Government Printer, Pretoria.

The Biological Value of White Fishmeal as Determined on Growing Sheep and Rats.

By D. B. SMUTS and J. S. C. MARAIS, Section Nutrition, Onderstepoort.

FISHMEAL as a feed for animals has probably first been used in Norway. Since 1905 fishmeal, as distinct from fish manure, was manufactured in appreciable quantities in England. It was, however, not until 1916, that it became a popular ingredient in rations for livestock. It was soon demonstrated that this feed was exceptionally good for young growing animals and poultry. Davidson (1928) showed that the value of fishmeal for feeding of pigs is associated with the protein and particularly with the amounts and proportions of mineral ingredients. By replacing fishmeal with vegetable proteins in the ration of pigs he obtained as good results as with fishmeal, if the former ration is supplemented by a mineral mixture. The same quality carcase as that obtained with fishmeal, could not be established. Plimmer and Rosedale (1934) determined the relative nutritive value of different proteins on chickens by the growth method. The value of these protein feeds was calculated numerically from the equation $1^2/TP$, where 1 equals increase in weight, T length of experiment and P protein consumption. On this basis they classified the proteins as follows:—caseinogen 100, fishmeal 85·3, meatmeal 62·8, wheatgerm 68, bloodmeal 48, lucerne 25·6. From these figures it appears as if fishmeal is a good protein for poultry. However, Halpin and co-workers (1936) found that excessive quantities of fishmeal in the ration of poultry caused "crippled" feet. Carbone (1937) calculated the composition of fishmeal from various sources and concluded that it is not such a satisfactory concentrate for beef cattle and milk cows as oil seed cakes, since it does not give such good growth. It is, however an excellent feed for pigs. Monroe, Krauss and Hayden (1937) compared white fishmeal with linseedmeal as a source of protein in the ration of dairy cattle from 6 months of age until the second calving stage. They found no significant difference in growth and milk production, although the health and general vigour of calves from the fishmeal group were slightly better.

It appears as if the quality of fishmeal is largely determined by the type of product used and the method of manufacturing. Bethke and Wieder (1934) found that cooking as well as high temperature destroy the vitamin content. The protein seems also to be effected. Thus the protein of vacuum dried fishmeal, as determined by these authors was superior to those of flame dried

fishmeals. Oshura and Itaya (1938) observed that the digestibility of fishmeal protein is highest for steamdried and lowest for flame-dried and roasted fishmeals. Sundried fishmeal has a much higher NH_3 content than machine dried fishmeal. Schneider (1932) by experiments on rats and pigs found that the protein of vacuum dried white fishmeal has a higher digestibility and is better utilizable than steam dried and flame dried Menhadden fishmeal. It is interesting in this respect that Davies (1936) found by chemical analysis of the crude protein fraction of fishmeals, that these meals are higher in non-protein nitrogen compounds than either meatmeal or blood meal. It is possible that flame drying increases the non-protein nitrogen compounds and hence decreases the digestibility of the protein as was found by the above workers. Swaminathan (1938) found a relationship between the non-protein content of grasses and the digestibility of the protein. A high non-protein content invariably points to a lower digestibility.

Experimental.

White fishmeal which is reported on in this study is a product recently put on the South African market. It contains an average of 67 per cent. protein. The biological utilization of its nitrogen was determined on growing sheep and rats. The weights of the sheep varied from 26 to 31 Kgm. The endogenous nitrogen and metabolic fecal nitrogen were determined previously on these sheep and the results then obtained were utilized in the calculation of the biological value of the protein of fishmeal. With rats the endogenous and metabolic fecal nitrogen were determined in a separate period prior to the actual metabolism period on fishmeal. The composition of the rations is given in Table 1. Wheat straw has now been introduced into our nitrogen low diets for sheep, since we have found no effect on the endogenous nitrogen excretion.

Table 1.

Composition of Rations on Percentage Bases.

	Sheep.	Rats.	Percentage.
White fishmeal	15·0	11·9	—
Wheat straw	50·0	—	—
Dex. starch	31·5	63·1	72·0
Sucrose	—	10·0	10·0
Butter fat	—	8·0	8·0
Codliveroil	0·5	2·0	2·0
Harris Yeast	—	2·0	2·0
Salt mixture*	—	2·0	2·0
Boneash	2·0	—	—
NaCl	1·0	1·0	1·0
Agar	—	—	3·0
Total	100·0	100·0	100·0
Per cent. Nitrogen	2·19	1·50	0·20

* New salt mixture of Hubbel, R., Mendel, J. B. and Wakeman, A. J. (J. Nutr. 14–273–285, 1937).

Discussion of Results.

