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The Nutritive Value of Mixed Proteins. The Biological Value of the Proteins of a Mixture of Yellow Maize Seed and Grape Seeds, and a Mixture of Yellow Maize Seed and Camelthorn Pods *(Acacia giraffae)*.

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Introduction.

The demand for animal feeds has increased so rapidly during the past few years, due mainly to greater improved markets for agricultural products, that an acute shortage of most feeding stuffs has arisen. In an attempt to meet this shortage uncommon feeds of doubtful value, which, during years of plenty are often wasted, have played an increasingly important part in the daily menu of farm stock. The use of these feeds has apparently come to stay and more information on their feeding value, availability and so forth, is strongly indicated.

The experiments undertaken are intended to collect data on some less generally accepted animal feeds such as acorns, fruit waste, grape seeds, camelthorn pods (*Acacia giraffae*) and the like, as well as on their supplementary value in rations. The present article deals with camelthorn pods and grape seeds.

Experimental.

Using rats of the Wistar Strain reared at this Institute, metabolism data were obtained for rations fed at about 8 per cent. level of protein. One set of data, with six rats, was collected for each ration, except where otherwise mentioned.

The method was that of Mitchell (1924), as outlined and described in detail by Marais and Smuts (1940).

The following were the rations (see Table 2) for which biological values were calculated:—

1. Yellow Maize Seed only as a source of protein.
2. Yellow Maize Seed plus Camelthorn pods in the ratio of 1:1. The fibre content was about 10 per cent.

For confirmatory purposes, another set of biological values was calculated from data obtained in a second metabolism test using the same ration.

3. Yellow Maize Seed plus Camelthorn pods in the ratio of 3 parts of the former to 1 part of the latter, in order to reduce the fibre content of the ration.
4. Yellow Maize Seed plus Grape Seeds in the same ratio as (3) to have a low fibre content, and to compare the results obtained with that ration.

The metabolism data are given in the tables and a summary of the main points of interest are to be found in Table 7.

Results.

The average biological values of the mixed proteins of yellow maize seed and camelthorn pods show that the protein of the camelthorn pod did not improve the nutritive value of the yellow maize protein in the case where the proportions of each were equalized in the ration. The average biological value dropped from 58·6 per cent. for the maize to 47·6 per cent. and 50·3 per cent. for the mixture in the two sets of tests.

Furthermore, the true digestibility of the maize protein was markedly decreased from 99 per cent. for the maize protein to 42·4 per cent. due to the high fibre content of the mixture, namely 10 per cent.

When the yellow maize seed was increased in the mixture so as to give a proportion of 3 parts of maize to 1 part of the pods, the average biological value was slightly higher than that of the maize protein, namely 62·4 per cent. as compared with 58·6 per cent. However, when comparing the true digestibility we find an average value of only 65·7 per cent. as compared with nearly 100 for the maize.

When comparing the nutritive value of the maize protein with that of the mixture (ratio 3 to 1), with the biological values as indices, the conclusion to be drawn, is that a slight improvement had resulted, apart from any other consideration. In reality, the addition of the pods had resulted in poorer digestible feed and as a result a lowered nett utilization of the nitrogen, namely only 41 per cent. in the case of the mixture compared with 58·3 per cent. in the case of maize. This fact again indicates that the " nett utilization " of the nitrogen is a safer value to use in judging the nutritive value of feeds, where the digestibility is affected by the inclusion of roughages in rations. This " nett utilization " in the case of maize means that for every 100 grams of the maize protein (or nitrogen), 99 grams are actually digested, and of this quantity 58·6 grams are utilized—a nett utilization of 58·3 grams.

For the mixture (ratio 3 to 1) only 65·7 grams were actually digested, and of this quantity only 41 grams nett were eventually utilized.

From the above, the conclusion arrived at is that the pods did not improve or supplement the maize. However, it is to be seen whether the pods have any beneficial effect when fed to ruminants. A further set of tests are to be carried out with sheep as experimental animals and the results will be given at a later stage.

