AmiPig

Ileal standardised digestibility of amino acids in feedstuffs for pigs

AFZ
Ajinomoto Eurolysine
Aventis Animal Nutrition
INRA - UMRVP
ITCF

Table of contents

This document was extracted from the AmiPig software. It contains only a part of the data available in the software. Particularly, standard deviations and apparent digestibilities are reported in the AmiPig software and not in this document.

Introduction

The amino acids contained in feedstuffs are not fully available to animal. It is therefore more efficient to formulate diets using values for digestible amino acids rather than total amino acids. The optimisation of amino acid supply leads to increased animal performance and, because the ingested protein is better balanced for animal's requirements, nitrogen excretion is reduced. Formulating to digestible amino acids, however, requires consistent and comparable data.

The AmiPig table provides amino acid ileal digestibility values for 62 common feedstuffs used in pig diets. These data (calculated from more than 350 samples) were obtained between 1987 and 1997 by INRA, Aventis Animal Nutrition and ITCF, associated with Ajinomoto Eurolysine. With further support from the French Ministry of Research, and with the help of the French Feed Database of the AFZ, these organisations have combined their databases to produce this unique, comprehensive and reliable corpus of pig amino acid digestibilities.

The three laboratories used comparable experimental protocols, including surgical procedure (the pigs were fitted with end-to-end ileo-rectal anastomosis) and the formulation of diets (the tested feedstuff was the sole source of protein of the diet). After a strict scientific assessment of their compatibility, the three databases were merged to obtain the AmiPig database. Apparent and standardised ileal digestibilities were calculated according to a unique concept.

In addition to the digestibility values, AmiPig contains, for each feedstuff, the total and digestible amino acid values, proximate analysis data, the standard deviations of these values and the numbers of samples used in the calculations. Other features include the ability to make comparison tables and graphs for the different feedstuffs and amino acid values, and the export to popular data formats.

For support and questions, contact:

AFZ

16 rue Claude Bernard
75231 Paris Cedex 05 FRANCE
Tel 33 (0) 1 44 08 18 08
Fax 33 (0) 1 44 08 18 53
Email : tran@inapg.inra.fr
Web : http://www.feedbase.com

Please use the following when referring to AmiPig in a document:

AFZ, Ajinomoto Eurolysine, Aventis Animal Nutrition, INRA, ITCF, 2000. AmiPig, Ileal standardised digestibility of amino acids in feedstuffs for pigs.

Database

Content

The AmiPig database contains the following data.

- Names and definitions of 62 common feedstuffs.
- Mean values, standard deviations and number of values for crude protein, individual amino acids, dry matter, crude fibre, ether extract, ash, Neutral Detergent Fibre, Acid Detergent Fibre, lignin, starch, calcium and phosphorus. Antitrypsic activity and tannins are given when relevant.
- Mean values and standard deviations for corrected apparent ileal digestibility, standardised digestibility and the content in standardised digestible nutrient for crude protein and individual amino acids.

Units

- The composition values and the digestible amino acid values are expressed in % as fed (fresh), with the exception of antitrypsic activity (TIA), expressed in Units of inhibited trypsin per milligram of sample.
- All the digestibility data are expressed in %.

A short introduction to amino acid digestibility

Animal growth requires a dietary supply of amino acids. Amino acids in feed are not 100 % digestible. The fibre matrix of the feedstuffs or the anti-nutritional factor content, for example, can be responsible for a reduction in the digestibility of some acids in some feedstuffs. In other words amino acids digestibility varies from one feedstuff to another and from one amino acid to another. Formulating diets based on digestible amino acids rather than on total amino acids improves accuracy.

Amino acids are digested in the small intestine. No absorption occurs in the large intestine, but the microflora metabolise some of the undigested amino acids, for their own growth and development. As a consequence amino acid absorption can be accurately determined only by measuring how much of the input amino acids remain at the end of the small intestine. This part of the small intestine is named the ileum hence the term ileal amino acid digestibility.

Ileal digestibility is expressed either as

- apparent digestibility or as,
- standardised digestibility (sometimes called true digestibility).

The difference between two systems lays in the consideration given to the basal endogenous losses of amino acids (brush border cells, enzymes secretions…) produced by the digestive tract itself. This production is not linked to the characteristic of the feed but to the level of feed intake and to the animal.

The **apparent digestibility** system ignores this fraction: what is collected at the end of the ileum is considered as undigested materials.

In the **standardised digestibility** system, basal endogenous losses are subtracted from what is collected at the end of the ileum to assess the digestibility. As a consequence standardised digestibility coefficients appears higher than apparent digestibility coefficients. Accordingly, requirements expressed as apparent digestibility are lower than the ones expressed as standardised.

Considering what is known today of the variability of the basal endogenous losses, **the authors recommend to work with the standardised digestibility system** because it differentiates between feed effects and animal effects.

Ileal digestibility of amino acids as an estimate of their availability: Concepts and definitions

By Bernard Sève – INRA – UMRVP

1. Introduction

The availability of amino acids (AA) is primarily determined by their digestibility measured at the end of the small intestine, i.e., at the ileum level, since it has been well established that there is no AA absorption from the large intestine. Furthermore, the microflora metabolise some of the undigested AA in the large intestine thus preventing them from appearing in the faeces. For this reason, the concept of "ileal digestibility" has been established. There is experimental evidence of an advantage of using ileal digestible rather than total supplies of AA in diet formulation. A number of organisations have published ileal digestibility data for the main feeds used in pig feeding (Aventis Animal Nutrition 1993; Jondreville et al 1995; CVB 1995; NRC 1998) but different expressions of ileal digestibility (apparent *vs* true or standardised values) have been proposed. The underlying hypotheses of each system and their implications should be well understood.

2. Measurement of ileal digestibility

Ileal digestibility may be measured from either total recovery of ileum flow from pigs fitted with ileo-rectal anastomosis (IRA), or from determination of the concentration of an indigestible marker, generally chromic oxide, in a sample of ileal digesta from pigs fitted with cannulae. Comparison of the two techniques has shown differences in opposite directions (Köhler et al 1990; Leterme et al 1990) or very similar figures (Yin et al 1993). Different IRA techniques have been compared. The ante-valvular end-to-end IRA technique, involving isolation of the large intestine, was validated in several experiments (Green et al 1987; Laplace et al 1994). In comparison, the end-to-side technique involved a risk of contamination of the ileum digesta with residual contents from the colon, and hence with its microflora. The same comparisons were made with or without conservation of the ileo-caecal valvula. This generally affected more the digestibility of non-starch polysaccharides than that of the amino acids.

3. Expression of ileal digestibility

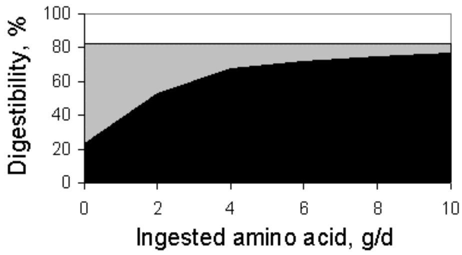
The endogenous fraction originating from gastric juices, brush border cells turnover or enzymes secretions accounts for 10 to 80 % of the nitrogen present in the collected ileal juices (Grala, 1994). The expression of ileal digestibility depends on the way this endogenous fraction is taken into account in the calculations.

3.1. Apparent digestibility

The apparent digestibility ignores the endogenous or exogenous origin of the indigestible nitrogen (N) or AA. In that system, total indigestible N or AA related to a particular feedstuff is assumed to be proportional to the dry matter intake of this feedstuff. If the diet used for the measurements contains other ingredients, the amount of indigestible N or amino acid generated by the dry matter (DM) of these ingredients is estimated. The indigestible N or amino acid from the tested feedstuff is then calculated "by difference", i.e., by discounting this amount. This should apply to the case of substitution of a basal diet for the tested feedstuff, regardless of whether the former contains protein or not. We term "corrected apparent digestibility" the apparent digestibility calculated this way from diets involving dilution of protein-rich feeds with protein-free ingredients. It is clear that this is the apparent digestibility of a diet that would be made of 100 % of the tested feedstuff. Without this correction, the apparent digestibility increases with the level of protein or AA, i.e. with the level of incorporation of the protein-rich feedstuff, in the diet (Fan et al 1994) (Figure 1). As a consequence, the uncorrected apparently digestible N or AA contents of high-protein feeds will be underestimated. Furthermore, it will not be additive with contents determined for low-protein feeds that do not need dilution for their evaluation

(Furuya and Kaji 1991). It is important to be aware that most apparent digestibility values of protein-rich feeds published so far are uncorrected and thus non-additive.

Figure 1. Variation of the apparent digestibility with the ingested amino acid at constant dry matter intake

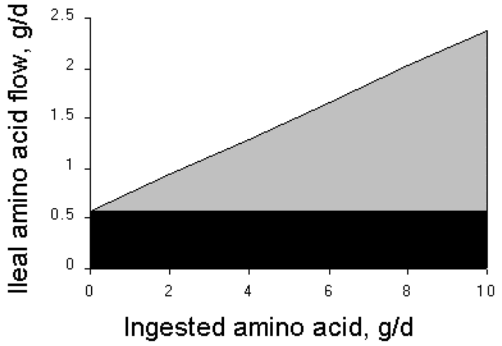


3.2. True and standardised digestibility

The lower apparent digestibility of low-protein vs. high-protein feeds may also be interpreted as the result of the dilution of protein with the non-protein components of the feeds. This is consistent with the hypothesis of a minimal endogenous loss, independent of feedstuff components; i.e. not proportional to protein intake, although it may be proportional to dry matter intake (DMI) (

Figure 2). This minimal loss is a characteristic of the animal and has been termed the ‘basal endogenous loss’. When a feedstuff protein content decreases, the relative importance of the basal endogenous loss increases, explaining the decrease in apparent digestibility. On this basis, it has been proposed to “standardise” the apparent digestibility into ‘true digestibility’ by subtracting the basal endogenous loss from the apparently indigestible fraction. This way, the true indigestible fraction is strictly proportional to protein, i.e., to the intake of the tested protein source.

Figure 2 Variation of the ileal flow of amino acid with the ingested amino acid at constant dry matter intake

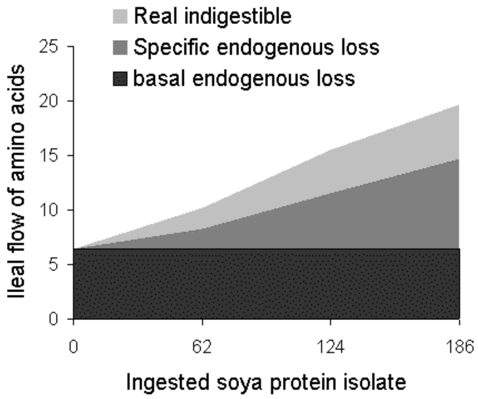


In order to avoid any confusion, the term “standardised digestibility” has been preferred to the term “true digestibility” (Jondreville et al 1995). The standardised digestibility concept is particularly well adapted to measurements made with dilution of a single protein feedstuff with protein-free ingredients, which was the method used in the experiments done for the present database. Furuya and Kaji (1991) demonstrated that, contrary to uncorrected apparent digestible AA, standardised digestible AA contents were additive. This expression of digestibility gives an estimate of amino acid availability clearly independent of the feedstuff protein content, as shown on Figure 1.

