Determinants of quality for soybean meals

NIR testing is improving and hopefully in the near future AME, PER and digestible lysine will be easy to determine using NIR. In the meantime NEOH SOON BIN* recommends that you should buy the soybean meal with the highest KOHPS or PDI and the lowest TIA or urease activity.

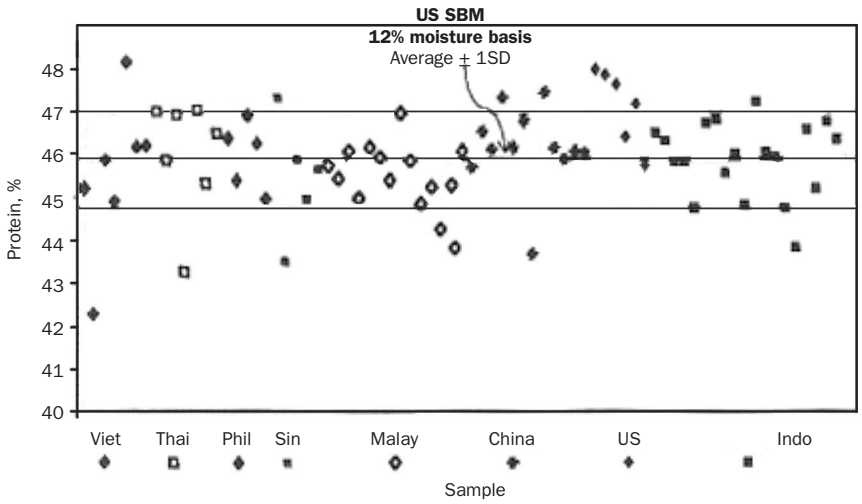
The quality of soybean meal is usually determined by measuring its protein, crude fiber and moisture content. Urease activity and KOH Protein Solubility (KOHPS) is used to determine whether the soybean meal is optimally processed.

Recently Protein Dispersibility Index (PDI) was suggested as a better indicator for optimum processing. In vitro/vivo digestibility has been recommended as an indicator of amino acid availability.

However recent studies has shown that the actual performance of various soybean meals in non-ruminant feeding can vary substantially despite having similar proximate analysis, urease activity, KOHPS and digestibility.

Other studies on various feed stuffs have also shown that available nutrients especially certain amino acids such as lysine and cystine can be much lower than indicated by measuring digestible nutrients.

Figure 1: Variation in crude protein analysis from different laboratories.



Recently Apparent Metabolizable Energy (AME), Protein Efficiency Ratio (PER) and digestible amino acids level have been shown to be able to predict broiler growth performance, but these tests are difficult to carry out and are costly.

Table 1: Trading specifications for soybean meal.

Parameters	Percent composition	
	Non-dehulled	Dehulled
Protein, %	42.5 – 44.0	46.5 – 48.0
Moisture, %	12.0 – 12.5	12.0 – 12.5
Fiber, %	7.0 max	3.5 max
Delta pH	< 0.2	< 0.2
KOHPS, %	> 72.0	> 72.0

The challenge is to find simple analysis methods that can be accurately predict the actual performance of the soybean meal in animal feeding.

INTRODUCTION

Soybean meal is used as a protein source in animal feed. It is usually traded as a commodity in the feed industry based on specifications listed in the table 1. Protein, fat, fiber, moisture, urease activity, trypsin inhibitor activity and protein solubility as well as in vitro and in vivo digestibility are used for determining the quality of soybean meal.

Soybean meal quality is dependent on proper processing. Over processing can reduce both the digestibility and the availability of amino acids especially lysine and cystine. The reduction in protein quality is due to the combination of the destruction of these amino acids and the reduced availability of those amino acids that are not destroyed. Over-processing of soybean meal can also reduce the availability of carbohydrates in particular simple sugars which are bonded with amino acids in the classic Maillard reaction. Under processing can leave intact anti-nutritional factors such as protease inhibitors which will cause moderate to severe growth depression.

