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THE AMINO ACID COMPOSITION AND THE PROTEIN VALUE OF FOUR SELECTED FISH MEALS FOR THE YOUNG CHICK

By

LEIF REIN NJAA, FINN UTNE, GJERMUND BOGE and OLAF R. BRÆKKAN

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INTRODUCTION

Norwegian herring meal was originally produced mainly from winter herring and one of the quality criteria of this meal was that the protein content was usually not below 70 %. Thus 33 commercial Norwegian herring meals contained between 71.8 and 78.4 % protein (NJAA, UTNE and BRÆKKAN, 1966a). The trend in the fisheries has led to herring catches all the year round, and in addition other pelagic species constitute a large part of the catches in different waters. Thus, the raw material for the reduction plants may vary from one season to another. The landed herring may vary during the year from large in the winter to very small during the summer. This may introduce variations in the composition of herring meals with regard to the main analytical criteria, e.g.: herring meals from very small herring was found to contain from 66.5 to 70.4 % protein (NJAA, UTNE and BRÆKKAN, 1966b). Low protein contents in Norwegian alleged herring meals were also reported in a Belgian study on the amino acid composition of fish meals (DE VUYST, VERVACK, VANBELLE, ARNOULD and MOREELS, 1964). Meals from the same species caught at different times of the year and meals from different species may also show differences in fat and ash contents as well as in the contents of amino acids and vitamins. The possibility of typical differences in the amino acid pattern is indicated by the high histidine content in mackerel muscle (BRÆKKAN and BOGE, 1962) which suggests that mackerel meal would be especially rich in this amino acid.

The present study is an attempt to throw some light on the influence of some of these factors on the composition and quality of meals produced from different raw materials. The investigation comprises four carefully controlled samples produced in the same factory in order to avoid effects due to possible differences in the production method. Seasonal difference is provided for by choosing one meal produced from winter herring and one from herring caught during the summer months. Species differences are implied by samples of a scad meal and a mackerel meal. The scad is novel as a species caught for fish meal production, a pure sample was obtained because the scad was especially numerous in 1966. The samples were analyzed for protein, fat, ash, calcium, amino acids and vitamins. Further was included a feeding experiment with young chicks.

MATERIALS

The meals tested were: A winter herring meal, produced March 1966; a North Sea herring meal, produced August 1966; a scad meal, produced August 1966; a mackerel meal, produced October 1966.

ANALYTICAL METHODS

Dry matter, protein, fat, ash, calcium and vitamins were determined by standard methods as previously described (NJAA, et al., 1966a). Soluble nitrogen was determined by two different methods, either extraction of 10 g meal with 100 ml 70 % ethanol or with 100 ml 5 % (w/v) trichloracetic acid (TCA) for one hour in Erlenmeyer flasks during frequent stirring followed by filtering. Aliquots of the extracts were digested as usual for N-determinations.

Amino acids were determined in hydrolysates obtained by digestion of samples equivalent to about 225 mg protein (N × 6.25) with 900 ml constant boiling HCl under reflux for 23 hrs. The amino acid composition of the hydrolysates was determined using a Technicon amino acid analyzer. Tryptophan was determined according to a modification of the method described by GRAHAM, SMITH, HIER and KLEIN (1947). The German firm Degussa analyzed the same samples with essentially the same equipment and technique, but determined methionine after performic acid oxidation. They have kindly permitted the inclusion of their results in the present paper.

CHICK EXPERIMENT

A growth experiment was performed with 24 groups of week-old male leghorn chicks kept in the laboratory on a standard diet from they were day-old. Each group consisted of 15 chicks alloted to the groups when they were one week old as previously described (BRÆKKAN, NJAA, UTNE and ØVSTHUS, 1957).

The meals were tested as supplements to a basal feed mixture which essentially was a commercial feed mixture from which animal protein had been omitted (Table 1). Each meal was added at three levels equivalent to 1.5, 3.0 and 6.0 % fish meal protein in the final mixtures.

Table 1. Percentage composition of the basal feed mixture.

Ground maize	35.0
Ground whole wheat	20.0
Ground oats	20.0
Wheat bran	10.0
Grass meal	4.0
Dried brewers yeast	1.0
Soya bean meal, extracted	6.0
Linseed cake meal	2.0
Mineral mixture (Commercial for poultry)	2.0

Vitamin A was added at 7 500 I.U./kg basal feed mixture, vitamin D at 750 I.U./kg and riboflavin at 40 mg/kg.