3.3. Real digestibility

It is well known that the true indigestible fraction may also contain endogenous protein (Figure 3). The latter, associated to the protein itself or to specific components of the protein source, has been termed the ‘specific endogenous loss’ (Sève, 1994 ; Boisen and Moughan 1996). Total endogenous losses, i.e. basal plus specific endogenous losses, are determined through isotope-dilution methods. When subtracted from the apparent indigestible fraction, they lead to calculation of the ‘real digestibility’ (Krawielitski 1977; Low 1982; de Lange et al 1990; Hess et al 1998). However, due to the difficulty inherent to the estimation of specific endogenous losses, further work will be necessary before this latter concept can have practical applications.

Figure 3. Partition of the true indigestible amino acids from a soya protein isolate into a real indigestible fraction and the specific endogenous losses (Sève et al 1994b)



4. Calculations

The standardised digestibility is calculated as follows:

[1] DStd = DApp + ($Endo_{DMI}$ x 10 / $AADiet_{DM}$)

DStd : AA Standardised Ileal Digestibility
DApp : AA Apparent Ileal Digestibility
$Endo_{DMI}$: amount of non-specific endogenous loss of AA in g per kg DMI
$AADiet_{DM}$: AA content of the diet, expressed in percentage of dry matter

DMI : dry matter intake. This does not imply necessarily that the basal loss per kg of DMI is constant as long as it may be estimated.

The corrected apparent digestibility could have been calculated as explained above (section 3.1). We may assume that protein-free ingredients stimulate AA losses at the minimum level selected to represent the basal endogenous loss. Therefore, under the condition that the basal endogenous loss may be considered as constant per kg of DMI, the corrected apparent digestibility may be recalculated from the standardised digestibility as follows:

[2] DAppCorr = DStd - $Endo_{DMI}$ x 10 / $AARM_{DM}$

DAppCorr : AA Corrected Apparent Ileal Digestibility
DStd : AA Standardised Ileal Digestibility
$Endo_{DMI}$: amount of non-specific endogenous loss of AA in g per kg DMI
$AARM_{DM}$: amino acid or protein content of the raw material, expressed in percentage of dry matter

This corresponds to the following relationship between the standardised and corrected apparent digestible AA contents:

[3] DCStd = DCAppCorr + basal endogenous loss per kg DMI

DCStd : Standardised Ileal Digestible AA per kg of feedstuff DM
DCAppCorr : Corrected Apparent Ileal Digestible AA per kg of feedstuff DM

Since it is independent of feedstuff components, the basal endogenous losses should be considered as a part of the body's protein expenses. Dietary standardised digestible AA levels should therefore meet a requirement higher than that expressed in corrected apparent digestible AA by an amount corresponding to the basal endogenous losses at least. Under this condition least-cost formulation with a given feedstuff matrix will lead to the same diet composition whether formulated using corrected apparent and standardised digestible AA data.

5. Estimating the basal endogenous losses of N and AA

5.1. Methodological aspects

True or standardised digestibility values are dependent on an estimate for the basal endogenous loss of N and each AA. The use of a protein-free diet was criticised on the basis that it might underestimate endogenous losses. This controversy was based first on the observation that peptide alimentation stimulates the endogenous losses (Butts et al 1993). However, this is the result of the confusion of basal with specific endogenous losses, the former being determined by animal characteristics, the latter by characteristics of the protein source. The second objection was that undernutrition could limit protein secretion and hence the endogenous losses. However, the main effect of complementary parenteral nutrition was to avoid the considerable increase in proline excretion that might occur with protein-free diets (de Lange et al 1989; Leterme et al 1994). Therefore, under the condition that it is not given for too long, the allowance of a protein-free diet is probably the most appropriate method to assess the obligatory digestive expense of AA by the pig (Sève and Henry 1996).

The evidence that fibre increased the basal endogenous loss measured with a protein-free diet (Mariscal-Landin et al 1995) raised some concern about its postulated independence of dietary components. However, in agreement with others (Taverner et al 1981), this response reached a plateau at 3-3.4 % crude fibre, very close to the level commonly encountered in standard diets, and it may be assumed that this level of fibre allows optimal functioning of the digestive tract, together with satisfactory feed intake. Within the present database, basal endogenous losses were measured with a starch-based protein-free diet enriched with about 4 % purified paper cellulose.

5.2. Factors of variation related to the animal

The proportionality of basal endogenous losses to dry matter intake is only approximate (Mariscal-Landin et al 1995; Stein and Easter 1997; Hess et al 1999). The intercept of the linear relationship between those losses and DMI was significant (Mariscal-Landin et al 1995) and the approximation held only at feed intake higher than 70 g DMI per unit metabolic weight. This was recently confirmed in a study showing, in addition, that the basal loss of N or AA per kg DM intake decreased with the weight of the pig (Hess and Sève 1999). Nevertheless, it is important to mention that, at constant live weight and feed intake, the individual quantitative and qualitative (AA pattern) variations remain high (Hess and Sève 1999). In addition, within the experimental program leading to the present database, it was shown that basal endogenous losses might be affected by unidentified genetic or environmental parameters associated with the site of measurement (Sève et al 2000). Altogether, these observations imply that, as far as possible, the basal endogenous loss and apparent digestibility should be assessed on the same pigs at similar live weight. For this reason, in the present database, the basal endogenous loss used to standardise digestibility was site-specific.

6. Conclusions

6.1.Why choosing the standardised rather than the apparent digestibility system?

The existence of a basal endogenous loss independent of the feedstuff and characteristic of the animal is now widely recognised. As long as the basal endogenous loss can be assumed to be strictly proportional to the dry matter intake of any feedstuff, it may be considered as part of the total losses attributable to the DM of that feedstuff. In this case, the corrected apparent or standardised digestible AA content can be calculated indifferently and converted to each other with equation [3]. However, it was shown (section 5.2) that factors related to the animal behaviour (level of feed intake) and characteristics (weight, age…) may suppress or change significantly this proportionality. Therefore, the true or standardised digestibility concept appears to be of much more general interest than the apparent digestibility concept.

6.2.Future prospects

The standardised digestibility takes in account the whole ileal loss of AA including the specific endogenous losses. As a predictor of amino acid availability, it should therefore be preferred to real digestibility that takes into account the undigested feed AA only. However, the endogenous losses imply an additional AA expense, i.e., an ‘AA metabolic cost’ associated with the synthesis of secreted protein (Huisman et al 1993; Grala et al 1994, 1999). The AA metabolic cost of the basal endogenous losses is independent of the feedstuff and should be considered as a part of the requirement of the animal. The AA metabolic cost of the specific endogenous losses should be deducted from the standardised digestible AA content in order to improve the estimation of their true availability in the feedstuff (Hess et al 2000). Other improvements are required to account for the unavailability of some ileal digestible amino acids from severely heated feeds (Batterham et al., 1990).

Nevertheless the present ileal digestibility database provides the most satisfactory approach to the AA availability involving the greatest number of pig feeds so far. Any further knowledge will be used to extend and improve this precious information.

Calculations

Abréviations

AADiet : amino acid or protein content of the diet, expressed in percentage of dry matter ($AADiet_{DM}$) or of the fresh matter (as fed basis) ($AADiet_{FM}$)

AARM : amino acid or protein content of the raw material, expressed in percentage of dry matter ($AARM_{DM}$) or of fresh matter (as fed basis) ($AARM_{FM}$)

DApp : Apparent ileal digestibility expressed in percentage

DAppCorr : Corrected apparent ileal digestibility expressed in percentage

DStd : Standardised ileal digestibility expressed in percentage

Digesta : amino acid or protein content of the digesta, expressed in percentage of dry matter

DMI : Intake of dry matter per day (gram)

DME : Excretion of dry matter per day (gram)

Endo : amount of amino acid or protein excreted of non-specific endogenous origin (related to the amount of feed intake and to the animal but not to the feedstuff characteristics). It is expressed as $g.kg^{-1}$ of dry matter intake ($Endo_{DMI}$) or as $g.kg^{-1}$ of fresh matter intake ($Endo_{FMI}$). These values were specific of the laboratory that carried out the experiment, and are presented at the end of this section.

FMI : Intake of fresh matter per day (gram)

LA, LB and LC : codes for the three laboratories having carried out the experiments (see materials and methods)

Apparent ileal digestibility

Note: this is an intermediate calculation not shown in the tables.

[LA, LB]

$DApp = [(AADiet_{DM} \times DMI) - (Digesta \times DME \times 100)] \times 100 / (AADiet_{DM} \times DMI)$

[LC]

$DApp = [(AADiet_{FM} \times FMI) - (Digesta \times DME \times 100)] \times 100 / (AADiet_{FM} \times FMI)$

Corrected apparent ileal digestibility

The corrected apparent ileal digestibility can be calculated either from the apparent digestibility or from the standardised digestibility. This is the apparent digestibility that is shown in the table.

[LA, LB]

$DAppCorr = DApp + Endo_{DMI} \times 10 \times (1/AADiet_{DM} - 1/ AARM_{DM})$

$DAppCorr = DStd - Endo_{DMI} \times 10 / AARM_{DM}$

[LC]

$DAppCorr = DApp + Endo_{FMI} \times 10 \times (1/AADiet_{FM} - 1/ AARM_{FM})$

$DAppCorr = DStd – Endo_{FMI} \times 10 / AARM_{FM}$

Ileal standardised digestibility

[LA, LB]

$DStd = DApp + (Endo_{DMI} \times 10 / AADiet_{DM})$

[LC]

$DStd = DApp + (Endo_{FMI} \times 10 / AADiet_{FM})$

Basal endogenous losses

The following table presents the basal endogenous losses of crude protein (N x 6.25) and individual amino acids expressed in $g.kg^{-1}$ DMI, for each of the participating laboratories. These were the values used to calculate the standardised digestibilities and corrected apparent digestibilities.

	LA	**LB**	**LC**
Crude protein	8.66	7.22	9.67
LYS	0.29	0.24	0.41
THR	0.33	0.27	0.39
MET	0.08	0.05	0.13
CYS	0.14	0.11	0.17
TRP	0.09	0.09	0.17
ILE	0.26	0.18	0.33
VAL	0.34	0.25	0.48
LEU	0.45	0.30	0.53
PHE	0.30	0.19	0.33
TYR	0.25	0.14	0.28
HIS	0.16	0.10	0.13
ARG	0.27	0.22	0.35
ALA	0.32	0.28	0.50
ASP	0.54	0.41	0.72
GLU	0.78	0.52	0.92
GLY	0.39	0.47	0.45
SER	0.35	0.25	0.38
PRO	0.54	N/A	0.53

Materials and methods

The experimental work was carried out between 1987 and 1997 at three centres: the INRA Station of Pig Research (Rennes, France), the Station of Nutrition of Aventis Animal Nutrition (Commentry, France) and the ITCF (Vendôme, France).

Note: LA, LB and LC refer to the above laboratories, but in a different order.

Ajinomoto Eurolysine and Agribrands Europe also contributed to the experimental work, particularly through amino acid analysis of the diets, feeds and digesta.

Animals and surgical technique

The pigs used were Large White or Large White x Piétrain (LA), Large White or Large White Landrace x Large White Piétrain (LB) or Large White or Large White x Landrace or Duroc (LC). They weighed around 30 kg at the time of surgery.

