Protein requirements of Arctic charr (*Salvelinus alpinus*).

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Abstract. The protein requirements of Arctic charr from first feeding to 1 kg was studied in six separate growth trials. All groups were fed six isoenergetic feed formulations, containing 34.7-49.2% crude protein (CP). Growth rate, FCR, PER and chemical composition were compared among groups. The results suggest that the CP in feed must be 45-49% to support maximum growth of fish up to 10g. However, the protein requirements are reduced considerably with increasing body mass. There was no significant difference in the growth rate of fish larger than 90 g fed 34.7% to 49.2% CP. Reduced CP in feed a had significant effects on FRC and resulted in increased PER and PPV in muscles of larger fish. The minimum CP required to maintain maximum growth in fish over 90 g is less than 34.7% and lower than the range of diets tested in this experiment.
In another set of experiments, fish meal was partially substituted with several types of plant meal. The results show that charr can grow well on plant protein diets. The results show that Arctic charr can efficiently convert plant protein into high quality fish proteins. This is an important step towards establishing a sustainable aquaculture of the species.

Introduction: Protein is the most expensive component of formulated aquafeeds. Therefore, it is important to determine the minimum protein level, for maximum growth, in feed formulation to reduce the cost of production. Furthermore, fish meal, which is the primary source of protein in fish feed for salmonids, is expensive and in limited supply. Therefore, it is of importance to find less expensive raw material of plant origin that can replace fish meal as a protein source in fish feed..
The objective of the present study was to determine the minimum protein requirements for Arctic charr from start feeding to harvest size. Additionally to test the growth response of Arctic charr fed diets where marine protein was substituted plant protein sources in the diet.

Materials and methods

Table 1. Raw material composition, % CP and %CF in feed in part II.

	Marine protein raw material (MPRM)					
Raw materials %:	**47,8**	**43,5**	**39,9**	**32,2**	**12,6**	**11,4**
Wheat	27	28	18,3	8,6	8	8
Herring meal		43,5	37,9	32,2	0	9,6
Herring bone meal	47,8	0	0	0	12,6	1,8
MGM					4,2	5
Wheat gluten meal					15,3	15
Hi Pro Soya					5	5
Rapeseed meal			17	33,9	27	26,5
Fish oil	24,1	25,65	23,9	22,1	24,6	24,7
% Crude Protein	36,0	35,6	36,5	37,8	36,2	38,2
% Crude Fat	29,5	29,0	27,6	28,1	29,2	29,0

Part I: Six isoenergetic extruded feed formulations with protein content from 34,7-49,2 %CP (capelin meal) and fat content from 21,8-25,6 %CF (fish oil) were fed to Arctic charr in six separate growth trials in fresh water. All treatments were in triplicates or quadruplicates and initial and final weight were: 0,07->3g, 3->10g, 30->90g, 90->230g, 230->660g &460->1050g . The fish were fed in excess and waste feed collected for FRC evaluation. Weight was measured regularly and the initial and final protein content in fish flesh was analysed for evaluation of PER.
Part II: Arctic charr (i.w. 550 g) were fed six different isoenergtic feed formulations (36-38% CP) containing different types of plant protein and fish meal (table 1). A general lineal model and nested two way Anova were used to compare variables and the confidence limits set to 95% ($p<0,05$).

Results:

