

## AMINO ACID CONTENT IN RAW MATERIALS TYPICALLY USED IN ASIA

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Prices on most commodities have fluctuated extensively over the last two to three years. That include typical feed ingredients like soya, rapeseed meal, corn, wheat, etc. Due to this variation the interest for a better utilization and evaluation of real value of the commonly used raw materials has increased substantially. Utilization is related to knowledge about the exact level of available nutrients in the raw material as it gives the basis for formulation of diets that exactly meet the requirements of the birds – not too much (waste of nutrients) and not too little (negative effect on performance). Real value of the raw material is also related to knowledge of available nutrients (e.g. digestibility and expected variation) and on top of this the prices of alternative raw materials.

When focusing on evaluation of protein quality, it is not the crude protein (CP) as such that are important but rather the content of digestible essential amino acids like lysine, methionine, threonine and tryptophan. When evaluating the quality and value it is therefore very important to look for these first limiting amino acids. The purpose of this article has therefore been to give updated information about the amino acid content in raw materials typically used in Asian layer feeds and do some simple value evaluation of these raw materials.

### PREDICTION OF AMINO ACID CONTENT IN RAW MATERIALS

The data in this article is based on raw material analyses performed by Evonik Degussa in 2009. The analyses were mainly done by NIR (AminoNIR<sup>®</sup>) but for peanut meal, millet, and mustard meal, where no NIR calibration for amino acids is available, the analyses were done by wet chemistry analysis (AminoLab<sup>®</sup>). In Table 1-9, the mean values and coefficient of variation (CV) for corn, millet, ricebran, coconut meal (copra), mustard, rapeseed meal, soybean meal, and peanut meal are compared with the table values from AminoDat<sup>®</sup>. All of these raw materials can contribute significantly to the amino acid content in layer feeds. Either because of inclusion rate of the raw material in the diet (e.g. corn and millet) or due to the high amino acid level in the particular raw material (e.g. peanut meal and soybean meal).

In Table 1 the analysed data for corn show a slightly lower CP level compared to the table values. However, the amino acid profile show a higher content of especially lysine expressed as % of CP. Regarding the lower CP level it is important to remember that it is an average number and the variation (CV) also show that it varies considerably.

Table 1. Crude protein (CP) and amino acid content in corn

	Corn			
	2009		AminoDat <sup>®</sup> 3.0	
	mean	CV, %	mean	CV, %
N	1154		765	
Dry Matter, %	86.8	2.1	88	-
		--- as is (%)	---	
CP	7.44	9.77	8.37	12.30
		--- % of CP	---	
MET	2.01	5.52	2.01	8.70
M+C	4.29	4.04	4.22	6.70
LYS	3.15	6.38	2.99	10.20
THR	3.61	2.22	3.55	3.70
TRP	0.80	6.37	0.76	7.90
ARG	4.88	4.84	4.72	7.70
ILE	3.36	2.90	3.29	5.40
LEU	11.88	4.51	11.89	6.40
VAL	4.68	2.51	4.58	4.80

(Source: Evonik Degussa Feed Additives)

In Table 2 the analysed data for millet from 2009 clearly show a lower CP level compared to the table values. However, as for corn there is a huge variation in the analysed CP values (CV>19%). Looking at the amino acid profile the lysine (% of CP) is almost 10 % higher than table values but like for CP a large variation was found. With such a high variation it is important not only to rely on table values as it will be discussed below.

Table 2. Crude protein (CP) and amino acid content in millet

	Millet			
	2009		AminoDat <sup>®</sup> 3.0	
	mean	CV, %	mean	CV, %
N	25		124	
Dry Matter, %	89.43	1.38	88	
		--- as is (%)	---	
CP	10.90	19.16	12.57	18.40
		--- % of CP	---	
MET	2.28	13.47	2.21	13.30
CYS	1.82	5.35	1.79	8.00
M+C	4.07	8.31	4.00	9.80
LYS	2.96	10.56	2.70	11.50
THR	3.79	3.38	3.72	4.80
TRP	-	-	1.76	11.70
ARG	4.45	6.49	4.31	6.70
ILE	4.04	4.68	4.11	4.60
LEU	9.94	7.56	10.03	6.10
VAL	5.22	3.76	5.39	5.90

(Source: Evonik Degussa Feed Additives)

Ricebran was divided in full fat and de-oiled material (Table 3 & 4). In Table 3 the full fat ricebran show an average CP level close to the table value and the amino acid profile is also not far off. The CP and amino acid profile also seem to vary less than for the millet.

