

**Project Title:** Nutrient Analysis, Metabolisable Energy and Digestible Amino Acids of Soybean meals of Different Origin for Broilers

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**Reference:** Project U11CX31642 (October 31, 2011). U.S. Soybean Export Council, Inc., 16305 Swingley Ridge Road, Suite 200, Chesterfield, MO 63017, USA

### **OVERALL OBJECTIVE**

To conduct surveys to determine nutritional value of soybean meals from different regions, with the aim of differentiating U.S. dehulled soybean meal from competitors. Once sufficient samples are evaluated, the ultimate aim is to develop Near Infra Red Spectroscopy (NIRS) calibrations for metabolizable energy and digestible amino acids specific to soybean meal that can be used by the feed industry to rapidly, efficiently and inexpensively measure the quality of US soybean meal on their premises. Activity also includes continuing refinement of the NIRS project, which will define the energy value and ileal digestible amino acids of US and competition meals.

### **STATEMENT OF WORK**

1. To receive or collect representative samples of soybean meal of different origins from South East Asia, Australia and New Zealand.
2. To analyze 15 representative soybean meal samples for proximate (moisture, crude protein, ash, crude fiber, ether extract), apparent metabolizable energy (AMEn) for broilers, ileal digestible amino acids for broilers, contents of sugar, reactive lysine, neutral detergent fiber (NDF) and non starch polysaccharides (NSP), protein solubility index and urease activity.
3. To provide a report of analysis to include 'Materials and Methods' and 'Summary of Analysis'.
4. To properly store and keep the identity of soybean meal samples so that specific Near Infra Red Spectroscopy (NIRS) calibrations can be developed in the future.

### **MATERIALS AND METHODS**

Shipments of a total of 14 soybean meal samples and one full-fat soybean (30 kg each) were received and the details of these samples are identified in Table 1. Upon receipt at Massey University, the samples were identified by codes, thoroughly mixed and representative samples (three sets of 1 kg each) were obtained. Two sets of samples are stored at -20 C for future use and one set was ground to pass through a 1-mm screen and used for laboratory analysis.

The nutritional evaluation of samples was carried out in three phases, namely, (i) laboratory evaluation, (ii) AME assay and (iii) ileal digestible amino acid assay. The experimental procedures for animal trials were approved by the Massey University Animal Ethics Committee and, complied with the New Zealand Code of Practice for the Care and Use of Animals for Scientific Purposes.

### **PHASE 1 – LABORATORY EVALUATION**

The samples (Table 1) were analysed for dry matter, crude protein, crude fat, NDF, ash, NSP, sucrose, amino acids, reactive lysine, urease test and KOH protein solubility. All analyses were performed in duplicates.

**Table 1.** Description of soybean meal samples assayed

Sample no	Origin	Source of sample	of Sample/ shipping code
1	India	New Zealand	IND-NZ-Tegel-25/05/2011
2	Argentina	New Zealand	ARG Cargill-NZ-Tegel- 25/05/2011
3	Argentina	New Zealand	ARG Mollinos-NZ-Tegel- 29/05/2011
4	Brazil	Thailand	BZ-SMB-DH-TH-CP-01-A-01/06/2011
5	India	Thailand	IND-SMB-DH-TH-CP-02-B-01/06/2011
6	USA	Philippines	US-DH-SBM-PHL-URC01-07/06/2011
7	USA	Philippines	US-DH-SBM-PHL-SFM1-02-08/06/2011
8	USA	Philippines	US-SBM-DH-LFUG-PHL-LFU6-04-10/06/2011
9	Argentina	Philippines	ARG-DH-SBM-PHL-SMF1 03-08/06/2011
10	India	Indonesia	IND-SBM-NDH-INDO SIERAD- 01B- 08/06/2011
11 <sup>1</sup>	Not known	Indonesia	FFSBM-INDO SIERAD-01A- 08/06/2011
12	Brazil	Indonesia	BRZ-SBM-INDO JAPFA-01-15/06/2011
13	Argentina	Indonesia	ARG-SBM-INDO SINTA-01A-14/06/2011
14	India	New Zealand	IND-SBM-NZ-Ingham--01/05/11
15	Brazil	New Zealand	BRA-DH-NZ-Ingham-01/05/11

<sup>1</sup> Full-fat soybean sample.

**Proximate and fiber composition:** The dry matter, crude protein, crude fat, NDF and ash contents were determined using standard procedures (AOAC, 2005). Nitrogen (N) content was determined by the combustion method using a CNS-2000 carbon, nitrogen and sulphur analyser (LECO® Corporation, St. Joseph, Michigan, USA). The crude protein content was calculated as N x 5.71.

**Sugar content:** The samples were first treated with hydroxylamine hydrochloride and the resulting oximes are converted to the trimethylsilyl (TMS) derivatives by the addition of hexamethyldisilazane and trifluoroacetic acid. The volatile derivatives are analysed by gas liquid chromatography with flame ionisation detector. Quantitation is by multipoint internal calibration.

**NSP analysis:** Total, soluble and insoluble NSP were analysed using an assay kit (Englyst Fiberzyme Kit GLC, Englyst Carbohydrate Services Limited, Cambridge, UK) based on the procedures described by Englyst et al. (1994).

**Amino acid analysis:** Amino acids were determined as described by Ravindran et al. (2009). Briefly, the samples were hydrolysed with 6N HCl (containing phenol) for 24 h at  $110 \pm 2$  °C in glass tubes sealed under vacuum. Amino acids were detected on a Waters ion-exchange HPLC system, and the chromatograms were integrated using dedicated software (Millenium, Version 3.05.01, Waters, Millipore, Milford, MA) with the amino acids identified and quantified using a standard amino acid mixture (Product no. A2908, Sigma, St. Louis, MO). The HPLC system consisted of an ion-exchange column, two 510 pumps, Waters 715 ultraWISP sample processor, a column heater, a post column reaction coil heater, a ninhydrin pump and a dual wavelength detector. Amino acids were eluted by a gradient of pH 3.3 sodium citrate eluent to pH 9.8 sodium borate eluent at a flow rate of 0.4 ml/ min and a column temperature of 60 °C. Cysteine and methionine were analysed as cysteic acid

and methionine sulphone, respectively, by oxidation with performic acid for 16h at 0 °C and neutralization with hydrobromic acid prior to hydrolysis.

**Reactive lysine content:** reactive lysine contents were determined according to the procedures of Moughan and Rutherford (1996). Briefly, the soybean meal is guanidinated by reacting with O-methylisourea. During this reaction, the  $\epsilon$ -amino (side chain) group of lysine is converted to homoarginine, which is analysed by HPLC.

**Urease index:** Urease activity was determined as the urease index, which is based on change in pH (AOAC, 1980).

**KOH protein solubility:** Protein solubility in potassium hydroxide was determined using the procedures of Araba and Dale (1990).

## PHASE 2 – APPARENT METABOLIZABLE ENERGY ASSAY

### Diets

The AME of soybean meal was determined by the difference method. In this method, a corn-soy basal diet was formulated (Table 2) and 15 test diets, each containing different soybean meal samples, were developed by replacing (w/w) 30% of the basal diet with soybean meal. Thus, a total of 16 diets were assayed.

