S. Afr. J. Anim. Sci. 5, 1–6 (1975)

AMINO ACID COMPOSITION OF SOME SOUTH AFRICAN FEEDSTUFFS

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OPSOMMING: AMINOSUURINHOUD VAN SOMMIGE SUID-AFRIKAANSE VOERE

Die aminosuursamestellings van grane en dierlike produkte is met hoendereier vergelyk, 'n eiwitbron van hoë biologiese waarde. As gevolg van hierdie vergelyking kon groepe eiwitbronne geselekteer word, wat mekaar aanvul en sodoende meer ekonomies benut word.

SUMMARY:

The amino acid content of grains and animal products was compared with whole egg, a protein source of high biological value. Groups of protein sources can be selected on the basis of this comparison, which are complementary, and can as a result be used more economically.

It is necessary to know the protein content of feed ingredients to facilitate the economic formulation of balanced rations. Efficient feed utilisation is further facilitated by the determination of the amino-acid content of the protein sources (Block & Weiss, 1956) which are then blended according to origin using those which compliment each other.

There are known differences in the amino acid compositions of animal proteins as compared to those of plant origin. Between plant species and even plant varieties differences have been recognized (Pomeranz, Finney & Hoseney, 1966) and are receiving substantial attention (Pick & Meade, 1970) in animal nutrition.

The known, marked differences between amino acid profiles of ingredients studied in the U.S.A. and Europe have drawn attention to the possible discrepancies of South African feed ingredients, with the further possibility of differences due to the development of local varieties in our particular climatic conditions. Improved knowledge regarding the amino acid concentrations of local products will improve the efficiency of protein utilisation and will at the same time, lower the formulation costs. This basic requirement motivated the present project. Another consideration was the need for data presented in such a form to permit their use directly in applied nutrition for feed formulation as well as for future basic research in nutritional pathology.

Procedure

Air-dried feed samples, finely ground in a Glen-Creston micro-hammermill, were used to evaluate the total protein content according to the Kjeldahl method of analysis (A.O.A.C., 1970). The samples for amino-acid analyses were prepared as follows:-

A 75 milligram milled sample was hydrolysed in a glass tube with 6 ml of 6N hydrochloric acid. Nitrogen gas was used to saturate the tube which was then flame sealed.

A series of such sealed samples were autoclaved for 24 hours at 120°C in an electric stereoclave to ensure total hydrolysis (Maxwell & Moffitt, 1965) (Oltjen et al., 1967). The tubes were opened, and the contents filtered through Whatman no. 1 filter paper (previously washed with, first, 1N hydrochloric acid, and then deionized water, and dried) to remove any precipitate which might have formed. The supernatant was collected in a 100 ml Quickfit round bottomed flask. The filter paper was rinsed several times with deionized water and the washings were collected in the same flask. The flask was connected to a rotary evaporator and both the supernatant and washings were carefully evaporated in a waterbath at a temperature not exceeding 60°C. On completion of the evaporation, approximately 25 ml of deionized water was added and again evaporated. The sample was transferred quantitatively to a volumetric flask and made up to volume with 0,2N sodium citrate buffer pH 2,2. The hydrolysate samples (which were practically clear) were stored at 4°C until required for analysis. Sample dilution was as shown in Table 1.

Table 1

Dilutions used in sample preparation

% Protein in sample	Sample weight (mg)	Final volume (ml)
5–10	75	10
10–20	75	20
20–30	75	25
30–50	75	40
50–60	75	50
60–70	75	60
70–80	75	75

The free amino acids were evaluated by ion exchange chromatography, using the method of Spackman, Stein & Moore (1958). A 0,5 ml sample was analysed on a Beckman 121 automatic amino acid analyser. Calibration standards were run on both columns at regular intervals. The physiological fluid method of analysis was used (Benson & Patterson, 1965). The results are given as grammes amino acid per 100 grammes protein. (Tables 2–4). In table 5 are listed the amino acids present in each sample relative to the amount of the corresponding amino acids in whole egg protein.