Table 3. Crude protein (CP) and amino acid content in Ricebran – full fat

	Ricebran – full fat			
	2009		AminoDat <sup>®</sup> 3.0	
	mean	CV, %	mean	CV, %
N	899		136	
Dry Matter, %	89.3	3.6	88	-
		--- as is (%) ---		
CP	13.68	7.08	13.06	14.80
		--- % of CP ---		
MET	1.95	4.25	2.00	5.90
CYS	2.13	3.51	2.06	6.00
M+C	4.11	3.02	4.06	4.70
LYS	4.70	5.87	4.62	6.70
THR	3.78	2.08	3.80	5.10
TRP	1.23	3.86	1.26	4.20
ARG	7.70	4.42	7.86	5.50
ILE	3.42	2.29	3.51	5.10
LEU	6.99	1.96	7.16	4.90
VAL	5.37	2.75	5.48	5.60

(Source: Evonik Degussa Feed Additives)

As for the full fat ricebran the de-oiled material show an average CP level and amino acid profile close to the table values (Table 4). The variation is at the same relative low level as full fat ricebran but it is interesting to note that lysine again is the amino acid that varies the most.

Table 4. Crude protein (CP) and amino acid content in de-oiled ricebran

	Ricebran – de-oiled			
	2009		AminoDat <sup>®</sup> 3.0	
	mean	CV, %	mean	CV, %
N	998		41	
Dry Matter, %	89.2	1.2	88	-
		--- as is (%) ---		
CP	16.83	5.36	16.99	6.10
		--- % of CP ---		
MET	1.95	4.07	1.93	5.30
CYS	1.97	2.62	1.94	6.30
M+C	3.93	2.19	3.86	4.70
LYS	4.48	5.88	4.43	7.30
THR	3.83	2.19	3.81	4.70
TRP	1.23	3.44	1.24	3.80
ARG	7.41	3.99	7.66	5.00
ILE	3.49	3.19	3.51	6.10
LEU	7.10	2.72	7.13	4.90
VAL	5.52	3.81	5.57	6.30

(Source: Evonik Degussa Feed Additives)

In Figure 1 the lysine, Met+Cys, threonine and tryptophan content in ricebran (full fat and de-oiled) expressed as % of CP is shown in response to the CP level. It seems like especially lysine and Met+Cys (% of CP) are lower in the de-oiled material where CP is normally above 15 %. This effect could be due to the processing as we in many raw materials often see a negative effect on lysine and cysteine content due to heat treatment.