**Table 2.** Percentage composition of the basal diet used in the AME assay

Ingredient	%
Corn	59.00
Soybean meal	35.18
Vegetable oil	1.78
Dicalcium phosphate	2.17
Limestone	0.78
Salt	0.20
Sodium bicarbonate	0.23
Trace mineral premix	0.25
Vitamin premix	0.05

*Assay procedures-* Day-old male broilers (Ross 308), obtained from a commercial hatchery, were raised in floor pens and fed a commercial broiler starter diets (230 g/kg crude protein) till day 21. Feed and water were available at all times. The temperature was maintained at 32 °C during the first week and gradually decreased to approximately 23 °C by the end of the third week. Ventilation was controlled by a central ceiling extraction fan and wall inlet ducts. On day 21, 320 birds of uniform body weight were selected and randomly assigned to 64 cages (5 birds per cage) and four replicate cages were randomly assigned to each of the 16 assay diets.

The AME assay was conducted by the classical total excreta collection method. The diets, in mash form, were fed for 8 days, with the first 4 days serving as an adaptation period. During the last 4 days, feed intake was monitored, and the excreta were collected daily, weighed and pooled within a cage. Pooled excreta were mixed well in a blender and, representative samples were obtained and freeze-dried. Dried excreta samples were ground to pass through a 0.5 mm sieve and stored in airtight plastic containers at - 4 °C for laboratory analyses. The dry matter, gross energy (GE) and nitrogen (N) of the diet and excreta samples were determined.

### Chemical analysis

Dry matter and N contents were determined as described previously. GE was determined using an adiabatic bomb calorimeter (Gallenkamp Autobomb, UK) standardised with benzoic acid.

### Calculations

The AME of soybean meals were calculated using the following formulas:

$$\text{AME}_{\text{diet}} (\text{MJ/kg}) = \frac{(\text{feed intake} \times \text{GE}_{\text{diet}}) - (\text{excreta output} \times \text{GE}_{\text{excreta}})}{\text{Total feed intake}}$$

$$\text{AME}_{\text{SBM}} (\text{MJ/kg}) = \frac{\text{AME of soybean meal diet} - (\text{AME basal diet} \times 0.70)}{0.30}$$

Correction for zero nitrogen retention was made using a factor of 36.54 kJ per gram nitrogen retained in the body and N-corrected AME was calculated.

### PHASE 3 – ILEAL AMINO ACID DIGESTIBILITY ASSAY

Total of 15 assay diets, based on dextrose and soybean meal, as the only source of protein were formulated to supply 18% crude protein in the diet (An example of assay diet is given in Table 3). All diets contained titanium oxide as an indigestible marker. Each diet was offered *ad libitum* to four cages (5 birds per cage) of male broilers from 28 to 33 days of age. On day 33 post-hatch, all birds were euthanized by an intracardial injection of sodium pentobarbitone solution (1 ml per 2 kg live weight), and the contents of the lower half of the ileum were collected by gently flushing with distilled water into plastic containers. Digesta samples were pooled within a cage. The ileum was defined as the portion of the small intestine extending from vitelline diverticulum to a point 40 mm proximal to the ileo-caecal junction. The digesta samples were processed as described by Ravindran et al. (2005). The digesta were frozen at -20 °C in airtight containers immediately after collection and subsequently freeze-dried. The digesta samples, as well as samples of ingredients and diets, were then ground to pass through 0.5-mm sieve and stored in airtight plastic containers. The diet and digesta samples were then analysed for dry matter, titanium oxide and amino acids, while ingredient samples were analysed for dry matter and amino acids.

**Table 3.** Percentage composition of the assay diet

Ingredient	
Soybean meal	41.60
Dextrose	52.50
Soybean oil	2.00
Titanium oxide	0.30
Sodium bicarbonate	0.20
Dicalcium phosphate	1.90
Limestone	1.00
Trace mineral premix	0.25
Vitamin premix	0.05
Salt	0.20

### Chemical Analysis

Dry matter and amino acid concentrations were determined as described previously. For the titanium oxide determination, the samples were first ignited at 500 °C to burn all organic material and the remaining minerals were digested (using 66 % sulphuric acid) to release titanium which was then determined using a colorimetric assay (Short et al., 1996)

#### Calculations

Apparent ileal amino acid digestibility coefficients were calculated from the dietary ratio of amino acid to titanium relative to the corresponding ratio in the ileal digesta.

$$\text{Amino acid digestibility coefficient} = \frac{(\text{AA} / \text{Ti})_d - (\text{AA} / \text{Ti})_i}{(\text{AA} / \text{Ti})_d}$$

where,  $(\text{AA} / \text{Ti})_d$  = ratio of amino acid to titanium in diet and  $(\text{AA} / \text{Ti})_i$  = ratio of amino acid to titanium in ileal digesta.

Apparent digestibility data were converted to standardized values, using basal endogenous AA values from birds fed nitrogen-free diet method. Endogenous AA flow was determined in a cohort assay as described by Ravindran et al. (2009).

$$\text{SID (\%)} = \text{AID (\%)} + \left[ \frac{\text{Basal EAA (g/kg DMI)}}{\text{Ing. AA (g/kg DM)}} \right] \times 100$$

Where, AID = % apparent ileal digestibility of the amino acid

Basal EAA = Basal endogenous of the amino acid

Ing. AA = Concentration of the amino acid in the ingredient

## RESULTS

The results are presented in 'dry matter basis' to enable comparison between samples of different origin. 'As received basis' values are also given as these are the values used in feed formulation matrices and by the feed industry. Data are summarised as shown below:

**Tables 4-9. Chemical composition and protein quality measures** (Data according to origin of soybean meal samples (US, India, Argentina, Brazil) and the full-fat soybean, and the overall comparative summary).

**Tables 10-15. Apparent metabolisable energy** (Data according to origin of soybean meal samples (US, India, Argentina, Brazil) and the full-fat soybean, and the overall comparative summary).

**Tables 16-20. Amino acid concentrations (including reactive lysine)** (Data according to origin of soybean meal samples (US, India, Argentina, Brazil) and the full-fat soybean, and the overall comparative summary).

**Tables 22-27. Amino acid profiles (expressed as % crude protein)** (Data according to origin of soybean meal samples (US, India, Argentina, Brazil) and the full-fat soybean, and the overall comparative summary).

**Tables 28-33. Standardised ileal amino acid digestibility** (Data according to origin of soybean meal samples (US, India, Argentina, Brazil) and the full-fat soybean, and the overall comparative summary.

**Table 34. Ileal endogenous amino acid flow values** (Determined in the current evaluation following feeding of a protein-free diet and used in the correction of apparent amino acid digestibility values to standardised values.