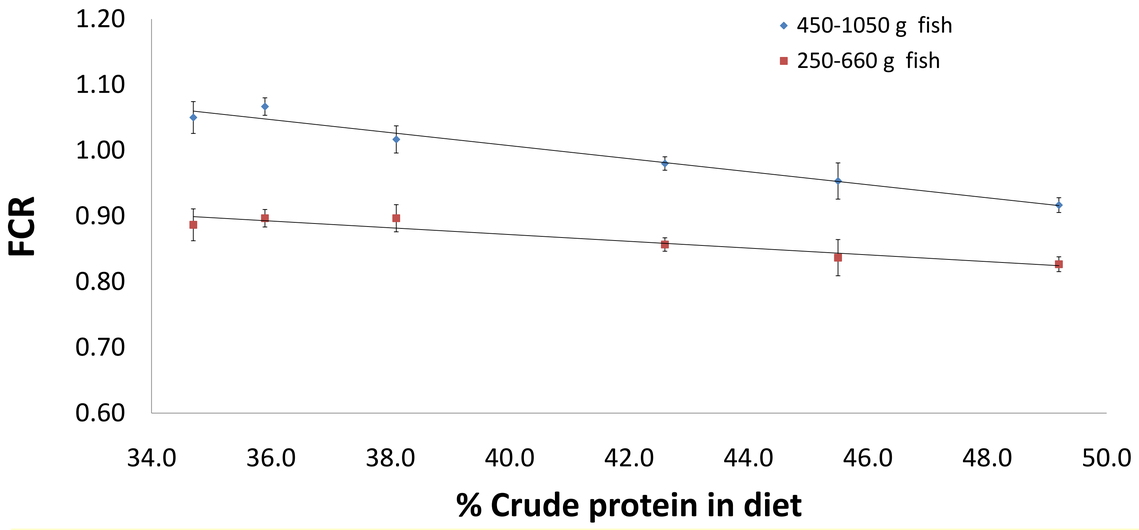

Fig.1. FRC in to size groups of fish fed different %CP in diet. Mean values ± S.E.M. (n= 3)

Part I: The protein requirements for maximum growth of charr from start feeding to 10 g was 45-49 %CP (Fig.2). The protein ratio in feed tested had no significant effect on growth of fish from 90 g to 1 kg+. Reduced protein content in feed resulted in significantly higher PER and low PPV in fish and significant increase in FCR (Fig. 1).

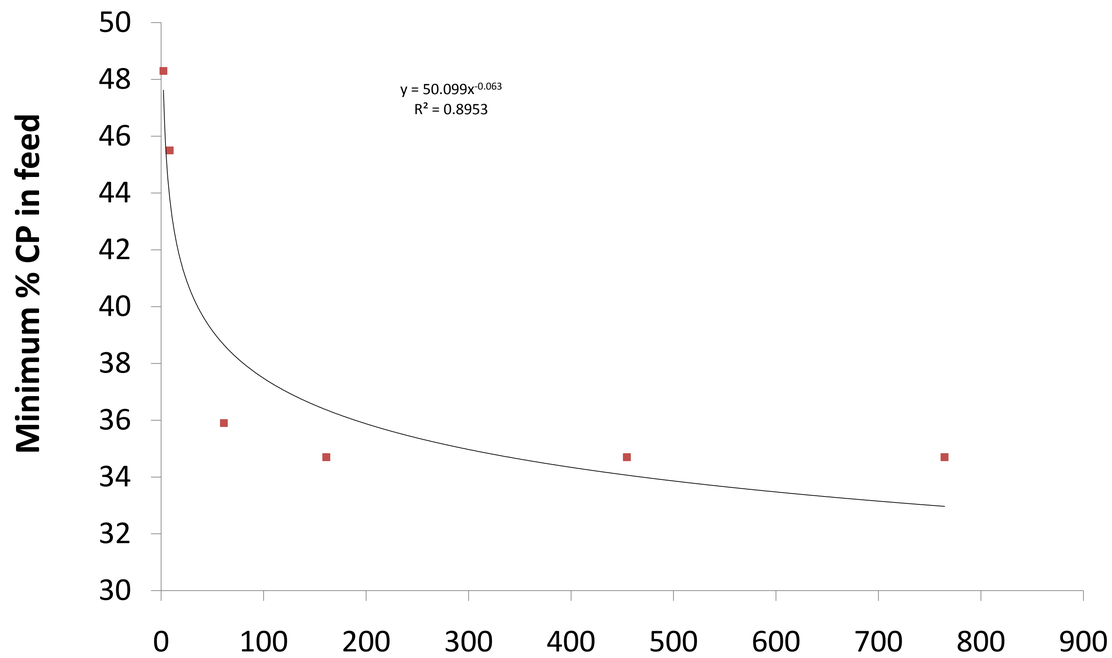

Fig.2. The minimum protein content of feed required for maximum growth of Arctic charr

Part II: Fish fed diet where 2/3 of the protein source was of plant origin and 1/3 was herring meal grew equally well as groups fed diets containing herring meal or herring bone meal as the only or major protein source. Groups fed diet with high inclusion of one plant protein source or diet with considerable substitution of herring bone meal with plant meal showed significantly lower final weight. Neither FCR nor PER was affected of feed composition.