Table 2

Amino acid content in products of animal origin (grammes amino acid per 100 grammes protein)

Amino Acid	Whole egg	Skim milk Powder	Milk Whey Powder	Milk Whey Powder		Blood meal	Blod meal	Carcase meal	Whale meat meal		Fish meal	Fish meal
Lysine	6,75	7,21	6,49	5,25		10,82	9,03	6,25	4,47		6,16	7,68
Histidine	1,96	2,04	1,57	1,07		5,19	4,24	2,60	1,65		2,04	2,47
Ammonia	3,25	3,32	5,18	5,25		4,65	2,75	4,55	5,10		2,93	4,46
Arginine	6,39	3,47	1,95	1,88		5,20	5,10	6,33	7,50		4,43	5,40
Hydroxi Proline	4,37	0,86	3,55	3,57		1,00	0,80	3,14	9,82		1,01	1,50
Aspartic Acid	9,04	7,05	8,79	8,77		8,42	9,29	7,05	5,42		9,91	8,14
Threonine	4,69	4,41	5,80	6,42		4,53	4,01	3,47	2,55		4,09	4,27
Serine	7,34	5,35	4,17	5,27		4,31	4,74	3,72	3,55		3,91	3,68
Glutamic Acid	11,92	16,541	4,491	5,54		7,93	9,79	9,56	9,25		13,20	11,70
Proline	4,37	8,47	7,05	7,50		4,03	4,85	8,01	10,46		5,19	4,57
Glycine	3,26	2,01	1,95	2,44		3,86	5,26	8,91	16,27		6,81	5,30
Alanine	5,47	3,25	4,45	5,18		6,69	7,65	6,73	7,24		6,62	5,59
Half Cystine	2,95	1,49	0,95	1,45		1,05	1,29	1,88	1,31		1,82	1,98
Valine	6,25	5,00	5,31	5,14		7,56	6,76	4,30	2,23		5,66	5,29
Methionine	3,55	2,59	1,76	1,25		1,51	1,45	1,44	0,77		3,37	3,25
Isoleucine	4,72	4,36	5,33	5,42		1,07	1,25	2,07	1,60		4,47	4,49
Leucine	8,09	9,05	8,65	9,63		10,27	9,71	7,40	3,96		7,86	7,32
Tyrosine	4,00	5,17	2,98	2,45		2,57	2,44	2,25	1,15		3,17	3,03
Phenylalanine	5,03	4,83	2,95	2,75		6,28	5,62	4,03	2,26		4,27	3,79
% Protein	53	35,0	11,80	12,20		80,0	72,2	50,2	83,5		68,8	65,5

Table 3

Amino acid content in oilcake meals (grammes amino acid per 100 grammes protein)

Amino Acid	Groundnut Cake Meal	Groundnut Cake Meal		Sunflower Cake Meal	Sunflower Cake Meal		Cottonseed Cake Meal		Maize Germ Cake Meal	Maize Germ Cake Meal		Soya bean meal (22% Fat)
Lysine	3,53	3,75		3,56	4,25		4,34		5,12	4,83		6,60
Histidine	2,40	1,98		2,40	2,06		2,89		2,96	3,64		2,15
Ammonia	4,58	4,37		5,52	5,24		4,98		4,30	4,28		4,62
Arginine	10,60	10,87		7,73	7,25		10,58		7,58	6,26		7,52
Hydroxi Proline	0,76	0,85		2,16	2,08		4,48		2,83	3,92		0,40
Aspartic Acid	11,47	10,25		8,81	8,05		8,62		6,75	6,12		10,34
Threonine	2,53	2,86		3,29	3,06		2,99		4,23	3,66		3,92
Serine	4,42	4,21		3,82	3,38		3,76		4,42	4,13		4,62
Glumatic Acid	17,30	17,42		19,26	20,77		17,85		12,35	13,66		17,10
Proline	3,68	3,65		4,02	4,13		4,12		6,52	7,52		4,58
Glycine	5,57	5,87		5,40	5,42		4,02		5,45	4,88		4,04
Alanine	3,87	3,69		4,02	3,98		3,82		5,68	5,48		4,05
Half Cystine	1,69	2,01		1,78	2,09		1,75		1,55	0,95		1,80
Valine	4,52	4,14		5,17	4,23		4,73		6,16	5,91		5,17
Methionine	0,81	0,75		1,62	2,34		1,15		0,98	1,37		1,05
Isoleucine	3,52	3,48		4,08	4,05		3,24		3,71	3,49		4,39
Leucine	6,18	6,57		5,92	5,83		5,62		7,87	7,70		7.09
Tyrosine	3,58	3,10		2,25	2,09		2,68		2,71	2,77		3,15
Phenylalanine	5,06	4,86		4,43	4,38		5,27		4,54	4,09		4,55
% Protein	48,8	48,5		44,8	44,1		44,0		27,7	26,1		33,70

