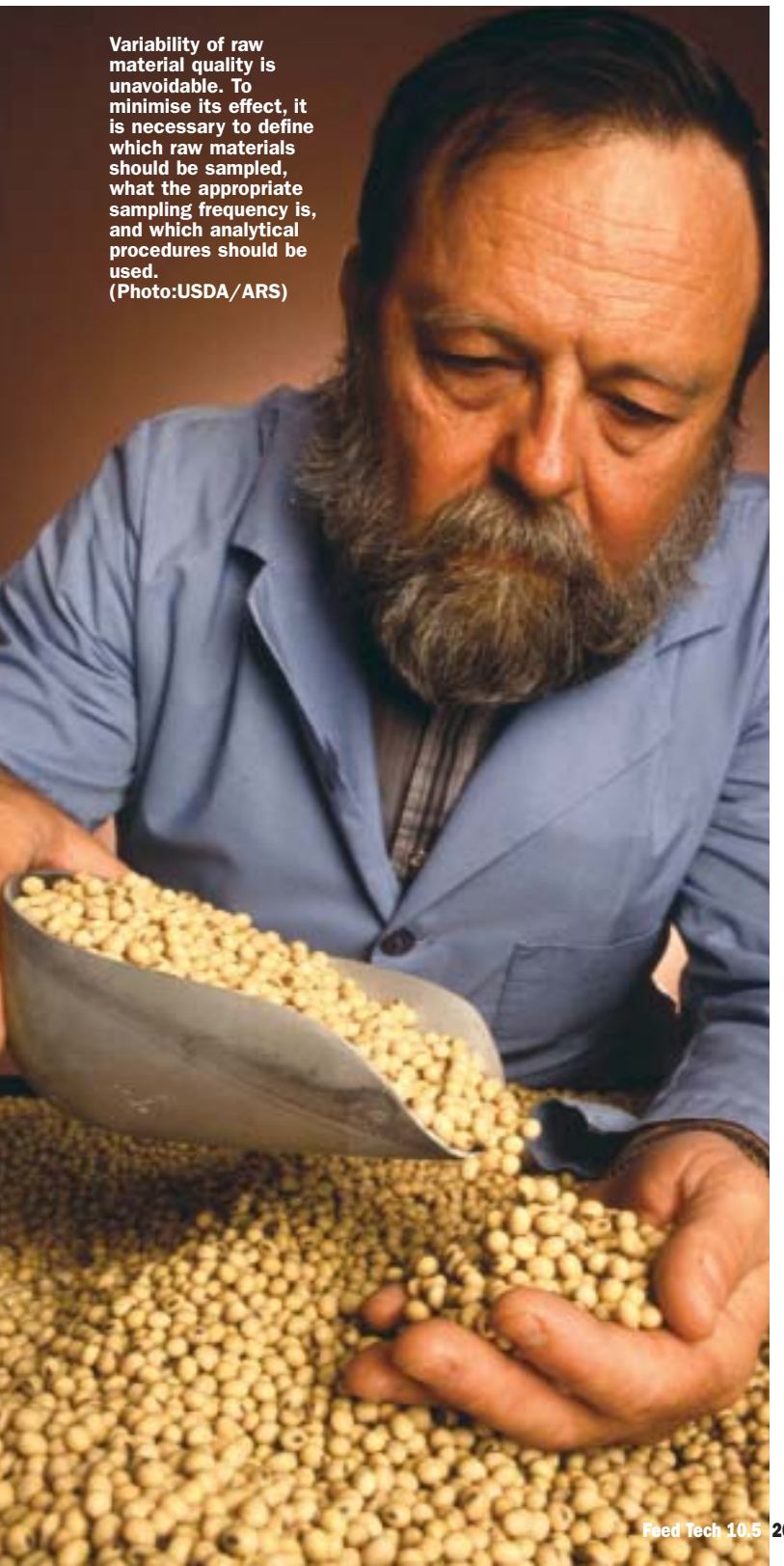
Managing variability of protein and amino acid content



Variability of raw material quality is unavoidable. To minimise its effect, it is necessary to define which raw materials should be sampled, what the appropriate sampling frequency is, and which analytical procedures should be used. (Photo:USDA/ARS)

The nutrient content of raw materials can be highly variable due to various external and internal factors. This variability affects the protein content and therefore the amino acids which represent one of the most important nutrients. In the feed mill this unevenness needs to be managed to be able to provide a feed with consistent values.

By Dick Ziggers

The production of quality and consistent feed in terms of nutrient content requires the implementation of raw material quality control programs. If the nutrient content of a raw material is not well known and/or is highly variable, the actual nutrient content of the feed will differ from that specified in the formulation program and from what is stated on the bag tag. That is, the feed will not have accuracy. This is true for any nutrient including protein and amino acids.

There will always be some variability in the raw material composition from one lot to another, regardless of the quality control program used. This variability is transferred to the feed and therefore can differ from one batch to another; in other words, the feed is lacking precision. The concepts of accuracy and preciseness can be visualised as shown in *Figure 1*. As the nutritionist and diet formulator define the nutrient specifications that will optimise animal performance and minimise feed cost, it is clear that any deviation from the specifications will have repercussions on animal performance.

