Amino Acids in Commercially Produced Blood Meals

Fifty-five samples of blood meal were obtained from 24 manufacturers representing nine commercial blood drying systems. A brief description is given for each processing method. Average dry matter, crude protein (N × 6.25), and amino acid content are given for blood meal samples of each process. The vat-dried blood was generally lower in crude protein and amino acid contents when compared with blood meals of other processing methods. The vat-dried blood was 21, 43, and 18% lower in lysine, cystine, and methionine, respectively, than the average for spray- and ring-dried bloods. Crude protein and dry matter content varied more for the vat blood meal. Blood meals from processes other than vat were similar in dry matter, protein, and amino acid content.

Blood meal is of considerable interest as a component of animal diets due to its high protein content. Historically, most blood has been dried by the "conventional" or vat method. This type of blood meal has had doubtful feeding value for livestock (Morrison, 1961; Cullison, 1975) and poor digestibility has been noted (Winter, 1929). Growth depression resulted when blood meal was fed to turkey poults at 3.75 and 7.50% of the diet (Lockhart et al., 1960); supplementation with isoleucine and methionine did not remove the depression. However, isoleucine and methionine supplementation of diets high in blood meal did have a positive effect in reducing growth depression in chicks (Fisher, 1968).

Kratzer et al. (1957) provided evidence that the nutritional quality of blood meals may be related to protein damage during processing. Vat- and spray-dried blood meals contained 7–8% and 10–12% biologically available lysine, respectively, for chicks and turkey poults. Hamm and Searcy (1976) reported that chemically available lysine values of dried poultry blood decreased as temperature and time of drying increased.

Other blood drying methods are now used commercially for the manufacture of blood meal. Little is known about these blood meals and how they compare with vat-dried blood meals. A study was initiated to determine the amino acid composition of blood meals produced by a variety of methods, including the conventional process. The results are reported herein.

EXPERIMENTAL SECTION

Test Materials. Fifty-five samples of blood meal were obtained from 24 different manufacturers. Samples were mixed thoroughly upon receipt and stored in tied plastic bags at 0 °C until used.

Analytical Methods. Analyses for each sample were done in duplicate. Amino acid content was determined for 15 amino acids excluding methionine, cystine, and tryptophan, by the method of Moore et al. (1958). Samples were hydrolyzed in 6 N HCl at 120 °C for 22 h. Hydrolysates of the 55 blood meals were analyzed on a Beckman 121 Amino Acid Analyzer with two columns. Analyses for methionine and cystine as methionine sulfone and cysteic acid were determined by the method described by Blackburn (1968) for 18 representative samples of blood meal. Nitrogen was determined by a modification of the micro-Kjeldahl method (AOAC, 1970) and is expressed as crude protein (nitrogen × 6.25). Dry matter content was determined by the vacuum oven method (AOAC, 1970).

Descriptions of Blood Meal Processing. Samples received represented nine different industrial drying methods. The following descriptions were provided upon request by the producers and are included to give as much information as possible about processing conditions. It should be noted that the temperatures cited are the processors estimates and were not specifically measured for the study. Blood processing methods may be divided into whole blood and coagulation systems.

In the whole blood systems there is no separation of blood solids from the liquid portion before drying. The conventional, fast conventional, and spray–drying methods are classified as whole blood systems.

In the vat (V) or conventional process, blood is dried in a batch dryer where the surrounding shell provides the heat source. Paddles within the tank stir the blood. Cattle shank or jaw bones are added during drying to keep the blood from sticking on the dryer sides. The blood remains in the dryer for 10 h or longer and reaches temperatures of 99 to 138 °C.

The fast conventional (FC) method is similar to the conventional method except drying is accelerated. The blood is dried in a batch cooker where the drive shaft, paddle, and one head of the dryer also contribute heat along with the shell to the drying process. Because of the faster turning rate and higher shell steam pressure, the blood dries in 3 to 4 h. Blood temperatures were reported to be in the range of 99–115 °C which appears inconsistent with the higher steam pressure utilized during drying.

The spray (S) drying system is much like the process involved in drying of milk. Blood is evaporated to 40–50% solids in vacuum at low heat (49 °C). Then the material is sprayed into a hot air stream (316 °C) and drying is completed.

