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Amino Acids Availability of Poultry Feedstuffs in Pakistan

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ABSTRACT

Quick bioassay technique of Sibbald (1986) involving adult cockerels was used to determine the amino acids availability of commonly used feedstuffs in Pakistan. Feedstuffs evaluated for amino acid availability were cereal grains (corn, rice, sorghum and wheat), cereal by-products (corn gluten feed, rice polishings and wheat bran), vegetable meals {corn gluten meal 30 and 60%, cottonseed meal expeller extracted (ee) and solvent extracted (se), guar meal, rapeseed meal (ee) and (se), sesame meal, soybean meal and sunflower meal}, and animal meals (blood meal, fish meal, meat meal and poultry by-product meal). Amino acid availability ranged from 82 to 94% in corn, 72 to 89% in rice, 68 to 94% in sorghum and 75 to 97% in wheat. The availability of amino acids ranged from 75 to 96, 76 to 87, and 67 to 86% in corn gluten feed, rice polishings and wheat bran, respectively. The amino acids availability ranged from 72 to 94% for corn gluten meal (30%), 82 to 98% for corn gluten meal (60%), 78 to 96% for cottonseed meal (ee), 69 to 91% for cottonseed meal (se), 64 to 93% for guar meal, 73 to 88% for rapeseed meal (ee), 82 to 93% for rapeseed meal (se), 82 to 95% for sesame meal, 82 to 89% for soybean meal and 81 to 94% for sunflower meal. In case of animal meals the availability of amino acids ranged from 80 to 98, 87 to 96, 82 to 91 and 48 to 81% for blood meal, fish meal, meat meal and poultry by-product meal, respectively.

Key Words: Amino Acids; Availability; Feedstuffs

INTRODUCTION

Knowledge of the biological availability of the amino acids in feedstuffs is important in ensuring that the amino acid requirements are met and optimum poultry performance is achieved. A number of techniques for determining biological availability of amino acids in feedstuffs have been developed. These include chick growth responses, chemical and microbiological assays, assays measuring plasma amino acids and balance experiments (Elwall & Soares, 1975). Rapid assay by Sibbald (1976) and its modifications by Sibbald (1986) and McNab and Blair (1988) made it possible to evaluate the poultry feedstuffs on the basis of the availability of amino acids. This assay has several advantages like high precision, cost effectiveness and time saving. Furthermore, direct determination of amino acids availability of unpalatable ingredients is also possible.

In Pakistan, poultry diets are usually formulated on the basis of chemical composition of feedstuffs. Feed formulation on the basis of chemical analysis of feedstuffs is inadequate, since all the nutrients analyzed chemically are not available to the birds. In Pakistan, wide range of feedstuffs are used in the poultry feed because quality feedstuffs such as corn, soybean and fish meal are not available in abundance. These feedstuffs vary in nutrients bio-availability due to the factors like climate, soil, crop varieties, poor processing and storage. Moreover, there are some other factors, which deteriorate the quality of feedstuffs such as contamination and adulteration. Under these conditions, table values developed by other countries are not suitable for local feed formulation. There is a need to evaluate local poultry feedstuffs for amino acid availability to generate information to be used for precise formulation of poultry diets. A study was, therefore, planned with the objective to determine the amino acids availability of indigenous poultry feedstuffs.

MATERIALS AND METHODS

Samples of 21 good quality feedstuffs weighing about 2 kg were collected from primary market. These feedstuffs included cereal grains: corn, rice, sorghum and wheat; cereal by-products: corn gluten feed, rice polishings and wheat bran; vegetable meals: corn gluten meal 30 and 60%, cottonseed meal (ee) and (se), guar meal, rapeseed meal (ee) and (se), sesame meal, soybean meal and sunflower meal; animal meals: blood meal, fish meal, meat meal and poultry by-product meal. These feedstuffs were coarsely ground (0.5 mm mesh sieve) and were stored in plastic bottles for subsequent use in the experiment.

