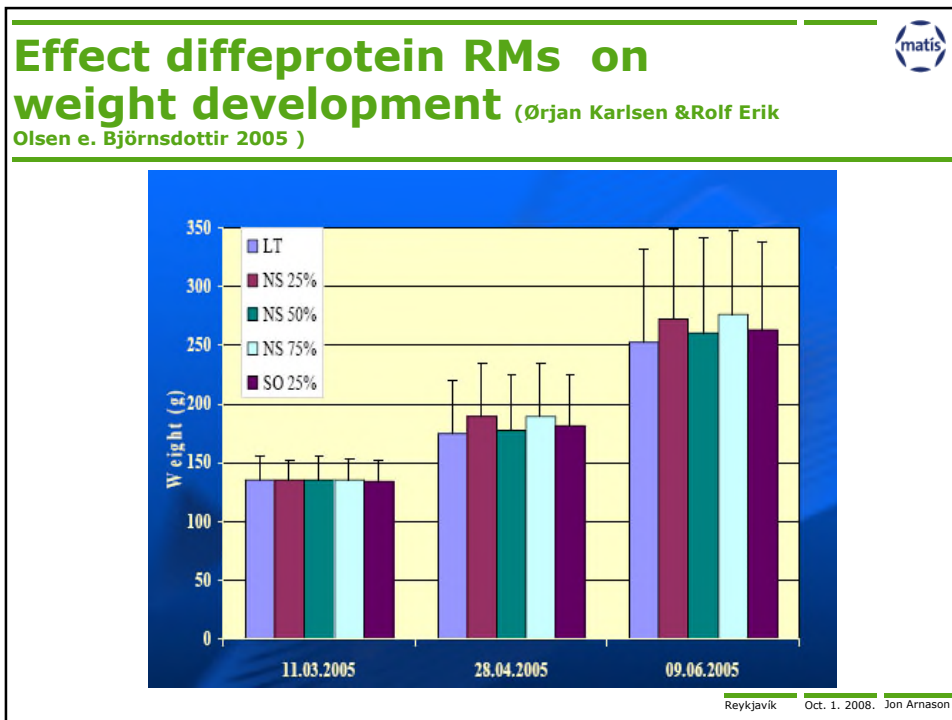
Substitution of fish meal




- **Why?**
 - Limited supply of fish meal
 - Sustainability
 - Feed cost

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Substitution with high ash meals




- **Fish bone meal**
- **Crab meal**

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Effect of ash content : Diets compared.


(Toppe et al 2005)



	Control	FboneL	FboneM	FboneH	CrabL	CrabM	CrabH
Moisture	64	69	64	64	61	63	67
Crude protein	499	497	498	502	511	496	490
Crude lipid	184	179	181	179	186	188	181
Total starch	141	118	95	70	103	82	46
Gelatinized starch (% of total)	105.5	102.1	100.0	98.6	100.0	97.6	93.5
Ash	84	117	148	180	117	148	184
Gross energy (MJ kg ⁻¹)	22.1	21.3	20.9	20.4	21.7	21.1	20.2
Calcium	13.5	25.0	37.0	49.0	25.0	38.0	48.0
Phosphorus	14.2	18.6	22.8	27.4	15.1	15.0	15.1
Chitin ^a	-	-	-	-	6.1	13	20

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Toppe et al 2005



	Control	FboneL	FboneM	FboneH	CrabL	CrabM	CrabH	Linear regression	
								P	r ²
Body weight at start, g	196 ± 2	196 ± 3	195 ± 3	195 ± 4	195 ± 5	196 ± 4	196 ± 3	ns	
Body weight at end, g	462 ± 36 ^{ab}	478 ± 21 ^{ab}	469 ± 19 ^{ab}	495 ± 19 ^{ab}	424 ± 27 ^a	454 ± 38 ^{ab}	503 ± 28 ^b	ns	
Weight gain, g/fish	266 ± 34 ^{ab}	282 ± 21 ^{ab}	273 ± 17 ^{ab}	300 ± 16 ^{ab}	228 ± 25 ^a	258 ± 40 ^{ab}	308 ± 25 ^b	< 0.05	0.23
SGR, %/day	0.90 ± 0.07^{ab}	0.94 ± 0.05^{ab}	0.92 ± 0.04^{ab}	0.98 ± 0.02^b	0.81 ± 0.06^a	0.88 ± 0.10^{ab}	0.99 ± 0.04^b	< 0.05	0.24
TGC	1.98 ± 0.18^{ab}	2.08 ± 0.12^{ab}	2.03 ± 0.09^{ab}	2.18 ± 0.07^b	1.76 ± 0.15^a	1.94 ± 0.24^{ab}	2.22 ± 0.12^b	< 0.05	0.24
Condition factor	1.28 ± 0.04	1.28 ± 0.04	1.25 ± 0.02	1.26 ± 0.01	1.21 ± 0.04	1.23 ± 0.06	1.26 ± 0.03	ns	
Feed consumption, % of av. fish weight/day	0.55 ± 0.02^{ab}	0.56 ± 0.01^{ab}	0.57 ± 0.01^{ab}	0.60 ± 0.01^b	0.51 ± 0.03 ^a	0.55 ± 0.04 ^{ab}	0.71 ± 0.03 ^b	< 0.001	0.45
FER, g fish growth/g feed eaten	1.31 ± 0.03 ^a	1.34 ± 0.04 ^a	1.32 ± 0.02 ^a	1.33 ± 0.03 ^a	1.33 ± 0.04 ^a	1.31 ± 0.07 ^a	1.13 ± 0.03 ^a	ns	

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Conclusion : Raw materials



- **Atlantic cod:**
 - **Tolerates high degree of FM substitution**
 - **Lesser effect of Crude fiber?**
 - **Lesser effect of ANF?**
 - **Tolerates high content of Minerals!**

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Overall conclusions



- **Comparison to other species:**
 - Similar protein needs as salmon
 - Different lipid metabolism
 - High tolerance to plant protein raw materials
- **Consequences to feed formulation:**
 - High potential to lower RM cost
 - High potential in sustainability

- **Concluding remarks:**

Many unanswered questions and possibilities !