The reality of raw material variability

It is well known that there can be significant variations in nutritional values between batches of raw materials (RMs), even within the same plant family/variety. These differences can be due to the geographical area where crops are grown, weather conditions during growth and harvesting; as well as storage conditions and the variety used. Post-harvest treatment and processing methods will also impact quality and nutritional value of materials such as meals and distillers' grains. The challenge for nutritionists and feed formulators is to have reliable way to monitor and control raw materials quality. So that they can be used accurately in feed formulations, allowing animal performance objectives to be met as efficiently as possible by limiting feed costs. New tools can link Near Infrared Reflectance (NIR) and laboratory results with formulation software to build a more precise raw material matrix, as well as creating accurate and efficient feed formulations.

All data presented in this article are extracted from Adisseo's NIR ecosystem called Precise Nutrition Evaluation (PNE).

Context

Traditionally, the characterization of raw materials is carried out using wet chemistry. These methods can be conducted on a range of parameters, with more or fewer tested, depending on requirements, and importantly budget.

Although chemical analysis is a reliable and accurate, it has some drawbacks:

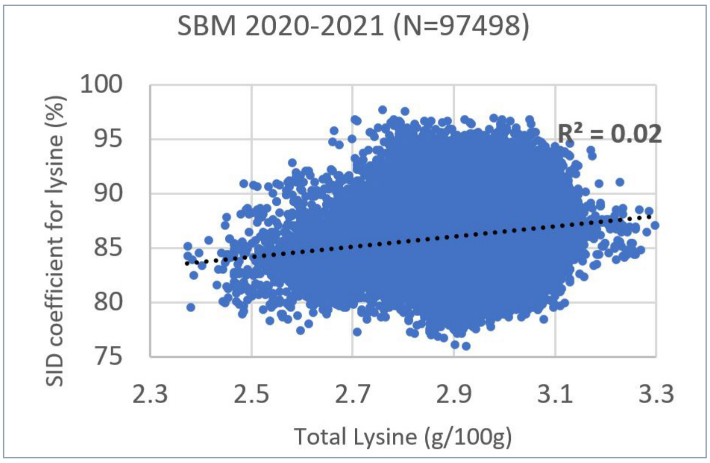
- It is relatively expensive when there are many samples and or parameters to analyse. Particularly if parameters need to be multiplied, for example adding total amino acids and/or phosphorus etc.
- It requires a relatively long analysis time (from several days to several weeks)
- It requires the consumption of reagents and materials in significant quantities

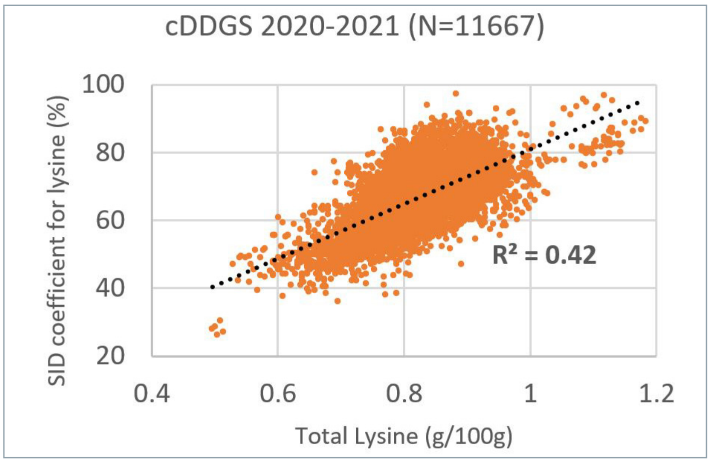
Nowadays, NIR analysis tools are readily available to feed mills. This method is ideally suited to complement and support standard quality control plans that use wet chemistry, as they tick several boxes for the nutritionist:

- Fast and accurate analysis - a result is generated in a few minutes
- Numerous analytical possibilities for a very low cost
- Non-destructive analysis - the sample can be reused after analysis
- Few consumables and no reagents are required - outlay is in the initial investment
- Simple and safe to use

One of the advantages of NIR analysis is that it is possible to carry out predictions, on the same spectrum, for analyses which are not commonly requested or impossible to perform in wet chemistry. This is the case for the digestibility of amino acids and energy, or the determination of phytic phosphorus. This aspect is particularly interesting, because for some raw materials, the use of table values or predictive equations may not represent the reality.