Technique of Sibbald (1986) was used to measure the amino acid availability of various feedstuffs using six birds for each feedstuff. Another six birds were kept as negative control to determine endogenous excretion of amino acids and this value was used to correct the excreta outputs of the birds used for assay of feedstuff. The birds were starved for 48 h. During fasting, all the birds were crop intubated with two doses of 50 mL each of an aqueous glucose solution (500 g kg^{-1}) at 8^{th} and 32^{nd} h after feed withdrawal (McNab & Blair, 1988). After fasting period, cockerels in treatment group were crop intubated with 50 g of ground sample of the feedstuff. In case of cereal grains, the feedstuff was fed straight, while in case of feedstuffs high in protein, were mixed with corn starch, mineral and vitamin premix in order to give the birds a complete feed containing 16 to 18% CP. Cockerels of the negative control group were crop intubated with 50 g of protein free diet containing 48% corn starch, 48% sucrose and 4% mineral and vitamin premix (Green *et al.,* 1987). The excreta voided during the exact 48 h following force feeding were collected at 24 h intervals. All the samples of excreta were collected separately for each cockerel. These were weighed, oven dried at 60^0C and ground (0.3 mm sieve). Amino acids analysis was performed on three pooled samples of excreta from cockerels on each feedstuff in an assay. The samples of 21 feedstuffs and excreta from their respective assays were analysed by Degussa amino acids laboratory, Germany for amino acids composition following the method of Spackman *et al.,* (1958). Amino acids availability for each feedstuff was calculated as the difference between amino acid intake and amino acid excreted by the fed birds and correction of the later for metabolic and endogenous amino acid excretion was also made. The calculations were made according to the following formula:

$$\text{AA Availability (\%)} = \frac{\text{IAA - (Ex AA - En AA)}}{\text{IAA}} \times 100$$

Where
AA = Amino acid
IAA = Ingested amino acid
Ex AA = Excreted amino acid
En AA = Endogenous amino acid

RESULTS AND DISCUSSION

Cereal grains. The amino acid contents and their availability in cereal gains are given in Table I. Availability of the amino acids ranged from 82 to 94% in corn, 72 to 89% in rice, 68 to 94% in sorghum and 75 to 97% in wheat. The availability was highest for Leu in corn and sorghum, Arg in rice and Cys in wheat, but was lowest for Lys and Try in corn, Met in rice, Lys in sorghum and wheat. The amino acid profile of local cereal grains was higher than that reported for corn (Sibbald, 1979; Sibbald, 1986; Sub, 1988; Ensminger *et al.,* 1990; Anonymous, 1993; 1996) and rice (Sub, 1988; Ensminger *et al.,* 1990). The amino acid profile of local sorghum was, however, comparable to the earlier reports (Sub, 1988; Ensminger *et al.,* 1990; Anonymous, 1993; 1996). Similar was the case of wheat for amino acid profile (Sub, 1988; Ensminger *et al.,* 1990; Anonymous, 1996). However, Sibbald (1986) observed higher values for amino acid in wheat as compared to local wheat particularly for Met, Cys, Lys, Thr and Arg. The corn of Gohar variety with white colour and rice tips of Basmati variety were used in the present experiment. These varieties are being commonly grown in NWFP and Punjab Provinces (Pakistan), respectively. The reason for better amino acid profile could be higher CP content, which is genetic characteristic of these cereals grown under different climatic conditions using different agronomic practices. Availability of all the indispensable amino acids in all the four cereal grains fell within the range reported by Sibbald (1986), Ensminger *et al.* (1990) and Anonymous (1993 & 1996) except that of Met in rice and wheat and Lys in sorghum and wheat which was lower in local cereal grains. Among the cereal grains, corn had higher availability than rice, sorghum and wheat because protein in the endosperm might adheres more tightly to starch granules in rice, sorghum and wheat than in corn (Boren, 1989). High tannin content in sorghum as compared to corn could be another factor for its low availability. Nelson *et al.* (1975) reported that as the tannin content increased in the sorghum, amino acids availability decreased.

Cereal by-products. The amino acid contents and their availability in cereal by-products are given in Table I. The availability of the amino acid ranged from 75 to 96% in corn gluten feed, 76 to 87% in rice polishings and 67 to 86% in wheat bran. The availability was highest for Phe in corn gluten feed and Arg in rice polishings and wheat bran, but was lowest for Lys in corn gluten feed and rice polishings and Val in wheat bran among indispensable amino acids. The amino acid profile of the three local cereal by-products was similar to that reported by Sibbald (1986), Sub (1988), Castanon *et al.* (1990), Ensminger *et al.* (1990) and Anonymous (1993 & 1996). However, Lys and Arg in local corn gluten feed were lower than the reported values. Availability of all the indispensable amino acids in the three local cereal by-products fell within the range reported by Sibbald (1986), Ensminger *et al.* (1990) and Anonymous (1993 & 1996). However, availability of Thr in local rice polishings was slightly higher and Phe in local wheat bran was lower. Among the cereal by-products, corn gluten feed had higher availability of amino acid than rice polishings and wheat bran. Availability of cereal by-products was lower than that of the grains from which they were derived. The cereal by-products are obtained from the bran portion of grains which contains structural carbohydrates tightly bound with protein, making it partially indigestible to the birds, resulting into lower availability of amino acids.