Quality determinants

Crude protein is the nitrogen content of the soybean meal multiplied by a factor of 6.25. Several methods are used to determine nitrogen content in the feed. The commonly used method is Kjeldahl. However this method provides inconsistent protein results as shown by the protein collaborative study carried out by American Soybean Association in 1998 in figure 1. The results show that protein results can vary from 42% to 48% using the Kjeldahl method from laboratory to laboratory. Another accepted method is Nitrogen Combustion or Dumas method. This method is accurate but the initial investment in equipment is high. Table 2 shows that the combustion method gives similar reading when compare to the Kjeldahl method.

Protein Dispersibility Index (PDI) was recently suggested as a better method for distinguishing the quality of soybean meal for feed use. The suggestion is that over processing soybean meal binds the more reactive amino acids such as lysine and cystine with sugars and other reactive compounds rendering them insoluble and becoming nutritionally unavailable. Unfortunately our own studies and those of Saio et al show that PDI drops quite quickly with time especially at higher storage temperatures. Figure 2 shows the effect of various storage temperatures on the PDI of soybean meal. This effect is probably due to the aggregation of protein making them insoluble but presumably still available nutritionally to the animal.

Protein Solubility in Potassium Hydroxide Solution (KOHPS) has been used for the detection of under processed and over processed soybean meal. The study of Araba and Dale has concluded that KOHPS in excess of 85% or less than 70% indicate under-processed or over-processed soybean meal. However our own research shown in Figure 3 and Figure 4 demonstrate that there is no correlation between KOHPS with either urease activity or PDI. This would seem to indicate that KOHPS is not a good indicator of

Table 2: Comparison of crude protein determination by Kjeldahl and Nitrogen Combustion (Soon Soon Oilmills unpublished data).

Sample marks	Protein %	
	By Kjeldahl	By Combustion
Raw Soybean	37.6	37.6
Non dehulled SBM	44.9	44.9
Dehulled SBM	46.3	46.5

Figure 2: Effect of sstorage temperatures on the PDI of soybean meal (Soon Soon Oilmills unpublished data).

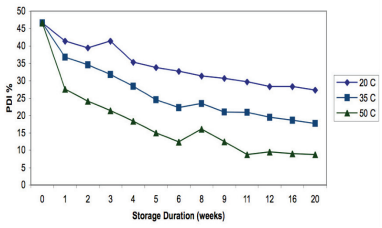


Figure 3: Correlation between PDI% and KOHPS% (Soon Soon Oilmills unpublished data).

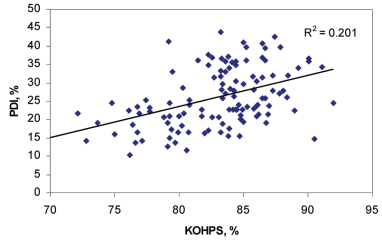


Figure 4: Correlation between delta pH and KOHPS% (Soon Soon Oilmills unpublished data).

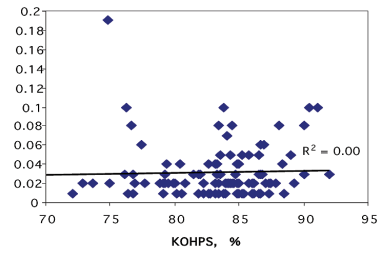


Figure 5: Correlation between TIA and delta pH (Soon Soon Oilmills unpublished data).