Each pig underwent surgery to create an end-to-end ileo-rectal anastomosis with complete isolation of the large intestine, according to the procedure described by Green et al., 1987. A simple T-cannula was placed in the distal colon to permit the evacuation of residual digesta and gases from the isolated intestine. After surgery, the animals were allowed to recover for 3 weeks (LA) or 4 weeks (LB, LC). They were placed in metabolism crates fitted with trays for the collection of the ileal juices (chyme).

Experimental diets

The raw materials were the sole protein source of the diets.

In addition of the feedstuff itself, the diets were supplemented with a vitamin-mineral premix. When the raw material contained more than 17% protein, the diet was adjusted to 16-18% protein content by adding a protein-free basal diet made of starch (wheat or maize starch), sugar and paper cellulose (LA and LB in the latter case). A small quantity of olive oil (LC) was added to improve palatability when necessary.

Water was mixed with the diets before feeding in a ratio of 2 to 1. The animals had free access to water.

Feeding plan

4 (or 5) pigs were given the diets in sequence in a Latin square design. The animals received the same diet for 7 consecutive days. They were fed twice a day (LA, LB) or once a day (LC). The daily feed allowance was 275 kcal per $kg^{0.75}$ body weight (LA), 90 g feed per $kg^{0.75}$ body weight (LB), or the amount of feed spontaneously eaten by all pigs within 30 minutes.

Digesta collection

After 4 days (LA) or 5 days (LB, LC) of adaptation, the digesta were collected during 3 (LA) or 2 (LB, LC) days. For LA and LB, the digesta were collected twice a day at feeding time. LA added 500 ml H2SO4 (0.7 $mol.l^{-1}$) to stop bacterial growth, while LB froze the digesta immediately. LC collected the digesta 6 times a day. The digesta were weighed, stored at 4°C, and, at the end of the collection period, they were pooled for each animal, mixed, homogenised and two aliquots were taken. One aliquot was oven-dried and used for the determination of dry matter while the other was freeze-dried for the determination of amino acids and other analyses.

Analytical methods

Dry matter

Dry matter in the feed samples (LA, LB) and the digesta (LA) was determined by oven drying at 103°C until constant weight (AFNOR NF V18-109). LB determined the digesta dry matter by oven drying at 80°C for 72 hours.

Nitrogen

Nitrogen was usually determined by the Kjeldahl method (AFNOR NF V18-100). LA used the Dumas method for several samples. The nitrogen content was multiplied by 6.25 to obtain the crude protein content.

Amino acids

Amino acids were determined by ion exchange chromatography (auto-analyser) after hydrolysis in 6N HCl at 110°C during 23 h (LB) or 24 h (LA, LC). Branched chain amino acids (valine, isoleucine and leucine) were determined after a 48-hour hydrolysis (LA). For estimation of sulphur amino acids (methionine and cystine) the samples were treated with performic acid before hydrolysis. Tryptophan content was measured by HPLC (High Pressure Liquid Chromatography) after an alkaline hydrolysis, either in a barium hydroxide solution (1.5 $mol.l^{-1}$, at 120°C for 18 hours, LA, LB) or in a sodium hydroxide solution (4.2 $mol.l^{-1}$, at 110° for 16 hours, LC).

Fibres

Crude fibre was determined by the Weende method (AFNOR NF V03-040).

Neutral Detergent Fibre, Acid Detergent Fibre and Acid Detergent Lignin were determined either by the method of BIPEA (XC 104 X90-03) (LB) or by the method of Van Soest and Wine (1967) modified by Giger et al. (1989) (LA).

Fat

Fat was determined by petroleum ether extraction without prior hydrolysis (2nd CEE directive 71/393, JOCE 18.1.84, A process).

Starch

Starch was determined by Ewers' polarimetric method (3rd directive CEE 72/199, JOCE 27.11.80).

Ash

Total ash was determined according to AFNOR method NF V18-101.

Antinutritional factors

Antitrypsic activity was determined according to the AOCS method (1983 Ba 12.75). The results are expressed as Units of inhibited trypsin by milligram of sample.

Tannins were determined by the method of Daiber (AFNOR NF V03-751).

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Tables

The following data (average values) are presented in pages 17 to 36

- Proximate analysis of feedstuffs (pages 17 and 18)
- Total amino acids (pages 19 to 24)
- Ileal standardised digestibilities (pages 25 to 30)
- Digestible amino acids (pages 31 to 36)

The AmiPig software also contains apparent digestibilities and standard deviations and, for certain feedstuffs, values for NDF, ADF, lignin, calcium, phosphorus, starch, tannins and antitrypsic activity.

Proximate analysis

	Obs.	DM	CP	CF	EE	Ash
Cereals						
Barley	*13*	88.7	10.9	4.6	2.1	2.2
Maize	*15*	87.4	8.9	1.9	3.6	1.3
Oats	*10*	89.2	10.5	11.6	4.7	2.5
Oats, decorticated	*1*	90.6	14.7	2.5	8.1	2.3
Rye	*8*	87	8.4	1.9	1.4	1.6
Sorghum	*13*	86.4	9.7	2	3	1.4
Triticale	*12*	87.3	10.3	2.3	1.4	1.8
Wheat	*17*	88.2	12.3	2.2	1.7	1.6
Cereal byproducts						
Barley brewers' grains	*1*	92.4	20.9	14.8	7.3	3.4
Barley distillers' grains, ethanol byproduct	*1*	91.8	21.5	5.8	5.7	3.4
Corn distillers	*1*	86.5	23.6	0.9	-	-
Corn gluten feed	*12*	89.3	20.2	7.7	2.9	6.0
Corn gluten meal	*5*	90.2	60.4	1.2	2.2	1.7
Maize germ meal, starch byproduct	*1*	95.3	27.5	10.2	7.0	2.0
Maize hominy feed	*1*	89.1	15.3	6.1	2.9	4.3
Rice bran	*4*	88.9	14.2	5.9	11.6	7.2
Wheat bran	*10*	87.4	15.4	8.7	3.9	4.7
Wheat distillers' grains, ethanol byproduct	*1*	91.4	27.4	5.4	6.3	4.6
Wheat feed flour	*4*	87.5	13.7	1.4	2.6	1.5
Wheat germs	*2*	88.4	27.0	3.6	11.3	4.1
Wheat gluten	*1*	94.3	81.0	2.8	-	-
Wheat gluten feed	*3*	90.9	14.0	6.0	3.2	4.7
Wheat middlings	*15*	87.6	15.7	5.0	4.0	3.1
Oil and protein seeds						
Faba bean	*6*	88.2	27.6	8.3	1.2	3.9
Lupin	*3*	90.7	31.1	14.0	-	3.5
Pea	*39*	88.0	21.4	5.4	0.9	2.8
Pea, extruded	*2*	88.7	23.3	5.4	1.2	3.4
Rapeseed, full-fat	*2*	92.5	19.9	7.2	38.8	4.2
Rapeseed, full-fat, treated	*2*	93.6	20.0	7.2	40.2	4.2
Soybean, full-fat, treated	*5*	88.2	35.8	5.2	19.7	5.0

Values expressed in % as fed

- Obs : number of observations
- DM : dry matter
- CP : crude protein (N x 6,25)
- CF : crude fibre
- EE : ether extract (crude fat)

Proximate analysis

	Obs.	DM	CP	CF	EE	Ash
Oil seed meals						
Cottonseed meal, decorticated	*8*	88.7	40.4	12.1	0.9	6.0
Cottonseed meal, partially decorticated	*1*	92.5	31.3	20.6	-	-
Groundnut meal, detoxified	*1*	87.6	50.3	5.1	-	-
Groundnut meal, not detoxified	*2*	89.3	47.3	6.0	-	-
Palm kernel meal, expeller	*5*	90.9	16.0	18.1	10.4	3.2
Rapeseed meal	*18*	90.0	35.2	11.5	3.4	7.5
Sesame meal, solvent extracted	*1*	93.2	40.5	9.9	-	-
Soybean meal, crude fibre < 5%	*13*	88.7	47.1	3.9	2.0	6.8
Soybean meal, crude fibre > 5%	*12*	88.4	44.6	6.4	2.0	6.5
Soybean meal, extruded	*3*	91.8	47.4	4.1	1.5	6.8
Sunflower meal, not decorticated	*2*	90.3	27.2	30.7	2.5	5.7
Sunflower meal, partially decorticated	*9*	90.6	33.4	22.9	1.6	6.4
Animal products						
Blood meal	*8*	90.7	85.4	4.2	3.1	5.2
Bone meal	*2*	91.8	38.4	2.6	-	-
Feather meal	*3*	92.6	80.5	5.3	7.4	2.0
Fish meal	*15*	90.8	65.5	0.4	8.2	15.5
Fish solubles	*1*	96.2	80.2	4.2	-	-
Greaves	*1*	97.9	82.9	4.0	-	4.3
Meat and bone meal	*17*	93.3	51.1	3.4	9.9	27.4
Meat and bone meal, low digestibility	*5*	92.5	54.7	1.9	-	26.9
Milk protein concentrate	*1*	91.5	48.7	2.1	1.8	8.6
Milk powder, skimmed	*1*	94.9	33.8	1.2	0.2	8.0
Milk powder, whole	*1*	92.4	33.8	1.2	39.6	7.7
Poultry offal meal	*5*	91.7	57.0	3.7	22.2	9.7
Whey, acid, dehydrated	*2*	93.7	10.5	0.1	0.2	14.3
Miscellaneous						
Alfalfa, dehydrated	*2*	91.1	17.6	18.2	-	-
Beet pulp, dehydrated	*1*	94.0	11.1	13.3	1.0	7.3
Potato protein concentrate	*2*	91.6	78.7	0.4	0.7	2.0
Soybean concentrate	*1*	95.6	65.4	3.3	0.4	7.3
Soybean hulls	*1*	89.0	11.6	25.4	1.4	4.6
Yeast, brewers	*1*	96.5	47.4	0.1	-	7.9
Yeast, brewers, high protein	*1*	88.9	69.0	0.7	3.2	7.8

Values expressed in % as fed

- Obs : number of observations
- DM : dry matter
- CP : crude protein (N x 6,25)
- CF : crude fibre
- EE : ether extract (crude fat)