**Table 4.** Chemical composition (%; mean  $\pm$  SD) and protein quality measures of the three US soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	6	7	8	
<b>Dry matter basis</b>				
Dry matter	88.0	88.3	88.2	88.2 $\pm$ 0.14
Crude protein	54.2	53.2	54.5	54.0 $\pm$ 0.68
Crude fat	1.5	1.7	1.5	1.6 $\pm$ 0.15
Crude fiber	4.0	4.4	4.5	4.3 $\pm$ 0.25
Ash	7.5	7.3	7.6	7.5 $\pm$ 0.16
NFE	38.4	33.3	31.9	34.5 $\pm$ 3.40
NDF	7.7	8.0	7.9	7.9 $\pm$ 0.16
Sugar	7.8	8.3	7.7	7.9 $\pm$ 0.32
Insoluble NSP	17.8	14.76	15.47	16.0 $\pm$ 1.58
Soluble NSP	3.0	2.67	2.07	2.6 $\pm$ 0.47
Total NSP	20.8	17.43	17.54	18.6 $\pm$ 1.91
<b>As received basis</b>				
Crude protein	47.7	47.0	48.1	47.6 $\pm$ 0.55
Crude fat	1.3	1.5	1.3	1.4 $\pm$ 0.13
Crude fiber	3.6	3.9	4.0	3.8 $\pm$ 0.22
Ash	6.6	6.5	6.7	6.6 $\pm$ 0.13
NFE	33.8	29.4	28.1	30.4 $\pm$ 2.95
NDF	6.8	7.1	6.9	6.9 $\pm$ 0.15
Sugar	6.9	7.3	6.8	7.0 $\pm$ 0.29
Insoluble NSP	15.7	13.0	13.6	14.1 $\pm$ 1.37
Soluble NSP	2.6	2.4	1.8	2.3 $\pm$ 0.42
Total NSP	18.3	15.4	15.5	16.4 $\pm$ 1.66
<b>Protein quality measures</b>				
Urease Index	0.16	0.09	0.08	0.11 $\pm$ 0.04
Protein solubility	78.5	76.3	79.5	78.1 $\pm$ 1.65

<sup>1</sup> See Table 1 for sample description.

**Table 5.** Chemical composition (%; mean  $\pm$  SD) and protein quality measures of the four Indian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	1	5	10	14	
<b>Dry matter basis</b>					
Dry matter	87.7	88.3	88.8	89.2	88.5 $\pm$ 0.59
Crude protein	52.3	52.8	49.6	50.8	51.4 $\pm$ 1.72
Crude fat	0.7	1.4	1.0	1.3	1.1 $\pm$ 0.36
Crude fiber	5.8	5.0	7.8	6.7	6.3 $\pm$ 1.44
Ash	8.0	7.5	7.4	7.8	7.7 $\pm$ 0.30
NFE	33.3	33.4	34.2	33.5	33.6 $\pm$ 0.51
NDF	11.5	9.4	16.0	12.6	12.3 $\pm$ 3.37
Sugar	4.8	5.0	5.2	5.1	5.0 $\pm$ 0.20
Insoluble NSP	19.90	20.77	20.45	20.54	20.4 $\pm$ 0.44
Soluble NSP	2.03	2.15	2.85	2.45	2.4 $\pm$ 0.44
Total NSP	21.93	22.91	23.29	22.99	22.8 $\pm$ 0.71
<b>As received basis</b>					
Crude protein	45.8	46.6	44.1	45.3	45.5 $\pm$ 1.32
Crude fat	0.6	1.2	0.9	1.1	1.0 $\pm$ 0.32
Crude fiber	5.1	4.4	6.9	5.9	5.6 $\pm$ 1.30
Ash	7.0	6.6	6.6	6.9	6.8 $\pm$ 0.22
NFE	29.2	29.5	30.4	29.9	29.7 $\pm$ 0.63
NDF	10.0	8.3	14.2	11.2	10.9 $\pm$ 3.04
Sugar	4.2	4.4	4.6	4.6	4.4 $\pm$ 0.21
Insoluble NSP	17.4	18.3	18.2	18.3	18.1 $\pm$ 0.48
Soluble NSP	1.8	1.9	2.5	2.2	2.1 $\pm$ 0.40
Total NSP	19.2	20.2	20.7	20.5	20.2 $\pm$ 0.75
<b>Protein quality measures</b>					
Urease Index	0.16	0.05	0.02	0.06	0.07 $\pm$ 0.07
Protein solubility	71.8	78.4	63.1	66.50	70.0 $\pm$ 7.66

<sup>1</sup>See Table 1 for sample description.

**Table 6.** Chemical composition (% dry matter basis; mean  $\pm$  SD) and protein quality measures of the four Argentinian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	2	3	9	13	
<b>Dry matter basis</b>					
Dry matter	87.8	88.2	88.9	89.0	88.5 $\pm$ 0.53
Crude protein	50.8	52.3	52.9	51.0	51.8 $\pm$ 1.08
Crude fat	2.0	2.3	1.8	2.1	2.1 $\pm$ 0.25
Crude fiber	3.5	4.4	3.9	4.8	4.1 $\pm$ 0.42
Ash	6.9	7.0	6.7	6.8	6.8 $\pm$ 0.14
NFE	36.8	34.0	34.7	35.3	35.2 $\pm$ 1.46
NDF	7.6	7.5	9.1	8.1	8.1 $\pm$ 0.92
Sugar	7.7	7.6	7.2	7.6	7.5 $\pm$ 0.26
Insoluble NSP	18.64	19.83	16.77	16.41	17.9 $\pm$ 1.54
Soluble NSP	1.64	1.28	1.04	1.59	1.4 $\pm$ 0.30
Total NSP	20.28	21.11	17.81	18.01	19.3 $\pm$ 1.72
<b>As received basis</b>					
Crude protein	44.6	46.1	47.0	45.4	45.8 $\pm$ 1.21
Crude fat	1.8	2.1	1.6	1.9	1.8 $\pm$ 0.22
Crude fiber	3.1	3.8	3.4	4.2	3.7 $\pm$ 0.37
Ash	6.0	6.2	5.9	6.1	6.0 $\pm$ 0.10
NFE	32.3	30.0	30.8	31.4	31.1 $\pm$ 1.19
NDF	6.7	6.6	8.1	7.2	7.2 $\pm$ 0.86
Sugar	6.8	6.7	6.4	6.8	6.7 $\pm$ 0.20
Insoluble NSP	16.4	17.5	14.9	14.6	15.8 $\pm$ 1.29
Soluble NSP	1.4	1.1	0.9	1.4	1.2 $\pm$ 0.26
Total NSP	17.8	18.6	15.8	16.0	17.1 $\pm$ 1.43
Urease Index	0.00	0.00	0.02	0.01	0.01 $\pm$ 0.01
Protein solubility	68.6	68.8	66.6	74.2	69.6 $\pm$ 1.24

<sup>1</sup>See Table 1 for sample description.