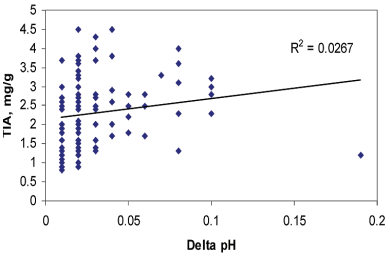


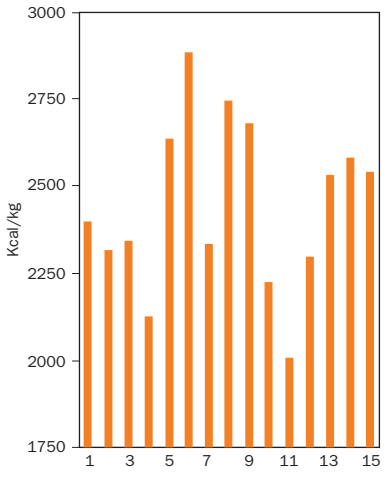
Table 3: In vivo poultry digestibility of lysine, methionine, and cystine of various soybean meal (unpublished data by Wiseman and Clarke–courtesy of ASA).

SBM Source	Description	Digestible lysine (%)	Digestible Methionine (%)	Digestible Cystine (%)
WismaMitra	SBM USA (dark)	88.1	88.6	76.9
Sunter	SBM USA (light)	90.4	91.1	81.3
	SBM India	88.8	89.2	75.7
Basilisa P.Reas	SBM brazil dehulled	86.0	87.8	74.7
Soon Soon	SBM dehulled	89.9	89.8	78.3
Khun Rungthip	Indian SBM	90.3	91.1	80.2
	SBM local bean	88.8	89.8	77.1

Table 4: Metabolizable Energy of soybean meal.

Reference source	Dehulled SBM ME (Kcal/kg)
NRC	2440
Feedstuffs	2475
Rhodimet	2460
ASA	2525

Figure 6 : AMEn of dehulled soybean meals measured by Bangkok Animal Research Center, Thailand. Jiang ZR, 2004.



under processing.

Trypsin Inhibitor Activity (TIA) is a direct measurement of trypsin inhibitors in soybean meal. It is a critical performance parameter due to the ability of trypsin inhibitor to inhibit protease activity in vivo thus slowing growth. Value below 5mg/g TIA is recommended. While TIA is a good indicator of under processing and the overall presence of anti nutritional factors, it cannot be used to predict over processing of soybean meal. The disadvantage of this method is that it is difficult to perform and is time consuming.

Urease activity is used as an indirect indicator of the presence of anti-nutritional factors such as trypsin inhibitor which would suggest that the soybean meal is under processed. The recommended value is 0.02 to 0.2 delta pH. While it has some value for detecting the under processing of soybean meal, it cannot be used for detecting over processing. In our own studies as shown in Figure 5, there is no correlation between urease activity (delta pH) and TIA for soybean meal within the range of 0.01 to 0.20 urease activity (delta pH).

In-vivo and in-vitro amino acid digestibility has been suggested to be a good indicator of the nutritional value of soybean meal. This is currently the acceptable criteria for amino acid nutrient value in feed formulation. However earlier studies by Batterham et al and Parsons et al have shown that the availability of amino acids especially lysine

Figure 7: AME comparison of dehulled soybean meals produced by Soon Soon (SS) using US soybeans with dehulled soybean meals from various countries.

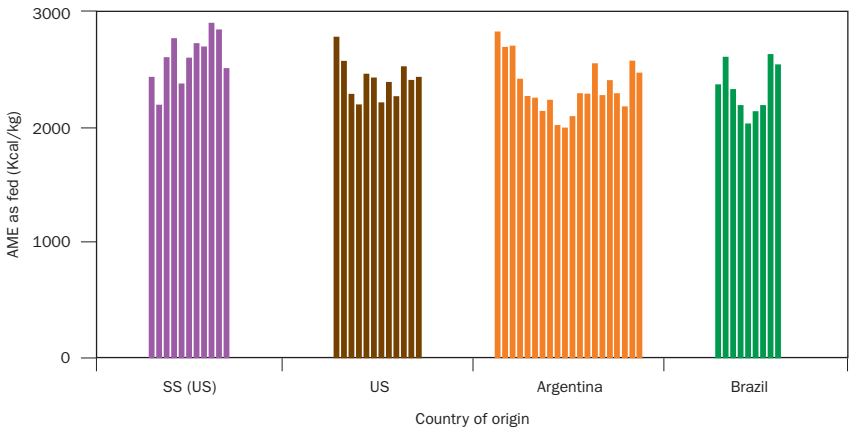


Figure 8: Comparison of PER between SBM of different origins (ASA unpublished data, 2003 – 2004).

