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The Biological Values of the Proteins of Oats, Barley, Wheatbran and Pollard.

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THE value of cereals in human and animal nutrition is fully recognized and appreciated. In fact it has become a regular and prominent portion of the daily dietaries of man and an inseparable portion in the balanced rations of stock.

Similarly its by-products have through years of experience attained an increasing popularity in the nutrition of farm animals. Lately the value of wheaten bran as a natural means of stimulating peristalsis in human beings has been recorded. Although these products as a group are not high in protein and therefore generally regarded as energy producing nutrients, they nevertheless contribute a fair quantity of protein to the daily aggregate of protein intake of both man and stock. It is consequently of importance that a detailed knowledge about the constitution and availability of the proteins contained in cereals and their by-products should be available, in order to assess their true nutritional value and to supplement in a practical way the indispensable amino acids which may be deficient. For this reason the above cereals and by-products were investigated by means of the Thomas-Mitchell nitrogen balance method for the estimation of their respective biological values.

In determinations on the biological values of proteins at different levels of protein intake Mitchell (1924) obtained values of 79 and 65 for oats at 5 and 10 per cent. protein levels. Smuts and Malan (1938) determined the biological value for rolled breakfast oats at 8 per cent. level as being 84, which is very near the value of 83 for pre-cooked oatmeal as determined by Murlin and Mattill (1938). In a comparison between barley and oats Osborne and Mendel (1920) could not assign any difference in the nutritive value between the two proteins. Neither oats nor barley can meet the growth requirements according to Steenbock and Gross (1918). Similar are the results of Hughes (1937) namely that barley as the only source of protein in the ration of pigs allows only slow growth, with a high food intake per unit bodyweight increase. For wheatbran and barley Gaucher and Popov (1936) determined the biological values 82 and 62 respectively. The proteins of bran and of the embryo are superior

to that of the endosperm according to Johns and Finks (1920), Osborne and Mendel (1919) and Boas Fixsen and Jackson (1932). A rather low biological value of 57 has been determined by Klein and co-workers (1926) for wheatbran, whilst Wan (1935) determined the much higher value of 72. Excellent growth and reproduction were observed on rats with treated and untreated wheatbran.

Experimental.

In principle the method described by Mitchell (1924) has been adopted. Male rats of 100-150 grams were used. It was found that the larger rats gave less trouble as regards food consumption and thereby the danger of any tissue breakdown that may be caused by insufficient energy intake was greatly minimised. Only one biological value was determined on a series of six rats. The nitrogen low period was conducted either prior to or after the protein periods. Six to seven day periods were allowed on a nitrogen low ration to establish constant nitrogen excretion. For the protein periods at least 10 days were allowed. The collection periods were of seven days' duration. The urine was collected in acid and the daily faeces digested by the Kjeldahl method. To distinguish between faeces of the preliminary periods and collection periods Fe_2O_3 was used as a marker. At the end of the collection period the week's digests of faeces were made up to volume and aliquots distilled for nitrogen determination. The urine collected over the period was made up to a known volume and aliquots digested for nitrogen determination. The rations were made up so as to contain approximately 8 per cent. protein. The composition of the rations are given in Table 1. All the rations were analysed for nitrogen. To prevent deterioration the rations were kept in an ice chest.

Results.

The nitrogen metabolism data as well as the calculations of the biological values are given in Table II. The standardizing periods on the nitrogen low ration preceded the protein periods in the cases of oats and barley and followed the protein periods directly again in the cases of wheatbran and pollard.

As can be seen from these results the biological values for oats, barley, wheatbran and pollard are 83 $\pm$2·04, 77 $\pm$1·98, 74 $\pm$2·82 and 84 $\pm$1·66 respectively. These biological values differ only slightly from the figures expressing the percentage utilizable protein which are 79 $\pm$2·73, 68 $\pm$2·52, 72 $\pm$2·82 and 83 $\pm$1·44 for oats, barley, wheatbran and pollard respectively. These small differences are due to the high digestibilities of the proteins. The digestibilities as determined are 95 $\pm$1·25, 89 $\pm$1·51, 98 $\pm$1·44 and 99 $\pm$0·82 for oats, barley, wheatbran and pollard respectively.

It is obvious from these results that these proteins are fairly well balanced and that they differ only slightly in their nutritive value; barley being the poorest and pollard the best. The explanation for the fact that pollard is better than wheatbran must be sought in the supplementary effect of the endosperm and epidermis of the wheat kernel, as pollard contains a higher percentage endosperm than wheatbran.

Summary.

The biological values and digestibilities of the proteins of whole oats seed, unpearled barley, wheatbran and pollard have been determined and a figure expressing the percentage utilizable protein calculated.

Table 1.

Percentage Compositions of Rations.