**Table 7.** Chemical composition (%; mean  $\pm$  SD) and protein quality measures of the three Brazilian soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	4	12	15	
<b>Dry matter basis</b>				
Dry matter	87.8	88.1	88.6	88.2 $\pm$ 0.40
Crude protein	52.6	52.1	51.2	52.0 $\pm$ 0.69
Crude fat	2.1	2.2	2.3	2.2 $\pm$ 0.11
Crude fiber	4.3	4.3	4.2	4.3 $\pm$ 0.09
Ash	6.6	6.6	6.8	6.7 $\pm$ 0.12
NFE	34.4	34.7	35.5	34.9 $\pm$ 0.55
NDF	7.0	7.7	7.6	7.4 $\pm$ 0.40
Sugar	6.3	6.0	6.1	6.1 $\pm$ 0.15
Insoluble NSP	18.27	15.75	18.12	17.4 $\pm$ 1.41
Soluble NSP	1.58	1.23	1.48	1.4 $\pm$ 0.18
Total NSP	19.85	16.98	19.6	18.8 $\pm$ 1.59
<b>As received basis</b>				
Crude protein	46.2	45.9	45.4	45.8 $\pm$ 0.40
Crude fat	1.9	2.0	2.1	2.0 $\pm$ 0.10
Crude fiber	3.8	3.8	3.7	3.8 $\pm$ 0.07
Ash	5.8	5.8	6.0	5.9 $\pm$ 0.13
NFE	30.2	30.6	31.4	30.7 $\pm$ 0.63
NDF	6.1	6.8	6.7	6.5 $\pm$ 0.37
Sugar	5.5	5.3	5.4	5.4 $\pm$ 0.12
Insoluble NSP	16.0	13.9	16.1	15.3 $\pm$ 1.25
Soluble NSP	1.4	1.1	1.3	1.3 $\pm$ 0.16
Total NSP	17.4	15.0	17.4	16.6 $\pm$ 1.41
<b>Protein quality measures</b>				
Urease Index	0	0	0	0
Protein solubility	73.4	73.9	70.6	72.6 $\pm$ 1.77

<sup>1</sup> See Table 1 for sample description.

**Table 8.** Chemical composition (%) and protein quality measures of a sample of full-fat soybean<sup>1</sup>

<b>Dry matter basis</b>	
Dry matter	91.4
Crude protein	38.5
Crude fat	20.1
Crude fiber	7.6
Ash	5.1
NFE	28.7
NDF	21.8
Sugar	6.8
Insoluble NSP	18.75
Soluble NSP	1.00
Total NSP	19.75
<b>As received basis</b>	
Crude protein	35.2
Crude fat	18.3
Crude fiber	7.0
Ash	4.7
NFE	26.2
NDF	19.9
Sugar	6.2
Insoluble NSP	17.1
Soluble NSP	0.9
Total NSP	18.0
<b>Protein quality measures</b>	
Urease Index	0.26
Protein solubility	63.1

<sup>1</sup> Sample no. 15; see Table 1 for sample description.

**Table 9.** Overall summary - Comparison of average nutrient contents and protein quality measures of soybean samples of different origin and a sample of full-fat soybeans

	<b>US</b>	<b>India</b>	<b>Argentina</b>	<b>Brazil</b>	<b>Full-fat soy</b>
<b>No of samples</b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>3</b>	<b>1</b>
<b>Dry matter basis</b>					
Dry matter	88.2	88.5	88.5	88.2	91.4
Crude protein	54.0	51.4	51.8	52.0	38.5
Crude fat	1.6	1.1	2.1	2.2	20.1
Crude fiber	4.3	6.3	4.1	4.3	7.6
Ash	7.5	7.7	6.8	6.7	5.1
NFE	34.5	33.6	35.2	34.9	28.7
NDF	7.9	12.3	8.1	7.4	21.8
Sugar	7.9	5.0	7.5	6.1	6.8
Insoluble NSP	16.0	20.4	17.9	17.4	18.75
Soluble NSP	2.6	2.4	1.4	1.4	1.00
Total NSP	18.6	22.8	19.3	18.8	19.75
<b>As received basis</b>					
Crude protein	47.6	45.5	45.8	45.8	35.2
Crude fat	1.4	1.0	1.8	2.0	18.3
Crude fiber	3.8	5.6	3.7	3.8	7.0
Ash	6.6	6.8	6.0	5.9	4.7
NFE	30.4	29.7	31.1	30.7	26.2
NDF	6.9	10.9	7.2	6.5	19.9
Sugar	7.0	4.4	6.7	5.4	6.2
Insoluble NSP	14.1	18.1	15.8	15.3	17.1
Soluble NSP	2.3	2.1	1.2	1.3	0.9
Total NSP	16.4	20.2	17.1	16.6	18.0
<b>Protein quality measures</b>					
Urease Index	0.11	0.07	0.01	0	0.26
Protein solubility	78.1	70.0	69.6	72.6	63.1

**Table 10.** Apparent metabolizable energy (AME) and nitrogen corrected AME (AMEn) (kcal/kg) for poultry of the three US soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	6	7	8	
<b>Dry matter basis</b>				
AME	2729	2714	2816	2753 $\pm$ 55
AMEn	2406	2425	2464	2432 $\pm$ 29
<b>As received basis</b>				
AME	2407	2397	2484	2429 $\pm$ 48
AMEn	2122	2141	2173	2146 $\pm$ 26

<sup>1</sup> See Table 1 for sample description.**Table 11.** Apparent metabolizable energy (AME) and nitrogen corrected AME (AMEn) (kcal/kg) for poultry of the four Indian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	1	5	10	14	
<b>Dry matter basis</b>					
AME	2522	2370	2296	2577	2442 $\pm$ 131
AMEn	2253	2044	1881	2234	2103 $\pm$ 176
<b>As received basis</b>					
AME	2212	2093	2039	2299	2161 $\pm$ 117
AMEn	1976	1805	1670	1993	1861 $\pm$ 153

<sup>1</sup> See Table 1 for sample description.**Table 12.** Apparent metabolizable energy (AME) and nitrogen corrected AME (AMEn) (kcal/kg) for poultry of the four Argentinian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	2	3	9	13	
<b>Dry matter basis</b>					
AME	2618	2688	2709	2719	2683 $\pm$ 45
AMEn	2315	2493	2351	2389	2387 $\pm$ 77
<b>As received basis</b>					
AME	2299	2370	2409	2350	2357 $\pm$ 46
AMEn	2033	2199	2090	2126	2112 $\pm$ 70

<sup>1</sup> See Table 1 for sample description.

**Table 13.** Apparent metabolizable energy (AME) and nitrogen corrected AME (AMEn) (kcal/kg) for poultry of the three Brazilian soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	4	12	15	
<b>Dry matter basis</b>				
AME	2720	2751	2697	2723 $\pm$ 27
AMEn	2411	2430	2401	2414 $\pm$ 15
<b>As received basis</b>				
AME	2388	2423	2390	2400 $\pm$ 20
AMEn	2116	2141	2127	2128 $\pm$ 12

<sup>1</sup>See Table 1 for sample description.

**Table 14.** Apparent metabolizable energy (AME) and nitrogen corrected AME (AMEn) (kcal/kg) for poultry of a sample of full-fat soybean<sup>1</sup>

<b>Dry matter basis</b>	
AME	3943
AMEn	3675
<b>As received basis</b>	
AME	3604
AMEn	3359

<sup>1</sup>Sample no. 15; see Table 1 for sample description.