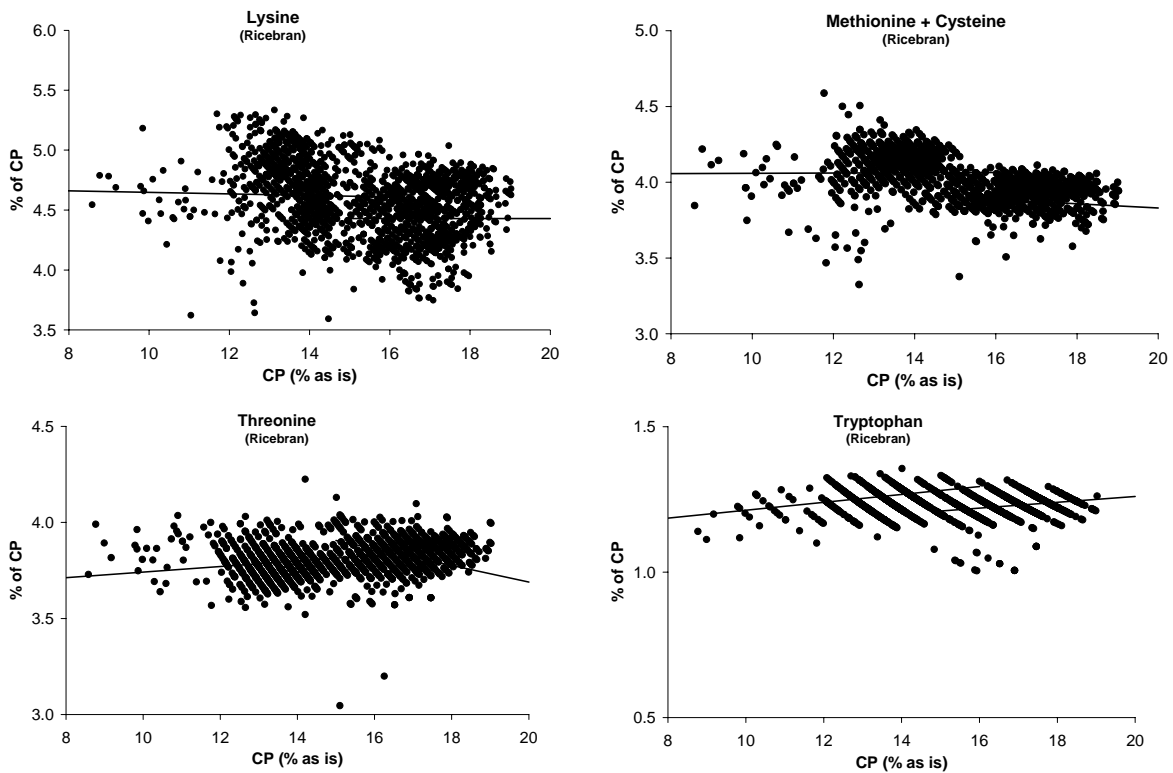


Figure 1. Lysine, Methionine+Cysteine, Threonine and Tryptophan content (% of CP) in Rice Bran in response to crude protein level (Source: Evonik Degussa Feed Additives).

In Table 5 the analysed data for coconut meal (copra) from 2009 clearly show a higher average CP level compared to the table values. However, this high CP can to a large extent be explained by the high dry matter level in the analysed samples. The average lysine and to some extent the Met+Cys are on the other hand lower compared with the table values. It is also evident that the lysine (% of CP) variation is much higher than the other amino acids.

Table 5. Crude protein (CP) and amino acid content in coconut meal (copra)

	Coconut meal			
	2009		AminoDat <sup>®</sup> 3.0	
	mean	CV, %	mean	CV, %
N	133		30	
Dry Matter, %	96.32		88	
		--- as is (%) ---		
CP	22.19	4.96	20.72	9.60
		--- % of CP ---		
MET	1.28	4.90	1.29	5.80
CYS	1.31	7.03	1.44	6.10
M+C	2.59	4.65	2.73	4.80
LYS	2.41	11.18	2.63	13.40
THR	2.89	2.78	2.95	4.20
TRP	0.77	3.00	0.75	5.60
ARG	10.17	9.45	10.95	8.60
ILE	3.09	2.46	3.13	3.50
LEU	6.02	2.29	6.04	2.10
VAL	4.75	2.21	4.83	3.50

(Source: Evonik Degussa Feed Additives)

The analysed data for mustard meal from 2009 show a slightly higher average CP level compared to the table values (Table 6). The amino acid profile seems to be close to the table values. However, also for mustard meal the lysine show higher variation compared to the other amino acids.

Table 6. Crude protein (CP) and amino acid content in mustard meal

	Mustard Meal			
	2009		AminoDat <sup>®</sup> 3.0	
	mean	CV, %	mean	CV, %
N	29		10	
Dry Matter, %	91.0	1.3	88	
		--- as is (%) ---		
CP	37.52	5.18	36.28	7.40
		--- % of CP ---		
MET	1.88	4.45	1.82	3.50
CYS	2.52	5.15	2.45	5.80
M+C	4.40	3.33	4.27	3.30
LYS	4.80	8.65	4.95	8.80
THR	3.93	2.62	4.01	7.10
TRP	-	-	1.43	0.00
ARG	6.22	6.10	6.47	4.50
ILE	3.77	2.28	3.84	6.30
LEU	6.60	1.57	6.73	5.80
VAL	4.76	2.10	4.81	7.10

(Source: Evonik Degussa Feed Additives)

In table 7 the analysed data for rapeseed meal (including canola) from 2009 show a similar average CP level compared to the table values. The average lysine (% of CP) is on the other

hand 5% higher compared to the table values. Again the lysine variation was found to be much higher than for the other amino acids. It is also worth noting that the lysine and threonine level is almost 10% higher than in mustard meal, clearly showing that these two raw materials can not be treated as the same.