Table 4

Amino acid content in grain and hay products (grammes amino acid in 100 grammes protein)

Amino Acid	Wheaten Bran	Wheaten Bran	Yellow Mealie Meal	Mealie Germ Meal	Sorghum Meal	Sorghum Meal	Oat Meal		Lucerne hay	Lucerne hay	Teff hay	Oat hay
Lysine	3,34	3,02	2,91	4,48	1,72	2,12	3,87		5,90	5,96	4,29	3,92
Histidine	2,47	2,98	2,82	2,85	2,20	2,16	3,21		1,67	1,70	1,15	1,35
Ammonia	4,93	3,23	4,07	3,24	4,52	4,75	6,01		4,54	6,50	4,22	7,50
Arginine	5,63	5,77	4,86	7,25	2,97	3,93	5,62		4,65	4,56	3,62	3,37
Hydroxi Proline	3,53	0,65	0,90	1,15	2,15	1,85	2,27		5,02	3,69	2,80	2,85
Aspartic Acid	6,30	8,45	6,15	6,81	6,11	5,96	7,24		9,60	9,18	7,01	8,59
Threonine	2,96	3,71	3,58	3,88	3,12	3,31	3,36		3,59	3,51	4,20	4,21
Serine	3,97	4,25	4,49	3,89	3,61	2,54	3,98		3,28	3,44	3,45	4,51
Glumatic Acid	20,24	15,70	15,31	14,87	18,57	18,48	16,81		7,27	7,30	8,71	10,58
Proline	9,58	9,62	9,30	7,15	7,75	6,73	4,67		6,81	4,80	5,60	4,02
Glycine	4,65	3,88	4,12	4,43	2,78	3,79	4,80		3,87	3,88	4,51	4,83
Alanine	4,11	4,31	5,09	6,20	8,48	8,16	4,56		4,47	4,56	5,39	5,00
Half Cystine	2,07	2,22	1,51	1,52	1,22	1,47	1,21		0,58	0,82	1,20	1,90
Valine	4,60	4,37	5,04	7,03	4,71	4,72	5,28		4,58	4,34	4,82	3,97
Methionine	1,25	2,19	2,35	1,45	1,53	1,94	1,26		0,75	1,05	0,88	1,49
Isoleucine	3,08	3,24	3,67	3,25	3,78	3,60	3,66		3,64	3,39	3,71	2,81
Leucine	5,79	10,31	11,39	9,46	12,28	11,82	6,84		5,95	5,57	6,64	4,91
Tyrosine	2,29	2,79	3,35	2,88	2,68	3,75	2,69		2,33	2,12	2,24	1,64
Phenylalanine	3,92	4,18	4,50	4,26	4,66	4,68	4,74		4,00	3,91	3,98	3,44
% Protein	17,0	9,60	9,45	10,40	12,00	12,50	9,8		16,8	15,0	4,65	4,20

Table 5

Comparison between feed ingredient and whole egg amino acid content in g per 100 g protein of feedstuffs expressed as a percentage of the level in whole egg protein