Comparing the mixture of maize seeds and grape seeds with that of maize seed alone, we again find a higher biological value, namely 64·4 for the mixture as compared with 58·6 for the maize. The true digestibilities, however, are 80 per cent. for the former and 99 per cent. for the latter, yielding a nett utilization of 51·5 per cent. for the mixture and 58·3 per

cent. for the maize. We conclude that the mixture of maize and grape seeds was inferior to maize alone; the grape seed protein was, however, superior to the camelthorn pod protein, when fed in the ratio of 3 parts maize to 1 part of these proteins, as can be deduced from their nett utilization.

These substitutes when fed to rats, under these conditions, did not improve the maize protein or supplement it, because of their poor digestibilities.

Summary and Conclusions.

1. Feeding camelthorn pods (13 per cent. crude protein) with maize to rats does not improve the nutritive value of the maize proteins. When the camelthorn pods are mixed with maize seed in the proportion 1 to 3, the biological value is slightly higher than that of the maize alone, but due to a lower true digestibility, the nett percentage utilization of the nitrogen in the mixture was decidedly lower.

2. Again, a mixture of grape seeds and maize seeds in the proportion of 1 to 3, yielded a higher biological value than the maize alone, but here also a lower true digestibility of the mixture resulted in a lower nett utilization of the nitrogen.

3. In these cases the biological value as an index of the nutritive value of the proteins, without considering the digestibilities, gives a somewhat misleading result. The nett utilization, calculated from both the biological value and the true digestibility yield a more accurate result and gives a better reflection of the nutritive value of the proteins.

4. The mixture of grape seeds and maize seeds proved to be superior to the mixture of camelthorn pods and maize seeds.

LITERATURE.

MARAIS, J. S. C., and SMUTS, D. B. (1940). "The Amino Acid Deficiencies of certain Plant Proteins and the Supplementary Effect between Plant Proteins as measured by means of their Biological Values", *Onderstepoort J.*, Vol. 15, Nos. 1 and 2, p. 225.

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Table 1.

Percentage Composition of Feeds.

Calculated on dry basis:

Feed.	Moisture.	Crude Protein.	Crude Fibre.	Ash.	Ether Sol. Ext.	N-free Extr.
Yellow maize seed.....	10·00	9·00	2·10	1·70	4·10	73·10
Camelthorn pods.....	7·45	12·97	28·00	4·78	1·81	44·99
Grape seeds.....	6·99	9·24	36·80	4·16	11·90	30·91

TABLE 2.

Percentage Composition of the Rations.

Ingredients.	N-Low Ration. (*a*).	N-Low Ration. (*b*).	Yellow Maize Seed Ration.	Yellow Maize Seed plus Camelthorn Pods (1 : 1).	Yellow Maize Seed plus Camelthorn Pods (3 : 1).	Yellow Maize Seed plus Grape Seeds (3 : 1).	Remarks.
Yellow maize seed.....	—	—	77·8	35·0	52·5	60·0	All seeds and pods finely ground.
Camelthorn pods.....	—	—	—	35·0	17·5	—	
Grape seeds.....	—	—	—	—	—	20·0	Whole egg, steam dried and ether extracted.
Whole egg.....	3·8	3·8	—	—	—	—	Butterfat prepared by filtering off the heat-coagulated casein.
Sucrose.....	10·0	10·0	7·2	10·0	10·0	5·0	
Butterfat.....	8·0	8·0	8·0	8·0	8·0	8·0	
Harris Vit. B.....	2·0	2·0	20·	2·0	2·0	2·0	
Cod liver oil.....	2·0	2·0	2·0	2·0	2·0	2·0	Hubbel-Salt Mixture. (1937), J. Nutrition, Vol. 14, p. 273.
Salt mixture.....	2·0	2·0	2·0	2·0	2·0	2·0	
Dextrinized starch.....	69·2	62·2	—	5·0	5·0	—	Harris vitamin B. concentrate.
NaCl.....	1·0	1·0	1·0	1·0	1·0	1·0	
Agar.....	2·0	9·0	—	—	—	—	
TOTAL.....	100·0	100·0	100·0	100·0	100·0	100·0	
Percentage N.....	0·59	0·59	1·27	1·41	1·375	1·38	

TABLE 3.