Table 7. Crude protein (CP) and amino acid content in rapeseed meal

	Rapeseed Meal			
	2009		AminoDat® 3.0	
	mean	CV, %	mean	CV, %
N	2134		232	
Dry Matter, %	89.8	1.7	88	-
		--- as is (%) ---		
CP	36.25	6.83	35.92	8.60
		--- % of CP ---		
MET	1.92	2.66	1.93	3.80
CYS	2.36	5.30	2.35	7.10
M+C	4.29	2.68	4.28	4.50
LYS	5.17	8.42	4.92	15.10
THR	4.26	4.04	4.20	4.70
TRP	1.34	2.19	1.33	4.60
ARG	5.93	4.58	5.76	9.00
ILE	3.86	1.69	3.85	3.60
LEU	6.85	1.91	6.82	2.80
VAL	4.97	2.27	4.94	4.00

(Source: Evonik Degussa Feed Additives)

In Table 8 the analysed data for high-pro soybean meal from 2009 show an average CP level that is slightly higher compared to the table values and an amino acid profile that is very similar. It is interesting to note that soybean meal is less variable but due to the normally high inclusion rate it is still very important to have a close eye on the actual content.

Table 8. Crude protein (CP) and amino acid content in soybean meal

	Soybean Meal – High-Pro			
	2009		AminoDat® 3.0	
	mean	CV, %	mean	CV, %
N	1427		495	
Dry Matter, %	88.3	1.1	88	
		--- as is (%) ---		
CP	48.59	3.50	47.64	2.30
		--- % of CP ---		
MET	1.34	2.47	1.34	5.10
CYS	1.45	3.11	1.46	6.40
M+C	2.80	2.44	2.81	5.00
LYS	6.08	2.38	6.10	3.00
THR	3.85	1.52	3.92	2.50
TRP	1.33	2.22	1.36	2.40
ARG	7.32	2.00	7.32	2.70
ILE	4.51	1.09	4.49	3.00
LEU	7.56	1.07	7.56	1.50
VAL	4.71	1.29	4.70	3.20

(Source: Evonik Degussa Feed Additives)

For the peanut meal the analysed data from 2009 clearly show a higher average CP level compared to the table values (Table 9), whereas the amino acid profile is similar to the table values. Both CP and amino acids levels vary a lot but in this case the lysine variation is actually not higher than for the other amino acids.

Table 9. Crude protein (CP) and amino acid content in peanut meal

	Peanut Meal			
	2009		AminoDat <sup>®</sup> 3.0	
	mean	CV, %	mean	CV, %
N	61		49	
Dry Matter, %	91.2	2.0	88	
		--- as is (%)	---	
CP	47.59	9.99	45.90	9.70
		--- % of CP	---	
MET	1.08	7.95	1.02	6.30
CYS	1.29	6.53	1.29	5.80
M+C	2.37	6.72	2.30	5.20
LYS	3.22	6.99	3.18	5.70
THR	2.57	2.74	2.59	2.80
TRP	0.96	2.07	0.99	1.90
ARG	11.02	2.76	11.14	3.90
ILE	3.22	1.90	3.18	3.10
LEU	6.14	1.70	6.18	1.70
VAL	3.90	2.74	3.91	3.10

(Source: Evonik Degussa Feed Additives)

As the figures in Table 1-9 reveals, a high variation in crude protein content as well as in the amino acid profile was found for all raw material except soybean meal (CV > 5 %). Especially lysine seems to vary a lot and in copra meal and millet the CV for total content was found to exceed 12 and 15 %, respectively.

From these data it is evident that the amino acid content still shows a very high variation. As an example the rapeseed meal sample with the highest level of total lysine has a content that was more than two times higher than the content in the samples with the lowest lysine level (1.01 vs. 2.30 % as is). The question is therefore how can we make sure that we get what we anticipate when these raw materials are being purchased.

The simplest way to evaluate nutrient content in a raw material is to look for table values. However, with the high variation it is clear that it would in many cases not give a precise answer to the question. The next step is then to calculate the amino acid content based on CP content where a constant ratio between CP content and the individual amino acids are expected. This will in many cases give a better estimation compared to the simple table value.

However, as figure 1 and 2 clearly shows such a constant ratio does not exist. In figure 2 the lysine, Met+Cys, threonine and tryptophan content in rapeseed meal expressed as % of CP is shown in response to the CP level for the samples originating from Canada/USA, China, and India. It seems like especially lysine (% of CP) are lower in the Indian material, whereas the material from Canada/USA in general show a higher lysine level. For the Chinese material is

seems like it is grouped in two categories. This effect could be due to the type of processing as we in many raw materials see a negative effect on lysine and to some extent cysteine content when the material is over processed (heat damaged). This is probably also the reason why we often see a higher variation in lysine content of CP. Heat damage is probably related to the so called Millard reaction where the ε-amino group in Lysine reacts with a sugar molecule resulting in a new structure rendering the amino acid unavailable for nutrition.