Table 2. Composition of the experimental feed mixtures.

	Protein content (%)	1.5% fish meal protein in the feed mixture				3.0% fish meal protein in the feed mixture				6.0% fish meal protein in the feed mixture			
		(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)
Basal	12.9	11 750	11 750	11 750	11 750	11 500	11 500	11 500	11 500	11 050	11 050	11 050	11 050
Winter herring meal	75.6	238				476				952			
North Sea herring meal	73.3		246				491				982		
Scad meal	69.5			259				518				1 036	
Mackerel meal	75.3				239				478				956
		11 988	11 996	12 009	11 989	11 976	11 991	12 018	11 978	12 002	12 032	12 086	12 006
Percent protein of feed mixture		14.3	14.0	14.3	14.3	15.6	15.3	15.3	15.3	17.8	17.7	18.0	17.9
Percent of protein from fish meal			10.6				19.5				33.5		

In Table 2 is given the composition of the diets used, the analyzed protein content and the calculated portion of the total feed protein derived from fish meal protein. Further was investigated the effect of methionine addition corresponding to 1 % of the fish meal protein. This supplement was added to the meals at all levels.

The experiment was intended to last for four weeks and amounts of feed assumed to be sufficient for this time was mixed at the start of the experiment. Unfortunately, the feed mixtures did only last for 26 days. It was therefore chosen to close the experiment at this time.

RESULTS

The results of the chemical analyses and of the vitamin assays are given in Table 3. The scad meal showed results clearly different from the other three meals investigated. The protein content was slightly less than 70 %, but the main difference was in the ash and calcium contents. Obviously the scad meal contained more bone than the other meals. Assuming that fish without bone on a dry matter basis contains about 0.1 % Ca and bone about 25 % Ca calculations indicate that the scad meal may contain about 19 % bone and the other meals 5—7 %. The difference was probably not due to a lower content of stickwater protein in the scad meal as the amounts of nitrogen extracted by 70 %

Table 3. Chemical composition and vitamin content of four fish meals produced from different raw materials.

	Winter herring meal	North Sea herring meal	Scad meal	Mackerel meal
Dry matter (%)	92.9	90.5	93.5	91.9
Protein (N × 6.25 %)	75.5	73.3	69.5	75.3
Fat (%)	6.4	7.5	7.2	8.6
Ash (%)	9.9	8.9	17.1	8.8
Calcium (%)	1.87	1.54	4.95	1.81
N-extract 70 % ethanol (% of tot.N)	11.2	13.6	12.1	19.8
N-extract 5 % TCA (% of tot.N)	16.6	19.1	17.7	22.4
Riboflavin (µg/g)	5.5	9.4	9.0	16.4
Pantothenic acid (µg/g)	29.0	29.2	20.7	30.6
Nicotinic acid (µg/g)	109	147	121	218
Vitamin B_{12} (µg/g)	0.28	0.29	0.30	0.36
Thiamin (µg/g)	0.45	1.30	2.8	0.63
Vitamin B_6 (µg/g)	—	—	3.7	5.6
Biotin (µg/g)	0.38	0.43	0.39	0.43

ethanol or 5 % TCA were not less than in the two herring meals. The mackerel meal showed higher values for N-extract than the other meals.

The vitamin analyses showed some differences between the meals. The mackerel meal had clearly higher contents of riboflavin and nicotinic acid. Compared with the winter herring meal riboflavin was about three times higher and nicotinic acid two times higher for the mackerel meal. The vitamin B_{12} content was also highest in the mackerel meal. The scad meal differed from the other meals by a lower pantothenic acid content and by a high thiamine content, the latter approaching values found in common grains. This may indicate the absense of thiaminase in this species. For biotin there were no obvious differences between the

Table 4. Amino acid content (g/16 g N) of four fish meals produced from different raw materials.