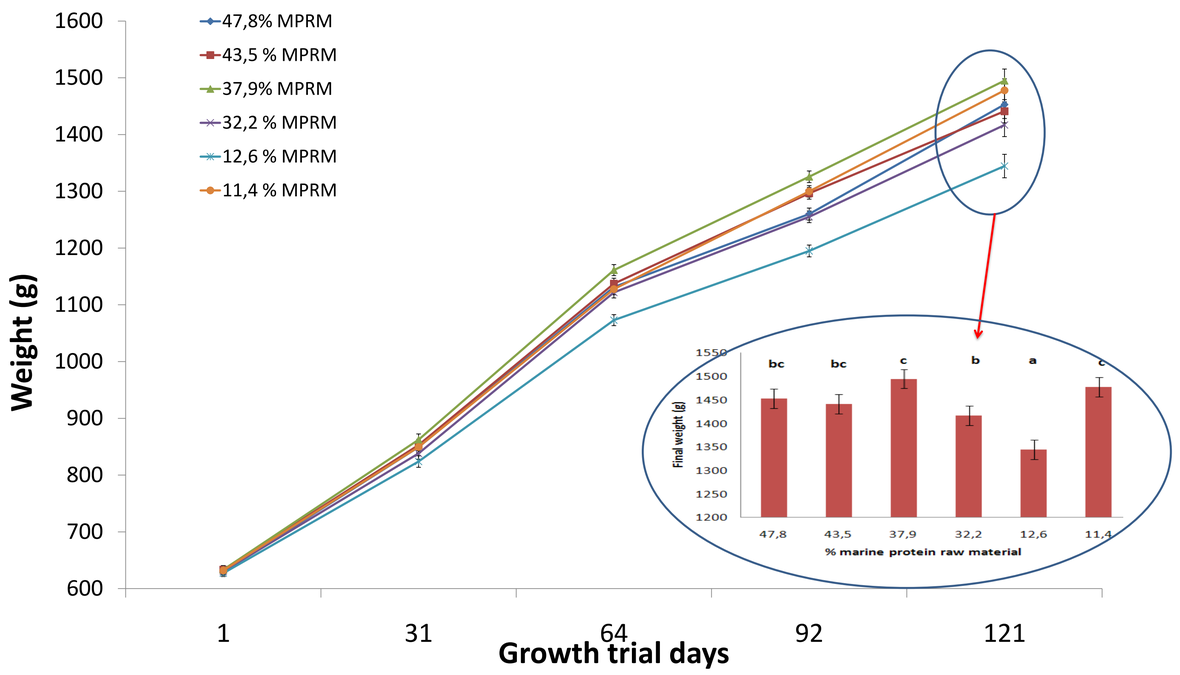

Fig.3. Growth of Arctic charr fed diet containing different protein raw material. Different letters in final weight indicate significant difference between the different diets, ($p< 0,05$). Mean values ± S.E.M. (n=3)

Discussion and conclusion:

- Start-feeding fry and small Arctic charr juveniles require 45-49% CP in diet for maximum growth.
- The protein requirements are significantly reduced with increasing fish size.
- The minimum protein requirements of charr larger than 100 g are less than 34,7%.
- The charr may compensate for lower CP in diet by increasing feed intake.It is possible to substitute a significant part of the marine proteins in diet for Arctic charr with plant protein without compromising growth. However, the origin and the quality of both the plant and marine protein raw material affect the growth of the fish.
- Formulation optimized for protein content and substantial substitution of marine raw material with plant proteins in diet for Arctic charr may reduce the raw material cost of feed by 25- 30%
- The good growth performance of fish fed diets where 2/3 of the fish meal was substituted with raw material of plant origin shows that Arctic charr can efficiently convert plant protein into high quality fish proteins. This is an important step towards establishing a sustainable aquaculture of the species.

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