Total amino acids

	CP	LYS	THR	MET	CYS	M+C	TRP
Cereals							
Barley	10.9	0.40	0.37	0.18	0.23	0.41	0.13
Maize	8.9	0.26	0.32	0.18	0.18	0.37	0.06
Oats	10.5	0.43	0.35	0.18	0.29	0.47	0.13
Oats, decorticated	14.7	0.59	0.55	0.31	0.43	0.74	0.22
Rye	8.4	0.34	0.29	0.14	0.19	0.34	0.10
Sorghum	9.7	0.21	0.31	0.17	0.17	0.34	0.10
Triticale	10.3	0.37	0.32	0.18	0.24	0.42	0.12
Wheat	12.3	0.34	0.35	0.19	0.25	0.45	0.14
Cereal byproducts							
Barley brewers' grains	20.9	0.73	0.72	0.37	0.39	0.76	0.23
Barley distillers' grains, ethanol byproduct	21.5	0.63	0.67	0.37	0.44	0.81	0.29
Corn distillers	23.6	0.67	0.88	0.36	0.47	0.83	0.10
Corn gluten feed	20.2	0.62	0.68	0.33	0.38	0.72	0.13
Corn gluten meal	60.4	1.04	2.05	1.38	1.02	2.40	0.30
Maize germ meal, starch byproduct	27.5	1.15	0.98	0.52	0.40	0.92	0.26
Maize hominy feed	15.3	0.43	0.50	0.27	0.27	0.54	0.10
Rice bran	14.2	0.71	0.57	0.32	0.31	0.63	0.16
Wheat bran	15.4	0.64	0.51	0.25	0.30	0.55	0.22
Wheat distillers' grains, ethanol byproduct	27.4	0.66	0.79	0.40	0.44	0.84	0.31
Wheat feed flour	13.7	0.43	0.40	0.23	0.28	0.51	0.15
Wheat germs	27.0	1.55	0.94	0.47	0.38	0.85	0.21
Wheat gluten	81.0	1.28	1.91	1.25	1.34	2.59	0.75
Wheat gluten feed	14.0	0.45	0.46	0.23	0.28	0.51	0.17
Wheat middlings	15.7	0.65	0.52	0.27	0.31	0.59	0.20
Oil and protein seeds							
Faba bean	27.6	1.66	0.94	0.21	0.34	0.55	0.22
Lupin	31.1	1.48	1.07	0.20	0.46	0.67	0.24
Pea	21.4	1.53	0.78	0.20	0.28	0.48	0.19
Pea, extruded	23.3	1.54	0.81	0.21	0.31	0.53	0.19
Rapeseed, full-fat	19.9	1.22	0.87	0.44	0.46	0.90	0.29
Rapeseed, full-fat, treated	20.0	1.17	0.87	0.47	0.47	0.93	0.26
Soybean, full-fat, treated	35.8	2.27	1.49	0.54	0.56	1.10	0.44

Values expressed in % as fed

- CP : crude protein (N x 6,25)
- M+C : methionine + cystine

Total amino acids

	CP	LYS	THR	MET	CYS	M+C	TRP
Oil seed meals							
Cottonseed meal, decorticated	40.4	1.52	1.19	0.52	0.57	1.10	0.47
Cottonseed meal, partially decorticated	31.3	1.35	1.12	0.55	0.50	1.06	-
Groundnut meal, detoxified	50.3	1.24	1.27	0.47	0.33	0.80	0.44
Groundnut meal, not detoxified	47.3	1.37	1.15	0.42	0.43	0.85	-
Palm kernel meal, expeller	16.0	0.37	0.46	0.24	0.17	0.41	0.11
Rapeseed meal	35.2	1.80	1.50	0.73	0.85	1.58	0.42
Sesame meal, solvent extracted	40.5	1.07	1.44	1.13	0.81	1.95	-
Soybean meal, crude fibre < 5%	47.1	2.87	1.79	0.65	0.68	1.33	0.58
Soybean meal, crude fibre > 5%	44.6	2.71	1.74	0.59	0.62	1.21	0.58
Soybean meal, extruded	47.4	2.92	1.94	0.77	0.68	1.45	0.63
Sunflower meal, not decorticated	27.2	0.97	1.00	0.66	0.41	1.07	0.35
Sunflower meal, partially decorticated	33.4	1.21	1.20	0.79	0.53	1.32	0.43
Animal products							
Blood meal	85.4	7.30	3.58	0.91	0.96	1.87	1.14
Bone meal	38.4	2.04	1.13	0.50	0.22	0.73	-
Feather meal	80.5	1.74	3.64	0.47	3.72	4.19	0.52
Fish meal	65.5	4.87	2.74	1.76	0.57	2.33	0.70
Fish solubles	80.2	3.53	2.08	1.28	0.31	1.58	-
Greaves	82.9	4.29	2.69	1.50	0.67	2.17	0.56
Meat and bone meal	51.1	2.51	1.56	0.68	0.49	1.17	0.31
Meat and bone meal, low digestibility	54.7	2.77	1.99	0.80	0.85	1.65	0.33
Milk protein concentrate	48.7	3.60	2.23	0.78	0.45	1.23	0.53
Milk powder, skimmed	33.8	2.81	1.45	0.78	0.26	1.04	-
Milk powder, whole	33.8	2.37	1.40	0.83	0.24	1.07	0.44
Poultry offal meal	57.0	2.42	2.35	0.74	1.63	2.37	0.43
Whey, acid, dehydrated	10.5	0.68	0.51	0.10	0.14	0.24	0.10
Miscellaneous							
Alfalfa, dehydrated	17.6	0.75	0.65	0.23	0.15	0.31	0.23
Beet pulp, dehydrated	11.1	0.34	0.31	0.13	0.08	0.21	0.08
Potato protein concentrate	78.7	6.10	4.42	1.74	1.38	3.12	0.74
Soybean concentrate	65.4	4.30	2.83	1.16	0.99	2.15	0.80
Soybean hulls	11.6	0.64	0.41	0.16	0.17	0.33	0.13
Yeast, brewers	47.4	3.22	1.99	0.65	0.32	0.97	0.52
Yeast, brewers, high protein	69.0	2.47	2.44	0.94	0.14	1.08	0.56

Values expressed in % as fed
- CP : crude protein (N x 6,25)
- M+C : methionine + cystine

Total amino acids (continued)

	ILE	VAL	LEU	PHE	TYR	P+T	HIS
Cereals							
Barley	0.39	0.54	0.73	0.53	0.29	0.82	0.25
Maize	0.32	0.43	1.06	0.43	0.29	0.72	0.24
Oats	0.38	0.51	0.74	0.50	0.28	0.78	0.24
Oats, decorticated	0.60	0.77	1.06	0.77	0.41	1.18	0.32
Rye	0.29	0.40	0.52	0.37	0.19	0.56	0.20
Sorghum	0.38	0.48	1.25	0.48	0.34	0.83	0.21
Triticale	0.34	0.45	0.64	0.43	0.23	0.66	0.23
Wheat	0.43	0.51	0.78	0.55	0.30	0.85	0.29
Cereal byproducts							
Barley brewers' grains	0.81	1.07	1.37	1.04	0.47	1.51	0.39
Barley distillers' grains, ethanol byproduct	0.83	1.08	1.43	1.14	0.60	1.74	0.44
Corn distillers	0.90	1.18	2.29	1.02	0.81	1.83	0.51
Corn gluten feed	0.62	0.92	1.64	0.70	0.51	1.21	0.60
Corn gluten meal	2.51	2.72	9.92	3.69	3.08	6.77	1.30
Maize germ meal, starch byproduct	0.90	1.42	1.87	1.09	0.68	1.77	0.89
Maize hominy feed	0.47	0.63	1.31	0.55	0.36	0.91	0.37
Rice bran	0.52	0.79	1.01	0.63	0.48	1.11	0.41
Wheat bran	0.49	0.70	0.97	0.61	0.40	1.02	0.44
Wheat distillers' grains, ethanol byproduct	0.94	1.14	1.69	1.18	0.66	1.84	0.66
Wheat feed flour	0.46	0.59	0.88	0.59	0.30	0.89	0.33
Wheat germs	0.80	1.24	1.55	0.86	0.67	1.54	0.55
Wheat gluten	2.79	2.83	5.10	3.88	2.39	6.27	1.74
Wheat gluten feed	0.44	0.65	0.83	0.52	0.26	0.78	0.34
Wheat middlings	0.50	0.73	0.99	0.63	0.41	1.04	0.39
Oil and protein seeds							
Faba bean	1.14	1.29	2.01	1.13	0.79	1.93	0.69
Lupin	1.45	1.32	2.28	1.22	1.15	2.37	0.81
Pea	0.89	0.98	1.48	0.99	0.60	1.59	0.53
Pea, extruded	0.89	1.02	1.53	1.00	0.68	1.67	0.59
Rapeseed, full-fat	0.83	1.05	1.34	0.82	0.60	1.42	0.58
Rapeseed, full-fat, treated	0.80	1.00	1.29	0.74	0.47	1.21	0.53
Soybean, full-fat, treated	1.79	1.84	2.83	1.91	1.39	3.31	0.98

Values expressed in % as fed

- P+T : phenylalanine + tyrosine

Total amino acids (continued)

	ILE	VAL	LEU	PHE	TYR	P+T	HIS
Oil seed meals							
Cottonseed meal, decorticated	1.29	1.78	2.30	2.01	1.15	3.15	1.09
Cottonseed meal, partially decorticated	1.09	1.60	1.98	1.75	0.99	2.74	0.88
Groundnut meal, detoxified	1.45	1.64	2.61	2.03	1.40	3.43	1.01
Groundnut meal, not detoxified	1.54	1.89	2.76	2.06	1.58	3.64	0.95
Palm kernel meal, expeller	0.55	0.79	0.94	0.59	0.34	0.94	0.26
Rapeseed meal	1.42	1.81	2.34	1.35	0.94	2.29	0.90
Sesame meal, solvent extracted	1.62	1.96	2.73	1.85	1.22	3.07	0.98
Soybean meal, crude fibre < 5%	2.19	2.22	3.49	2.29	1.64	3.92	1.28
Soybean meal, crude fibre > 5%	2.13	2.18	3.36	2.29	1.66	3.93	1.21
Soybean meal, extruded	2.29	2.30	3.54	2.27	1.57	3.84	1.27
Sunflower meal, not decorticated	1.14	1.27	1.64	1.17	0.49	1.66	0.63
Sunflower meal, partially decorticated	1.41	1.62	2.03	1.48	0.77	2.24	0.85
Animal products							
Blood meal	1.23	7.37	10.67	5.70	2.41	8.11	5.24
Bone meal	0.98	1.48	2.04	1.14	0.69	1.83	0.53
Feather meal	3.83	6.07	6.72	3.94	2.27	6.20	0.60
Fish meal	2.84	3.32	4.75	2.55	2.06	4.61	1.96
Fish solubles	1.47	2.17	3.05	1.64	0.72	2.36	1.08
Greaves	2.65	4.00	5.12	2.84	1.85	4.68	1.33
Meat and bone meal	1.44	2.19	2.97	1.66	1.13	2.79	1.04
Meat and bone meal, low digestibility	1.70	2.80	3.70	2.03	1.26	3.29	0.99
Milk protein concentrate	2.38	2.08	3.18	1.81	1.55	3.36	0.92
Milk powder, skimmed	1.93	2.30	3.35	1.69	1.76	3.45	0.95
Milk powder, whole	1.64	1.89	2.99	1.54	1.47	3.01	0.73
Poultry offal meal	2.39	3.37	4.22	2.38	1.67	4.05	1.19
Whey, acid, dehydrated	0.44	0.39	0.59	0.21	0.11	0.32	0.28
Miscellaneous							
Alfalfa, dehydrated	0.68	0.87	1.13	0.73	0.50	1.22	0.33
Beet pulp, dehydrated	0.33	0.42	0.44	0.25	0.30	0.55	0.22
Potato protein concentrate	4.45	4.98	7.59	4.86	4.63	9.49	2.17
Soybean concentrate	3.35	3.32	5.19	3.40	2.22	5.62	1.79
Soybean hulls	0.44	0.51	0.73	0.43	0.32	0.75	0.27
Yeast, brewers	2.07	2.15	2.88	1.54	1.31	2.85	0.97
Yeast, brewers, high protein	2.37	3.76	3.62	1.90	1.37	3.27	1.10

Values expressed in % as fed

- P+T : phenylalanine + tyrosine

Total amino acids (continued)