The second type of drying is where the blood is first coagulated, usually by steam, and there is separation of much of the liquid from the solids by centrifugation or filtration. The liquid portion is assumed to be composed of components not coagulated and not entrapped in the coagulant. Some small particles (size dependent on filtering process) of coagulated blood are also present. A measurement of the liquid discard portion from the ring-drying process was found to contain 4.2 g of solids/100 mL of liquid.

There are four processes which use centrifugation. Two processes employ a decanter type centrifuge from which the blood solids are separated. In one process (DS), the solids enter a steam tube dryer which operates at 172 °C; blood remains in the dryer for approximately 30 min. In the other process (DC), the blood solids are dried in a conventional type dryer for 2 h with temperatures similar to process V.

Flash (F) drying employs a continuous decanting type centrifuge to remove the solids, which are then dried in a flash dryer with a hot air stream (260 to 427 °C). The blood reaches temperatures of 102 °C in a short drying time of 3.5 min.

In process P the solids are separated by means of a scroll type centrifuge on a continuous basis and then enter a rotary drum dryer where the blood reaches temperatures

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of 76–93 °C and remains in the dryer for less than 5 min.

The ring (R) process employs a dewatering press which removes some of the liquid, after which the semidried blood enters the ring dryer and is driven through the elliptically shaped ring by a hot air stream (427 to 454 °C).

The final process, continuous (C), uses a shaker screen to separate the solids which are then fed on a continuous basis to a jacketed series type dryer. Passage through the five units of the dryer takes approximately 45 min. Drying temperature usually remains below 93 °C.

RESULTS AND DISCUSSION

Shown in Table I are the numbers of samples analyzed, the average dry matter, crude protein, and amino acid content (on a dry matter basis) for blood meal samples produced by nine different processes.

The discussion will emphasize processes V (vat), S (spray), and R (ring) as these included a greater number of samples. The other processes will be compared as possible.

Type of Blood Processed. In the vat-dried blood, there were four samples each of meal from beef, pork, and a mixture of beef and pork blood. For one sample, the source of blood was unknown. FC blood meal was from pork blood. S blood meal had two samples of beef blood, two samples were mixtures, and the type of blood used for the six other samples was unknown. DC blood meal was dried beef blood. Three samples of DS blood were produced from pork blood, and the type of blood of the other samples was unknown. Process C blood meal was produced from a mixture of beef and pork blood. R blood meal was mainly from beef blood with the source of two samples unknown. Process P and F samples were both from beef blood.

A comparison of four samples of beef or pork (vat-dried blood) shows that pork blood meal contained more histidine, arginine, proline, glycine, and isoleucine, while beef blood meal contained more lysine, threonine, valine, leucine, tyrosine, and phenylalanine. It is probable that the type of blood dried would add to variation between samples. However, from this study it is difficult to make a valid comparison due to the different manufacturing processes and places of manufacture.

Dry Matter. Dry matters of blood meal produced by these different processing methods ranged from 89.34 to 95.56%. Values for processes V and S were similar, 93.59 and 94.18%, respectively, while process R was lower with a value of 89.92%. Processes V and DS showed the most variation in dry matter content.

Crude Protein. The crude protein contents ranged from 86.96 to 100.41%. Whole blood processes V and FC with crude protein values of 86.96 and 92.20%, respectively, were lower in crude protein than the coagulated blood systems, where ring-dried blood contained 97.66% crude protein. Protein in spray (S) dried blood was intermediate (94.26%). Process V had the most variation.

Amino Acids. Average lysine content ranged from 7.55 to 10.23% on a dry matter basis. V and FC bloods were much lower in lysine, containing 7.55 and 7.62%, respectively, when compared with the other methods. Lysine contents of S and R blood meals were 9.46 and 9.76%, respectively.

Methionine contents of selected samples ranged from 0.52 to 1.01%. V blood meal contained 0.62% while S and R bloods contained 0.70 and 0.82%, respectively.

Cystine contents of selected samples ranged from 0.57 to 1.23%. Process V blood meal contained 0.57% which was 43% less than the S and R bloods which contained 0.99 and 1.00% cystine, respectively.