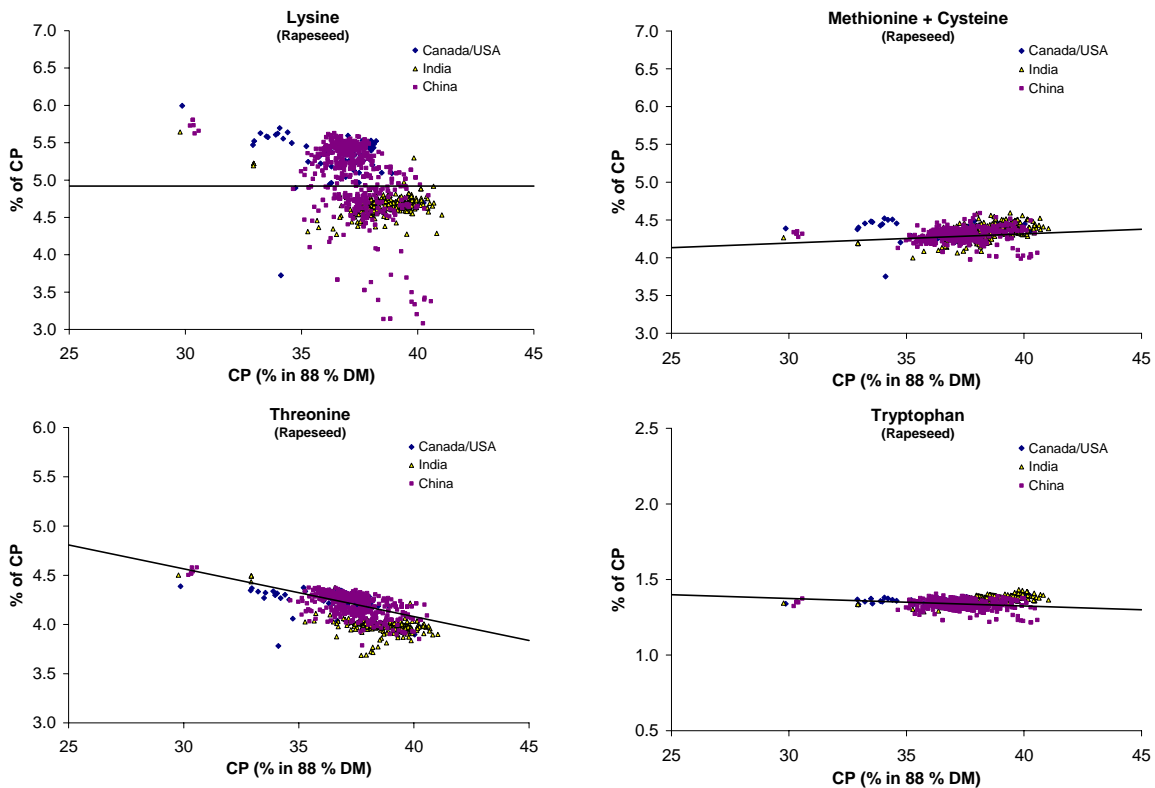


Figure 2. Lysine, Methionine+Cysteine, Threonine and Tryptophan content (% of CP) in rapeseed meal in response to crude protein level (Source: Evonik Degussa Feed Additives).

Thus, if in these cases a constant factor for the amino acid content of CP is used to calculate the amino acid level the result will in many cases be either an over or under estimation of the amino acid level. Based on the present data it is clear how important it is to have reliable information about the real amino acid content in order to be prepared for the purchase decisions and feed optimization. The data also shows that it is not enough to use table values, and calculations of amino acid content based on a fixed percentage of CP are also not enough. The optimal solution would therefore be to analyse the amino acids content every time a new shipment is delivered. In fact this can be done with limited expenses by using the NIR technology and the calibrations Evonik Degussa Feed Additives has developed for analyses of amino acid content in feed ingredients.