	ARG	ALA	ASP	GLU	GLY	SER	PRO
Cereals							
Barley	0.54	0.43	0.63	2.52	0.43	0.46	1.06
Maize	0.38	0.66	0.56	1.65	0.32	0.42	0.72
Oats	0.66	0.49	0.80	2.08	0.50	0.49	0.55
Oats, decorticated	0.90	0.75	1.22	3.13	0.77	0.80	-
Rye	0.48	0.39	0.65	2.03	0.38	0.37	0.77
Sorghum	0.36	0.87	0.65	2.05	0.31	0.43	0.80
Triticale	0.54	0.44	0.65	2.58	0.43	0.46	0.61
Wheat	0.58	0.42	0.61	3.40	0.46	0.55	1.19
Cereal byproducts							
Barley brewers' grains	0.85	0.99	1.14	4.60	0.83	0.86	-
Barley distillers' grains, ethanol byproduct	0.98	0.78	1.12	5.20	0.75	0.90	-
Corn distillers	0.93	1.63	1.55	4.00	1.02	1.03	0.44
Corn gluten feed	0.91	1.29	1.13	2.92	0.84	0.82	1.63
Corn gluten meal	1.81	5.27	3.53	13.13	1.47	3.16	5.71
Maize germ meal, starch byproduct	1.81	1.50	1.74	3.29	1.34	1.21	-
Maize hominy feed	0.55	0.96	0.85	2.22	0.59	0.65	-
Rice bran	1.25	0.82	1.31	1.98	0.81	0.67	0.61
Wheat bran	1.11	0.72	1.10	2.98	0.79	0.66	0.91
Wheat distillers' grains, ethanol byproduct	1.19	0.93	1.26	6.85	0.99	1.27	-
Wheat feed flour	0.69	0.51	0.71	3.69	0.56	0.60	1.23
Wheat germs	1.89	1.43	2.02	3.65	1.35	1.01	0.92
Wheat gluten	2.81	1.85	2.30	22.52	2.34	3.86	10.95
Wheat gluten feed	0.76	0.65	0.93	2.65	0.67	0.62	-
Wheat middlings	1.06	0.71	1.04	3.29	0.76	0.69	1.03
Oil and protein seeds							
Faba bean	2.34	1.12	2.80	4.76	1.14	1.30	1.15
Lupin	3.26	1.07	3.15	7.31	1.28	1.60	1.21
Pea	1.83	0.92	2.43	3.64	0.91	1.01	0.86
Pea, extruded	1.95	0.97	2.50	3.70	1.03	1.05	0.98
Rapeseed, full-fat	1.25	0.87	1.51	3.51	1.00	0.87	1.31
Rapeseed, full-fat, treated	1.18	0.84	1.33	3.21	0.93	0.87	-
Soybean, full-fat, treated	2.81	1.59	4.26	7.05	1.55	1.93	1.87

Values expressed in % as fed

Total amino acids (continued)

	ARG	ALA	ASP	GLU	GLY	SER	PRO
Oil seed meals							
Cottonseed meal, decorticated	4.17	1.52	3.80	7.69	1.68	1.71	1.31
Cottonseed meal, partially decorticated	3.54	1.26	2.95	6.82	1.34	1.45	1.22
Groundnut meal, detoxified	5.10	1.60	4.99	7.70	2.48	2.13	1.98
Groundnut meal, not detoxified	5.21	1.75	4.88	8.23	2.51	2.09	1.82
Palm kernel meal, expeller	1.63	0.61	1.20	2.86	0.66	0.66	0.45
Rapeseed meal	2.05	1.50	2.44	5.87	1.71	1.51	2.15
Sesame meal, solvent extracted	4.84	1.89	3.38	8.04	2.11	1.83	1.35
Soybean meal, crude fibre < 5%	3.52	1.93	5.17	8.56	1.87	2.36	2.30
Soybean meal, crude fibre > 5%	3.34	1.90	5.01	8.16	1.87	2.28	2.22
Soybean meal, extruded	3.62	2.09	5.35	8.61	1.98	2.54	-
Sunflower meal, not decorticated	2.04	1.12	2.34	4.96	1.52	1.18	1.12
Sunflower meal, partially decorticated	2.83	1.38	2.79	6.26	1.83	1.42	1.47
Animal products							
Blood meal	3.71	6.41	9.02	8.30	3.98	4.02	3.42
Bone meal	2.60	2.97	2.76	4.67	5.92	1.45	3.58
Feather meal	5.28	3.71	5.35	8.67	6.15	8.85	7.83
Fish meal	3.78	3.91	5.73	8.46	4.14	2.57	2.74
Fish solubles	4.20	5.41	4.65	8.66	10.91	3.17	5.09
Greaves	5.59	6.19	5.87	9.63	11.10	2.90	6.77
Meat and bone meal	3.41	3.56	3.61	5.98	6.15	1.94	4.09
Meat and bone meal, low digestibility	3.62	3.79	4.07	6.48	6.25	2.63	4.27
Milk protein concentrate	2.07	2.31	4.44	5.85	1.88	2.23	-
Milk powder, skimmed	1.22	1.18	2.60	7.51	0.68	1.79	3.21
Milk powder, whole	1.22	0.96	2.38	6.53	0.60	1.84	-
Poultry offal meal	3.71	3.03	4.14	6.93	4.75	3.90	4.34
Whey, acid, dehydrated	0.11	0.35	0.75	1.45	0.16	0.39	-
Miscellaneous							
Alfalfa, dehydrated	0.71	0.81	2.17	1.57	0.75	0.71	0.61
Beet pulp, dehydrated	0.24	0.36	0.63	2.01	0.36	0.37	-
Potato protein concentrate	4.00	3.81	9.52	8.53	3.65	4.15	4.15
Soybean concentrate	5.18	2.92	7.84	12.32	2.81	3.74	1.10
Soybean hulls	0.58	0.50	1.01	1.45	0.75	0.62	-
Yeast, brewers	1.92	2.79	3.95	5.45	1.76	1.98	-
Yeast, brewers, high protein	3.41	4.61	4.88	12.88	2.44	2.10	-

Values expressed in % as fed

Ileal standardised digestibility

	CP	LYS	THR	MET	CYS	M+C	TRP
Cereals							
Barley	80	75	75	84	84	84	79
Maize	86	80	83	91	89	90	80
Oats	76	73	69	84	75	78	78
Oats, decorticated	79	79	80	85	85	85	82
Rye	77	72	71	81	84	83	76
Sorghum	79	74	76	85	77	81	79
Triticale	87	83	82	90	91	91	88
Wheat	88	81	83	89	91	90	88
Cereal byproducts							
Barley brewers' grains	78	82	81	89	77	83	83
Barley distillers' grains, ethanol byproduct	83	73	84	89	87	88	86
Corn distillers	62	58	62	76	59	67	28
Corn gluten feed	69	66	70	84	69	76	66
Corn gluten meal	92	89	92	95	92	94	87
Maize germ meal, starch byproduct	68	61	71	81	67	74	71
Maize hominy feed	72	65	65	86	67	77	60
Rice bran	70	75	68	78	68	73	74
Wheat bran	72	72	69	79	76	77	78
Wheat distillers' grains, ethanol byproduct	82	66	80	86	82	84	81
Wheat feed flour	93	90	90	94	94	94	92
Wheat germs	85	89	82	90	81	86	81
Wheat gluten	89	64	78	89	95	92	79
Wheat gluten feed	68	57	67	72	72	72	66
Wheat middlings	84	84	80	88	83	86	86
Oil and protein seeds							
Faba bean	84	88	82	83	77	79	81
Lupin	85	86	81	83	83	83	-
Pea	80	83	76	80	72	75	73
Pea, extruded	90	93	90	86	88	87	89
Rapeseed, full-fat	72	78	71	81	80	80	73
Rapeseed, full-fat, treated	73	81	72	85	81	83	75
Soybean, full-fat, treated	78	82	79	81	77	79	80

Ileal standardised digestibilities expressed in %

- CP : crude protein (N x 6,25)
- M+C : methionine + cystine

Ileal standardised digestibility

	CP	LYS	THR	MET	CYS	M+C	TRP
Oil seed meals							
Cottonseed meal, decorticated	77	63	71	73	76	75	68
Cottonseed meal, partially decorticated	74	70	75	79	69	74	-
Groundnut meal, detoxified	77	61	71	74	75	74	72
Groundnut meal, not detoxified	90	88	89	92	88	90	-
Palm kernel meal, expeller	54	37	52	68	47	59	52
Rapeseed meal	76	75	75	87	81	84	80
Sesame meal, solvent extracted	91	87	89	94	94	94	-
Soybean meal, crude fibre < 5%	89	92	88	93	89	91	92
Soybean meal, crude fibre > 5%	87	89	86	91	84	87	88
Soybean meal, extruded	87	89	86	88	85	87	86
Sunflower meal, not decorticated	81	80	82	92	81	88	85
Sunflower meal, partially decorticated	82	82	81	92	82	88	84
Animal products							
Blood meal	82	86	85	85	77	82	88
Bone meal	81	86	85	89	66	81	-
Feather meal	77	65	78	71	70	70	72
Fish meal	89	93	92	93	86	91	89
Fish solubles	93	96	96	96	84	94	-
Greaves	82	84	80	85	79	83	79
Meat and bone meal	81	84	82	86	67	79	80
Meat and bone meal, low digestibility	66	72	64	76	46	62	78
Milk protein concentrate	90	94	86	89	86	88	90
Milk powder, skimmed	89	97	91	97	84	94	-
Milk powder, whole	90	89	94	96	95	96	97
Poultry offal meal	76	77	76	80	68	73	69
Whey, acid, dehydrated	70	83	70	74	66	71	79
Miscellaneous							
Alfalfa, dehydrated	60	59	65	76	35	56	46
Beet pulp, dehydrated	53	50	31	61	22	43	41
Potato protein concentrate	87	89	90	91	78	86	75
Soybean concentrate	94	95	94	93	94	94	94
Soybean hulls	57	60	61	71	63	66	63
Yeast, brewers	69	74	66	69	49	63	55
Yeast, brewers, high protein	59	52	58	51	32	48	40

Ileal standardised digestibilities expressed in %

- CP : crude protein (N x 6,25)
- M+C : methionine + cystine

Ileal standardised digestibility (continued)

	ILE	VAL	LEU	PHE	TYR	P+T	HIS
Cereals							
Barley	81	80	83	84	83	83	81
Maize	88	87	93	91	90	91	89
Oats	79	77	81	84	80	82	83
Oats, decorticated	83	81	83	83	85	84	83
Rye	77	75	78	82	77	80	79
Sorghum	83	81	86	85	85	85	78
Triticale	87	86	88	90	90	90	89
Wheat	89	86	90	91	90	91	90
Cereal byproducts							
Barley brewers’ grains	89	86	88	91	94	92	85
Barley distillers’ grains, ethanol byproduct	90	86	90	92	93	93	87
Corn distillers	72	66	78	79	76	78	59
Corn gluten feed	78	75	84	84	83	83	70
Corn gluten meal	92	91	95	94	94	94	92
Maize germ meal, starch byproduct	74	72	76	81	78	80	84
Maize hominy feed	75	73	83	84	88	85	74
Rice bran	72	71	72	74	80	77	84
Wheat bran	77	75	79	82	81	82	80
Wheat distillers' grains, ethanol byproduct	83	80	85	90	88	89	80
Wheat feed flour	93	91	95	96	95	95	96
Wheat germs	86	85	88	88	87	88	90
Wheat gluten	91	89	93	95	94	95	-
Wheat gluten feed	70	66	73	78	78	78	73
Wheat middlings	86	84	87	89	88	89	89
Oil and protein seeds							
Faba bean	85	82	87	87	84	85	87
Lupin	88	80	87	89	88	89	90
Pea	79	77	80	80	81	80	84
Pea, extruded	91	89	92	93	94	94	94
Rapeseed, full-fat	68	70	71	73	74	73	73
Rapeseed, full-fat, treated	73	73	75	75	72	74	82
Soybean, full-fat, treated	78	78	79	81	82	81	84