Table I. Average Dry Matter, Crude Protein, and Amino Acid Contents of Blood Meals Produced by Different Processes

Process	Whole blood systems			Coagulated blood systems				
	V	FC	S	DC	DS	C	R	F	P
No. of samples anal.	13	2	10	2	7	3	12	5	3
Dry matter, %[a]	93.59 ± 1.61[a]	95.56 ± 0.21	94.18 ± 0.83	89.34 ± 0.09	94.20 ± 1.82	91.78 ± 0.80	89.92 ± 0.92	95.30 ± 0.57	94.05 ± 0.28
Crude protein, %[b,d]	86.96 ± 1.42	92.20 ± 0.32	94.26 ± 0.36	100.41 ± 0.34	97.09 ± 1.14	96.83 ± 2.10	97.66 ± 0.33	96.00 ± 0.84	96.55 ± 0.29
Amino acids, %[b]									
Lysine	7.55 ± 0.14	7.62 ± 0.08	9.46 ± 0.19	9.52 ± 0.11	9.00 ± 0.21	8.65 ± 0.19	9.76 ± 0.25	9.35 ± 0.17	10.23 ± 0.06
Histidine	3.76 ± 0.10	4.29 ± 0.03	6.05 ± 0.30	4.23 ± 0.05	5.60 ± 0.22	4.71 ± 0.10	5.48 ± 0.27	5.43 ± 0.34	6.13 ± 0.05
Arginine	3.89 ± 0.14	3.98 ± 0.04	4.14 ± 0.06	4.12 ± 0.08	4.42 ± 0.15	4.03 ± 0.08	4.25 ± 0.11	3.75 ± 0.07	4.23 ± 0.02
Aspartic acid	9.58 ± 0.18	10.84 ± 0.13	10.51 ± 0.09	11.04 ± 0.04	11.44 ± 0.36	11.16 ± 0.29	10.61 ± 0.15	11.09 ± 0.25	10.42 ± 0.04
Threonine	3.36 ± 0.14	3.14 ± 0.03	3.89 ± 0.14	5.00 ± 0.04	3.96 ± 0.35	3.50 ± 0.15	4.45 ± 0.15	4.55 ± 0.13	4.47 ± 0.01
Serine	3.36 ± 0.18	3.54 ± 0.05	3.97 ± 0.10	4.78 ± 0.04	4.06 ± 0.20	3.80 ± 0.21	4.35 ± 0.09	4.16 ± 0.10	4.03 ± 0.02
Glutamic acid	8.70 ± 0.14	9.36 ± 0.06	8.74 ± 0.10	10.11 ± 0.04	9.67 ± 0.25	9.23 ± 0.20	9.46 ± 0.14	9.15 ± 0.16	9.08 ± 0.04
Proline	4.02 ± 0.21	4.06 ± 0.06	3.72 ± 0.09	4.16 ± 0.03	3.89 ± 0.07	3.88 ± 0.15	3.94 ± 0.09	3.89 ± 0.06	4.12 ± 0.05
Glycine	4.91 ± 0.38	4.58 ± 0.04	4.29 ± 0.08	4.48 ± 0.03	4.57 ± 0.18	4.48 ± 0.16	4.34 ± 0.05	4.36 ± 0.13	4.06 ± 0.03
Alanine	7.17 ± 0.11	7.60 ± 0.04	7.73 ± 0.09	8.74 ± 0.04	7.98 ± 0.17	7.93 ± 0.31	8.04 ± 0.07	8.67 ± 0.15	7.94 ± 0.03
Cystine[c]	0.57 ± 0.08 (4)	0.86 (1)	0.99 ± 0.002 (3)	1.02 (1)	1.23 ± 0.03 (3)	1.02 (1)	1.00 ± 0.002 (4)	0.94 ± 0.00 (2)	1.08 (1)
Valine	7.78 ± 0.17	8.38 ± 0.11	8.84 ± 0.11	9.76 ± 0.08	9.22 ± 0.39	9.17 ± 0.25	9.44 ± 0.09	9.86 ± 0.19	9.32 ± 0.04
Methionine[c]	0.62 ± 0.02 (4)	0.52 (1)	0.70 ± 0.03 (3)	0.95 (1)	0.95 ± 0.11 (3)	0.61 (1)	0.82 ± 0.08 (4)	1.00 ± 0.003 (2)	1.01 (1)
Isoleucine	1.01 ± 0.05	1.12 ± 0.01	0.93 ± 0.03	0.92 ± 0.01	1.49 ± 0.16	1.04 ± 0.04	1.01 ± 0.02	0.82 ± 0.03	0.91 ± 0.01
Leucine	11.25 ± 0.22	12.42 ± 0.10	12.55 ± 0.10	13.82 ± 0.11	13.01 ± 0.31	13.04 ± 0.41	12.71 ± 0.16	13.40 ± 0.17	12.97 ± 0.02
Tyrosine	2.22 ± 0.07	2.36 ± 0.01	2.49 ± 0.06	3.10 ± 0.02	2.74 ± 0.13	2.48 ± 0.12	2.85 ± 0.05	2.74 ± 0.07	2.80 ± 0.03
Phenylalanine	6.06 ± 0.15	6.44 ± 0.06	6.78 ± 0.10	7.90 ± 0.06	6.88 ± 0.18	6.90 ± 0.36	7.09 ± 0.07	7.67 ± 0.18	7.34 ± 0.07