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.	Nett-N Utilization.
							Per Gm. Food.	Per Day.				Per 100 Gm. Weight.	Per Day.							
Yellow Maize Seed Ration (N = 1·288 per cent.).																				
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
36	91	100	96	10·9	140·4	26·1	2·35	25·7	+0·4	140·0	71·0	18·3	17·6	53·4	86·6	+43·3	81	97	61·9	60·0
37	95	103	99	10·9	140·4	26·3	2·57	28·0	−1·7	140·4	72·6	17·7	17·5	55·1	85·3	+41·5	81	100	60·8	60·8
38	93	103	98	9·3	119·6	20·6	2·62	24·3	−3·7	119·6	70·4	18·0	16·8	53·6	66·0	+28·6	83	100	55·2	55·2
39	100	106	103	9·7	124·9	22·2	2·52	24·4	−2·2	124·9	68·7	17·3	17·8	50·9	74·0	+34·0	82	100	59·2	59·2
40	87	97	92	10·0	128·8	21·4	2·53	25·3	−3·9	128·8	72·0	18·3	16·9	55·1	73·7	+35·4	83	100	57·0	57·0
41	86	91	89	9·8	126·2	23·5	2·74	26·8	−3·3	126·2	68·9	16·7	14·9	54·0	72·2	+33·8	81	100	57·2	57·2
															Average...		82	99	58·6	58·3
N-low Ration (a).																				
36	101	107	104	9·9	—	23·3	2·35	—	—	—	19·0	18·3	—	—	—	—	—	—	—	—
37	105	112	109	9·8	—	25·2	2·57	—	—	—	19·2	17·7	—	—	—	—	—	—	—	—
38	106	110	108	7·4	—	19·4	2·62	—	—	—	19·4	18·0	—	—	—	—	—	—	—	—
39	106	110	108	7·7	—	19·4	2·52	—	—	—	19·4	17·3	—	—	—	—	—	—	—	—
40	95	100	98	7·5	—	19·0	2·53	—	—	—	17·9	18·3	—	—	—	—	—	—	—	—
41	93	96	95	7·3	—	20·0	2·74	—	—	—	15·9	16·7	—	—	—	—	—	—	—	—

TABLE 4 (*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.	Nett-N Utilization.
							Per Gm. Food.	Per Day.				Per 100 Gm. Weight.	Per Day.							
Yellow Maize Seed Plus Camelthorn Pods (1 : 1) *Ration* ($N = 1{\cdot}407$ *per cent.*).																				
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
54	83	87	85	9·4	132·2	99·8	2·53	23·8	76·0	56·2	44·8	20·0	17·0	27·8	28·4	−12·4	25	42·5	50·6	21·5
55	84	86	85	9·0	126·6	94·0	2·44	22·0	72·0	54·6	46·6	17·3	14·7	31·9	22·7	−14·0	26	43·1	41·6	17·9
56	91	92	92	8·5	133·7	98·0	2·59	24·6	73·4	60·3	50·8	18·0	16·6	34·2	26·1	−15·1	27	45·1	43·3	19·5
57	77	79	78	8·8	123·8	98·4	2·51	22·1	76·3	47·5	36·0	18·2	14·2	21·8	25·7	−10·6	21	38·3	54·2	20·8
58	85	86	86	8·6	121·0	87·2	2·52	21·7	65·5	55·5	47·4	18·0	15·5	31·9	23·6	−13·6	28	45·9	42·6	19·6
59	78	82	80	8·8	123·8	95·3	2·30	20·3	75·0	48·8	39·2	20·6	16·5	22·7	26·1	−10·7	23	39·4	53·5	21·1
															Average...		25	42·4	47·6	20·1
N-low Ration (*b*).																				
54	95	109	102	10·7	—	27·1	2·53	—	—	—	20·4	20·0	—	—	—	—	—	—	—	—
55	94	111	103	10·7	—	26·1	2·44	—	—	—	17·8	17·3	—	—	—	—	—	—	—	—
56	104	117	111	10·7	—	27·7	2·59	—	—	—	20·0	18·0	—	—	—	—	—	—	—	—
57	88	105	97	10·0	—	25·1	2·51	—	—	—	17·7	18·2	—	—	—	—	—	—	—	—
58	94	112	103	10·7	—	27·0	2·52	—	—	—	18·6	18·0	—	—	—	—	—	—	—	—
59	92	112	102	10·7	—	24·5	2·30	—	—	—	21·0	20·6	—	—	—	—	—	—	—	—