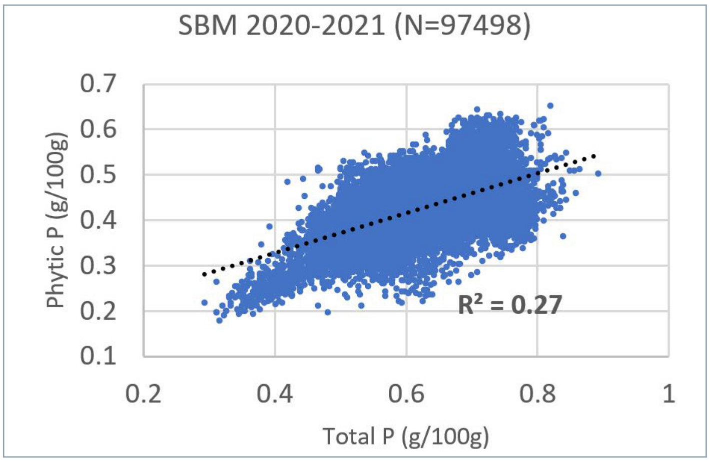
For example, there isn't a good correlation between total lysine and digestible lysine in soyabean meal or corn DDGS (see 4 graphs below). This means that estimating digestible lysine from total lysine isn't very accurate.

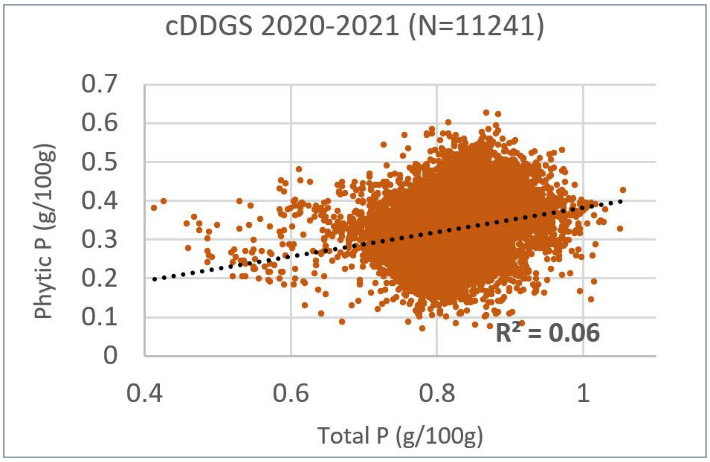




Adisseo NIR data, 2020-2021

For a soybean meal at 2.9 total lysine, the digestibility coefficient can vary from 75.6% to 97.1%.
For phosphorus, it's not possible to predict phytic phospohrus content based on total phosphorus determination as presended in the graphs below (R^2 are very low). Thus determining the potential of phosphorus released by a phytase can be challenging.
The graphs below show that there is no correlation.





Adisseo NIR data, 2020-2021

The tables below illustrate these difficulties by showing the variation in different measures of lysine and phosphorus, in soyabean meal (SBM) and corn DDGS.

SBM 46	Total Lysine (g/100g)	SID Lysine (%)	Digestible Lysine (g/100g)	Total P (g/100g)	Phytic P (g/100g)
N	97,498	97,498	97,498	95,202	95,202
Average	2.92	86.17	2.52	0.63	0.43
SD	0.08	2.55	0.11	0.05	0.04
CV %	2.7	3.0	4.3	8.5	10.4

cDDGS	Total Lysine (g/100g)	SID Lysine (%)	Digestible Lysine (g/100g)	Total P (g/100g)	Phytic P (g/100g)
N	11,667	11,667	11,667	11,246	11,246
Average	0.83	66.92	0.56	0.82	0.33
SD	0.06	7.86	0.10	0.06	0.08
CV %	7.7	11.7	17.5	7.6	23.8

Adisseo NIR data, 2020-2021

For these reasons Adisseo has developed its own NIR ecosystem called Precise Nutrition Evaluation (PNE). The system integrates calibrations built on not only common chemical analyses, but also *in vivo* digestibility tests - on growing broilers for energy and caecectomized cockerels for amino acid digestibility.

