Feedstuffs. Reprint

What ever happened to stochastic method of feed formulation?

AS a graduate student, I was drawn to feed formulation like a child to candy. I was taught to solve feed formulations using SAS, Lindo, Brill and other similar programs, and I was a solid student of linear programs (LPs) and formulation programs by the end of my doctorate.

Once I entered the "real world" of production formulation, my interest in feed formulation continued to grow, and it became evident that I needed to make use of a broader amount of information. For example, I became incredibly aware that not all corn contained the exact same level of lysine and other nutrients but varied considerably due to the variety, growing season, moisture, etc.

Of course, corn was probably one of the least-variable products I utilized, whereas processed ingredients with assorted product streams varied considerably more in their nutrient profile, making it difficult to reconcile their value in the formulation. I thought there had to be a better way.

Like many students and professionals of my era, I utilized the Brill Systems formulation product; Bob Brill was an ambitious and smart guy who seemed to understand the needs of the formulator quite well and was working diligently to advance it by leaps and bounds in the 1990s. I remember Brill Systems bringing forward a Stochastic Formulation method, which, to my understanding, was developed with Dr. Tom D'Alfonso.

As a young nutritionist I was fascinated with the use of statistics and mathematics to better our lives. I bought a book on stochastics and attempted to read through it but struggled to grasp Markov Chains and similarly abstract words/ideas that I was obviously not prepared to assimilate just yet. Fortunately, my good friends Brill and D'Alfonso had incorporated some stochastic methodology into Brill formulation software. After what I'm sure was a rather feeble attempt to use the software, I still couldn't quite figure out how to formulate using stochastics while accounting for the value of the nutrient variance.

For me, there were really two questions I wanted to answer with my formulation tool:

1. How do I make sure the formulation takes into account enough information

Bottom Line

with
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to ensure that it meets the nutrient levels necessary to avoid affecting animal performance?

2. How do I penalize highly variable or reward less-variable ingredients in purchasing decisions?

In those days, I spent a good bit of my time thinking about formulation methods, and stochastic formulation was continuously on my mind. I had other issues with formulation that seemed to be more relevant, like how to deal with production minimums for phytase enzymes and how to get the proper ratios of nutrients to energy.

These aspects helped me decide to change platforms, and I developed a great working relationship with Bill Holder at Agridata/Creative Formulation Concepts/Concept 5. Our discussions typically revolved around topics like formulating for least cost per pound of gain and least cost per calorie, but with a little help from Holder, I was also able to demystify my own thoughts on nutrient variance and how the concept might be more easily incorporated into feed formulation.

In my view at the time, using stochastic formulation at the formula level clearly would improve the odds of obtaining a target nutrient level in any given formula. However, I didn't yet understand how to value the change in odds, and I couldn't see how stochastics did much to fairly value ingredients with highly variable nutrient values (this was in error).

For example, I had one meat and bone meal source that was very consistent and another supplier that utilized various streams of hot dogs or deadstock that made their product more variable. I could not really rationalize how the individual ingredient variance was being reconciled in the formula. Holder helped me see that the margin of safety concept was similar to a stochastic method essentially on the front-end/matrix level rather than at the formulation level.

This was the breakthrough I needed to solidify a formulation concept around the use of variance in nutrient profiles to make formulation better.

The idea is quite simple: Make the nutrient profile of the individual ingredient determine the formulation value of the ingredient. I looked at the mean plus or minus one standard deviation (SD), which would cover 74% of all values, but this seemed excessive. I then examined one-half SD, which encompasses about 69% of all values, and this fit well enough