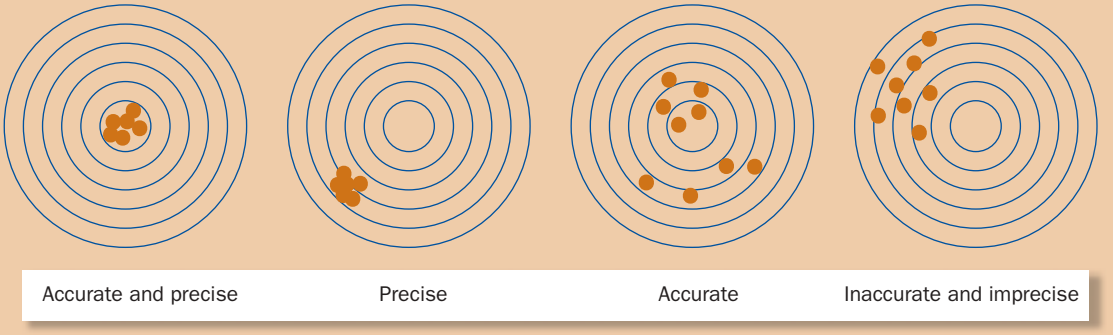
Effect on feed cost

The effects of raw material quality on animal performance depend on species, type of nutrient and direction of the deviation, i.e. surplus or deficiency. Some of these effects are shown in *Table 1*. Essential

Table 1 – Effect of deviations in feed nutrient content on animal performance and feed cost.

Nutrients	Real < Theoretical	Real > Theoretical
Energy	↑ Intake/Feed conversion	↑ Feed cost
	↑ Extretions	↓ Intake
	↓ Animal production	↓ Animal production
	↑ Variability of flock	↑ Fat deposition
Minerals	Several effects depending on mineral and species: Cu in sheep, Ca and P in layers, etc.	
Protein/Amino Acids	↓ Animal production	↑ Feed cost
	↑ Variability of flock	↑ N-extretion

Figure 1 – The concepts of accuracy and precision represented by bull's eyes.



amino acids provided by raw materials or supplemented as crystalline amino acids to the feed have a very strong influence on animal performance and feed cost. As such, incorrectly assessing the amino acid content of raw materials will provoke costly deviations of the final amino acid supply in the feed from target values. The cost of the formula will increase when there is a surplus on the amino acid contribution. On the other hand, a shortcoming in the amino acids will suppress animal performance.

By rectifying the amino acid content of the raw material in the formulation program one can see the change in feed cost. For example, correcting a 5% deviation in the essential amino acid content of soybean meal would reduce broiler feed cost by about ¤0.70/tonne., assuming current prices for major raw materials and synthetic amino acids.

The effect on animal performance can be equally important. In a broiler trial at Kaposvar University in Hungary the feeds were supplemented with 0.04, 0.08 and 0.12% DL-Methionine. Higher supplementation resulted in increased growth and better flock uniformity with a higher percentage of broilers between 1,700 and 1,900 grams.

Control of variability

To minimise the effect of raw material variability on feed quality and livestock production, producers usually set up quality control plans. It is fundamental in these plans to decide:

1. The frequency of analysis for each raw material. This depends on the contribution of the raw material to the total variability (standard deviation) of each nutrient in the feed. As a rule of thumb it can be said that the higher the inclusion level of a raw material and the higher the variability of the nutrient in this raw material, the higher should be the frequency of analysis.
2. The sampling protocol. Such a protocol should define the procedure according to which samples are taken in order to minimise bias. The sampling devices should be able to catch any type of particle to avoid selection processes that could distort the composition of the samples. They should also be able to take samples from any part of bulk and bags. In practice, the number of samples taken from each truck or lot usually depends on other limiting factors such as manpower, time, sample devices, etc.

Table 2 – Feed composition and CP content according to linear and stochastic formulation methods

Ingredients (%)	Method 0	Method 1	Method 2 (69%)	SF (50%)	SF (69%)
Corn	59.33	55.881	57.91	59.33	58.46
Soybean meal	22.35	25.35	23.55	22.35	23.09
Fat	4.38	4.92	4.60	4.38	4.52
Corn gluten meal	3.00	3.00	3.00	3.00	3.00
Meat and bone meal	10.00	10.00	10.00	10.00	10.00
Dicalcium phosphate	0.35	0.35	0.35	0.35	0.35
Salt	0.25	0.25	0.25	0.25	0.25
Correctors	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.09	0.07	0.08	0.09	0.08
%CP (computer)	23.00	24.15	23.00	23.00	23.00
%CP (real)	23.00	24.15	23.46	23.00	23.00
Theoritical prob. (%)[1]	50	-	69	50	69
Real prob. (%)[2]	50	98	80	50	69
Cost, €/ton	177.69	180.21	178.70	177.69	178.31

Method 0 (50%): LP without safety margins (50% probability to cover the CP specifications)

Method 1: LP + 5% safety margin in the CP specifications of the formula

Method 2 (69%): LP with 0.5 x SD correction of the CP content of each ingredient (69% probability to meet or exceed the CP specs)

SF: stochastic formulation to cover with a 50% (SF(50%)) or a 69% probability (SF 69%) the CP specs.

