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The Nutritive Value of the Protein of a few South African Soybean Meals.

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Introduction.

Extracted Soybean Meals have been used extensively in most countries, especially during periods of animal and human food shortage. In the Far East the soybean has been a popular food for centuries, and lately it has been found to be a useful diet for diabetics.

Analysis of eleven varieties of soybeans by Hamilton (1940) indicated that the protein content varied from 35·88 to 43·69 per cent. For some South African types, Viljoen (1937) reported the protein content to vary from 37·5 to 42·0 per cent. The protein content varied according to soil and climatic conditions. Soybeans have not as yet been popular in South Africa, and have only recently received some attention as a source of protein.

In experiments, where raw soybeans were used as a source of protein alone, poor growth results were obtained, especially when compared to the peanut (Schmidt, 1934). Similarly, Basu (1937) obtained poor growth with rats when fed soybeans and reproduction was adversely affected, when soybeans were used for any long period as feed.

However, when the raw product (after the oil extraction) was heated, surprisingly better results were obtained. It was not only more palatable, but also proved to be more digestible, had a higher protein efficiency and was therefore more economical (Freeman, 1941).

Injury to the protein complex on application of heat was reported by Boas-Fixsen (1935) and Seegers *et al.* (1935). Also Hayward *et al.* (1936) showed that casein, meat, liver, cereals, fish, etc., when exposed to high temperatures were inferior to the raw products.

Soybean Meal protein, however, whether cooked for 90 minutes at 105° -121° C. or heated for short periods at 140°-150° C., proved to be superior to the raw product as indicated by Johnson *et al.* (1939). Soybean protein was found to be deficient in the amino-acid cystine by Shrewsbury *et al.* (1933) in their paired-feeding experiments at 10 per cent. and 15 per cent. protein levels, and also by Mitchell and Smuts (1932) in paired-feeding experiments with rats.

Good supplementation between the proteins of soybean meal and maize, and soybean meal and Timothy hay, in low protein basal rations, was reported by Miller *et al.* (1937).

The average biological value of raw soybean was given as 55 at 8 per cent. protein level with rats, by Smuts and Marais (1938). Basu *et al.* (1937) reported a value of 58 at 10 per cent. protein level while Olsen *et al.* (1940) reported a value of 61 for the extracted meal and 68 for the heated soybean meal. The digestibilities were, however, the same. Chang *et al.* (1941) reported a value of 64 for soybean meal. Feeding lambs on soybean meal at 10 per cent. protein level, Turk *et al.* (1935) obtained an average value of 72·8.

According to Csonka *et al.* (1935) and Hayward *et al.* (1936) these differences in biological values of the proteins of soybeans are due to differences in the varieties.

Since there appears to be a wide variation in the protein content of soybeans, it becomes desirable to discriminate between the different varieties and to take into account the possible differences in the nutritive value of their proteins before making up a ration. Hayward *et al.* (1936) considered the improvement brought about by heat application to be due to a change in the cystine complex; the improvement was comparable to the beneficial effect when raw soybean meal was supplemented with cystine.

Csonka *et al.* (1934) found wide variations for cystine in soybean varieties. Similarly Hamilton (1940) found the cystine content of eleven varieties to differ from ·213 to ·553 per cent.

Experimental.

Three samples of soybean meals (after oil extraction) were obtained from two different sources for biological tests.

1. A raw soybean meal.

2. Its heat-processed meal called " Soma meal " (both 1 and 2 from the Delmas Mills).

3. A soybean meal, " specially processed " (not baked) from the Premier Milling Co., Johannesburg.

One set of biological values for protein was obtained for each meal by using six bucks (rats of the Wistar Strain) in each test. In these tests the protein periods (at 8 per cent. level) were carried out first, to be followed immediately afterwards by the N-low periods.

The percentage composition of the rations are given in Table 1.

The preparatory periods in the protein tests were of ten days duration followed by a seven day collection period of faeces and urine. The preparatory period in the N-low tests were of seven days duration followed by a seven day collection period of faeces and urine.

The method described by Mitchell (1924) has been followed.

The metabolism data are given in Table 2.

TABLE 1.

The Percentage Composition of the Rations.