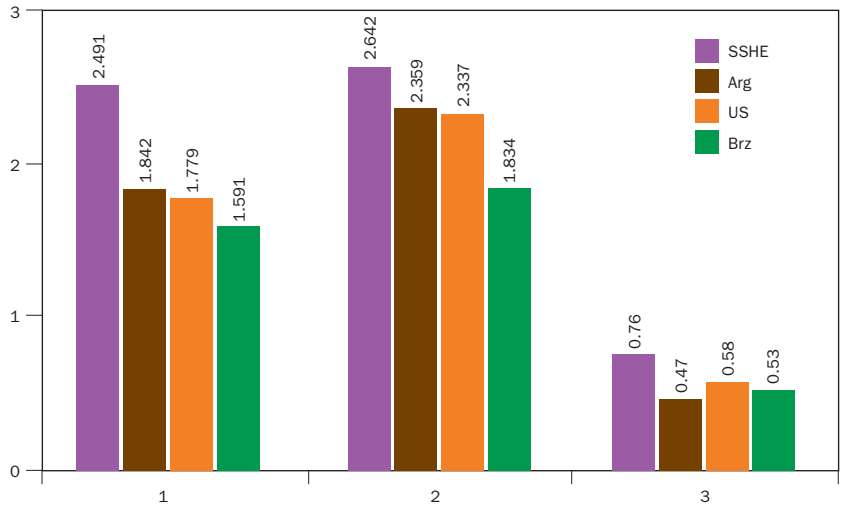


Figure 9: Correlation of AMEn and the body weight gain.

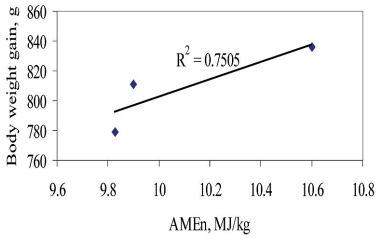


Figure 10: Correlation of AMEn and FCR.

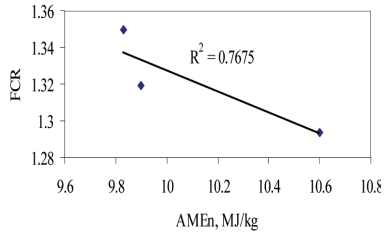


Figure 11: Correlation between AMEn and PER.

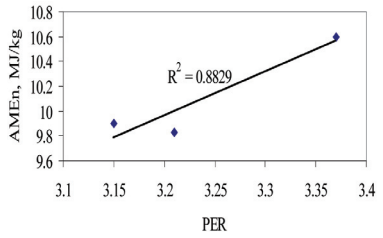


Figure 12: Correlation between FCR and AME.

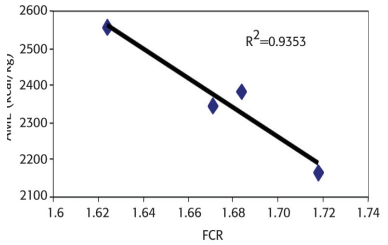
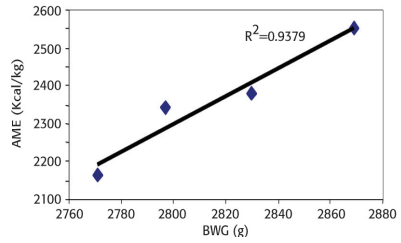


Figure 13: Correlation between BWG and AME.



and cystine can be substantially lower than as measured by in vivo digestibility. A study commissioned by the ASA shows that the in-vivo amino acid digestibility of various soybean meals were almost the same except for cystine. (Table 3)