TABLE 4 (*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.	Nett-N Utilization.
							Per Gm. Food.	Per Day.				Per 100 Gm. Weight.	Per Day.							
Yellow Maize Seed Plus Camelthorn Pods (1:1) *Ration* (*N* = 1·45 *per cent.*).																				
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
60	141	141	141	9·2	133·4	92·0	2·50	23·0	69·00	64·40	48·8	13·65	19·25	29·55	34·85	— 7·4	31·0	48·0	54·1	26·0
61	142	141	142	9·0	130·5	97·6	2·13	19·17	78·43	52·10	50·1	17·30	24·50	25·60	26·47	—17·2	25·2	40·0	50·8	20·3
62	136	138	137	9·5	137·7	99·1	2·37	22·5	76·60	61·10	46·6	13·10	17·95	28·65	32·45	— 8·0	28·0	44·3	53·1	23·5
63	137	141	139	9·0	130·5	97·2	2·28	20·52	76·68	53·84	49·3	16·15	22·50	26·80	27·02	—16·0	25·6	41·3	50·2	20·7
64	149	146	148	9·0	130·5	97·6	2·07	18·63	78·97	51·53	47·5	13·10	19·40	28·10	23·43	—14·6	25·2	39·5	45·5	18·0
65	130	133	132	9·5	137·7	106·5	2·65	25·2	81·30	56·40	46·0	12·65	16·70	29·30	27·10	—14·8	22·6	40·0	48·2	19·2
																Average...	26·3	42·2	50·3	21·3
N-low Ration (*b*).																				
60	143	150	147	9·5	—	23·70	2·50	—	—	—	19·9	13·65	—	—	—	—	—	—	—	—
61	145	150	148	10·0	—	21·30	2·13	—	—	—	25·6	17·30	—	—	—	—	—	—	—	—
62	144	147	146	10·0	—	23·75	2·37	—	—	—	19·1	13·10	—	—	—	—	—	—	—	—
63	142	143	143	9·0	—	20·50	2·28	—	—	—	23·1	16·15	—	—	—	—	—	—	—	—
64	148	156	152	10·0	—	20·70	2·07	—	—	—	19·9	13·10	—	—	—	—	—	—	—	—
65	134	141	138	9·5	—	25·20	2·65	—	—	—	17·45	12·65	—	—	—	—	—	—	—	—

TABLE 5.

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.	Nett-N Utilization.
							Per Gm. Food.	Per Day.				Per 100 Gm. Weight.	Per Day.							
Yellow Maize Seed Plus Camelthorn Pods (3 : 1) *Ration* (*N* = 1·375 *per cent.*).																				
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
72	172	183	178	12·0	165·0	81·1	2·61	31·4	49·7	115·3	70·0	14·4	25·6	44·4	70·9	+13·9	50·8	70·0	61·5	43·0
73	138	143	141	10·0	137·5	77·2	2·64	26·4	50·8	86·7	52·9	16·7	23·5	29·4	57·3	+ 7·4	43·9	63·1	66·0	41·7
74	177	177	177	12·0	165·0	86·9	2·46	29·5	57·4	107·6	65·0	13·7	24·2	40·8	66·8	+13·1	47·4	65·2	62·1	40·4
75	169	172	171	12·5	171·9	93·5	2·50	31·3	62·2	109·7	65·9	18·0	30·8	35·1	74·6	+12·5	45·6	63·9	68·0	43·4
76	186	187	187	12·5	171·9	90·3	2·78	34·7	55·6	116·3	73·2	13·5	25·3	47·9	68·4	+ 8·4	47·5	67·7	59·0	40·0
77	173	174	174	10·0	137·5	72·0	2·32	23·2	48·8	88·7	60·2	13·2	23·0	37·2	51·5	+ 5·3	47·6	64·5	58·0	37·6
															Average...		47·1	65·7	62·4	41·0
N-low Ration (*b*).																				
72	185	186	186	11·5	—	30·0	2·61	—	—	—	26·8	14·4	—	—	—	—	—	—	—	—
73	142	146	144	10·0	—	26·4	2·64	—	—	—	24·0	16·7	—	—	—	—	—	—	—	—
74	180	183	182	12·0	—	29·5	2·45	—	—	—	25·0	13·7	—	—	—	—	—	—	—	—
75	175	179	177	12·0	—	30·0	2·50	—	—	—	31·9	18·0	—	—	—	—	—	—	—	—
76	198	206	202	13·5	—	37·6	2·78	—	—	—	27·2	13·5	—	—	—	—	—	—	—	—
77	180	183	182	12·0	—	27·8	2·32	—	—	—	24·0	13·2	—	—	—	—	—	—	—	—