	Winter herring meal		North Sea herring meal		Scad meal		Mackerel meal	
	A	B	A	B	A	B	A	B
Aspartic acid	8.33	7.81	8.40	7.30	8.47	9.03	8.88	9.04
Threonine	4.31	3.87	4.83	4.91	4.08	4.25	4.56	4.41
Serine	3.98	3.55	4.41	4.14	3.91	4.19	4.19	3.93
Glutamic acid	12.50	11.69	12.66	12.29	13.22	13.00	12.87	12.84
Proline	4.25	4.28	4.26	4.03	4.81	4.92	4.73	4.11
Glycine	6.49	5.97	6.09	5.54	7.22	7.35	6.43	5.98
Alanine	6.33	5.94	6.15	6.00	6.22	6.65	6.14	6.16
Valine	5.10	4.98	5.13	5.13	4.60	4.94	5.16	5.46
Cystine	0.83	1.10	0.69	0.84	1.00	0.88	0.95	1.11
Methionine	2.56	2.34	2.36	2.66	2.38	2.82	2.81	2.75
Isoleucine	4.04	4.08	4.13	4.03	3.77	4.34	4.23	4.50
Leucine	8.33	7.32	7.95	7.15	7.24	7.31	8.02	8.24
Tyrosine	3.07	3.03	2.56	2.75	2.85	3.18	3.17	3.39
Fenylalanine	3.67	3.60	3.85	3.71	3.55	3.79	3.87	3.90
Lysine	7.00	7.10	7.19	7.03	6.65	7.94	7.19	7.84
Histidine	2.20	2.04	2.38	2.01	2.52	2.64	2.89	2.77
Arginine	6.65	6.04	5.91	5.95	5.39	5.81	5.68	5.83
Tryptophan		*0.66		0.69		0.78		*0.94

A: Analysed January 1967 by Degussa, Frankfurt a. M. Germany. The authors express their thanks for permission to publish these results.

B: Analyzed November 1967 at our laboratory.

* These samples were also analyzed for tryptophan in our laboratory by a microbiological technique, and by Dr. B. Eggum, Landøkonomisk Forsøgslaboratorium, Copenhagen, Denmark and Dr. K. J. Frandsen, Øtoftegaard, Taastrup, Denmark. The results were respectively for winter herring meal and mackerel meal: 0.71, 1.15 and 1.16, and 0.94, 1.26 and 1.24 g/16 g N.

meals. Values for vitamin B_6 are only reported for the mackerel meal and the scad meal. It was not possible to carry out adequate assays on the two herring meals, propably due to the inhibitory effect of protamines in the soft roe (BRÆKKAN and BOGE, 1964). Mackerel meal showed a higher value for vitamin B_6 than the scad meal. However, even this value is low compared with values for herring and mackerel muscle (BRÆKKAN and BOGE, 1960). Relative to the protein content they found values five to six times as high in mackerel muscle as the present result for mackerel meal. Therefore, inhibitory substances may have been present also in these meals. The generally higher vitamin values in mackerel meal compared with herring meal are in accord with the analyses of whole herring and whole mackerel reported by BRÆKKAN and PROBST (1953).

The amino acid analyses are reported in Table 4. No striking differences could be observed between the four meals. Our data and those from Degussa agree as regards the following differences: Winter herring

Table 5. Weight gains in chicks given the experimental feed mixtures containing three levels of protein from four fish meals produced from different raw materials.

Added fish meal protein	Days	Winter herring meal		North Sea herring meal		Scad meal		Mackerel meal	
		Methionine		Methionine		Methionine		Methionine	
		not added	added	not added	added	not added	added	not added	added
1.5%	7	43,4	41.1	41.7	41.2	42.4	40.2	41.1	41.6
	14	112.3	106.0	106.6	108.1	109.2	107.4	106.8	110.4
	21	191.2	183.2	188.5	189.0	185.4	191.3	184.8	189.0
	26	255.5	248.0	254.8	260.5	256.7	256.5	259.5	261.9
		(*2.73)	(2.73)	(2.77)	(2.80)	(2.69)	(2.77)	(2.76)	(2.73)
3.0%	7	46.2	47.9	49.0	42.9	48.0	47.6	43.6	48.7
	14	124.2	129.4	126.7	117.0	117.9	125.1	117.3	129.2
	21	206.0	221.8	212.2	207.2	214.8	216.3	207.9	223.3
	26	276.1	305.4	283.4	287.4	296.5	297.9	285.7	299.7
		(2.57)	(2.54)	(2.52)	(2.54)	(2.50)	(2.49)	(2.48)	(2.64)
6.0%	7	53.4	52.0	53.1	51.8	54.8	54.3	49.9	54.2
	14	142.0	141.1	143.9	138.2	145.0	142.7	141.7	146.5
	21	238.5	250.1	252.5	239.1	254.0	250.0	249.8	254.0
	26	332.1	337.7	351.7	340.0	345.4	340.7	341.1	345.3
		(2.34)	(2.19)	(2.22)	(2.22)	(2.17)	(2.21)	(2.25)	(2.26)