Vegetable meals. The amino acid contents and their availability in vegetable meals are shown in Table II. The availability of the amino acids ranged from 72 to 94% in corn gluten meal (30%), 82 to 98% in corn gluten meal (60%), 78 to 96% in cottonseed meal (ee), 69 to 91% in cottonseed meal (se), 64 to 93% in guar meal, 73 to 88% in rapeseed meal (ee), 82 to 93% in rapeseed meal (se), 82 to 95% in sesame meal, 80 to 89% in soybean meal and 81 to 94% in sunflower meal. The availability was highest of Phe in corn gluten meal (30%) and cottonseed meal (ee), Leu in corn gluten meal (60%) and sesame meal and Arg in cottonseed meal (se), guar meal, rapeseed meal (ee),

Table I. Amino acid contents and their availability in cereal grains and cereal by-products (% DM basis)

Amino acids	Corn	Rice	Sorghum	Wheat	Corn gluten feed	Rice polishing	Wheat bran
Met	0.27 (90)	0.23(72)	0.23(83)	0.22(79)	0.41(92)	0.32(79)	0.25(75)
Cys	0.27(91)	0.22(74)	0.23(91)	0.32(97)	0.50(90)	0.31(80)	0.33(76)
Lys	0.45(82)	0.37(82)	0.28 (68)	0.42 (75)	0.48 (75)	0.60(76)	0.61(72)
Thr	0.49(86)	0.32(73)	0.41(85)	0.40(82)	0.78(84)	0.53(81)	0.58(73)
Try	0.10(82)	0.13(81)	0.15(85)	0.17(84)	0.10(83)	0.19(81)	0.21(77)
Arg	0.65(90)	0.76(89)	0.51(85)	0.66(83)	0.67(92)	1.12(87)	1.01(83)
Ile	0.49(89)	0.38(79)	0.54(87)	0.47(82)	0.69(91)	0.52(78)	0.49(73)
Leu	1.62(94)	0.78(82)	1.85(94)	0.91(86)	2.00(95)	1.05(79)	0.96(78)
Val	0.63(89)	0.55(81)	0.60(87)	0.60(83)	1.08(91)	0.79(80)	0.66(71)
His	0.38(89)	0.24(88)	0.31(85)	0.32(87)	0.59(86)	0.39(76)	0.36(72)
Phe	0.68(93)	0.50(81)	0.74(94)	0.59(89)	0.80(96)	0.67(84)	0.61(72)
Gly	0.54(-)	0.44(-)	0.41(-)	0.61(-)	1.00(-)	0.76(-)	0.74(-)
Ser	0.65(91)	0.44(80)	0.57(91)	0.58(90)	0.86(93)	0.66(83)	0.67(79)
Pro	1.17(91)	0.47(77)	1.27(92)	1.32(96)	1.90(91)	0.64(78)	0.91(80)
Ala	0.97(91)	0.56(80)	1.22(91)	0.54(76)	1.73(93)	0.87(77)	0.74(67)
Asp	0.93(87)	0.82(81)	0.89(84)	0.71(75)	1.12(85)	1.25(81)	1.24(76)
Glu	2.49(93)	1.63(84)	2.73 (94)	3.47(94)	3.04(91)	2.17(85)	2.89(86)

Figures in brackets indicate availability (%)

Table II. Amino acid contents and their availability in vegetable meals (% DM basis)