TABLE 6.

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 Gm. Food.	Metabolic-N. Per Day.	Food-N in Faeces.	Absorbed N.	Daily Urinary N.	Endogenous-N. Per 100 Gm. Weight.	Endogenous-N. Per Day.	Food-N in Urine.	Retained N.	N-Balance.	Apparent Digestibility.	True Digestibility.	Biological Value.	Nett-N Utilization.
Yellow Maize Seed Plus Grape Seeds (3:1) *Ration* ($N = 1{\cdot}38$ *per cent.*).																				
	Gm.	Gm.	Gm.	Gm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.	Mgm.				
66	153	160	157	12·0	154	64·1	2·07	24·84	39·3	114·7	64·8	13·3	20·9	43·9	70·8	+25·1	58	75	61·7	46·3
67	134	142	139	12·0	154	59·6	2·50	30·00	29·6	124·4	62·4	13·9	19·3	43·1	81·3	+32·0	61	81	65·4	53·0
68	152	150	146	13·0	179	63·4	2·61	34·00	29·4	149·6	72·6	18·0	26·3	46·3	103·3	+43·0	65	84	69·1	58·0
69	137	142	140	12·0	154	59·6	2·32	27·84	31·8	122·2	69·8	17·6	24·6	45·2	77·0	+24·6	61	79	63·0	49·7
70	142	150	146	13·0	179	63·6	2·66	34·60	29·0	150·0	71·4	15·5	22·6	48·8	101·2	+44·0	65	84	67·6	56·8
71	135	144	140	12·0	154	64·3	2·29	27·48	36·8	117·2	70·2	16·1	22·5	47·7	69·5	+19·5	58	76	59·4	45·1
															Average...		61	80	64·4	51·5
N-low Ration (*b*).																				
66	176	190	183	15·0	—	31·1	2·07	—	—	—	24·4	13·3	—	—	—	—	—	—	—	—
67	152	151	152	10·2	—	25·5	2·50	—	—	—	21·2	13·9	—	—	—	—	—	—	—	—
68	162	160	161	10·9	—	28·4	2·61	—	—	—	29·0	18·0	—	—	—	—	—	—	—	—
69	159	173	166	15·0	—	34·8	2·32	—	—	—	29·2	17·6	—	—	—	—	—	—	—	—
70	163	160	162	10·3	—	27·4	2·66	—	—	—	25·1	15·5	—	—	—	—	—	—	—	—
71	152	152	152	10·1	—	23·1	2·29	—	—	—	24·9	16·1	—	—	—	—	—	—	—	—

TABLE 7.

Average Biological Values, etc.

Ration.	Apparent Digestibility.	True Digestibility.	Biological Value.	Nett N Utilization.
1. Yellow maize seed.....	82	99	58·6 ± 1·016	58·3
2. Yellow maize seed (above) plus Camelthorn pods (1 : 1) (Crude Fibre ± 10 per cent).....	25	42·4	47·6 ± 2·358	20·1
3. Yellow maize seed (above) plus Camelthorn pods (1 : 1), same as 2.....	26·3	42·2	50·3 ± 1·293	21·3
4. Yellow maize seed, plus Camelthorn pods (3 : 1) (Crude Fibre ± 7 per cent.).....	47·1	65·7	62·4 ± 1·594	41·0
5. Yellow maize seed, plus grape seeds (3 : 1)	61	80	64·4 ± 1·501	51·5