*) The values in the parenthesis are feed utilizations expressed as kg feed per kg weight gain (at 26 days).

meal was lowest in glutamic acid and histidine and highest in arginine; North Sea herring meal was lowest in proline, glycine, cystine and tyrosine and highest in threonine; scad meal was lowest in valine and arginine and highest in glutamic acid, proline and glycine; mackerel was lowest in none and highest in aspartic acid and histidine.

The chick experiment showed no significant differences between meals and no significant effect of adding methionine to the meals. The effect of increasing the fish meal level was an increased growth. There was, however, no interaction between protein levels on the one hand, and either meal type or methionine addition on the other.

DISCUSSION

The commercial value of a fish meal is normally related to the protein content. The biological value of a protein source may, however, be as much dependent on the raw material and the method of processing. A proper evaluation of a protein source should therefore include both biological testing and determination of the amino acid composition. Thus, the larger feed producers check the common ingredients in these respects.

The chick experiment did not show any differences in the biological utilization of the four meals tested. Addition of methionine at a level of 1 % of the fish meal protein also failed to improve the performance of the chicks. This indicates that the production method did not affect the amount of available methionine. The amounts added represent an increase of about 35 % of the methionine present in the fish meals. For the three protein levels studied this would mean increases of about 3, 6 and 9 % of the total S-containing amino acids present.

The fact that there was no differences between the meals at any of the three levels tested indicates that the four meals supplemented the basal diet equally well at all levels, and also that the differences between the raw materials did not result in differences in the biological protein value.

The great similarity in the amino acid analyses between the four experimental meals seems to be a general trend for shoal-fish meals. In Table 6 are collected some analyses of Norwegian alleged herring meals as well as analyses of Peruvian fish meal and British Columbia herring meal. By comparing these results with those in Table 4 the great similarity is evident. In a very recent paper by Olley, Ford and Williams (1968) a similar finding is reported. Although the mackerel meal in Table 4 was not as high in histidine as might have been expected

Table 6. Amino acid analyses of Norwegian herring meal, British Columbia herring meal and Peruvian fish meal, taken from various sources.

Authority	Herring meal								Peruvian fish meal	
	(1)	(2)	(3)	(4a)	(4b)	(4c)	(4d)	(5)	(1)	(2)
Protein content (% N × 6.25)	65.1	71.9	74.5	72.9	74.7	73.6	72.8	71.6	63.6	64.1
Aspartic acid	10.3	8.2	9.1	8.7	9.0	9.3	8.9		10.2	9.1
Threonine	4.4	4.3	4.0	4.1	4.2	4.4	4.4	4.0	4.5	4.4
Serine	4.3	3.6	4.1	3.8	3.9	4.1	4.0		4.4	3.7
Glutamic acid	14.2	12.2	11.7	12.0	12.9	13.0	12.9		13.5	13.2
Proline	5.2	4.6	4.6	4.0	4.0	4.0	3.9		4.5	4.4
Glycine	6.1	6.3	6.3	6.7	7.0	6.6	5.9	7.2	6.0	5.9
Alanine	8.4	6.2	7.4	6.4	6.4	6.3	6.5		6.9	6.1
Valine	5.7	5.7	5.3	4.9	4.9	5.2	5.7	7.9	5.8	5.3
Cystine	1.0	0.9	1.3	0.9	0.9	1.1	1.0	1.0	1.2	0.9
Methionine	2.9	2.5	2.5	2.5	2.4	1.4	2.6	2.7	2.4	2.6
Isoleucine	4.7	4.4	6.1	4.1	4.0	4.6	4.6	4.2	4.5	4.9
Leucine	7.5	7.1	6.9	7.2	7.1	7.4	7.7	7.2	8.2	7.6
Tyrosine	3.3	2.7	2.9	2.6	2.9	3.3	2.7	2.8	3.6	3.1
Phenylalanine	4.3	3.7	3.5	3.6	3.6	3.8	3.9	3.6	4.5	4.0
Lysine	7.1	7.2	8.2	7.4	7.6	7.7	7.4	8.2	7.7	8.1
Histidine	2.2	2.2	1.8	2.1	2.1	3.0	2.0	2.7	2.4	2.7
Arginine	5.6	4.9	7.9	6.1	5.7	5.6	5.4	7.8	6.2	5.8
Tryptophan	0.8		0.7					0.9	1.7	

(1) DE VUYST *et al.* (1964): Means of six samples of Norwegian alleged herring meal and of 13 samples of Peruvian fish meal.