**Table 15.** Overall summary - Comparison of apparent metabolizable energy (AME) and nitrogen corrected AME (AMEn) (kcal/kg) for poultry of soybean samples of different origin and a sample of full-fat soybeans

	US	India	Argentine	Brazil	Full-fat soy
<b>No of samples</b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>3</b>	<b>1</b>
<b>Dry matter basis</b>					
AME	2753	2442	2683	2723	3943
AMEn	2432	2103	2387	2414	3675
<b>As received basis</b>					
AME	2429	2161	2357	2400	3604
AMEn	2146	1861	2112	2128	3359

**Table 16.** Amino acid concentrations (% as received basis) of the three US soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	6	7	8	
Crude protein	47.7	47.0	48.1	47.6 $\pm$ 0.55
Aspartic Acid	5.57	5.53	5.47	5.52 $\pm$ 0.05
Threonine	1.84	1.86	1.82	1.84 $\pm$ 0.02
Serine	2.14	2.23	2.15	2.17 $\pm$ 0.05
Glutamic Acid	7.68	8.01	8.08	7.93 $\pm$ 0.21
Proline	2.16	2.27	2.15	2.20 $\pm$ 0.07
Glycine	1.88	1.90	1.85	1.87 $\pm$ 0.03
Alanine	1.93	1.89	1.89	1.90 $\pm$ 0.02
Valine	2.36	2.51	2.46	2.44 $\pm$ 0.07
Isoleucine	2.24	2.16	2.30	2.23 $\pm$ 0.07
Leucine	3.57	3.70	3.60	3.63 $\pm$ 0.07
Tyrosine	1.86	1.71	1.71	1.76 $\pm$ 0.09
Phenylalanine	2.52	2.45	2.39	2.45 $\pm$ 0.06
Histidine	1.25	1.35	1.30	1.30 $\pm$ 0.05
Lysine	2.99	3.10	3.18	3.09 $\pm$ 0.10
Arginine	3.45	3.36	3.44	3.42 $\pm$ 0.05
Cysteine	0.81	0.76	0.79	0.79 $\pm$ 0.03
Methionine	0.74	0.68	0.70	0.70 $\pm$ 0.03
Reactive lysine	2.76	2.83	2.84	2.81 $\pm$ 0.04
As % total lysine	92.5	91.3	89.3	91.1 $\pm$ 1.65

<sup>1</sup> See Table 1 for sample description.

**Table 17.** Amino acid concentration (% , as received basis) of the four Indian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	1	5	10	14	
Crude protein	45.8	46.6	44.1	45.3	45.5 $\pm$ 1.32
Aspartic Acid	5.85	5.92	5.52	5.55	5.71 $\pm$ 0.21
Threonine	1.79	1.68	1.65	1.63	1.69 $\pm$ 0.07
Serine	2.30	2.17	2.09	1.98	2.14 $\pm$ 0.13
Glutamic Acid	8.40	8.10	8.44	8.56	8.37 $\pm$ 0.20
Proline	2.14	2.25	2.04	2.32	2.19 $\pm$ 0.12
Glycine	1.96	2.03	1.89	1.93	1.95 $\pm$ 0.06
Alanine	1.80	1.80	1.79	1.83	1.80 $\pm$ 0.02
Valine	2.03	2.18	2.12	2.09	2.11 $\pm$ 0.06
Isoleucine	2.14	2.05	2.26	2.24	2.17 $\pm$ 0.10
Leucine	3.18	3.56	3.26	3.40	3.35 $\pm$ 0.17
Tyrosine	1.80	1.79	1.60	1.59	1.69 $\pm$ 0.12
Phenylalanine	2.46	2.37	2.41	2.31	2.39 $\pm$ 0.06
Histidine	1.35	1.16	1.27	1.21	1.25 $\pm$ 0.08
Lysine	2.71	2.82	2.76	2.91	2.80 $\pm$ 0.08
Arginine	3.37	3.19	3.17	3.45	3.29 $\pm$ 0.14
Cysteine	0.72	0.66	0.66	0.69	0.68 $\pm$ 0.03
Methionine	0.68	0.66	0.64	0.61	0.64 $\pm$ 0.03
Reactive lysine	2.40	2.45	2.48	2.51	2.46 $\pm$ 0.04
As % total lysine	88.7	86.6	89.7	86.3	87.8 $\pm$ 1.62

<sup>1</sup>See Table 1 for sample description.

**Table 18.** Amino acid concentration (% as received basis) of the four Argentinian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	2	3	9	13	
Crude protein	44.6	46.1	47.0	45.4	45.8 $\pm$ 1.21
Aspartic Acid	5.54	5.67	5.69	5.52	5.60 $\pm$ 0.08
Threonine	1.79	1.69	1.73	1.83	1.76 $\pm$ 0.06
Serine	2.14	2.18	2.17	2.11	2.15 $\pm$ 0.03
Glutamic Acid	8.05	8.36	8.57	8.14	8.28 $\pm$ 0.23
Proline	2.30	2.16	2.04	1.95	2.11 $\pm$ 0.15
Glycine	1.80	2.02	1.90	1.96	1.92 $\pm$ 0.10
Alanine	1.90	1.96	1.98	1.92	1.94 $\pm$ 0.03
Valine	2.17	2.23	2.18	2.26	2.21 $\pm$ 0.04
Isoleucine	2.20	2.24	2.18	2.07	2.18 $\pm$ 0.07
Leucine	3.38	3.41	3.28	3.47	3.38 $\pm$ 0.08
Tyrosine	1.69	1.86	1.69	1.80	1.76 $\pm$ 0.08
Phenylalanine	2.50	2.59	2.60	2.51	2.55 $\pm$ 0.05
Histidine	1.24	1.34	1.27	1.29	1.29 $\pm$ 0.04
Lysine	2.92	2.86	2.70	2.77	2.81 $\pm$ 0.10
Arginine	3.42	3.35	3.26	3.57	3.40 $\pm$ 0.13
Cysteine	0.67	0.73	0.70	0.71	0.70 $\pm$ 0.03
Methionine	0.64	0.66	0.62	0.59	0.62 $\pm$ 0.03
Reactive lysine	2.62	2.57	2.46	2.50	2.54 $\pm$ 0.07
As % total lysine	89.6	90.1	91.1	90.5	90.3 $\pm$ 0.62

<sup>1</sup>See Table 1 for sample description.



**Table 19.** Amino acid concentrations (% as received basis) of the three Brazilian soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	4	12	15	
Crude protein	46.2	45.9	45.4	45.8 $\pm$ 0.40
Aspartic Acid	5.85	5.81	5.26	5.64 $\pm$ 0.33
Threonine	1.72	1.81	1.76	1.76 $\pm$ 0.04
Serine	2.17	2.16	2.06	2.13 $\pm$ 0.06
Glutamic Acid	8.08	7.79	8.12	8.00 $\pm$ 0.18
Proline	2.15	2.25	2.26	2.22 $\pm$ 0.06
Glycine	2.00	1.88	1.93	1.94 $\pm$ 0.06
Alanine	1.99	2.00	2.12	2.04 $\pm$ 0.07
Valine	2.08	2.12	2.35	2.18 $\pm$ 0.15
Isoleucine	2.15	2.13	2.08	2.12 $\pm$ 0.04
Leucine	3.49	3.51	3.61	3.54 $\pm$ 0.06
Tyrosine	1.86	1.88	1.55	1.76 $\pm$ 0.18
Phenylalanine	2.74	2.68	2.34	2.58 $\pm$ 0.21
Histidine	1.14	1.23	1.30	1.22 $\pm$ 0.08
Lysine	2.94	2.89	2.76	2.86 $\pm$ 0.09
Arginine	3.27	3.37	3.29	3.31 $\pm$ 0.06
Cysteine	0.80	0.71	0.66	0.72 $\pm$ 0.07
Methionine	0.68	0.57	0.60	0.62 $\pm$ 0.05
Reactive lysine	2.61	2.63	2.50	2.58 $\pm$ 0.07
As % total lysine	88.6	91.0	90.4	90.0 $\pm$ 1.22

<sup>1</sup> See Table 1 for sample description.