Amino acids	Corn gluten meal (30%)	Corn gluten meal (60%)	Cottonseed meal (ee)	Cottonseed meal (se)	Guar meal	Rapeseed meal (ee)	Rapeseed meal (se)	Sesame meal	Soybean meal	Sunflower meal
Met	0.48(90)	1.61(97)	0.68(85)	0.72(73)	0.47(79)	0.68(84)	0.74(89)	0.77(89)	0.72(84)	0.71(89)
Cys	0.57(90)	1.15(95)	0.74(90)	0.82(86)	0.52(81)	0.85(81)	1.03(82)	1.02(89)	0.83(82)	0.58(89)
Lys	0.49(72)	1.06(85)	1.78(78)	1.96(69)	1.66(83)	1.99(79)	1.86(83)	1.80(87)	3.13(86)	1.08(81)
Thr	0.88(86)	2.14(92)	1.38(87)	1.49(75)	1.16(71)	1.55(76)	1.56(83)	1.62(84)	2.03(85)	1.20(85)
Try	0.09(77)	0.33(82)	0.55(87)	0.60(81)	0.59(81)	0.45(78)	0.54(88)	0.50(88)	0.71(87)	0.44(90)
Arg	0.74(90)	2.00(95)	4.74(94)	5.40(91)	4.76(93)	1.97(88)	2.66(93)	2.13(90)	3.98(89)	2.69(94)
Ile	0.76(86)	2.60(95)	1.40(85)	1.55(74)	1.19(74)	1.28(75)	1.53(86)	1.48(88)	2.33(84)	1.34(86)
Leu	2.17(94)	10.05(98)	2.54(88)	2.81(78)	2.29(78)	2.29(80)	2.65(89)	2.63(91)	3.93(85)	2.11(87)
Val	1.22(88)	3.04(94)	2.01(87)	2.19(77)	1.46(72)	1.70(76)	1.94(85)	1.89(87)	2.47(83)	1.65(87)
His	0.65(88)	1.35(92)	1.30(87)	1.41(85)	1.04(84)	0.96(81)	1.10(88)	1.07(85)	1.48(85)	0.84(89)
Phe	0.96(94)	4.00(98)	2.30(96)	2.63(88)	1.53(82)	1.31(81)	1.55(92)	1.48(85)	2.60(88)	1.53(86)
Gly	1.11(-)	1.71(-)	1.86(-)	1.99(-)	2.11(-)	1.72(-)	1.98(-)	1.91(-)	2.23(-)	1.87(-)
Ser	0.95(91)	3.34(97)	1.80(91)	2.00(83)	1.75(82)	1.52(81)	1.53(83)	1.59(88)	2.64(86)	1.38(90)
Pro	2.31(91)	6.20(98)	1.79 (89)	1.93(84)	0.79(64)	1.98(80)	2.22(88)	2.24(95)	2.55(85)	1.38(93)
Ala	1.94(90)	5.58(97)	1.79(83)	1.92(73)	1.65(67)	1.56(73)	1.71(82)	1.70(83)	2.30(80)	1.45(81)
Asp	1.21(82)	3.88(93)	3.92(88)	4.37(82)	3.91(80)	2.38(76)	2.66(82)	2.44(82)	6.11(87)	2.95(87)
Glu	3.56(90)	12.55(97)	8.00(91)	8.59(88)	7.18(84)	5.58(86)	6.81(91)	6.11(90)	8.87(88)	6.11(92)

Figures in brackets indicate availability (%)

soybean meal and sunflower meal, while of Lys in corn gluten meal (30%), cottonseed meal (ee & se) and sunflower meal, Thr in guar meal and sesame meal, Try in corn gluten meal (60%), Ile in rapeseed meal (ee) and Cys in rapeseed meal (se) and soybean meal was lowest among indispensable amino acids. The amino acid profile of most of the vegetable meals was within the reported range for these ingredients by Sibbald (1986), Ensminger *et al.* (1990) and Anonymous (1993 & 1996). However, Lys content in rapeseed, soybean and sunflower meals were lower in the indigenous meals than the reported ones. Excessive heating during processing might had resulted into Maillard products and Lys in advanced Maillard compounds is not recoverable during amino acid analysis (Hurrel, 1990). The increase in autoclaving time from 0-60 min has been reported to decrease the Lys concentration for canola meal from 1.77 to 1.35% (Anderson-Hafermann *et al.,* 1993), for sunflower meal from 1.43 to 0. 89% (Zhan & Parsons, 1994) and for soybean meal from 3.11 to 2.83% (Fernandez & Parsons, 1996). The Lys was higher and Met and Arg were lower in local sesame meal due to variation in varieties of sesame meal and their cultivation under different agronomic practices in different parts of the world. The amino acid contents in local solvent extracted cottonseed and rapeseed meals were comparatively higher than the values reported by Sibbald (1986) and Ensminger *et al.* (1990). Higher protein in local solvent extracted cottonseed (49.40%) and rapeseed meals (40.33%) and their varietial characteristics could be the possible factors which might have resulted into higher amino acid profile in these meals. Cottonseed and rapeseed meals were also obtained from an old local expeller extraction method which is rarely practised in other countries. The information on the amino acid contents of such feedstuffs is not available in the literature. Similarly the information on amino acid contents of guar meal was scanty.

Availability of all the essential amino acids in vegetable meals was within the range reported by Sibbald (1986), Ensminger *et al.* (1990) and Anonymous (1993 & 1996). However, availability of Met in cottonseed (se), soybean and sunflower meals and Lys in soybean and sunflower meals was lower than the reported values. Processing of these meals involves much heat and pressure to break the seed and extract as much oil as possible. Thus, there is a possibility of formation of Maillard compounds between the reducing sugars in meals and amino acids, particularly Lys (Mauron, 1981). The formation of such compounds, through excessive heating during processing could be the possible reason for low availability of Lys and Met in these meals. Parson *et al.* (1992) found 3% decrease in digestibility of Met in soybean meal with autoclaving. Availability of essential amino acids in cottonseed meal and rapeseed meal was inferior to other meals. Presence of anti-nutritive factors i.e., gossypol or cyclopropene fatty acids in cottonseed meal and erucic acid and glucosinolate in rapeseed meal, which make the protein indigestible to the bird might be the possible reason for low availability of amino acids in these meals.