Ingredients.	N Low.	Oats Seed.	Barley.	Wheat Bran.	Pollard.
Whole oats seed	—	69·6	—	—	—
Whole barley	—	—	82·5	—	—
Wheat bran	—	—	—	69·6	—
Pollard	—	—	—	—	45·5
Butterfat(1)	8·0	8·0	8·0	8·0	8·0
Cod liver oil	2·0	2·0	2·0	2·0	2·0
Sucrose	10·0	10·0	2·5	10·0	10·0
Harris yeast(2)	2·0	2·0	2·0	2·0	2·0
Salt mixture(3)	2·0	2·0	2·0	2·0	2·0
Whole egg(4)	3·8	—	—	—	—
NaCl	1·0	1·0	1·0	1·0	1·0
Agar	2·0	—	—	—	—
Starch (dextrinized)	69·2	5·4	—	5·4	29·5
Total	100·0	100·0	100·0	100·0	100·0
Percentage N	0·64	1·46	1·59	1·56	1·58

(1) The butter fat has been filtered through a course filter paper to remove casein.

(2) Vitamin B. preparation prepared by " The Harris Laboratories ", Tuckahoe, New York.

(3) A new salt mixture described by Hubbel, R., Mendel, J. B. and Wakeman, A. J. (1937), J. Nutr. Vol. 14, pp. 273–285.

(4) The whole egg has been dried on a waterbath and extracted with ether.

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TABLE 2.

Nitrogen Metabolism Data and the Calculation of the Biological Value.

N-Low Period.

Rat No.	Initial Wgt.	Final Wgt.	Average Wgt.	Daily Food Intake.	Daily N Intake.	Daily Faecal N.	Metabolic N. Per Gram Food.	Metabolic N. Per Day.	Food N in Faeces.	Absorbed N.	Daily Urinary N.	Endogenous N. Per 100 Gram Wgt.	Endogenous N. Per Day.	Food N in Urine.	N Retained.	N Balance.	Apparent Digestibility.	True Digestibility.	Biological Value.	Percentage utilizable Protein.
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
7	120	119	120	10·7	—	39·6	3·70	—	—	—	18·5	15·4	—	—	—	—	—	—	—	—
8	164	157	161	11·0	—	37·0	3·36	—	—	—	24·6	15·3	—	—	—	—	—	—	—	—
9	144	135	140	9·0	—	31·4	3·49	—	—	—	26·4	18·9	—	—	—	—	—	—	—	—
10	132	127	130	10·1	—	33·2	3·29	—	—	—	19·2	14·8	—	—	—	—	—	—	—	—
11	107	107	107	9·1	—	30·2	3·32	—	—	—	16·0	15·0	—	—	—	—	—	—	—	—
12	134	132	133	10·1	—	31·6	3·13	—	—	—	19·3	14·5	—	—	—	—	—	—	—	—
Whole Oats Seed Period (1·46 *per cent. N*).																				
7	139	139	139	10·4	151·8	51·6	3·70	38·5	13·1	138·7	43·2	15·4	21·4	21·8	116·9	+57·0	66	91	84	76
8	177	179	178	11·7	170·8	46·8	3·36	39·3	7·5	163·3	66·4	15·3	27·2	39·2	124·1	+57·6	73	96	76	73
9	160	168	164	11·9	173·7	47·4	3·49	41·5	5·9	167·8	46·4	18·9	31·0	15·4	152·4	+79·9	75	97	91	88
10	147	153	150	10·6	154·8	39·6	3·29	34·9	4·7	150·1	51·6	14·8	22·2	29·4	120·7	+63·6	74	97	80	78
11	130	140	135	12·1	176·7	47·4	3·32	40·2	7·2	169·5	47·2	15·0	20·3	26·9	142·6	+82·1	73	96	84	81
12	152	160	156	12·7	185·4	55·8	3·13	39·8	16·0	169·4	50·4	14·5	22·6	27·8	141·6	+79·2	70	91	84	76
																	72	95	83	79
N-Low Period.																				
7	140	138	139	9·3	—	35·8	3·85	—	—	—	21·6	15·5	—	—	—	—	—	—	—	—
8	137	135	136	8·9	—	33·0	3·71	—	—	—	20·0	14·7	—	—	—	—	—	—	—	—
9	138	140	139	8·7	—	30·2	3·47	—	—	—	19·2	13·8	—	—	—	—	—	—	—	—
10	132	134	133	8·8	—	34·4	3·91	—	—	—	18·4	13·8	—	—	—	—	—	—	—	—
11	142	144	143	9·9	—	38·2	3·86	—	—	—	17·6	12·3	—	—	—	—	—	—	—	—
12	127	132	130	9·6	—	34·1	3·55	—	—	—	19·6	15·1	—	—	—	—	—	—	—	—
Whole Barley Period (1·59 *per cent. N*).																				
7	125	155	140	16·3	259·2	82·4	3·85	62·7	19·7	239·5	73·6	15·5	21·7	51·9	187·6	+103·2	68	92	78	72
8	124	150	137	15·9	252·8	87·2	3·71	59·0	28·2	224·6	81·6	14·7	20·1	61·5	163·1	+ 84·0	68	89	73	65
9	130	158	144	15·4	244·9	79·2	3·47	53·4	25·8	219·1	70·4	13·8	19·9	50·5	168·6	+ 95·3	68	89	77	69
10	120	142	131	13·6	216·2	69·6	3·91	53·2	16·4	199·8	72·0	13·8	18·1	53·9	145·9	+ 64·6	68	92	73	67
11	140	156	148	14·6	232·1	82·4	3·86	56·4	26·0	206·1	53·6	12·3	18·2	35·4	170·7	+ 96·1	64	89	83	74
12	120	136	128	14·2	225·8	88·8	3·55	50·4	38·4	187·4	64·0	15·1	19·3	44·7	142·7	+ 73·0	61	83	76	63
																	66	89	77	68

TABLE 2—(*continued*).