	Skim milk powder	Whey powder	Whey powder	Blood meal	Blood meal	Carcase meal	Whale meal	Fish meal	Fish meal	Ground nut cake meal	Ground nut cake meal	Sunflower cake meal	Sunflower cake meal	Cottonseed cake meal	Maize germ cake meal	Maize germ cake meal	Soya bean meal	Wheaten Bran	Yellow maize meal	Yellow maize meal	Maize germ meal	Sorghum	Sorghum	Oat meal	Lucerne meal	Lucerne meal	Teff hay	Oat straw
Lysine	107	96	78	160	134	93	66	91	114	52	56	53	63	64	76	72	98	50	45	43	66	26	31	57	87	88	64	58
Histidine	104	80	55	260	216	133	84	104	126	122	101	122	105	147	151	186	110	126	152	144	145	112	110	164	85	87	59	69
Arginine	54	31	29	81	80	99	117	69	85	166	170	121	113	166	119	98	114	88	90	76	114	47	62	88	73	71	57	53
Threonine	94	124	137	97	86	74	54	87	91	54	61	70	65	64	90	78	84	63	79	76	83	67	71	72	77	75	90	90
Valine	80	85	82	121	108	69	36	91	85	72	66	83	84	76	99	95	83	74	70	81	113	75	76	85	73	69	77	64
Methionine	73	50	35	43	41	41	22	95	92	23	21	46	66	32	28	39	30	35	62	66	41	43	55	36	21	30	25	42
Isoleucine	92	113	115	23	27	44	34	100	95	75	74	86	86	69	79	74	93	65	69	78	69	80	76	78	77	72	79	60
Leucine	112	107	119	127	120	92	49	97	91	76	81	73	72	70	97	95	88	72	127	141	117	152	146	85	74	69	82	61
Tyrosine	129	75	61	64	61	56	29	79	76	90	78	56	52	67	68	69	79	57	70	84	72	67	94	67	58	53	56	41
Phenylanine	96	59	55	125	112	80	45	85	75	70	75	71	85	86	102	96	131	78	83	90	85	93	93	94	80	78	79	68
Half Cystine	51	32	49	36	44	64	44	62	67	57	68	60	59	53	32	61	61	70	75	51	52	41	50	41	20	28	41	64

Results

The amino acid composition of twenty-one feed ingredients are tabulated, nine protein sources showing duplicate values from different origins.

Discussion

Tables 2, 3 and 4 have the concentrations of total protein content of each source together with the amino acid contents expressed as grammes of amino acid per 100 grammes protein. The efficient rate of recovery of 93,2% amino acids is an indication that the 24 hour hydrolysates used were resulting in vitually total hydrolysis of the protein and furthermore that any degradation of amino acids taking place was minimal. An exception was the tryptophan fraction which is destroyed by the method of acid hydrolysis.

Whole dry egg was used as reference standard to permit comparison of the protein sources. Table 5 indicates the ratios of amino acids between the protein sources evaluated and the corresponding amino acids of egg. This egg standard has been attributed a biological value of 96% (Block & Mitchell, 1947). The most limiting amino acids of the respective protein sources are summarised as follows:

Arginine – whey, skim milk powder
Methionine – carcass meal, whale meal, groundnut cake, cottonseed cake, soya bean cake, maize germ, wheat bran, yellow maize, oats.

Other salient features are that the sorghum samples had substantially lower (26 & 31%) lysine values than maize (45 & 43%). This explains in part the poorer performance of the former, despite the virtual 3% higher total protein content as compared to that of maize. The favourable lysine figure obtained for lucerne (87,88%) is also noteworthy, particularly when considering the costs of synthetic amino acid supplementation. The primary protein supplement to date in the Republic is fish meal, representing over half of actual protein supplemented in commercial formulations, (Department of Agricultural Economics and Marketing, 1973). The use of this product, when considering the excellent performance on Table 5, will remain of prime importance at current and even at higher market prices.

Preference amongst the primary South African oil cakes goes to sunflower cake as the methionine figures are 46 and 66% as compared to groundnut cake 23 and 21% and cottonseed cake 32%. Soya bean meal has a very good lysine ratio (98%), but only 30% methionine. Furthermore, the negligable local production classifies it for practical purposes as only of "acadmic interest" in animal nutrition. The current low prices of soya bean meal on the overseas market could however result in batch importations which could find a way into local feeding from time to time.

The current 1973–74 season has been particularly favourable due to good rains with resulting yields which, in many areas, will be double or more than those of previous seasons. This will ease the previous years' shortage of oil cake. However, it is also possible for the individual farmer to reduce his protein dependance on purchases by the inclusion of milled mature sunflower heads (±18% protein) in the feeding programme of ruminants. Levels of up to 15% blended with maize can be considered with benefit.

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