Ileal standardised digestibilities expressed in %
- P+T : phenylalanine + tyrosine

Ileal standardised digestibility (continued)

	ILE	VAL	LEU	PHE	TYR	P+T	HIS
Oil seed meals							
Cottonseed meal, decorticated	74	76	76	83	81	82	76
Cottonseed meal, partially decorticated	77	79	80	86	82	85	80
Groundnut meal, detoxified	83	81	86	90	90	90	-
Groundnut meal, not detoxified	92	92	94	95	95	95	90
Palm kernel meal, expeller	66	66	70	75	67	72	61
Rapeseed meal	78	77	82	83	80	82	84
Sesame meal, solvent extracted	91	90	92	94	92	93	92
Soybean meal, crude fibre < 5%	91	90	90	91	92	91	92
Soybean meal, crude fibre > 5%	88	87	88	89	90	90	90
Soybean meal, extruded	87	87	88	89	88	89	90
Sunflower meal, not decorticated	86	84	87	90	92	91	86
Sunflower meal, partially decorticated	85	83	85	87	89	88	84
Animal products							
Blood meal	86	84	84	86	86	86	82
Bone meal	85	84	86	86	85	85	86
Feather meal	86	83	83	86	76	82	71
Fish meal	93	92	94	92	92	92	89
Fish solubles	97	96	98	99	98	99	95
Greaves	88	88	88	90	88	89	85
Meat and bone meal	84	83	85	85	82	84	79
Meat and bone meal, low digestibility	72	68	70	72	70	71	71
Milk protein concentrate	91	90	93	92	89	91	95
Milk powder, skimmed	88	89	96	98	97	97	95
Milk powder, whole	89	92	97	98	98	98	97
Poultry offal meal	81	77	80	81	78	80	70
Whey, acid, dehydrated	80	69	77	82	78	80	80
Miscellaneous							
Alfalfa, dehydrated	70	68	73	72	69	71	60
Beet pulp, dehydrated	59	42	59	52	53	52	61
Potato protein concentrate	89	89	91	91	89	90	89
Soybean concentrate	94	94	95	96	96	96	97
Soybean hulls	68	61	70	72	64	69	58
Yeast, brewers	72	66	73	66	64	65	77
Yeast, brewers, high protein	54	64	55	53	54	53	52

Ileal standardised digestibilities expressed in %
- P+T : phenylalanine + tyrosine

Ileal standardised digestibility (continued)

	ARG	ALA	ASP	GLU	GLY	SER	PRO
Cereals							
Barley	83	71	76	88	76	81	84
Maize	91	89	87	93	82	89	89
Oats	88	69	76	86	70	74	72
Oats, decorticated	86	77	83	87	80	85	-
Rye	80	69	77	89	72	78	90
Sorghum	82	81	82	86	66	81	50
Triticale	91	80	85	95	85	88	94
Wheat	88	80	83	95	86	89	95
Cereal byproducts							
Barley brewers' grains	95	81	80	90	80	86	-
Barley distillers' grains, ethanol byproduct	93	80	84	93	82	89	-
Corn distillers	76	67	59	69	46	66	-
Corn gluten feed	86	80	70	79	65	77	75
Corn gluten meal	95	93	93	93	84	95	79
Maize germ meal, starch byproduct	84	71	60	75	63	75	-
Maize hominy feed	86	79	72	80	62	76	-
Rice bran	86	73	71	81	66	71	64
Wheat bran	86	69	74	88	70	77	81
Wheat distillers' grains, ethanol byproduct	88	78	77	90	80	84	-
Wheat feed flour	96	86	89	97	93	95	97
Wheat germs	94	85	86	91	83	83	79
Wheat gluten	87	75	73	98	84	91	95
Wheat gluten feed	80	62	67	83	63	72	-
Wheat middlings	91	80	83	93	80	86	89
Oil and protein seeds							
Faba bean	91	80	88	89	80	86	79
Lupin	93	79	88	90	81	86	86
Pea	89	75	82	84	78	79	78
Pea, extruded	94	87	91	94	89	92	92
Rapeseed, full-fat	81	72	72	82	72	71	82
Rapeseed, full-fat, treated	84	75	75	84	76	73	-
Soybean, full-fat, treated	86	78	82	82	77	81	80

Ileal standardised digestibilities expressed in %

Ileal standardised digestibility (continued)

	ARG	ALA	ASP	GLU	GLY	SER	PRO
Oil seed meals							
Cottonseed meal, decorticated	90	73	80	86	73	78	84
Cottonseed meal, partially decorticated	90	75	79	86	73	79	78
Groundnut meal, detoxified	91	72	85	88	69	76	78
Groundnut meal, not detoxified	97	92	93	94	82	90	93
Palm kernel meal, expeller	78	62	50	63	49	64	51
Rapeseed meal	87	80	76	87	78	78	78
Sesame meal, solvent extracted	96	90	90	93	83	89	92
Soybean meal, crude fibre < 5%	95	87	91	92	87	91	92
Soybean meal, crude fibre > 5%	93	85	88	89	84	88	90
Soybean meal, extruded	95	83	89	91	86	89	-
Sunflower meal, not decorticated	95	83	85	91	72	82	87
Sunflower meal, partially decorticated	93	82	84	90	73	82	87
Animal products							
Blood meal	86	85	82	86	85	85	87
Bone meal	84	83	82	84	81	83	83
Feather meal	84	79	63	73	81	82	77
Fish meal	94	92	88	94	89	91	93
Fish solubles	99	97	89	97	95	96	98
Greaves	92	87	68	86	84	81	87
Meat and bone meal	86	83	76	83	81	80	84
Meat and bone meal, low digestibility	75	72	55	71	71	61	72
Milk protein concentrate	94	88	92	92	91	87	-
Milk powder, skimmed	96	89	93	87	83	79	96
Milk powder, whole	88	90	94	91	93	80	-
Poultry offal meal	85	79	65	78	80	78	78
Whey, acid, dehydrated	51	56	74	81	54	61	-
Miscellaneous							
Alfalfa, dehydrated	77	69	76	71	52	64	64
Beet pulp, dehydrated	58	48	59	84	25	38	-
Potato protein concentrate	92	86	90	87	84	89	100
Soybean concentrate	99	91	96	97	95	96	-
Soybean hulls	84	56	69	74	38	59	-
Yeast, brewers	78	74	75	77	67	69	-
Yeast, brewers, high protein	61	52	62	72	53	54	-

Ileal standardised digestibilities expressed in %

Digestible amino acids

	CP	LYS	THR	MET	CYS	M+C	TRP
Cereals							
Barley	8.71	0.30	0.28	0.15	0.19	0.35	0.11
Maize	7.60	0.21	0.26	0.17	0.16	0.33	0.05
Oats	7.81	0.31	0.24	0.15	0.21	0.37	0.10
Oats, decorticated	12.26	0.46	0.44	0.26	0.36	0.63	0.18
Rye	6.52	0.25	0.20	0.12	0.16	0.28	0.07
Sorghum	7.66	0.16	0.24	0.15	0.13	0.28	0.08
Triticale	9.08	0.30	0.26	0.17	0.22	0.38	0.10
Wheat	10.80	0.28	0.29	0.17	0.23	0.40	0.13
Cereal byproducts							
Barley brewers' grains	17.00	0.60	0.59	0.33	0.30	0.63	0.19
Barley distillers' grains, ethanol byproduct	18.32	0.46	0.56	0.33	0.38	0.71	0.25
Corn distillers	14.55	0.39	0.54	0.27	0.28	0.55	0.03
Corn gluten feed	13.89	0.41	0.48	0.28	0.26	0.55	0.08
Corn gluten meal	55.66	0.92	1.89	1.30	0.94	2.24	0.26
Maize germ meal, starch byproduct	18.94	0.70	0.69	0.42	0.27	0.68	0.18
Maize hominy feed	10.61	0.28	0.32	0.23	0.18	0.42	0.06
Rice bran	9.91	0.53	0.38	0.25	0.21	0.46	0.12
Wheat bran	11.12	0.46	0.35	0.20	0.22	0.42	0.17
Wheat distillers' grains, ethanol byproduct	23.07	0.44	0.63	0.34	0.36	0.70	0.25
Wheat feed flour	12.99	0.39	0.36	0.22	0.26	0.48	0.14
Wheat germs	23.02	1.38	0.77	0.42	0.30	0.73	0.17
Wheat gluten	71.82	0.82	1.48	1.11	1.28	2.39	0.60
Wheat gluten feed	9.59	0.26	0.31	0.17	0.20	0.37	0.11
Wheat middlings	13.23	0.54	0.42	0.24	0.26	0.50	0.17
Oil and protein seeds							
Faba bean	23.26	1.46	0.77	0.17	0.26	0.43	0.19
Lupin	26.39	1.26	0.87	0.17	0.38	0.55	-
Pea	17.18	1.27	0.60	0.16	0.20	0.36	0.14
Pea, extruded	20.24	1.42	0.73	0.18	0.28	0.46	0.18
Rapeseed, full-fat	14.35	0.95	0.61	0.35	0.37	0.72	0.21
Rapeseed, full-fat, treated	14.64	0.95	0.62	0.39	0.38	0.77	0.20
Soybean, full-fat, treated	28.07	1.87	1.17	0.44	0.43	0.87	0.35