Taking action

Good characterisation of raw materials used to formulate feeds, is the first step in the process of feed formulation. However, it is a mistake to rely solely on the data in feed formulation software, without knowing more about the quality and the variability of the raw materials being used.

The raw material values used in each feed formulation program can be defined as a 'black box': something confidential, mysterious, and crucial for the company. Feed formulations are largely dependent on the database used by the formulation software. Updating these databases is a difficult and time-consuming job for the formulator or nutritionist. There will be numerous analytical results from multiple laboratories (chemical & NIR), which they must transform into nutritional values that can be used to formulate feeds. The frequency and the way these databases are updated is specific to each company.

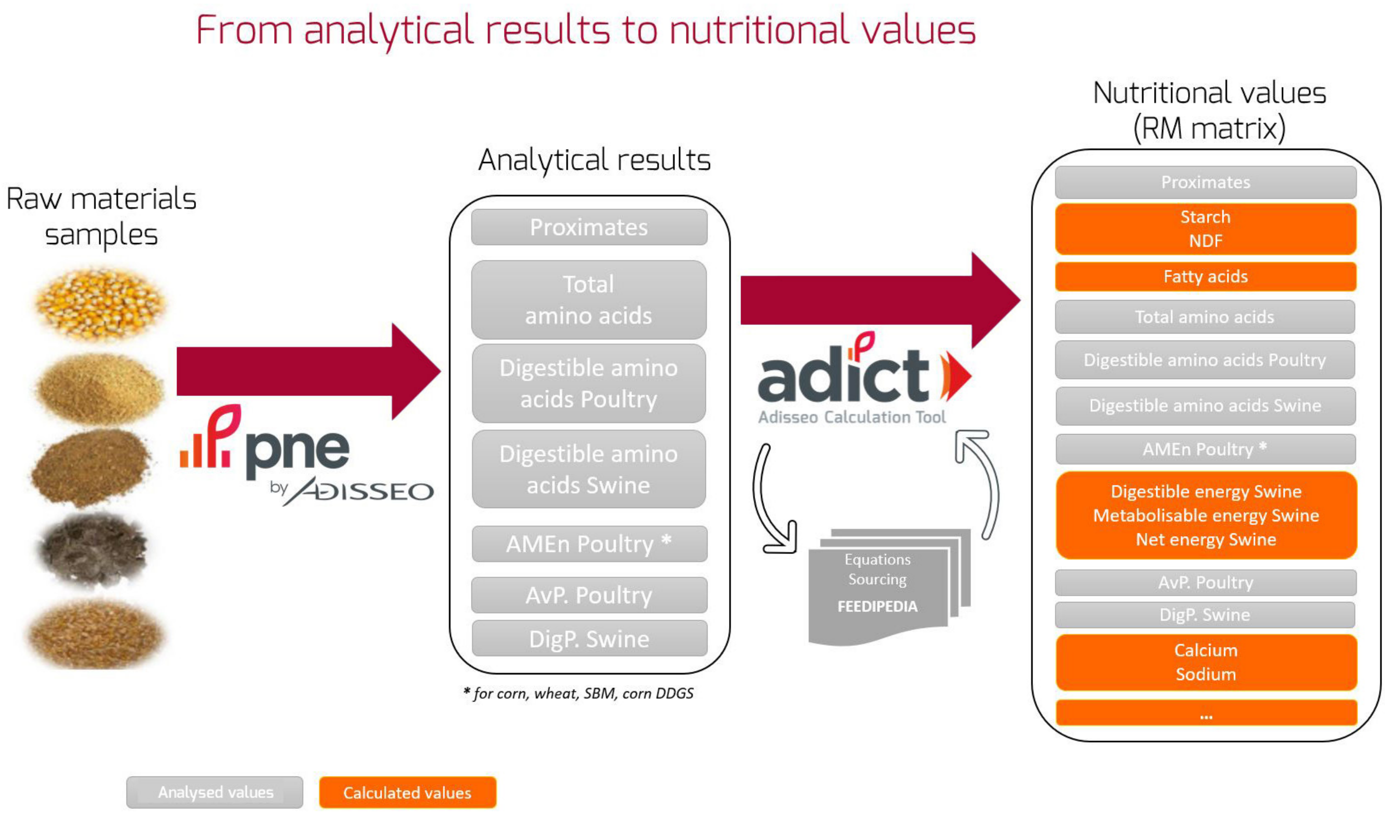
Adict – a tool that links PNE and lab results with feed formulation software