### DIGESTIBILITY AFFECTS THE RAW MATERIAL VALUE

When evaluating raw materials it is important not only to look at the total level of nutrients but rather the digestible level of nutrients. The reason is that digestibility varies between amino acids

and also depends on the raw material. In Table 10 the digestibility coefficients are shown for the raw materials presented in this article.

Table 10. Amino acid standardized digestibility coefficients for raw materials

	Corn	Millet	Ricebran	Mustard	RSM	Copra	SBM	Peanut
Lys	92	78	74	-	80	52	90	76
Met	94	88	77	-	84	84	91	86
M+C	90	84	72	-	80	70	86	82
Thr	85	80	69	-	73	60	85	85
Trp	81	85	79	-	80	51	89	87
Arg	93	78	86	-	87	84	93	91
Ile	95	88	75	-	79	78	89	89
Leu	94	93	73	-	82	80	89	90
Val	92	86	75	-	79	79	88	89

(Source: Evonik Degussa Feed Additives).

The figures show lower digestibility for lysine in a number of the so called alternative raw materials. This information is important to take into account when the value is evaluated. In table 11 a layer diet based on corn, ricebran, soybean meal and DDGS is used to evaluate shadow prices for millet, mustard meal, rapeseed meal, copra meal, and peanut meal. For all these raw materials the shadow price is higher when the diet is formulated with total amino acid specs. However, by doing so the actual available amino acids for the bird is not taken into account and when using these raw materials the diet will contain lower digestible amino acids than required and thereby affect performance negatively. Thus, real raw material value (shadow price) should be done based on digestible amino acid level in the respective raw materials.

Table 11. Shadow prices based on diet formulation and nutrient specs for a laying hen diets formulated based 110 g/hen/day of intake

Ingredients	Price (USD/MT)	Composition (g/kg)	Minimum Specs (g/kg)	
Corn, ASA 2010	210	380	Crude protein	160
Ricebran, ASA 2010	150	221	Crude fat	5 - 6
SBM, ASA 2010	510	167	Linoleic acid	1.0
DDGS (corn based)	200	120	Crude fiber	4.5 – 5.5
CaCO <sub>3</sub>	300	82.5	ME (kcal/kg)	2600
DCP, 22%	400	19.7	SID Lys	7.5
NaCl	85	3.4	SID Met	3.8
Vit + Min	-	4.9	SID Met + Cys	6.8
DL-Methionine	4500	1.90	SID Thr	5.2
L-Lysine HCL	2200	0.70	SID Arg	7.7
L-Threonine	2900	0.05	SID Ile	5.9
Total	264	1000	SID Val	6.6
Shadow prices	Total AA	SID AA	Calcium	37.0
Millet, ASA 2010	223	221	Dig. Phosphorus	4.0
Mustard, ASA 2010	361	337	Sodium, min	1.7

Ingredients	Price (USD/MT)	Composition (g/kg)	Minimum Specs (g/kg)	
Rapeseed, ASA 2010	362	336	Chloride, max	2.5
Copra meal, ASA 2010	242	227		
Peanut meal, ASA 2010	325	314		

### VARIATION AFFECTS THE RAW MATERIAL VALUE

The high variation found in the present raw materials will affect the value of these raw materials, as the variation together with price and digestible nutrient content are the main factors determining the real value of the raw materials. A high variation will always lower the value of a raw material because it affects the magnitude of the safety margin needed to ensure that the purchased raw material actually contain the expected content of the nutrient in question. Statistically it can be shown that if one standard deviation (std) is subtracted from the mean value, a total of 83% of the batch will contain at least this level of the nutrient. It should therefore be common practice when formulating a feed ration to work with a safety margin between ½ and 1 std, i.e. ½ to 1 std is subtracted from the mean value. In table 12 the mean values of amino acids and variation are compared for rapeseed meal separated according to origin and lysine level in the Chinese material. As the figures shows, there are relative large differences between the mean values and the values including a safety margin of one std. Especially the Chinese material with low lysine levels where the figure with safety margin (1.57%) is more than 8 % lower than the mean value (1.71).

Table 12. Crude protein (CP) and amino acid content with and without a safety margin (1 std) in Rapeseed meal from 3 sources.