Ingredients.	N. Low.	Raw Soybean Meal A.	Raw Soybean Meal B.	Processed Soybean Meal ("Somameal").	Remarks.
Raw soybean meal (*ex* Delmas).	—	22·9	—	—	1. Whole egg was dried on waterbath and ether extracted.
Raw soybean meal (*ex* Johannesburg)	—	—	20·8	—	
"Somameal"	—	—	—	21·2	2. Butterfat was prepared from butter by filtering off the heat-precipitated casein.
Whole egg	3·8	—	—	—	
Sucrose	10·0	10·0	10·0	10·0	
Butterfat	8·0	8·0	8·0	8·0	
Harris yeast	2·0	2·0	2·0	2·0	3. Harris yeast was the concentrate prepared by the Harris Laboratory, Tuckahoe, New York.
Cod liver oil	2·0	2·0	2·0	2·0	
Salt mixture	2·0	2·0	2·0	2·0	
Dextrinized starch	69·2	52·1	54·2	53·8	
NaCl	1·0	1·0	1·0	1·0	4. The salt mixture was that of Hubbel *et al* (1937). J. *Nutrition*, Vol. 14, p. 273.
Agar	2·0	—	—	—	
Total	100·0	100·0	100·0	100·0	
Percentage N	0·59	1·43	1·43	1·44	5. Cod liver oil was the "Medicinal" brand.

TABLE 2 (*a*).

Nitrogen Metabolism Data—Calculation of the Biological Value.

Rat No.	Initial Weight.	Final Weight.	Average Weight.	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.	Retained N.	N Balance.	Apparent Digestibility.	True Digestibility.	Biological Value.	Percentage Nett N — Utilization.
							Per Gram, Food.	Per Day.				Per 100 Gram Weight.	Per Day.							
RAW SOYBEAN MEAL RATION (N = 1·43 PER CENT.).																				
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
1	110	111	111	6·5	93	28·9	1·82	11·8	17·1	75·9	53·8	13·95	15·5	38·3	37·6	+10·3	69	82	49·6	40·7
2	116	122	119	8·0	114·5	34·8	1·76	14·1	20·7	93·8	60·6	13·26	15·8	44·8	49·0	+19·1	70	82	52·2	42·8
3	122	127	125	7·5	107·2	34·4	1·57	11·8	22·6	84·6	60·8	13·95	17·45	43·35	41·3	+12·0	68	79	48·8	38·6
4	144	143	144	8·0	114·5	41·9	1·94	15·5	26·4	88·1	70·0	15·2	22·2	47·8	40·3	+ 2·6	63	77	45·8	35·3
5	132	134	133	7·5	107·2	40·4	1·94	14·55	25·85	81·3	60·1	12·6	16·76	41·3	40·0	+ 6·7	62	76	49·3	37·5
6	117	118	118	6·5	93	30·0	2·10	13·65	16·35	76·6	52·0	13·0	15·35	36·63	40·0	+11·0	68	82	52·2	42·8
															AVERAGE.....		67	80	49·6	39·7
N - Low Period.																				
1	119	125	122	8·0	—	14·55	1·82	—	—	—	17·0	13·95	—	—	—	—	—	—	—	—
2	126	132	129	8·5	—	14·96	1·76	—	—	—	17·1	13·26	—	—	—	—	—	—	—	—
3	131	142	137	9·0	—	14·10	1·57	—	—	—	19·1	13·95	—	—	—	—	—	—	—	—
4	149	154	152	10·0	—	19·4	1·94	—	—	—	23·1	15·2	—	—	—	—	—	—	—	—
5	139	150	145	9·5	—	18·4	1·94	—	—	—	18·3	12·6	—	—	—	—	—	—	—	—
6	123	130	127	8·5	—	17·8	2·10	—	—	—	16·5	13·0	—	—	—	—	—	—	—	—

TABLE 2 (*b*).

Nitrogen Metabolism Data—Calculation of the Biological Value.

Rat No.	Initial Weight.	Final Weight.	Average Weight.	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.	Retained N.	N Balance.	Apparent Digestibility.	True Digestibility.	Biological Value.	Percentage Nett N — Utilization.
							Per Gram, Food.	Per Day.				Per 100 Gram Weight.	Per Day.							
PROCESSED SOYBEAN MEAL RATION (N = 1·43 PER CENT.).																				
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
7	112	121	117	10·1	144	58·7	2·15	21·7	37·0	107·0	56·5	12·4	14·5	42·0	65·9	+28·8	59	74	60·8	45·0
8	130	140	135	10·6	151	70·6	2·11	22·4	48·2	102·8	60·8	12·1	16·4	44·2	58·6	+19·8	53	68	57·0	38·7
9	109	116	113	9·5	135·5	48·4	1·86	17·7	30·7	104·8	67·6	13·6	15·4	52·2	52·6	+19·5	64	77	50·2	38·6
10	107	111	109	9·0	128·5	45·2	2·03	18·3	26·9	101·6	62·8	14·1	15·4	47·4	54·2	+20·5	65	79	53·4	42·2
11	98	107	103	8·6	122·6	41·2	1·91	16·4	24·8	97·8	63·0	13·3	13·7	49·3	48·5	+18·4	66	80	49·6	39·7
12	126	130	128	10·3	147	52·2	2·07	21·3	30·9	116·1	68·3	16·7	21·4	46·9	69·2	+26·5	64	79	59·6	47·0
														AVERAGE.....			62	76	55·1	41·9
N-Low Period.																				
7	126	128	127	9·0	—	19·4	2·15	—	—	—	15·8	12·4	—	—	—	—	—	—	—	—
8	139	143	141	8·3	—	17·5	2·11	—	—	—	17·0	12·1	—	—	—	—	—	—	—	—
9	119	125	122	9·0	—	16·7	1·86	—	—	—	16·6	13·6	—	—	—	—	—	—	—	—
10	109	114	112	7·9	—	16·0	2·03	—	—	—	15·8	14·1	—	—	—	—	—	—	—	—
11	111	117	114	8·5	—	16·2	1·91	—	—	—	15·2	13·3	—	—	—	—	—	—	—	—
12	136	140	138	9·5	—	19·6	2·07	—	—	—	23·0	16·7	—	—	—	—	—	—	—	—