[1] Theoretical Prob: Percentage of produced feed intended to fulfil the formula specs.

[2] Real prob.: Percentage of produced feed that really fulfils the formula specifications.

Source: Roush, W.B., Penn State University

3. The appropriate means to statistically evaluate results of analysis. All analytical data should be archived together with detailed information about the respective raw material so that crucial informed decisions can be made. A good software support system to manage this large quantity of information is essential, as this allows for flexible data management, graphic visualisation and statistical analysis.

Advantages of raw material QC

Good quality control has important advantages beginning at the reception of the raw materials. More and more feed mills are being equipped with the most advanced NIR (near infra red spectrophotometers) machines, which, if furnished with the right calibration software, allow for rapid and accurate estimates of the nutrient content of many raw materials before unloading.

Based on the results obtained from the analysis of the lot (truck), some decisions can be made:

- To refuse the lot, when the deviation of a specific nutrient is too high compared to the regular values;
- To negotiate a discount with the supplier to obtain a new price for the raw material to get the same feed cost (parametric analysis);
- To distribute lots to different silos. This would enable the feed miller to use two qualities of a raw material in feed formulation as two different raw materials, or
- To reformulate with the new composition. This makes sense when the actual quality deviates significantly from the expected value(s).

The routine analysis of raw materials also allows for medium and long-term management of the variability. Better information about raw material variability can become an additional criterion when comparing ingredients or suppliers of the same ingredient as well as during feed formulation.

Managing variability

In practice there are several ways to control the variability via feed formulation. Linear programming (LP)

is the most common tool to deal with variabilities. There are two methods. One is to update the matrix of the raw materials according to the average nutrient content and to include an arbitrary safety margin for compensation of variability in the ingredients. The other is to update the matrix of ingredients to the average nutrient content corrected for variation. This method doesn't require any margin on the nutrient specifications to correct the variability of the ingredients as nutrient variability is already accounted for in the ingredient matrix.

Similar to LP, stochastic formulation (SF) tries to optimise the inclusion rate of the different ingredients to fulfil the nutrient specifications of the formula at the lowest possible cost. However, the SF allows on an individual nutrient basis, the feed percentage that will fulfil the limits defined in the specifications to be decided. In the SF, the matrix of the ingredients includes the average deviations for each nutrient. Therefore it is essential to closely monitor ingredient quality in order to maximise the benefit from this type of formulation. As an example *Table 2* shows the effect of different formulation methods on the crude protein content of one feed.

Stochastic formulation may be the method with the most advantages to manage ingredient variability. It allows decisions on accuracy and individual nutrients, which will be the percentage of produced feed that will comply with the formula specifications. Within a certain safety margin, the cost is always the minimum and it promotes the employment of ingredients with lower variability. The real feed composition complies very well with the composition in the computer and on the tag. A disadvantage of SF can be that it requires an exhaustive control of the raw material variability, and sometimes the proposed least cost solutions can be very expensive if many nutrients are subjected to high safety margins.

Amino acids in feed QC

Usually protein is one of the most important nutrients to consider in quality control of raw materials. However, often amino acids are not considered and/or not analysed. *Table 3* describes the different possibilities to update the amino acid content of typical raw materials. Chromatographic analysis is an accurate method but costly, thus not very well suited for routine analysis. Another commonly used method is wet chemistry of NIR. Once the CP has been analysed, the estimation of the amino acids can be done proportionally to the protein content, or with the help of regression equations that relate the amino acid content with the CP content. This method is better because for a number of important feed ingredients an increase or drop in crude protein does not always mean a proportional change in amino acid content. The best method, however, is NIR, because it combines accuracy with speed and low cost.

Many commercially available formulation software packages allow for equations to be written into the software that automatically update some nutrients when others have beeen changed. By using such equations, it is easy to adjust the content of all relevant amino acids while updating only the CP content. Regular updates can make worthwhile improvements in feed cost and/or animal performance.

Conclusion

Variability of raw material quality is unavoidable. To minimise its effect, it is necessary to define which raw materials should be sampled, what the appropriate sampling frequency is, and which analytical procedures should be used.

A good quality control program is advantageous as early as the reception of the raw material, and it can lead to lot refusals, price renegotiation with suppliers, linear programming matrix updates, or separate storage solutions.

There are also long-term advantages resulting from proper management of variability, i.e. assessment of raw materials and suppliers according to variability or adequate safety margins in formulation.

Formulation management, including monitoring the amino acid content via NIR, allows cost-effective and nutritionally adequate feed production, and it is crucial to maintaining good animal performance.

For cost-effective feed formulation practices, stochastic formulation also is a possible alternative to traditional linear programming.

This is an edited version of the article "How to manage the variability of protein and amino acid contents in raw materials" by Carlos Dapoza from Degussa, which was published in the company's AminoNews 07.01.