	Rapeseed meal					
	India (N=313)		China - Low (N=218)		China - High (N=388)	
	mean	- 1 std	mean	- 1 std	mean	- 1 std
MET	0.71	0.69	0.71	0.67	0.72	0.70
CYS	0.97	0.91	0.88	0.82	0.88	0.84
M+C	1.68	1.60	1.59	1.51	1.61	1.55
LYS	1.79	1.72	1.71	1.57	1.98	1.92
THR	1.54	1.50	1.54	1.49	1.59	1.56
TRP	0.53	0.50	0.49	0.47	0.50	0.49
ARG	2.41	2.27	2.13	1.98	2.20	2.13
ILE	1.48	1.43	1.42	1.36	1.43	1.39
LEU	2.56	2.48	2.51	2.41	2.56	2.50
VAL	1.88	1.82	1.82	1.74	1.84	1.80

When using the figures with the safety margin included in least cost feed formulation of a layer diet the price where Indian rapeseed meal voluntarily comes into the diet (shadow price) are 321 US\$/ton (see Table 11 for nutritional composition and raw material prices used for this optimization). If the mean values without a safety margin for amino acid content were used then the shadow prices would have been 332 US\$/ton. This small example clearly shows how variation, i.e. magnitude of the safety margins, can affect the value of the raw materials.

Thus, in a purchase decision it is important that the value/price evaluation of protein raw materials are based on the actual amino acid content and the shadow prices taking the main feed formulations into account. If the decision is only taken based on a few key nutrients like CP and energy the purchaser could end up paying too high a price for the raw materials and thereby affect the feed price negatively.

### CORRECT PREDICTION ESSENTIAL FOR GOOD PRODUCTION RESULTS

A wrongly evaluated raw material may not only affect the feed price. It may also have a strong effect on production results. In figure 3 the effect of digestible lysine level on feed conversion ratio (FCR) is shown for light and heavy layers.

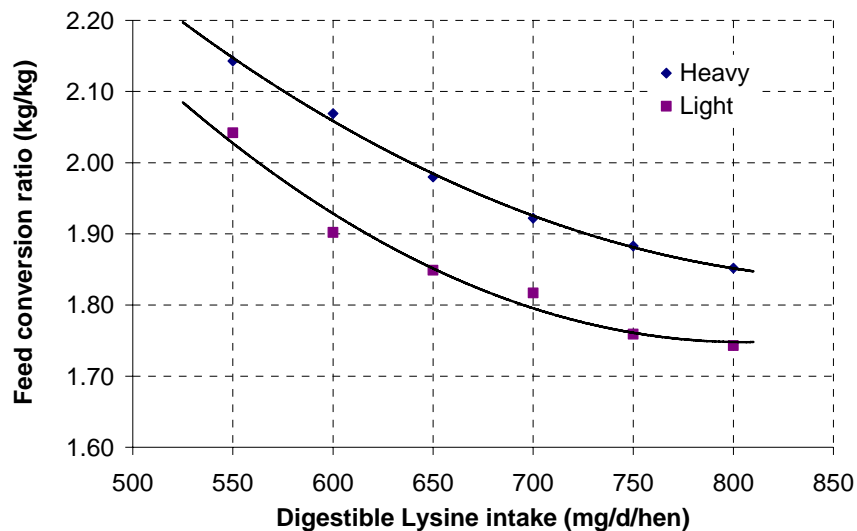


Figure 3. Feed conversion ratio in light (Lohmann LSL Classic) and heavy (Lohmann Brown Classic) layers in relation to lysine intake (Bonekamp et al., 2007)

It is clear looking at the graph that if the lysine level is reduced by 10% from 750 mg/d/hen the effect on FCR would be quite significant, i.e. in the magnitude of 5 to 7 points. Actually a reduction from 750 to 675 mg/d/hen in light birds would the FCR from 1.88 to 1.95. If not the evaluation of the amino acid content in the purchased raw materials are accurate and taking the variation into consideration it is possible that the balanced protein level unintentionally could be lowered by these 10 % in some feed batches.

### CONCLUSION

The results from the analytical survey show a high variation for amino acid content in a number of raw materials. Especially the lysine levels seem to vary a lot. Based on the figures presented above it is clear that for most of the raw materials it is not possible to make good estimations of the amino acid level based book values or on CP content alone. It is therefore important on a regular basis to get information about the actual amino acid content in order to evaluation the raw materials correctly and prevent drop in performance due to unexpected low amino acid levels.

It is also shown how digestibility affects the value of the raw materials and how variation, if it is not controlled properly, can have a strong impact on the real value of the raw material. If digestibility and variation is not accounted for it can unintentionally lead to production of feed with too low levels of amino acids which will affect production results.

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