Nitrogen Metabolism Data and the Calculation of the Biological Value.

N-Low Period.

Rat No.	Initial Wgt.	Final Wgt.	Average Wgt.	Daily Food Intake.	Daily N Intake.	Daily Faecal N.	Metabolic N.		Food N in Faeces.	Absorbed N.	Daily Urinary N.	Endogenous N.		Food N in Urine.	N Retained.	N Balance.	Apparent Digestibility.	True Digestibility.	Biological Value.	Percentage utilizable Protein.
							Per Gram Food.	Per Day.				Per 100 Gram Wgt.	Per Day.							
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
13	129	130	130	10·2	—	36·6	3·59	—	—	—	17·2	13·2	—	—	—	—	—	—	—	—
14	126	130	128	8·4	—	28·8	3·43	—	—	—	19·6	15·3	—	—	—	—	—	—	—	—
15	143	144	144	12·2	—	36·0	2·95	—	—	—	28·8	20·0	—	—	—	—	—	—	—	—
16	141	139	140	8·4	—	31·8	3·79	—	—	—	26·4	18·9	—	—	—	—	—	—	—	—
17	130	129	130	7·5	—	27·2	3·63	—	—	—	18·4	14·2	—	—	—	—	—	—	—	—
18	125	125	125	10·3	—	37·8	3·67	—	—	—	14·8	11·8	—	—	—	—	—	—	—	—

Wheatbran Period (1·56 *per cent. N*).

1	122	140	131	13·8	215·3	49·6	3·59	49·5	0·1	215·2	70·4	13·2	17·3	53·1	162·1	+ 95·3	77	100	75	75
14	118	136	127	12·7	198·1	46·4	3·43	43·6	2·8	195·3	82·4	15·3	19·4	63·0	132·3	+ 69·3	77	99	68	67
15	125	145	135	13·9	216·8	60·0	2·95	41·0	19·0	197·8	74·4	20·0	27·0	47·4	150·4	+ 82·4	72	91	76	69
16	127	155	141	16·0	249·6	68·0	3·79	60·6	7·4	242·2	70·4	18·9	26·6	43·8	198·4	+ 111·2	73	97	82	80
17	116	130	123	11·7	182·5	44·8	3·63	42·5	2·3	180·2	72·8	14·2	17·5	55·3	142·9	+ 64·9	75	99	69	68
18	110	122	116	10·5	163·8	38·4	3·67	38·5	−0·1	163·8	58·4	11·8	13·7	44·7	119·1	+ 67·0	77	100	73	73
																	75	98	74	72

N-Low Period.

19	118	116	117	9·3	—	39·3	4·23	—	—	—	17·6	150·	—	—	—	—	—	—	—	—
20	113	115	114	9·7	—	29·0	2·99	—	—	—	23·6	20·7	—	—	—	—	—	—	—	—
21	114	110	112	7·7	—	26·6	3·45	—	—	—	19·2	17·1	—	—	—	—	—	—	—	—
22	135	139	137	10·0	—	36·4	3·64	—	—	—	12·4	9·1	—	—	—	—	—	—	—	—
23	129	129	129	9·3	—	37·2	4·00	—	—	—	21·6	16·7	—	—	—	—	—	—	—	—
24	145	149	147	10·8	—	41·8	3·87	—	—	—	22·4	15·2	—	—	—	—	—	—	—	—

Pollard Period (1·58 *per cent. N*).

19	121	121	121	13·2	208·6	55·2	4·23	55·8	−0·6	208·6	51·2	15·0	18·2	33·0	175·6	− 102·2	74	100	84	84
20	109	119	114	9·8	154·8	37·6	2·99	29·3	8·3	145·6	40·8	20·7	23·6	17·2	129·3	+ 76·4	76	95	88	84
21	105	121	113	11·4	180·1	41·6	3·45	39·3	2·3	177·8	55·2	17·1	19·3	35·9	141·9	− 83·3	77	99	80	79
22	123	144	134	13·0	205·4	48·0	3·64	47·3	0·7	204·6	38·2	9·1	12·2	26·0	178·6	+119·2	77	100	87	87
23	129	143	136	12·2	192·8	46·4	4·00	48·8	−2·4	192·8	60·8	16·7	22·7	38·1	154·7	+ 85·6	76	100	80	80
24	135	160	148	15·3	241·7	57·6	3·87	59·2	− 1·6	241·8	62·4	15·2	22·5	39·9	201·9	+121·7	76	100	83	83
																	76	99	84	83