The metabolism data and the calculation of the biological value, apparent and true digestibilities of the nitrogen of white fishmeal on rats are given in Table 2. The same data pertaining to sheep are given in Table 3. Rats were put for 8 days on a nitrogen low ration, the composition of which is given in Table 1, and then on a collection period of 8 days on the same ration. The endogenous Nitrogen per 100 gm. weight and the metabolic fecal nitrogen per grm. food consumed, determined in this period were utilized in calculating these fractions in the subsequent protein period. After a preliminary period of 11 days on the protein period, collection was carried out over a period of 8 days on the same ration. As will be seen from Table 2 the average apparent and true digestibilities for the 6 rats were 79 and 97 per cent. respectively. The apparent digestibility of vacuum dried white fishmeal on rats as reported by Schneider is 80·7. This value is very nearly the same as ours. Since the apparent digestibility does not take into account the body's contribution of nitrogen in the total fecal excretion of nitrogen, it is *not a real measure* for the true *digestibility of the* fishmeal nitrogen. For this reason the true digestibility has been determined, the value of which is 97 per cent. Actually then the white fishmeal nitrogen is 97 per cent. digested. The average biological value for the 6 rats is 90. This figure is somewhat higher than the vacuum dried white fishmeal of Schneider (1932) on which he found an average value of 84. This difference is very small, if it is taken into account that his meal was fed at 10 per cent. and ours at 9 per cent. level.

Referring to the metabolism data on sheep as reproduced in Table 3, it is evident that the digestibilities as well as the biological value are lower than in rats. It must be noted, however, that the level of protein feeding in the case of sheep is approximately 14 per cent., where it is only 9 per cent. in the case of rats. Whether this difference in level alone is the cause of the lower values is impossible to say. It is quite possible as Timarin suggested, that the difference may be due to a different intensity of enzyme action or to a varying degree of wastage of digestive protein by putrefactive fermentation according to the rates of passage of the food through the alimentary canal of these two species of animals. The alimentary canal of the pig is probably less complicated than the sheep, and resembles more closely that of the rat. Schneider (1932) at a 12 per cent. level of white fishmeal obtained an apparent digestibility of 80 per cent. for pigs in comparison with our value of 63 for sheep. The rat in his experiments and ours showed values of 84 and 79 per cent. digestibility respectively. The true digestibility of the nitrogen contained in white fishmeal in our experiment with sheep is 87 per cent.

As will be seen from Table 3, the average biological value of white fishmeal with sheep is 74. This is lower than the value of 83 reported by Schneider (1932) on pigs. It would appear therefore as if data obtained from rats can be applied to the pig, but the application of such data is doubtful with animals like the sheep, having a more complicated alimentary tract.

TABLE 2.

Biological Value of an 8 per cent. White Fishmeal Ration.
Nitrogen Metabolism Data and the Calculation of the Biological Value.

Animal No.	Initial Weight.	Final Weight.	Average Weight.	Daily Food Intake.	Daily N Intake.	Daily Fecal N.	Body N in Feces.		Food N in Feces.	Absorbed Nitrogen.	Daily Urinary N.	Body N in Urine.		Food N in Urine.	Food N Retained.	Biological Value.	Apparent Digestibility.	True Digestibility.
							Per gm. Food.	Per Day.				Per 100 gm.	Per Day.					
	gm.	gm.	gm.	gm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.	mgm.			
N low ration containing 0·21 per cent. N.																		
1	142	130	136	7·8	—	19·1	2·45	—	—	—	3·5	23·2	—	—	—	—	—	—
2	127	120	124	6·9	—	22·0	3·19	—	—	—	31·4	25·3	—	—	—	—	—	—
3	87	80	84	5·4	—	13·8	2·56	—	—	—	18·7	22·3	—	—	—	—	—	—
4	98	89	94	5·5	—	15·7	2·85	—	—	—	23·4	24·9	—	—	—	—	—	—
5	92	88	90	6·1	—	17·3	2·84	—	—	—	22·5	25·0	—	—	—	—	—	—
6	81	79	80	6·4	—	14·7	2·30	—	—	—	19·6	24·5	—	—	—	—	—	—
White Fishmeal Ration containing 150 per cent N.																		
1	160	184	172	12·3	184·5	37·8	2·45	30·1	7·7	176·8	52·0	23·2	39·9	12·1	164·7	93	80	96
2	137	167	152	12·3	184·5	43·8	3·19	39·2	4·6	179·9	56·4	25·3	38·5	17·9	162·0	90	76	98
3	95	117	106	9·1	136·5	26·4	2·56	23·3	3·0	133·5	36·6	22·3	23·6	13·0	120·5	90	81	98
4	94	123	109	9·3	139·5	29·8	2·85	26·5	3·3	136·2	40·3	24·9	27·1	13·2	123·0	90	79	98
5	80	118	99	10·6	159·0	31·5	2·84	30·1	1·4	157·6	44·3	25·0	24·8	19·5	138·1	88	80	99
6	91	124	108	11·5	172·5	35·4	2·30	26·5	8·9	163·6	45·8	24·5	26·5	19·3	144·3	88	80	95
															AVERAGE.....	90	79	97

The biological value of 74 nevertheless justifies the conclusion that the protein of white fishmeal is well constituted, and utilized exceedingly well by young sheep.