Values expressed in % as fed

- CP : crude protein (N x 6,25)
- M+C : methionine + cystine

Digestible amino acids

	CP	LYS	THR	MET	CYS	M+C	TRP
Oil seed meals							
Cottonseed meal, decorticated	31.10	0.96	0.84	0.38	0.43	0.82	0.31
Cottonseed meal, partially decorticated	22.98	0.94	0.83	0.44	0.35	0.78	-
Groundnut meal, detoxified	38.80	0.75	0.90	0.35	0.25	0.59	0.32
Groundnut meal, not detoxified	42.60	1.20	1.03	0.39	0.38	0.77	-
Palm kernel meal, expeller	8.53	0.14	0.24	0.17	0.08	0.25	0.05
Rapeseed meal	26.62	1.36	1.12	0.63	0.69	1.32	0.34
Sesame meal, solvent extracted	36.68	0.92	1.28	1.06	0.76	1.82	-
Soybean meal, crude fibre < 5%	41.79	2.63	1.57	0.61	0.60	1.21	0.53
Soybean meal, crude fibre > 5%	38.44	2.40	1.48	0.54	0.52	1.05	0.51
Soybean meal, extruded	41.35	2.58	1.66	0.68	0.57	1.26	0.54
Sunflower meal, not decorticated	21.09	0.77	0.82	0.60	0.33	0.93	0.30
Sunflower meal, partially decorticated	27.24	1.00	0.98	0.72	0.44	1.16	0.36
Animal products							
Blood meal	70.42	6.33	3.02	0.77	0.75	1.52	1.04
Bone meal	31.28	1.77	0.95	0.45	0.15	0.60	-
Feather meal	62.28	1.13	2.84	0.33	2.62	2.95	0.37
Fish meal	58.21	4.56	2.52	1.65	0.49	2.13	0.66
Fish solubles	74.86	3.40	1.99	1.23	0.25	1.48	-
Greaves	67.77	3.59	2.15	1.28	0.53	1.81	0.44
Meat and bone meal	41.51	2.11	1.28	0.58	0.32	0.92	0.25
Meat and bone meal, low digestibility	36.15	1.98	1.28	0.61	0.39	1.02	0.26
Milk protein concentrate	44.43	3.37	1.91	0.70	0.39	1.08	0.48
Milk powder, skimmed	30.04	2.72	1.32	0.75	0.22	0.97	-
Milk powder, whole	30.11	2.10	1.31	0.80	0.23	1.02	0.43
Poultry offal meal	43.32	1.90	1.79	0.60	1.11	1.72	0.30
Whey, acid, dehydrated	7.44	0.57	0.37	0.08	0.11	0.18	0.13
Miscellaneous							
Alfalfa, dehydrated	10.64	0.46	0.43	0.17	0.05	0.17	0.11
Beet pulp, dehydrated	5.93	0.17	0.09	0.08	0.02	0.09	0.03
Potato protein concentrate	68.19	5.46	3.96	1.58	1.15	2.72	0.52
Soybean concentrate	62.33	4.08	2.65	1.08	0.93	2.01	0.75
Soybean hulls	6.06	0.38	0.25	0.11	0.11	0.22	0.08
Yeast, brewers	33.18	2.39	1.32	0.45	0.16	0.61	0.28
Yeast, brewers, high protein	41.64	1.28	1.42	0.48	0.04	0.52	0.23

Values expressed in % as fed

- CP : crude protein (N x 6,25)
- M+C : methionine + cystine

Digestible amino acids (continued)

	ILE	VAL	LEU	PHE	TYR	P+T	HIS
Cereals							
Barley	0.31	0.43	0.61	0.45	0.24	0.69	0.20
Maize	0.28	0.38	0.99	0.39	0.26	0.65	0.21
Oats	0.30	0.39	0.60	0.41	0.23	0.64	0.20
Oats, decorticated	0.49	0.62	0.88	0.64	0.35	0.99	0.26
Rye	0.22	0.30	0.41	0.31	0.14	0.45	0.15
Sorghum	0.31	0.39	1.08	0.41	0.29	0.70	0.17
Triticale	0.29	0.39	0.57	0.39	0.21	0.60	0.21
Wheat	0.38	0.43	0.70	0.50	0.27	0.77	0.26
Cereal byproducts							
Barley brewers’ grains	0.72	0.92	1.21	0.95	0.44	1.39	0.33
Barley distillers’ grains, ethanol byproduct	0.74	0.93	1.28	1.05	0.56	1.61	0.38
Corn distillers	0.65	0.78	1.79	0.80	0.61	1.42	0.30
Corn gluten feed	0.48	0.69	1.38	0.59	0.42	1.01	0.42
Corn gluten meal	2.32	2.48	9.39	3.47	2.90	6.37	1.19
Maize germ meal, starch byproduct	0.67	1.02	1.43	0.88	0.53	1.41	0.75
Maize hominy feed	0.35	0.46	1.08	0.46	0.32	0.78	0.27
Rice bran	0.37	0.56	0.73	0.47	0.38	0.85	0.34
Wheat bran	0.38	0.53	0.76	0.50	0.33	0.83	0.35
Wheat distillers' grains, ethanol byproduct	0.78	0.91	1.44	1.06	0.58	1.64	0.52
Wheat feed flour	0.43	0.54	0.83	0.57	0.28	0.85	0.32
Wheat germs	0.69	1.05	1.36	0.76	0.58	1.34	0.50
Wheat gluten	2.54	2.53	4.75	3.69	2.24	5.93	-
Wheat gluten feed	0.31	0.43	0.61	0.40	0.20	0.60	0.25
Wheat middlings	0.43	0.62	0.86	0.56	0.36	0.92	0.35
Oil and protein seeds							
Faba bean	0.97	1.06	1.74	0.99	0.66	1.65	0.60
Lupin	1.27	1.05	1.98	1.08	1.02	2.10	0.73
Pea	0.70	0.75	1.18	0.80	0.49	1.28	0.44
Pea, extruded	0.81	0.90	1.41	0.93	0.64	1.57	0.55
Rapeseed, full-fat	0.57	0.74	0.95	0.59	0.44	1.04	0.42
Rapeseed, full-fat, treated	0.59	0.73	0.97	0.55	0.34	0.89	0.43
Soybean, full-fat, treated	1.41	1.43	2.25	1.55	1.15	2.70	0.82

Values expressed in % as fed
- P+T : phenylalanine + tyrosine

Digestible amino acids (continued)

	ILE	VAL	LEU	PHE	TYR	P+T	HIS
Oil seed meals							
Cottonseed meal, decorticated	0.96	1.35	1.77	1.69	0.94	2.61	0.83
Cottonseed meal, partially decorticated	0.83	1.26	1.58	1.51	0.81	2.31	0.70
Groundnut meal, detoxified	1.21	1.33	2.25	1.83	1.27	3.09	-
Groundnut meal, not detoxified	1.43	1.73	2.59	1.95	1.51	3.46	0.86
Palm kernel meal, expeller	0.36	0.52	0.65	0.45	0.23	0.68	0.16
Rapeseed meal	1.11	1.39	1.93	1.13	0.75	1.87	0.75
Sesame meal, solvent extracted	1.48	1.76	2.52	1.74	1.11	2.85	0.90
Soybean meal, crude fibre < 5%	1.98	1.98	3.14	2.08	1.51	3.57	1.17
Soybean meal, crude fibre > 5%	1.88	1.89	2.96	2.04	1.49	3.51	1.08
Soybean meal, extruded	2.00	1.99	3.09	2.02	1.38	3.41	1.14
Sunflower meal, not decorticated	0.98	1.07	1.42	1.05	0.44	1.50	0.54
Sunflower meal, partially decorticated	1.19	1.35	1.73	1.29	0.68	1.97	0.72
Animal products							
Blood meal	1.04	6.23	9.05	4.89	2.07	6.96	4.40
Bone meal	0.84	1.25	1.75	0.98	0.58	1.56	0.46
Feather meal	3.31	5.02	5.57	3.36	1.72	5.10	0.43
Fish meal	2.64	3.05	4.44	2.36	1.91	4.26	1.74
Fish solubles	1.42	2.09	2.97	1.62	0.71	2.33	1.02
Greaves	2.33	3.52	4.52	2.55	1.62	4.17	1.12
Meat and bone meal	1.22	1.82	2.51	1.41	0.93	2.34	0.82
Meat and bone meal, low digestibility	1.21	1.86	2.54	1.44	0.88	2.31	0.69
Milk protein concentrate	2.16	1.86	2.95	1.66	1.38	3.04	0.87
Milk powder, skimmed	1.70	2.05	3.23	1.65	1.71	3.36	0.90
Milk powder, whole	1.46	1.73	2.90	1.52	1.44	2.96	0.71
Poultry offal meal	1.95	2.59	3.36	1.93	1.29	3.22	0.84
Whey, acid, dehydrated	0.36	0.28	0.48	0.17	0.09	0.26	0.24
Miscellaneous							
Alfalfa, dehydrated	0.48	0.59	0.83	0.53	0.34	0.87	0.20
Beet pulp, dehydrated	0.20	0.18	0.26	0.13	0.16	0.29	0.13
Potato protein concentrate	3.98	4.47	6.93	4.43	4.12	8.56	1.94
Soybean concentrate	3.16	3.12	4.93	3.26	2.13	5.40	1.73
Soybean hulls	0.30	0.31	0.51	0.31	0.21	0.51	0.16
Yeast, brewers	1.49	1.43	2.10	1.02	0.84	1.86	0.75
Yeast, brewers, high protein	1.27	2.39	1.98	1.00	0.74	1.74	0.57

Values expressed in % as fed

- P+T : phenylalanine + tyrosine

Digestible amino acids (continued)

	ARG	ALA	ASP	GLU	GLY	SER	PRO
Cereals							
Barley	0.45	0.31	0.48	2.23	0.33	0.37	0.90
Maize	0.35	0.59	0.49	1.53	0.26	0.38	0.64
Oats	0.58	0.34	0.61	1.80	0.34	0.36	0.39
Oats, decorticated	0.78	0.58	1.01	2.73	0.62	0.68	-
Rye	0.38	0.27	0.50	1.80	0.27	0.29	0.69
Sorghum	0.29	0.70	0.53	1.77	0.20	0.35	0.41
Triticale	0.49	0.35	0.55	2.43	0.37	0.41	0.57
Wheat	0.51	0.33	0.51	3.24	0.40	0.50	1.13
Cereal byproducts							
Barley brewers' grains	0.81	0.80	0.91	4.12	0.66	0.74	-
Barley distillers' grains, ethanol byproduct	0.91	0.62	0.93	4.82	0.61	0.80	-
Corn distillers	0.71	1.09	0.92	2.76	0.47	0.69	-
Corn gluten feed	0.78	1.04	0.79	2.30	0.54	0.63	1.22
Corn gluten meal	1.71	4.88	3.27	12.24	1.24	2.99	4.53
Maize germ meal, starch byproduct	1.52	1.06	1.04	2.47	0.84	0.91	-
Maize hominy feed	0.47	0.76	0.61	1.78	0.36	0.49	-
Rice bran	1.08	0.59	0.93	1.60	0.53	0.47	0.40
Wheat bran	0.96	0.49	0.80	2.63	0.55	0.51	0.74
Wheat distillers' grains, ethanol byproduct	1.05	0.73	0.97	6.16	0.79	1.07	-
Wheat feed flour	0.66	0.44	0.64	3.60	0.52	0.57	1.20
Wheat germs	1.77	1.20	1.75	3.31	1.12	0.84	0.73
Wheat gluten	2.46	1.38	1.67	22.04	1.97	3.49	10.45
Wheat gluten feed	0.61	0.40	0.62	2.19	0.42	0.45	-
Wheat middlings	0.97	0.57	0.86	3.07	0.61	0.59	0.92
Oil and protein seeds							
Faba bean	2.13	0.90	2.45	4.25	0.91	1.12	0.91
Lupin	3.04	0.84	2.76	6.59	1.04	1.37	1.04
Pea	1.63	0.69	1.99	3.05	0.71	0.80	0.67
Pea, extruded	1.84	0.85	2.28	3.48	0.92	0.96	0.91
Rapeseed, full-fat	1.01	0.63	1.10	2.88	0.73	0.61	1.07
Rapeseed, full-fat, treated	0.99	0.63	0.99	2.71	0.70	0.64	-
Soybean, full-fat, treated	2.42	1.24	3.48	5.79	1.20	1.56	1.50

Values expressed in % as fed

Digestible amino acids (continued)