[a] Mean ± SE of the mean. [b] Dry matter basis. [c] Number in parentheses indicates number of samples analyzed for cystine and methionine. [d] Crude protein is N × 6.25.

Isoleucine, which has been shown to be deficient in blood meal for chicks (Fisher, 1968), ranged from 0.82 to 1.49%. For blood meal produced by the three major processes, V, S, and R, the isoleucine contents were quite similar, i.e., 1.01, 0.93, and 1.01%, respectively.

In terms of amino acid content, blood from method V was consistently lower in amino acids excepting proline, glycine, and isoleucine when compared with blood meals from S and R. The relatively higher contents of proline and glycine in processes V and FC may relate to the presence of collagen in bone which is known to contain high levels of glycine and proline.

The lower amounts of lysine, cystine, and other amino acids may be due to the long drying time used in the V system. Bjarnason and Carpenter (1970) observed 15 and 92% decreases in lysine and cystine contents, respectively, when bovine plasma albumin was heated at 145 °C for 27 h. Other researchers have also shown a 5–10% decline in lysine content upon severe heat treatment of animal protein (Hurrell and Carpenter, 1974; Varnish and Carpenter, 1975). Hamm and Searcy (1976), in experiments with the drying of chicken broiler blood in shallow pans in an oven found a decrease of 23% in total lysine content (as compared with raw blood) in blood dried at 193 °C for 4 h. However, total lysine content of blood dried at 103 °C for 16 h did not change. It should be noted that a small decrease in lysine or other amino acids with V bloods may be due to the addition of bones during drying, thereby diluting the meal.

Concerning the other processes, blood meal from process FC was similar to process V in amino acid content. Blood meals of processes DC, DS, C, F, and P were all fairly similar to processes S and R, with P blood meal high in lysine (10.23%).

As mentioned earlier, little was known about the amino acid composition of blood meals of the newer processes. However, amino acid composition of two types of blood meal was published in the feed composition tables of the Nutrient Requirements of Poultry (National Academy of Sciences, 1971). Amino acid composition for ingredient number 5-00-380 (animal blood, dehydrated, ground) compares well with process V and FC blood meals, excepting cystine and methionine which are approximately 2.5 and 1.5 times greater than the values presented here. Crude protein contents are approximately the same, while dry matter contents for processes V and FC are 3 to 5% higher than ingredient 5-00-380.

Blood meal, ingredient number 5-00-381 (animal blood, spray dehydrated) had a lysine content of 9.01% which is lower than that of processes S, DC, R, F, and P, but close to that of processes DS and C. Methionine contents for processes DC, DS, F, and P are close to that listed (1.1%).

Generally, vat-dried blood was lower in amino acids when compared to spray- and ring-dried blood meal. The percentage reduction in essential amino acid content of vat-dried blood when compared to spray- and ring-dried blood, respectively, was as follows: cystine, 42.4 and 43.0%; histidine, 37.9 and 31.4%; lysine, 20.2 and 22.6%; threonine, 13.6 and 24.5%; tyrosine, 10.8 and 22.1%; methionine, 11.4 and 24.4%; valine, 12.0 and 17.6%; phenylalanine, 10.6 and 14.5%; leucine, 10.4 and 11.5%; and arginine, 6.0 and 8.5%.

Vat-dried blood contained greater amounts of proline, glycine, and isoleucine. Percentage increase in comparison with spray- and ring-dried blood meals, respectively, was as follows: proline, 7.46 and 1.99% greater; glycine, 12.6 and 11.6%; and isoleucine, 8.1 and 0.0%.

Blood meals of the other processes were similar to ring and spray bloods in dry matter, crude protein, and amino acid content, excepting for some of the differences pointed out in the above discussion.

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