Composition and nutrient profile of diets formulated using different methods

	----Model*----				
Ingredients	**LP**	**SP1**	**MS1**	**SP2**	**MS2**
Corn	56.09	55.47	55.11	55.49	53.65
Soybean meal	31.00	31.03	30.93	30.91	31.95
Corn oil	5.30	5.53	5.69	5.56	5.95
Meat and bone meal	5.00	5.00	5.00	5.00	5.00
Dicalcium phosphate	0.804	1.067	1.209	1.071	1.146
Limestone	0.539	0.599	0.708	0.598	0.769
Salt	0.350	0.350	0.350	0.350	0.350
Vitamin/mineral mix	0.250	0.250	0.250	0.250	0.250
DL-methionine	0.600	0.610	0.617	0.625	0.627
L-lysine	0.065	0.097	0.126	0.149	0.297
Cost, $/metric ton	171.53	173.70	175.27	175.36	181.68
Calculated nutrient content					
Calcium, %	1.000	1.076	1.148	1.077	1.161
Phosphorus, %	0.700	0.746	0.773	0.748	0.765
Protein, %	23.02	23.00	23.00	23.00	23.54
Metab. energy, kcal/kg	3,232	3,200	3,234	3,234	3,234
Methionine, %	0.93	0.938	0.945	0.954	0.96
Lysine, %	1.214	1.243	1.270	1.294	1.468
Fiber, %	2.377	2.342	2.353	2.361	2.355

*Formulated by: a linear program (LP); stochastic programs SP1 (α = 0.69 for calcium, phosphorus, methionine and lysine) and SP2 (α increased to 0.90 for amino acids), and margin of safety linear programs MS1 (same α levels as SP1) and MS2 (same α levels as SP2).

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for highly variable and less-variable ingredients. In the end, I tested formulation outcomes using the one SD and one-half SD values, and I reconciled that the one-half SD value gave me enough economic pressure to more fairly value ingredients than using the mean alone.

One interesting point was brought up by Dr. John Patience and further verified in a recent conversation with D'Alfonso: As the number of ingredients in a formula is increased, the probability of not meeting the target actually tends to get smaller. Not ironically, this is exactly the point of stochastic modeling/formulation.

D'Alfonso's work in poultry diet formulations (Table) considered the economic difference between formulating with an LP to the average and then comparing to a stochastic solution or to an LP solved with safety margins (D'Alfonso et al., 1995). For either the stochasitic or safety margin, D'Alfonso looked at solving to an α of 0.69 or 0.90 (α meaning the constrained nutrient would be met 69% or 90% of the time, respectively, instead of 50%). His data demonstrated that the LP with the safety margin incurred a significant penalty compared to the stochastic method ($1.57 per metric ton), and the penalty grew rapidly as the safety margin increased ($6.32 per metric ton).

Because stochastic methods more correctly represent the expected variance, the degree of "over-formulation" is much smaller than by using the safety margin approach. Thus, I do believe incorporating stochastic methods in formulation has real value, but I think in the form described by D'Alfonso, stochastic formulation solves only one of the target objectives I mentioned previously.

I am not sure if the stochastic methods Brill employed would properly value each ingredient relative to its own variance, thus allowing me to make a more informed purchasing decision (my second objective). It is likely accurate to assume that there is an interaction between variance and inclusion rate, such that a stochastically solved formula might use low levels of many ingredients to "balance" variance risk.

However, balancing risk is not my goal; I have a finite number of bins, and products must compete for this space. Minimizing variance/risk of missing formulation is not my primary objective. There are still quite a few questions that seem unanswered, so I'm still not sure if using Brill's system at the time would have given me a completely accurate value determination of each ingredient.

Nevertheless, today I understand that solving using safety margins is likely to be more expensive than using stochastics, but it is still better than ignoring variance among ingredients, and it allows me to more fairly value highly variable ingredients.

The Bottom Line

I believe it's important to keep moving forward, and I've always challenged myself and my colleagues to adopt improved methods. While we may be able to see the ultimate end point of a goal, the path to the end is almost always winding and uncharted. I think of formulation in the same context:

- I know that using a safety margin is better than not using one.
- I know that applying the safety margin to each individual ingredient will more fairly value a range of ingredients better than applying it to the formula.
- I believe that stochastics represents an improvement over safety margins, but I don't think we were ready for it when it first appeared.

Perhaps in the not-so-distant future, we will see a formulation package that successfully includes implementation of stochastics, but in the meantime, don't hesitate to take a few steps forward by evaluating other techniques that improve the value of a feed formulation system.

Reference

D'Alfonso, T.H., W.B. Roush and J.A. Ventura. 1992. Least cost poultry rations with nutrient variability: A comparison of linear programming with a margin of safety and stochastic programming models. Poult. Sci. 71:255-262. ■