**Table 20.** Amino acid concentration (% , as received basis) of a sample of full-fat soybean<sup>1</sup>

Crude protein	35.2
Aspartic Acid	4.03
Threonine	1.40
Serine	1.66
Glutamic Acid	6.43
Proline	1.88
Glycine	1.57
Alanine	1.48
Valine	2.01
Isoleucine	1.76
Leucine	2.49
Tyrosine	1.36
Phenylalanine	1.80
Histidine	0.96
Lysine	2.36
Arginine	2.65
Cysteine	0.56
Methionine	
Reactive lysine	1.93
As % total lysine	81.9

<sup>1</sup> Sample no. 15; see Table 1 for sample description.

**Table 21.** Overall summary - Comparison of average amino acid concentration (% , as received basis) of soybean samples of different origin and a sample of full-fat soybeans

	US	India	Argentina	Brazil	Full-fat soy
No of samples	3	4	4	3	1
Crude protein	47.6	45.5	45.8	45.8	35.2
Aspartic Acid	5.52	5.71	5.60	5.64	4.03
Threonine	1.84	1.69	1.76	1.76	1.40
Serine	2.17	2.14	2.15	2.13	1.66
Glutamic Acid	7.93	8.37	8.28	8.00	6.43
Proline	2.20	2.19	2.11	2.22	1.88
Glycine	1.87	1.95	1.92	1.94	1.57
Alanine	1.90	1.80	1.94	2.04	1.48
Valine	2.44	2.11	2.21	2.18	2.01
Isoleucine	2.23	2.17	2.18	2.12	1.76
Leucine	3.63	3.35	3.38	3.54	2.49
Tyrosine	1.76	1.69	1.76	1.76	1.36
Phenylalanine	2.45	2.39	2.55	2.58	1.80
Histidine	1.30	1.25	1.29	1.22	0.96
Lysine	3.09	2.80	2.81	2.86	2.36
Arginine	3.42	3.29	3.40	3.31	2.65
Cysteine	0.79	0.68	0.70	0.72	0.56
Methionine	0.70	0.64	0.62	0.62	0.50
Reactive lysine	2.81	2.46	2.54	2.58	1.93
As % total lysine	91.1	87.8	90.3	90.0	81.9

**Table 22.** Amino acid profile (% crude protein basis) of the three US soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	6	7	8	
Aspartic Acid	11.7	11.8	11.4	11.6 $\pm$ 0.21
Threonine	3.9	4.0	3.8	3.9 $\pm$ 0.09
Serine	4.5	4.8	4.5	4.6 $\pm$ 0.16
Glutamic Acid	16.1	17.1	16.8	16.7 $\pm$ 0.49
Proline	4.5	4.8	4.5	4.6 $\pm$ 0.20
Glycine	3.9	4.0	3.8	3.9 $\pm$ 0.10
Alanine	4.0	4.0	3.9	4.0 $\pm$ 0.06
Valine	4.9	5.3	5.1	5.1 $\pm$ 0.20
Isoleucine	4.7	4.6	4.8	4.7 $\pm$ 0.09
Leucine	7.5	7.9	7.5	7.6 $\pm$ 0.22
Tyrosine	3.9	3.6	3.6	3.7 $\pm$ 0.18
Phenylalanine	5.3	5.2	5.0	5.2 $\pm$ 0.16
Histidine	2.6	2.9	2.7	2.7 $\pm$ 0.13
Lysine	6.3	6.6	6.6	6.5 $\pm$ 0.20
Arginine	7.2	7.2	7.2	7.2 $\pm$ 0.04
Cysteine	3.1	2.9	3.1	3.0 $\pm$ 0.10
Methionine	1.5	1.4	1.5	1.5 $\pm$ 0.05

<sup>1</sup>See Table 1 for sample description.

**Table 23.** Amino acid profile (% crude protein basis) of the four Indian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	1	5	10	14	
Aspartic Acid	12.8	12.7	12.5	12.3	12.6 $\pm$ 0.23
Threonine	3.9	3.6	3.7	3.6	3.7 $\pm$ 0.14
Serine	5.0	4.7	4.8	4.4	4.7 $\pm$ 0.26
Glutamic Acid	18.3	17.4	19.2	18.9	18.4 $\pm$ 0.80
Proline	4.7	4.8	4.6	5.1	4.8 $\pm$ 0.22
Glycine	4.3	4.3	4.3	4.3	4.3 $\pm$ 0.04
Alanine	3.9	3.9	4.1	4.0	4.0 $\pm$ 0.09
Valine	4.4	4.7	4.8	4.6	4.6 $\pm$ 0.16
Isoleucine	4.7	4.4	5.1	4.9	4.8 $\pm$ 0.32
Leucine	6.9	7.6	7.4	7.5	7.4 $\pm$ 0.30
Tyrosine	3.9	3.8	3.6	3.5	3.7 $\pm$ 0.19
Phenylalanine	5.4	5.1	5.5	5.1	5.3 $\pm$ 0.19
Histidine	2.9	2.5	2.9	2.7	2.7 $\pm$ 0.21
Lysine	5.9	6.1	6.3	6.4	6.2 $\pm$ 0.22
Arginine	7.4	6.8	7.2	7.6	7.2 $\pm$ 0.32
Cysteine	2.8	2.5	2.5	2.6	2.6 $\pm$ 0.10
Methionine	1.5	1.4	1.4	1.3	1.4 $\pm$ 0.06

<sup>1</sup>See Table 1 for sample description.

**Table 24.** Amino acid profile (% crude protein basis) of the four Argentinian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	2	3	9	13	
Aspartic Acid	12.4	12.3	12.1	12.2	12.2 $\pm$ 0.15
Threonine	4.0	3.7	3.7	4.0	3.8 $\pm$ 0.20
Serine	4.8	4.7	4.6	4.7	4.7 $\pm$ 0.08
Glutamic Acid	18.0	18.1	18.2	17.9	18.1 $\pm$ 0.13
Proline	5.1	4.7	4.3	4.3	4.6 $\pm$ 0.39
Glycine	4.0	4.4	4.0	4.3	4.2 $\pm$ 0.19
Alanine	4.3	4.2	4.2	4.2	4.2 $\pm$ 0.02
Valine	4.9	4.8	4.6	5.0	4.8 $\pm$ 0.14
Isoleucine	4.9	4.9	4.6	4.6	4.8 $\pm$ 0.18
Leucine	7.6	7.4	7.0	7.6	7.4 $\pm$ 0.30
Tyrosine	3.8	4.0	3.6	4.0	3.8 $\pm$ 0.20
Phenylalanine	5.6	5.6	5.5	5.5	5.6 $\pm$ 0.05
Histidine	2.8	2.9	2.7	2.8	2.8 $\pm$ 0.09
Lysine	6.6	6.2	5.7	6.1	6.1 $\pm$ 0.34
Arginine	7.7	7.3	6.9	7.9	7.4 $\pm$ 0.42
Cysteine	2.6	2.8	2.7	2.7	2.7 $\pm$ 0.10
Methionine	1.4	1.4	1.3	1.3	1.4 $\pm$ 0.07

<sup>1</sup>See Table 1 for sample description.