Animal meals. The amino acid contents and their availability in animal meals are shown in Table III. The availability of the amino acids ranged from 80 to 98% in blood meal, 87 to 96% in fish meal, 82 to 91% in meat meal and 48 to 81% in poultry by-product meal. The availability was highest of Cys in blood meal and fish meal, Phe in meat meal and Met in poultry by-product meal, while of Ile in blood meal, Met in fish meal, Val in meat meal and Cys in poultry by-product meal was the lowest among indispensable amino acids.

The amino acid profile of blood, meat and poultry by-product meals was similar to that reported by Sibbald (1986), Ensminger *et al.* (1990) and Anonymous (1993 & 1996). However, Lys and Arg in local blood meal and Met and Lys in local poultry by-product meal were slightly lower, while, Met, Lys and Try in indigenous meat meal were higher than the reported values. The amino acid contents of fish meal were lower than those reported by Sibbald (1986), Ensminger *et al.* (1990) and Anonymous (1993 & 1996). Low protein content of local fish meal as compared to the reported (61 vs 63-66%) might be the possible reason for low amino acid profile of local fish meal. Slight variation in some amino acids in local as compared to reported animal meals might be due to variation in products source and its processing technique.

Table III. Amino acid contents and their availability in animal meals (% DM basis)

Amino acids	Blood meal	Fish meal	Meat meal	Poultry by-product meal
Met	1.02(90)	1.19(88)	1.10(90)	0.06(81)
Cys	1.08(98)	0.49(96)	0.54(82)	1.87(48)
Lys	7.20(93)	3.30(92)	3.38(88)	2.24(66)
Thr	4.23(93)	1.92(90)	1.98(85)	2.24(66)
Try	1.37(93)	0.47(92)	0.60(87)	0.45(77)
Arg	3.31(93)	3.17(92)	2.60(91)	3.19(73)
Ile	0.99(80)	2.11(89)	1.97(83)	2.22(63)
Leu	10.50(92)	3.77(93)	3.80(87)	4.06(69)
Val	6.99(90)	2.74(89)	2.51(82)	3.18(62)
His	5.20(91)	1.07(88)	1.33(82)	0.85(79)
Phe	5.85(96)	2.06(96)	2.04(91)	2.35(69)
Gly	3.69(-)	5.69(-)	3.36(-)	4.48(-)
Ser	4.29(97)	1.86(92)	1.80(85)	3.90(58)
Pro	3.13(97)	3.60(90)	2.56(84)	4.41(62)
Ala	6.40(90)	4.18(87)	2.98(82)	3.13(75)
Asp	8.75(93)	4.49(87)	4.45(82)	3.92(68)
Glu	7.57(89)	6.78(89)	6.41(86)	6.17(72)

Figures in brackets indicate availability (%)

Availability of all the essential amino acids in blood, fish and meat meals was comparable with the reported (Sibbald, 1986; Ensminger *et al.*, 1990; Anonymous, 1993 & 1996). Availability of most amino acid in poultry by-products meal was lower than the reported ones (Sibbald, 1986; Ensminger *et al.*, 1990; Anonymous, 1993 & 1996. Indigenous poultry by-product meal contained fair amount of feathers, which were not separated during processing. Presence of feathers in the meal which contained indigestible keratin might have reduced the availability of amino acid. The value of Cys particularly in the excreta of both fed and fasted cockerel was erroneous resulting into high availability. Muztar *et al.* (1980) reported that Cys had been found to undergo destruction to varying degrees during HCl hydrolysis. The amount of destruction being essentially inversely proportional to the concentration of Cys in the sample. Moreover, Cys was susceptible to destruction as a result of bacterial action in the chicken excreta. Because excreta contained much less Cys than feed, the relative destruction of this amino acid in excreta was generally greater. Thus, the Cys availability values were probably overestimated. The values of Gly were also much erroneous in excreta and were discounted. Soares *et al.* (1971) reported that uric acid of bird excreta get hydrolysed during analysis resulting into high Gly in excreta samples. It is concluded from the findings of the present study that the amino acid profile and their availability in cereal grains are better, cereal by-products and vegetable meals comparable and animal meals lower than the reported.

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