TABLE 2 (*c*).

Nitrogen Metabolism Data—Calculation of the Biological Value.

Rat No.	Initial Weight.	Final Weight.	Average Weight.	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 Weight.	Endogenous N: Per Day.	Food N in Urine.	Retained N.	N Balance.	Apparent Digestibility.	True Digestibility.	Biological Value.	Percentage Nett N — Utilization.
SOMAMEAL (HEAT—PROCESSED SOYBEAN MEAL) (N = 1·44 PER CENT.).																				
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
13	168	184	176	12·2	176	49·0	2·29	27·9	21·1	154·9	72·8	12·9	22·7	50·1	104·8	+54·2	72	88	67·8	59·6
14	146	165	156	12·8	184·6	51·4	2·00	25·6	25·8	158·8	80·5	13·4	20·9	59·6	99·2	+52·7	72	86	62·6	53·8
15	151	168	160	11·6	167·5	49·3	2·31	26·8	22·5	145·0	78·8	13·4	21·4	57·4	87·6	+39·4	71	87	60·4	52·6
16	152	162	157	11·6	167·5	48·2	2·17	25·2	23·0	144·5	82·4	15·0	23·5	58·9	85·6	+36·9	71	86	59·2	50·9
17	145	159	152	12·8	184·6	56·4	2·21	28·3	28·1	156·5	78·0	16·5	25·1	52·9	103·6	+50·2	70	85	66·3	56·4
18	149	165	157	12·8	184·6	53·8	2·06	26·4	27·4	157·2	81·8	14·9	23·4	58·4	98·8	+49·0	71	85	63·5	54·0
																AVERAGE.....	·71	86	63·3	54·5
N-Low Period.																				
13	178	183	181	11·4	—	26·1	2·29	—	—	—	23·4	12·9	—	—	—	—	—	—	—	—
14	158	168	163	11·0	—	22·0	2·00	—	—	—	21·9	13·4	—	—	—	—	—	—	—	—
15	169	178	174	11·4	—	25·5	2·31	—	—	—	23·3	13·4	—	—	—	—	—	—	—	—
16	154	158	156	9·3	—	20·2	2·17	—	—	—	23·4	15·0	—	—	—	—	—	—	—	—
17	154	162	158	11·0	—	24·3	2·20	—	—	—	26·1	16·5	—	—	—	—	—	—	—	—
18	162	170	166	11·0	—	22·7	2·06	—	—	—	24·7	14·9	—	—	—	—	—	—	—	—

Results and Summary.

From the metabolism data in the tables, the following are the main points of interest:—

1. *Raw Product and its Heated Product or "Soma meal"* (ex Delmas).

The mean biological value of the Raw meal was: $49 \cdot 6 \pm 3 \cdot 092$ which is considerably lower than the mean biological value of $63 \cdot 3 \pm 1 \cdot 354$ of the Heated Soybean Meal. The heat application had also improved the digestibility from 67 per cent. to 71 per cent. In calculating the Nett Percentage Nitrogen Utilization, the heated product was 54·5 as compared to only 39·7 of the raw product.

2. *"Processed" (not baked) Soybean Meal.*

This meal had a mean biological value of $55 \cdot 1 \pm 1 \cdot 945$, which is higher than that of the Delmas Mills. The digestibility, however, is lower, namely, 62 per cent.

Comparing the Nett Percentage Nitrogen Utilization the difference is slight, namely, 41·9 per cent. in the case of the processed meal and 39·7 per cent. in the case of the Delmas Raw Meal.

The superiority of the proteins of the "Soma meal" (one heated South African variety of Soybean) confirms the findings of previous workers, namely, Hayward *et al.* (1936) and Johnson *et al.* (1939), indicating that in practice it would be the best policy to use the heated meals, not only because of a better palatability but also because of its higher protein efficiency.

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