To help its customers, Adisseo has developed a new tool – Adict, the Adisseo calculation tool – that fills the gap existing between analytical results and the formulation program. Very easily and very quickly, the tool integrates customers' analytical results and use them to create a new ingredient matrix, based on the actual quality of the raw materials received by the factory.

Not all the nutrient values used to formulate feed can be analysed and many of them must be calculated. The tool includes these calculations for each nutrient without analytical results, using the equations from the Feedipedia system (https://www.feedipedia.org/). When a parameter included in the equation is analysed by a lab, it incorporates this analysed value into the equation to calculate the nutrient value. This is very important because it means the calculation gives a result that takes the actual quality of the ingredient into account.

Adict is unique in that it can link to Adisseo's NIR tool (PNE) – in just a few clicks, it is able to import the values predicted by PNE. If customers are used to distinguishing raw materials by their origin or supplier, it is possible to add filters to the request, enabling them to specify which analytical results to import; to achieve a more precise and accurate matrix.

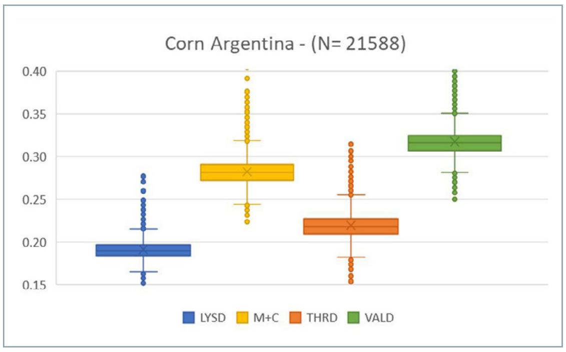
The picture below summarizes the global process



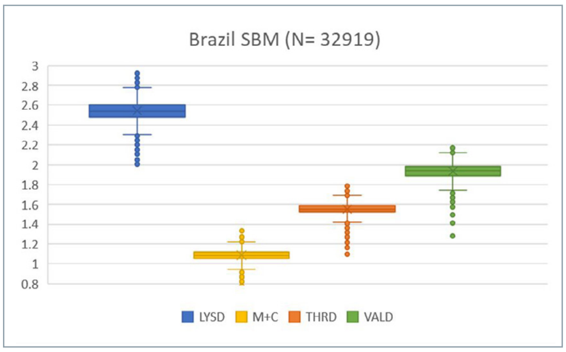
PNE + Adict: Adisseo's solution to optimise feed costs and maintain animal performance

In the context of very tight supply and prices at a global level, monitoring precisely the characteristics of raw materials received at the feed mill has become a necessity rather than an option. Precise characterisation of the raw materials available at the plant, requires detailed monitoring of nutritional safety margins; to achieve animal growth objectives, whilst at the same time making feed costs savings. In this real-life example, a nutritionist wants to estimate a safety margin for amino acids (Lysine, Methionine, Threonine, Tryptophan & Valine) in a Corn - SBM - cDDGS based diet. The corn is of Argentinian origin, the soya of Brazilian origin and the DDGS of North American origin. The tables and graphs below show the variability of these raw materials over the period 2020-2021. (PNE data)