	ARG	ALA	ASP	GLU	GLY	SER	PRO
Oil seed meals							
Cottonseed meal, decorticated	3.76	1.12	3.06	6.61	1.24	1.35	1.12
Cottonseed meal, partially decorticated	3.16	0.94	2.32	5.87	0.97	1.14	0.94
Groundnut meal, detoxified	4.62	1.15	4.22	6.80	1.72	1.62	1.54
Groundnut meal, not detoxified	5.04	1.61	4.53	7.72	2.05	1.89	1.70
Palm kernel meal, expeller	1.27	0.38	0.61	1.81	0.32	0.43	0.22
Rapeseed meal	1.78	1.20	1.86	5.08	1.33	1.17	1.68
Sesame meal, solvent extracted	4.64	1.69	3.04	7.45	1.74	1.62	1.24
Soybean meal, crude fibre < 5%	3.33	1.69	4.68	7.84	1.63	2.13	2.11
Soybean meal, crude fibre > 5%	3.10	1.62	4.41	7.22	1.55	2.00	1.98
Soybean meal, extruded	3.43	1.74	4.76	7.81	1.70	2.25	-
Sunflower meal, not decorticated	1.93	0.92	1.99	4.51	1.09	0.96	0.97
Sunflower meal, partially decorticated	2.64	1.13	2.34	5.92	1.35	1.17	1.29
Animal products							
Blood meal	3.19	5.48	7.49	7.10	3.36	3.42	2.97
Bone meal	2.17	2.47	2.27	3.93	4.80	1.21	2.97
Feather meal	4.43	2.94	3.40	6.29	5.00	7.21	6.07
Fish meal	3.57	3.62	5.06	7.91	3.70	2.34	2.53
Fish solubles	4.14	5.24	4.12	8.38	10.35	3.05	4.98
Greaves	5.11	5.38	3.98	8.27	9.31	2.34	5.88
Meat and bone meal	2.94	2.97	2.75	4.98	5.00	1.54	3.41
Meat and bone meal, low digestibility	2.72	2.73	2.27	4.56	4.41	1.60	3.09
Milk protein concentrate	1.95	2.04	4.09	5.41	1.72	1.95	-
Milk powder, skimmed	1.17	1.05	2.42	6.56	0.56	1.41	3.08
Milk powder, whole	1.07	0.86	2.23	5.93	0.56	1.48	-
Poultry offal meal	3.17	2.40	2.69	5.43	3.80	3.04	3.38
Whey, acid, dehydrated	0.05	0.22	0.58	1.19	0.12	0.25	-
Miscellaneous							
Alfalfa, dehydrated	0.55	0.57	1.69	1.11	0.40	0.46	0.39
Beet pulp, dehydrated	0.14	0.17	0.37	1.68	0.09	0.14	-
Potato protein concentrate	3.69	3.30	8.58	7.46	3.06	3.70	4.13
Soybean concentrate	5.12	2.65	7.51	11.97	2.67	3.59	-
Soybean hulls	0.49	0.28	0.69	1.07	0.29	0.37	-
Yeast, brewers	1.50	2.05	2.97	4.17	1.18	1.36	-
Yeast, brewers, high protein	2.07	2.39	3.01	9.22	1.30	1.13	-

Values expressed in % as fed

Authors

The AmiPig database is brought to you by the following organisations:

- AFZ – Association Française de Zootechnie / French Feed Database
- Ajinomoto Eurolysine
- Aventis Animal Nutrition
- INRA - Institut National de la Recherche Agronomique / UMRVP
- ITCF - Institut Technique des Céréales et des Fourrages

The AFZ (French Association for Animal Production), established in 1949, is a non-profit making association of individuals and organisations working in the field of animal productions. The missions of AFZ are:

- to bring together specialists in all fields of animal productions and to promote information exchange and work collaborations
- to contribute to the dissemination and application of knowledge related to animal productions
- to promote an objective and positive image of animal productions and of products of animal origin

AFZ pursues these objectives in several ways. Principal among them are:

- its participation in the European Federation of Animal Production
- the organisation of meetings and field trips
- the organisation of the permanent exhibition "Des animaux bien élevés", aimed at the general public
- the operation of the French Feed Database

The French Feed Database of the AFZ was in charge of the management and statistical processing of the experimental data used to create the AmiPig database, and of the design specifications of the AmiPig software.

Established in 1989, io – the French Feed Database is committed to the dissemination of reliable and comprehensive information about the chemical composition and nutritive value of feedstuffs. It is the central hub of a network of 19 member organisations including compound feed manufacturers, raw material producers, R&D institutes and trade organisations. Most of the data stored by the French Feed Database come from the network members' laboratories, the other source of data being the scientific literature. Data include numerical values (such as protein content or poultry metabolisable energy), samples descriptions (geographical and industrial provenance, sampling dates...), methods of analysis and literature references. The French Feed Database contains composition and nutritional data for more than 2000 raw materials and 650 parameters, for a total of more than 1 million data.

Services include:

- Data files (raw or processed data)
- Monographs on raw materials
- Monographs on criteria
- Literature searches and reviews
- Statistical studies
- Software design and development
- Scientific and commercial illustration
- Expertise in feed information management

Please contact us for further information about our services.

Contact info :

AFZ / io - Banque de Données de l'Alimentation Animale
16 rue Claude Bernard
75231 Paris Cedex 05
Tel 33 1 44 08 18 08 - Fax 33 1 44 08 18 53
Email : tran@inapg.inra.fr
Web site : http://www.feedbase.com

AJINOMOTO

AJINOMOTO ANIMAL NUTRITION

AJINOMOTO EUROLYSINE

Ajinomoto Eurolysine manufactures and markets L-Lysine, L-Threonine and L-Tryptophan for feed usage. Operating in Europe, it contributes together with the other companies of the Ajinomoto Animal Nutrition network to make Ajinomoto the worldwide leader in feed grade amino acids.

Europe, Africa, Middle East, Central Europe and Eastern countries

Ajinomoto Eurolysine
France
Tel. : + 33.(0).1.44.40.12.12
Fax : + 33.(0).1.44.40.12.13

North America

Heartand Lysine Inc.
United States
Tel. : + 1.773.380.70.00
Fax : + 1.773.380.70.06
Web site http://lysine.com

South America

Ajinomoto Biolatina Indùstria e commercio Ltda.
Brazil
Tel: + 55 11 5579-6971
Fax: + 55 11 5575-7146

Southeast, Southwest Asia, Oceania

Ajinomoto Co., (Thailand) Ltd.
Thailand
Tel. : + 66.2.245.16.14
Fax : + 66.2.247.56.17

Japan, East Asia

Ajinomoto Co., Inc. Animal Nutrition Dept
Japan
Tel. : + 81.3.52.50.81.40
Fax : + 81.3.52.50.82.70

China

Chuanhua Ajinomoto Co., Ltd.
People’s Republic of China
Tel. : + 86 (28) 368.4305
Fax : + 86 (28) 330.1878

Aventis Animal Nutrition is dedicated to developing, manufacturing and marketing vitamins, amino acids, enzymes and other nutritional feed additives for animals. It serves customers worldwide with several lines of efficient, high-performance products, marketed in a variety of forms suitable for all types of feed and animal species:

- The Rhodimet™ line of methionine products.
- The Microvit™ line of vitamins.
- The Rovabio™ line of enzymes.
- The Smartamine™ line of specialty products for ruminants.

All these products, which are specially formulated to be incorporated into animal feed, have been extensively tested in field conditions. They comply with the quality standards required for use in the most efficient animal production facilities, thereby helping to improve the competitiveness and profitability of animal production.

Aventis Animal Nutrition supports its product lines with a broad array of innovative services:

- Practical Guides to ensure efficient product use:
  - Amino acids: The Rhodimet™ Nutrition Guide (nutritional information) and the Rhodimet™ User's Guide (application technology).
  - Vitamins: The Microvit™ Nutrition Guide and the Microvit™ User's Guide.
- The Vitamin Certification System and the Blend Certification System to appraise the technological and biological efficacy of vitamin products and premixes. These methods enable premix or feed producers to select just the right vitamin or premix source for their particular plant configuration and usage parameters.
- Systems and software to help improve product effectiveness.

In response to market demand, Aventis Animal Nutrition has established an international organization.

- The marketing organization is based in four regions: Europe/Middle East/Africa/CIS, North America, Latin America, and Asia-Pacific.
- Manufacturing facilities are located in different continents.
- Research and development activities are conducted in co-operation with researchers, research centers and universities around the world.

Europe/Middle East/Africa/CIS

Aventis Animal Nutrition SA
42, avenue Aristide Briand
BP 100
92164 Antony Cedex
France

Tel : 33 (0)1 46 74 70 00
Fax : 33 (0)1 40 96 96 96

North America

Aventis Animal Nutrition Inc.
3480 Preston Ridge Road
Suite 650
Alpharetta, GA 30005-2028
USA
Tel : 1 678 339 15 00
Fax : 1 678 339 16 00

Latin America

Aventis Animal Nutrition Brasil Ltda
Av. Maria Coelho de Aguiar, 215
Bloco B – 2° andar
CEP 05804-902 Sao Paulo
Brazil
Tel : 55 11 37 41 77 41
Fax : 55 11 37 41 70 80

Asia Pacific

Aventis Animal Nutrition Asia-Pacific Pte Ltd
Regional Operations Centre
1 Loyang Way 4
Singapore 507 028
Singapore
Tel : 65 543 11 21
Fax : 65 545 37 08

The Institut National de la Recherche Agronomique, founded in 1946, is a national public scientific and technological establishment, under the joint authority of the Ministries of Research and Agriculture. INRA has a threefold mission to guarantee consumers high-quality food, to ensure that agricultural and agro-food companies are competitive, and to contribute to integrated land development and sustainable management of natural resources.

Contact info :

INRA / UMRVP
35590 Saint-Gilles
FRANCE
Telephone : 33 2 23 48 50 52
Fax : 33 2 23 48 50 80
INRA http://www.inra.fr
UMRVP http://www.rennes.inra.fr/umrvp/umrvp.html

The pig and veal calf research unit aims at conducting basic and applied research in order to meet both the demand of the animal production sector (farmer, feed and meat industry) and that of the citizens (safe and high quality food, sustainable management of natural resources, animal welfare). The main research objectives include:

- to improve the competitiveness of farms by increasing the added value of products
- to improve the quality and diversity of animal products
- to propose new pig production systems with improved animal welfare and lower impact on the environment

The research unit, which employs 120 people including 35 research scientists, is structured into 4 research groups:

- Tissue growth and meat quality (9 scientists)
- Production and welfare of reproductive sows and piglets (6 scientists)
- Feeding and environmental pollution (7 scientists)
- Physiology and physio-pathology of digestion and protein metabolism (12 scientists)

Experimental facilities are available for physiological studies in pigs and calves, as well as performance trials in pigs (240 reproductive sows and their offspring).



Formed in 1959 by French Farmers' Organisations, the Technical Institute for Cereals and Forage (ITCF) is financed and run by a Board of Directors composed of Farmers. The aim of ITCF is to develop and disseminate techniques and information enabling farmers and their partners to adapt to the changing needs of the market and to maintain their international competitiveness, while protecting the environment. This aim is carried out in close liaison with all professional organisations of the whole industries, as well as public and private research sectors, both national and abroad. From the production techniques to the food and non-food outlets, from the choice of crop species and varieties to the farming systems, the actions of ITCF meet the technical and economic concerns of cereal, maize, pulses, potato and forage producers.

Contact info :

Institut Technique des Céréales et des Fourrages
8 avenue du Président Wilson - 75116 Paris
FRANCE
Telephone : 33 1 44 31 10 00
Fax : 33 1 44 31 10 10
Web site http://www.itcf.fr