**Table 25.** Amino acid profile (% crude protein basis) of the three Brazilian soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	4	12	15	
Aspartic Acid	12.7	12.7	11.6	12.3 $\pm$ 0.63
Threonine	3.7	3.9	3.9	3.8 $\pm$ 0.11
Serine	4.7	4.7	4.5	4.6 $\pm$ 0.09
Glutamic Acid	17.5	17.0	17.9	17.5 $\pm$ 0.45
Proline	4.7	4.9	5.0	4.8 $\pm$ 0.17
Glycine	4.3	4.1	4.2	4.2 $\pm$ 0.12
Alanine	4.3	4.4	4.7	4.4 $\pm$ 0.19
Valine	4.5	4.6	5.2	4.8 $\pm$ 0.37
Isoleucine	4.7	4.6	4.6	4.6 $\pm$ 0.04
Leucine	7.6	7.6	8.0	7.7 $\pm$ 0.21
Tyrosine	4.0	4.1	3.4	3.8 $\pm$ 0.37
Phenylalanine	5.9	5.8	5.2	5.6 $\pm$ 0.42
Histidine	2.5	2.7	2.9	2.7 $\pm$ 0.20
Lysine	6.4	6.3	6.1	6.2 $\pm$ 0.15
Arginine	7.1	7.4	7.2	7.2 $\pm$ 0.14
Cysteine	3.1	2.7	2.5	2.8 $\pm$ 0.28
Methionine	1.5	1.3	1.3	1.3 $\pm$ 0.11

<sup>1</sup>See Table 1 for sample description.

**Table 26.** Amino acid profile (% crude protein basis) of a sample of full-fat soybean<sup>1</sup>

Aspartic Acid	11.4
Threonine	4.0
Serine	4.7
Glutamic Acid	18.3
Proline	5.3
Glycine	4.4
Alanine	4.2
Valine	5.7
Isoleucine	5.0
Leucine	7.1
Tyrosine	3.9
Phenylalanine	5.1
Histidine	2.7
Lysine	6.7
Arginine	7.5
Cysteine	2.2
Methionine	1.4

<sup>1</sup>Sample no. 15; see Table 1 for sample description.

**Table 27.** Overall summary - Comparison of average amino acid profile (% crude protein basis) of soybean samples of different origin and a sample of full-fat soybeans

	US	India	Argentina	Brazil	Full-fat soy
No of samples	3	4	4	3	1
Aspartic Acid	11.6	12.6	12.2	12.3	11.4
Threonine	3.9	3.7	3.8	3.8	4.0
Serine	4.6	4.7	4.7	4.6	4.7
Glutamic Acid	16.7	18.4	18.1	17.5	18.3
Proline	4.6	4.8	4.6	4.8	5.3
Glycine	3.9	4.3	4.2	4.2	4.4
Alanine	4.0	4.0	4.2	4.4	4.2
Valine	5.1	4.6	4.8	4.8	5.7
Isoleucine	4.7	4.8	4.8	4.6	5.0
Leucine	7.6	7.4	7.4	7.7	7.1
Tyrosine	3.7	3.7	3.8	3.8	3.9
Phenylalanine	5.2	5.3	5.6	5.6	5.1
Histidine	2.7	2.7	2.8	2.7	2.7
Lysine	6.5	6.2	6.1	6.2	6.7
Arginine	7.2	7.2	7.4	7.2	7.5
Cysteine	3.0	2.6	2.7	2.8	2.2
Methionine	1.5	1.4	1.4	1.3	1.4



**Table 28.** Standardised ileal amino acid digestibility (%) of the three US soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	6	7	8	
Crude protein	86.0	87.1	85.8	86.3 $\pm$ 0.66
Aspartic Acid	85.9	86.9	85.5	86.1 $\pm$ 0.70
Threonine	82.7	85.1	82.2	83.3 $\pm$ 1.54
Serine	86.3	88.2	85.4	86.6 $\pm$ 1.41
Glutamic Acid	89.2	90.8	88.7	89.6 $\pm$ 1.10
Proline	87.0	89.0	85.6	87.2 $\pm$ 1.68
Glycine	86.0	87.1	85.8	86.3 $\pm$ 0.72
Alanine	86.9	88.4	86.1	87.2 $\pm$ 1.16
Valine	86.2	87.9	85.5	86.5 $\pm$ 1.25
Isoleucine	87.3	88.8	86.3	87.5 $\pm$ 1.26
Leucine	87.0	88.7	86.5	87.4 $\pm$ 1.14
Tyrosine	89.4	89.9	87.7	89.0 $\pm$ 1.15
Phenylalanine	87.9	89.7	86.4	88.0 $\pm$ 1.64
Histidine	87.8	89.2	82.6	86.5 $\pm$ 3.47
Lysine	90.4	90.7	91.8	91.0 $\pm$ 0.74
Arginine	90.9	92.4	89.9	91.1 $\pm$ 1.24
Cysteine	77.6	77.3	74.1	76.3 $\pm$ 1.90
Methionine	89.5	90.4	88.6	89.5 $\pm$ 0.91
Average of all AA	86.9	88.3	85.8	87.0 $\pm$ 1.22

<sup>1</sup> See Table 1 for sample description.

**Table 29.** Standardised ileal amino acid digestibility (%) of the four Indian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	1	5	10	14	
Crude protein	83.6	83.1	80.7	81.6	82.2 $\pm$ 1.35
Aspartic Acid	82.9	83.2	78.3	82.7	81.8 $\pm$ 2.34
Threonine	80.7	80.3	78.2	80.1	79.8 $\pm$ 1.09
Serine	84.4	82.7	80.6	84.0	82.9 $\pm$ 1.72
Glutamic Acid	87.2	87.4	84.7	88.0	86.8 $\pm$ 1.47
Proline	82.5	83.0	80.3	84.3	82.5 $\pm$ 1.68
Glycine	81.9	82.8	78.7	83.2	81.6 $\pm$ 2.05
Alanine	85.1	84.3	83.3	84.3	84.3 $\pm$ 0.73
Valine	84.5	83.7	83.2	84.4	84.0 $\pm$ 0.62
Isoleucine	85.5	84.5	83.9	85.2	84.8 $\pm$ 0.72
Leucine	85.6	84.5	83.7	84.6	84.6 $\pm$ 0.74
Tyrosine	86.3	86.6	85.0	86.7	86.1 $\pm$ 0.80
Phenylalanine	86.9	85.7	85.3	82.2	85.0 $\pm$ 2.00
Histidine	84.2	85.1	78.5	84.3	83.0 $\pm$ 3.01
Lysine	87.7	86.2	87.7	87.8	87.4 $\pm$ 0.77
Arginine	89.7	89.7	89.6	90.2	89.8 $\pm$ 0.24
Cysteine	71.1	66.8	63.7	50.1	62.9 $\pm$ 9.11
Methionine	88.6	86.3	87.0	87.0	87.2 $\pm$ 0.97
Average of all AA	84.4	83.7	81.9	82.9	83.2 $\pm$ 1.09

<sup>1</sup> See Table 1 for sample description.