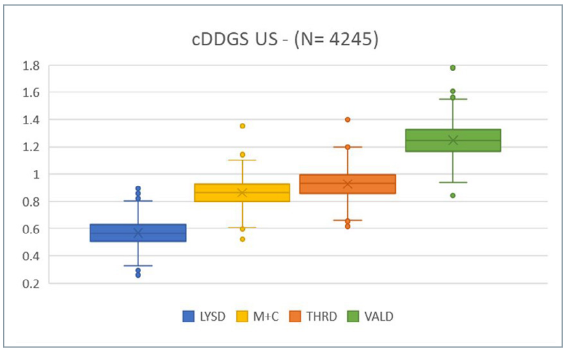
Corn	Lysine Dig.	Methionine Dig.	Cystine Dig.	M+C Dig.	Threonine Dig.	Tryptophan Dig.	Valine Dig.
N	21,588	21,588	21,588	21,588	21,588	21,588	21,585
Average	0.19	0.15	0.13	0.28	0.22	0.06	0.32
Min	0.14	0.12	0.10	0.22	0.15	0.04	0.25
Quartile 1	0.18	0.14	0.13	0.27	0.21	0.06	0.31
Median	0.19	0.15	0.13	0.28	0.22	0.06	0.32
Quartile 3	0.20	0.15	0.14	0.29	0.23	0.06	0.32
Max	0.28	0.20	0.21	0.40	0.31	0.11	0.49
SD	0.01	0.01	0.01	0.02	0.02	0.00	0.02
CV %	5.7	4.6	7.6	5.5	7.1	7.9	5.6



SBM	Lysine Dig.	Methionine Dig.	Cystine Dig.	M+C Dig.	Threonine Dig.	Tryptophan Dig.	Valine Dig.
N	32,918	32,918	32,918	32,918	32,918	32,918	32,918
Average	2.54	0.57	0.52	1.09	1.55	0.58	1.93
Min	2.00	0.36	0.26	0.63	1.10	0.40	1.28
Quartile 1	2.48	0.55	0.50	1.05	1.52	0.56	1.89
Median	2.54	0.56	0.52	1.08	1.55	0.57	1.94
Quartile 3	2.60	0.58	0.54	1.12	1.59	0.60	1.98
Max	2.97	0.67	0.72	1.36	1.81	0.70	2.21
SD	0.10	0.02	0.04	0.06	0.06	0.03	0.08
CV %	3.8	4.1	7.5	5.2	3.6	5.7	4.0



cDDGS	Lysine Dig.	Methionine Dig.	Cystine Dig.	M+C Dig.	Threonine Dig.	Tryptophan Dig.	Valine Dig.
N	4,317	4,244	4,312	4,244	4,020	4,310	4,314
Average	0.57	0.50	0.36	0.86	0.93	0.19	1.25
Min	0.26	0.36	0.16	0.52	0.62	0.11	0.84
Quartile 1	0.51	0.47	0.32	0.80	0.86	0.18	1.17
Median	0.57	0.50	0.36	0.86	0.93	0.19	1.24
Quartile 3	0.63	0.53	0.40	0.93	0.99	0.21	1.32
Max	0.90	0.81	0.54	1.35	1.40	0.26	1.78
SD	0.09	0.04	0.06	0.09	0.10	0.02	0.11
CV %	15.9	8.2	15.3	10.2	10.3	11.6	9.0



Using this information three different raw materials' scenarios have been created in the feed formulation program:

Scenario 1 Values of **Median** used for digestible amino acids for corn, cDDGS and SBM

Scenario 2 Values of **Quartile 1** used for digestible amino acids for corn, cDDGS and SBM

Scenario 3 Values of **Quartile 3** used for digestible amino acids for corn, cDDGS and SBM

A formulation for broiler growers was then optimized according to the three scenarii (all the other parameters – RM prices and availabilities, nutritional constraints – were the same):

Raw material	Price (€/t)	Scenario 1 (Median)	Scenario 2 (Quartile 1)	Scenario 3 µ (Quartile 3)
Corn	230	56.5	56.9	56.1
Soybean meal 48 (fat <5%)	410	30.7	30.8	30.6
Corn DDGS (fat >6%)	315	5.6	4.9	6.1
Soya oil	1200	3.1	3.1	3.2
Monocalcium phosphate	640	1.69	1.70	1.69
Calcium carbonate (powder)	49	0.92	0.92	0.92
Broiler premix 0.5%	500	0.50	0.50	0.50
Rhodimet NP99	2600	0.30	0.33	0.28
L-Lysine HCl 98%	1650	0.26	0.28	0.25
Salt	100	0.24	0.24	0.22
AdiSodium	350	0.13	0.15	0.12
L-Threonine 98.5%	1850	0.10	0.12	0.08
L-Valine 96.5%	4300		0.03	
Feed price (€/t)		**339.39**	**341.20**	**338.39**
Cost difference vs median digestible amino acids profile (€/t)			**1.81**	**-1.00**