The Apparent Metabolizable Energy (AME) of dehulled SBM is stated as between 2440-2525 kcal/kg (Table 4). Dr Jiang Zhirong of Ajinomoto Co (Thailand) has demonstrated that the AME of soybean meals can vary tremendously. (Figure 6)

In recent years, the AME of soybean meals from various origins has been measured by ASA and Soon Soon Oilmill. The results were tabulated in Figure 7. These results show that there are up to 10% differences in the AME of dehulled soybean meals from different origins. Furthermore, the soybean meals produced by Soon Soon Oilmill from US soybeans had 7.3% more AME when compared to US soybean meals indicating that processing plays am important role in determining the AME of soybean meal.

Protein Efficiency Ratio (PER) testing in broiler chicks is defined as the ratio of weight gain divided by protein intake. The PER of various soybean meals have been tested by ASA and is presented in figure 8. Surprisingly there is up to 50% differences in the PER between different soybean meals (Table 5).

Table 5: Percentage of improvement in PER of Soon Soon High Efficiency SBM when compared with SBM of other Origins.

Origin	Test 1 (%)	Test 2 (%)	Test 3 (%)	Average increase in PER (%)
US	+40.0	+13.1	+31.0	+28.03
ARG	+35.2	+12.0	+61.7	+36.31
BRZ	+56.6	+44.1	-	+50.32

The question is whether there is a correlation between AME and PER with growth rates and FCR in broiler chicken? A recent study by NeohSB et al,2006, (Figure 9 & 10) using broiler chicken grown from 1-21days demonstrated that there is a good correlation between AME and body weight gain (R2 = 0.75) and FCR (R2 = 0.77). Interestingly, there is a good correlation between AME and PER (Figure 11). Therefore, it can be concluded that AME and PER can be a good determinants of broiler growth performance.

Another recent study conducted by David Creswell et al, 2008 compared the performance of 4 soybean meals of different origins. The body weight gain (BWG) and feed conversion ratio (FCR) of broiler chicks show remarkable correlation with AME and digestible lysine (Figure 12-15). The almost perfect correlation of R2 approximately 0.9 indicates that the AME and digestible lysine are powerful determinants of quality for soybean meals. Interestingly, AME and digestible lysine are also well correlated R2 = 0.89 (Figure 16). This would seem to indicate that the processing conditions that give high AME will also give high digestible lysine.

Conclusions

The best determinants of quality for soybean meals are AME, PER and digestible lysine. Actual physical testing of these methods are tedious and time consuming. However, NIR

Figure 16: Correlation between AMEn and digestible lysine.

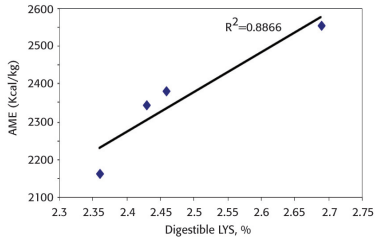


Figure 14: Correlation between BWG and digestible lysine.

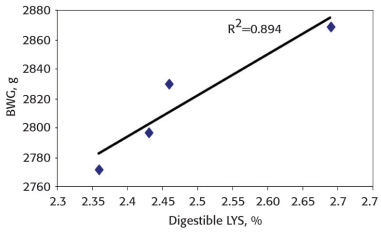
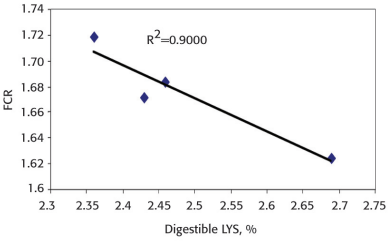


Figure 15: Correlation between FCR and digestible lysine.



testing is improving and hopefully in the near future these parameters will be easy to determine using NIR.

In the meantime, soybean meal buyers should buy the soybean meal with the highest KOHPS or PDI and the lowest TIA or urease activity. For example, a soybean meal with KOHPS >85% and urease activity 0.02 is probably better in quality compared to one with KOHPS 75% and urease activity 0.3. ■

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