**Table 30.** Standardised ileal amino acid digestibility (%) of the four Argentinian soybean meal samples

	Sample no <sup>1</sup>				Mean $\pm$ SD
	2	3	9	13	
Crude protein	85.8	84.5	83.4	88.0	85.4 $\pm$ 1.98
Aspartic Acid	85.0	84.7	82.6	87.7	85.0 $\pm$ 2.09
Threonine	83.0	83.7	81.5	85.3	83.4 $\pm$ 1.57
Serine	87.2	85.9	84.9	88.3	86.6 $\pm$ 1.50
Glutamic Acid	89.3	89.0	87.9	91.9	89.5 $\pm$ 1.67
Proline	84.8	86.1	83.8	85.3	85.0 $\pm$ 0.96
Glycine	85.2	83.9	84.2	88.0	85.3 $\pm$ 1.88
Alanine	87.1	86.7	86.1	89.4	87.3 $\pm$ 1.44
Valine	86.9	86.4	85.9	88.9	87.0 $\pm$ 1.29
Isoleucine	87.9	87.1	86.6	89.6	87.8 $\pm$ 1.30
Leucine	87.8	87.0	86.3	89.5	87.6 $\pm$ 1.36
Tyrosine	88.7	88.9	87.9	91.2	89.2 $\pm$ 1.41
Phenylalanine	88.5	88.0	87.5	90.4	88.6 $\pm$ 1.28
Histidine	86.0	86.4	82.3	87.7	85.6 $\pm$ 2.31
Lysine	91.0	89.4	90.6	92.5	90.9 $\pm$ 1.28
Arginine	91.5	90.9	90.3	93.4	91.5 $\pm$ 1.33
Cysteine	72.1	69.7	67.2	76.5	71.4 $\pm$ 3.94
Methionine	90.6	88.8	87.7	91.9	89.7 $\pm$ 1.88
Average of all AA	86.6	86.0	84.9	88.7	86.6 $\pm$ 1.58

<sup>1</sup>See Table 1 for sample description.

**Table 31.** Standardised ileal amino acid digestibility (%) of the three Brazilian soybean meal samples

	Sample no <sup>1</sup>			Mean $\pm$ SD
	4	12	15	
Crude protein	86.1	86.6	83.9	85.5 $\pm$ 1.43
Aspartic Acid	84.5	85.2	85.0	84.9 $\pm$ 0.35
Threonine	83.1	83.7	82.5	83.1 $\pm$ 0.59
Serine	85.8	86.2	85.6	85.8 $\pm$ 0.30
Glutamic Acid	88.9	89.9	88.8	89.2 $\pm$ 0.64
Proline	85.4	84.6	85.9	85.3 $\pm$ 0.65
Glycine	85.5	86.1	85.8	85.8 $\pm$ 0.30
Alanine	86.9	87.4	85.6	86.7 $\pm$ 0.93
Valine	86.4	87.0	85.0	86.1 $\pm$ 1.02
Isoleucine	87.0	87.7	86.2	87.0 $\pm$ 0.77
Leucine	87.0	87.5	85.4	86.6 $\pm$ 1.09
Tyrosine	88.9	89.7	86.9	88.5 $\pm$ 1.47
Phenylalanine	88.1	88.3	82.9	86.4 $\pm$ 3.05
Histidine	87.3	85.2	85.9	86.1 $\pm$ 1.05
Lysine	88.3	92.5	88.8	89.9 $\pm$ 2.30
Arginine	91.1	92.2	90.6	91.3 $\pm$ 0.80
Cysteine	73.4	76.5	61.7	70.6 $\pm$ 7.81
Methionine	90.4	91.6	87.9	89.9 $\pm$ 1.85
Average of all AA	86.3	87.1	84.7	86.1 $\pm$ 1.23

<sup>1</sup> See Table 1 for sample description.

**Table 32.** Standardised ileal amino acid digestibility (%) of a sample of full-fat soybean<sup>1</sup>

Crude protein	77.1
Aspartic Acid	77.3
Threonine	75.1
Serine	76.3
Glutamic Acid	82.1
Proline	83.9
Glycine	77.4
Alanine	79.5
Valine	78.8
Isoleucine	79.3
Leucine	79.5
Tyrosine	79.1
Phenylalanine	82.0
Histidine	74.3
Lysine	85.1
Arginine	84.8
Cysteine	60.7
Methionine	81.3
Average of all AA	78.6

<sup>1</sup> Sample no. 15; see Table 1 for sample description.

**Table 33.** Overall summary - Comparison of standardised ileal amino acid digestibility (%) of soybean samples of different origin and a sample of full-fat soybeans

	US	India	Argentina	Brazil	Full-fat soy
No of samples	3	4	4	3	1
Crude protein	86.3	82.2	85.4	85.5	77.1
Aspartic Acid	86.1	81.8	85.0	84.9	77.3
Threonine	83.3	79.8	83.4	83.1	75.1
Serine	86.6	82.9	86.6	85.8	76.3
Glutamic Acid	89.6	86.8	89.5	89.2	82.1
Proline	87.2	82.5	85.0	85.3	83.9
Glycine	86.3	81.6	85.3	85.8	77.4
Alanine	87.2	84.3	87.3	86.7	79.5
Valine	86.5	84.0	87.0	86.1	78.8
Isoleucine	87.5	84.8	87.8	87.0	79.3
Leucine	87.4	84.6	87.6	86.6	79.5
Tyrosine	89.0	86.1	89.2	88.5	79.1
Phenylalanine	88.0	85.0	88.6	86.4	82.0
Histidine	86.5	83.0	85.6	86.1	74.3
Lysine	91.0	87.4	90.9	89.9	85.1
Arginine	91.1	89.8	91.5	91.3	84.8
Cysteine	76.3	62.9	71.4	70.6	60.7
Methionine	89.5	87.2	89.7	89.9	81.3
Average of all AA	87.0	83.2	86.6	86.1	78.6

**Table 34.** Basal ileal endogenous flow of amino acids (g/kg dry matter intake) used in the standardisation of amino acid digestibility values<sup>1</sup>

Nitrogen	1.305
Aspartic Acid	0.585
Threonine	0.603
Serine	0.521
Glutamic Acid	0.869
Proline	0.326
Glycine	0.626
Alanine	0.368
Valine	0.445
Isoleucine	0.34
Leucine	0.512
Tyrosine	0.275
Phenylalanine	0.259
Histidine	0.173
Lysine	0.288
Arginine	0.365
Cysteine	0.222
Methionine	0.096

<sup>1</sup> Determined along with the current AA digestibility assays, following feeding of protein-free diets.

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31 October 2011