Nutrient	Unit	Value	Value	Value
Weight	%	100	100	100
Dry matter	%	87.9	87.9	87.9
Moisture	%	12.1	12.1	12.1
Crude protein	%	20.5	20.5	20.5
Crude fat	%	6.3	6.2	6.4
Ash	%	5.8	5.8	5.9
Crude fibre	%	3.5	3.5	3.5
Starch (Ewers)	%	37.8	38.1	37.6
C18:2 (linoleic ac.)	%	3.1	3.1	3.2
Total Phosphorus	%	0.76	0.75	0.76
Av. phosphorus Poultry	%	0.41	0.41	0.41
Total Calcium	%	0.85	0.85	0.85
Sodium	%	0.16	0.16	0.16
Potassium	%	0.88	0.87	0.88
Chlorine	%	0.25	0.25	0.25
AMEn Broiler (kcal)	kcal/kg	2900	2900	2900
Dig. lysine Poultry	%	1.12	1.12	1.12
Dig. methionine Poultry	%	0.59	0.60	0.57
Dig. meth+cyst Poultry	%	0.84	0.84	0.84
Dig. threonine Poultry	%	0.75	0.75	0.75
Dig. tryptophan Poultry	%	0.22	0.21	0.23
Dig. valine Poultry	%	0.84	0.84	0.87

In all these scenarios nutritional constraints were the same, to achieve the same level of broiler performance. However, the use of different qualities of ingredients had an impact on both the raw material (RM) composition and cost of the feed.
On one hand, a difference in amino acid digestibility profile that could be perceived as low or negligeable, has an important impact on RM composition and feed cost. In the case of scenario 2, a lower amino acid digestibility profile requests a higher usage of synthetic amino acids in the diet (around +10-15%), and sometimes the use of additional amino acids is called (for L-valine in this example). Changes in the inclusion of macro ingredients (corn, cDDGS, SBM, etc.) is not so important; however together, all these changes have a huge effect on the cost of the feed.
On the other hand, when the digestible amino acid profile is better, there are some cost savings and RM composition is adapted to achieve nutritional constraints of the feed. In scenario 3 lower levels of synthetic amino acids are used, compared with scenario 1, since raw materials themselves contribute a greater amount. :

Another way to express the impact of the different scenarios on the nutritional values of feed, is to calculate what the values of the feed would be if the composition is optimised with median values, but the raw materials values are modified.
In the table below, the expected values of feed optimised with scenario 1, are highlighted in blue. When the same RM composition is kept, but with the usage of Quartile 1 RM values, the final digestible amino acid content of the feed is lower than expected. For example, 2.1% of digestible lysine (0.02 pt) is lost, which will reduce broiler performance in the field.
When the Quartile 3 RM values are used, some nutrients are 'wasted' because final amino acid digestibility is greater than are required for optimal broiler performance.

Nutrient	**Unit**	**expected values**	**with values of Quartile 1**		**with values of Quartile 3**	
			feed values	***evolution rate (%)***	**feed values**	***evolution rate (%)***
Dig. lysine Poultry	%	1.12	1.10	*-2.1*	1.15	*2.4*
Dig. methionine Poultry	%	0.59	0.58	*-1.5*	0.60	*1.5*
Dig. meth+cyst Poultry	%	0.84	0.82	*-2.4*	0.86	*2.4*
Dig. threonine Poultry	%	0.75	0.73	*-2.5*	0.77	*2.6*
Dig. tryptophan Poultry	%	0.22	0.21	*-3.2*	0.23	*4.8*
Dig. valine Poultry	%	0.84	0.82	*-3.0*	0.86	*2.5*

Conclusion

Adisseo's PNE+Adict solution helps formulators and nutritionists to improve their feed formulation, thanks to a better knowledge of raw material quality and variability.
All those results reinforce the need of a proper quality control process to assess what are the real nutrients present in the different raw materials used in feed formulation. And more than that, finding appropriate tools that allow to use simply the results of the NIR information in daily formulation could be a real asset to manage feed costs while preserving animal performance.
PNE and Adict are the Adisseo's tools that support nutritionists and formulators in achieving their goals.

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