(2) PION *et al.* (1963): One sample of Norwegian alleged herring meal and one sample of Peruvian fish meal.

(3) BOGE (1960): One sample of Norwegian whole winter herring meal.

(4) Degussa (personal communication) Four samples of Norwegian alleged herring meal. We are indepted to the firm Degussa, Frankfurt a. M. F.R. Germany for permision to include these results.

(5) MARCH *et al.* (1962): Mean of six samples of British Columbia whole herring meal produced during the 1960—61 season.

from the values reported for mackerel muscle (BRÆKKAN and BOGE, 1962), the result differs sufficiently from those for herring meals as to be a possible criterium for the origin of a meal. The scad meal also showed a relatively high histidine content, but this meal showed the further difference that the ash content was very high (Table 3). Meal 4c in Table 6 showed the high histidine content of 3 %. This meal, however, showed a very low methionine content. Generally methionine cause analytical difficulties and one is inclined to ascribe such deviating values to analytical error caused by the lability of methionine towards oxidation

(NJAA, 1962). DE VUYST et al., (1964) also reported some very low methionine values.

The tryptophan values reported for our experimental meals agree fairly well with literature values (BOGE, 1960; MARCH et al., 1962; DE VUYST et al., 1964). Two of the meals were also analyzed by three other methods in collaboration with Dr. B. EGGUM, Landøkonomisk Forsøgslaboratorium, Copenhagen, Denmark and Dr. K. J. FRANDSEN, ØTOFTEGAARD, TAASTRUP, Denmark. Dr. EGGUM applied column chromatography of an alkali digest, Dr. FRANDSEN used a modification of the colorimetric method of Roth and Schuster (LORENTZO-ANDREN and FRANDSEN, 1960), and microbiological assays were carried out in our laboratory. The two former methods gave somewhat higher values whereas the microbiological method agreed fairly well with our chemical determination (Table 4), DE VUYST et al. (1964) applied the method of Roth & Schuster (VERVACK, 1960) and found values for Norwegian alleged herring meals of the same order of magnitude as our present results whereas they found considerably higher values for Peruvian fish meal. The differences in the findings indicate that a study of the methods used for tryptophan is warranted.

The vitamin analyses of the experimental meals may be compared with the values reported for winter herring meal by NJAA et al. (1966a) and with those reported for British Columbia herring meals by MARCH et al. (1962). By both comparisons the winter herring meal in the present study was low in riboflavin. The North Sea herring meal was higher in nicotinic acid than the winter herring meal. This is in accord with results reported by BAKKEN and BRÆKKAN (1955). They found that meals from herring caught during the months May to August had a higher nicotinic acid content than meals from herring caught in the period November to March. The scad meal was slightly low in pantothenic acid and the mackerel meal was high in riboflavin and in nicotinic acid.

With regard to the chemical analyses (Table 3) both the two herring meals and the mackerel meal fell below 10—12 % ash and 1.8—2.2 % calcium reported for whole herring meals (MARCH et al., 1962a; OLSEN, 1967). The scad meal, on the other hand, showed higher values, in agreement with the results reported by OLSEN (1967).

SUMMARY

A winter herring meal, a North Sea herring meal, a scad meal and a mackerel meal were tested as supplements to a basal vegetable chick diet and were analyzed for amino acids, vitamins and the common chemical constituents.

The four meals were equally well utilized by the young chick at three different protein levels and supplementation of the fish meal proteins with 1 % methionine was without any effect.

The amino acid composition of the four meals were very similar, the mackerel meal and the scad meal showed higher histidine values than the two herring meals.

The vitamin assays showed mackerel meal to be highest in riboflavin, nicotinic acid and vitamin B_{12}. The scad meal was high in thiamine.

The chemical analyses showed the two herring meals and the mackerel meal to be of similar composition whereas the scad meal was high in ash and calcium.

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