Summary and Conclusions.

By means of nitrogen metabolism experiments with white fishmeal on rats and sheep, it was found, that the apparent and true digestibilities of the white fishmeal protein are respectively 79 and 97 per cent. with rats, and 63 and 87 per cent. with sheep.

The biological value as determined by rats at approximately 9 per cent. protein level is 90 and for sheep at approximately 14 per cent. level 74.

It is concluded that white fishmeal is a good protein feed for growing sheep.

REFERENCES.

BETHKE, R. M. and WILDER, O. H. (1934). Effect of the method of manufacture on the nutritive value of fishmeals as determined by growth studies on chickens. *J. Agric. Res.* (U.S.), Vol. 49, No. 8, pp. 715-722.

CARBONE, E. (1937). La forina di pesce nele alimentazoine del bestiana. *Rio. Zootec.*, Vol. 14, pp. 429-435.

DAVIES, W. L. (1936). The crude protein fraction of fishmeals and other meatmeals. *The Analyst*, Vol. 61, No. 725, pp. 512-575.

DAVIDSON, H. R. (1928). Substitutes for fishmeal in the rations of fattening pigs. *J. Ministry Agric.*, Vol. 53, p. 5.

HALPIN, J. G., HOLMES, C. E., ELVEHYEM, C. and HART, E. B. (1936). Too much fishmeal caused crippled feet in chickens. *Wisc. Agric. Exp. St. Bull.* 430.

MONROE, E. F., KRAUSS, W. E. and HAYDEN, C. (1937). White fishmeal for growth and milk production. *Bi-monthly Bull. Ohio Agric. Exp. St.* No. 22, pp. 46-52.

PLIMMER, H. A. and ROSEDALE, J. L., RAYMOND, W. H., LOWNDES, J. (1934). The relative values of proteins. *Biochem. J.*, Vol. 28, No. 5, pp. 1863-1886.

OSHUMA, K. and ITAYA, S. (1938). The relation of qualities and the manufacturing method of fishmeal and scrap. *J. Agric. Chem. Soc. Japan*, 1938, Vol. 14, pp. 512-517.

SCHNEIDER, B. H. (1932). Nitrogen balance studies with various fishmeals. *J. Agric. Res.* (U.S.), Vol. 44, No. 9, pp. 723-732.

SWAMINATHAN, M. (1938). The relative amounts of the protein and non-protein nitrogenous constituents occurring in foodstuffs and their significance in the alteration of the digestibility coefficient of protein. *Indian J. Med. Res.*, Vol. 25, pp. 847-855.

TIMARIN, S. (1938). Versuche über die Verwertung von Eiweiss durch Wächsende Kinder. *Landwirtsch. Versuch. Stat.*, No. 129, pp. 124-150.

TABLE 3.

Metabolism Data of young Sheep on Fishmeal Ration Containing 2·19 per cent Nitrogen.

Animal No.	Average Weight.	Food Consumption.	Dry Matter Intake.	Nitrogen Intake.	N. in Feces.	Metabolic Fecal N. Daily.	Absorbed N.	N. in Urine.	Endogenous N. Daily.	Food N. Retained.	Biological Value.	N. Balance.	Apparent Digestibility.	True Digestibility.
	Kgm.	Gm.	Grm.	Grm.	Grm.	Grm.	Grm.	Grm.	Grm.	Grm.				
30	24	490	447	10·73	3·66	2·50	9·57	3·56	1·01	7·02	73	3·51	66	89
31	31	490	447	10·73	4·15	2·68	9·26	3·55	1·40	7·11	77	3·03	61	86
32	26	490	447	10·73	4·06	2·59	9·28	4·00	1·35	6·63	71	2·70	62	86
33	31	490	447	10·73	3·95	2·68	9·46	4·15	1·61	6·92	73	3·33	63	88
34	27	490	447	10·73	3·96	2·68	9·45	3·45	1·24	7·24	77	3·32	63	88
											74	—	63	87