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Formulating swine diets for pork carcass fat quality discussed

Bottom Line

with
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AS swine nutritionists, we are always looking for a way to represent the value of a particular ingredient or nutrient that seems to best match our targeted outcome.

The case for managing pork fat quality presents a number of challenges that combine both the ingredient and nutrient levels, coupled with the fact that the half-life of carcass fat is about 140 days (Jack Odle, personal communication), so we should not expect to change the fat once it is laid down. For these reasons, most people would agree, in general, that the more fat a pig is fed, the more it looks like the fat that it was fed.

It is known that the pig's inability to generate polyunsaturated fatty acids (PUFAs) means that any PUFAs in the carcass originated from ingredient sources. So, an important question to answer is: "What is the best way to represent/restrict PUFAs in the diet formulation?"

For me, managing fat quality began in the late 1990s, not necessarily because the industry fed diets high in PUFAs but, at a minimum, because pigs at that time had very low rates of *de novo* fat synthesis. Swine nutritionists faced a challenge with a lack of fat cell fill rather than which fatty acid was being put in the mostly empty fat cells.

This was a different problem compared to what occurred when the Renewable Fuel Standard (RFS) became law in 2005. Expansion of the ethanol industry made dried distillers grains with solubles (DDGS) widely available to producers in most traditional hog production regions. In order to move the mountain of DDGS essentially mandated by the RFS, pork producers had to quickly figure out how to effectively utilize high levels of this new feedstuff.

Increased DDGS usage led to something of a disaster in pork fat quality: We had a feedstuff relatively high in PUFAs that needed to be included in feeds at upwards of 50-60% of the ration. Those little fat cells that I couldn't get any fat into were suddenly being filled with a lot of diet-originated fatty acids (mostly linoleic acid, 18:2) instead of more traditional saturated or mono-unsaturated fats coming from *de novo* synthesis.

Dr. Dean Boyd was at PIC at the time and published a technical report (Boyd, 1997) showing how one could practically utilize the iodine value (IV) of the dietary fat, coupled with the level of fat, to establish a scalarized value (IVP = IV x % fat x 0.10 — for example, for corn: 125 IV x 3.5% fat x 0.1 = 43.75 IVP) and manage carcass fat quality (Table).

This method could broadly relate changes in diet composition to changes in carcass composition, especially when everything from fish oil to canola oil was available to use.

With DDGS, many researchers believed they could better predict carcass fat quality changes by relating specifically to the 18:2 content of the diet. Dr. Trey Kellner reported similar prediction accuracy for IVP versus 18:2 in his early work, but his most recent work (Kellner et al., 2014 and 2016), among other research, was able to demonstrate that 18:2 content was slightly better than IVP (Table).

I am not really surprised by these results, given that a large portion of the variance in IVP was substantially due to a change in the corn oil/18:2 content. One of the key differences between Kellner's 2014 and 2017 work may be related to the method of analysis for IVP. In the earlier work, the researchers utilized wet chemistry methods for establishing IV, whereas in the later work, they applied the gas chromatograph (GC) calculation method (which yield perhaps less accurate results).

In my prior career, I found that GC equipment required tremendous skill to operate and lacked repeatability compared to well-executed wet chemistry IV analysis for the average user. One scientist we worked with referred to our GC as "a random numbers generator" because of the number of samples, the size of the sample and the length of the column used to separate the fatty acids (many fatty acids ended up in the flush).

This is not to say that GC cannot be accurate and valuable, but we had additional examples where a highly skilled GC operator simply changed a column as part of planned maintenance and caused a two-point IV shift. You could not really tell any difference in individual fatty acids, but the combined/calculated IV was significantly different on the same samples.

Thus, I believe that the use of fatty acids to compute an IV value is less than optimal across the board compared to a well-done chemical IV measure.

Dr. Mark Knauer at North Carolina State University reported a project to the National Pork Board (Knauer, 2016) that effectively validated the work Kellner and others have shown and, in my opinion, gives a reasonable prediction of the expected IV content of carcass fat (Table).

If I compare the various sources of information for predicting carcass IV, I tend to conclude that with every three-point change in diet IVP, I can expect about a one-point change in carcass IV. Given this assumption, I can now begin to calculate a best-cost feeding strategy that includes managing carcass fat quality.

This is not unique to IVP; the same exercise can be done with 18:2, for example, but with 18:2, it will always be a less robust method than using IVP simply because IVP includes all fatty acids with double bonds and unsaturated fatty acids.

In my opinion, establishing a maximum for total IVP consumption seems like a good method for managing carcass fat quality. The same can be done for total 18:2 consumption as well if using corn/soybean meal-based ingredients. In this method, we would establish a target carcass IV to not exceed a certain threshold and compute the corresponding average diet IVP that is not to be exceeded.

For example, suppose we do not desire to exceed a carcass backfat IV of 68 for a Japan-based customer. Using the Knauer equation to solve for a 68

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Comparison of carcass composition prediction from diet constituents

Boyd 1997	Backfat IV = 52.4 + (0.315 x IVP)
Kellner 2014	Backfat IV = 55.06 — (0.256 × IVP); R^2 = 0.93
Kellner 2016	Backfat IV = 42.99 + (0.373 × IVP); R^2 = 0.85
Knauer 2016	Backfat IV (Pen) = 47.78 + (0.38 x IVP); R^2 = 0.90

carcass backfat IV, we would target an average diet not to exceed 53.2 diet IVP. In my hypothetical finisher, I budget 600 lb. of feed, which means I don't want to exceed 53.2 x 600 = 31,920 units of total IVP consumed. I can now utilize a linear or binary optimization method to find the best combination of diets to not exceed my total IVP constraint. I also can incorporate expectations of performance in a growth/intake model to further refine the answer.

In my experience, ingredients like fat and DDGS often are more valuable in grower/early-finisher diets, and this method of optimizing a nutrient maximum among diet phases will allow me to take advantage of these high-value ingredients in earlier diets while offering lower IVP ingredients in later finishing if the solver determines that to be the lowest-cost solution.

The Bottom Line

A lot of information is available that allows the nutritionist to relate the impact of dietary fat composition on the ending carcass composition. There are several very good measures of diet/carcass fat quality, including important fatty acids like linoleic acid, and more robust indices such as IV/IVP that can either be computed from the fatty acid profile or measured directly.

Scalarizing the total consumption of either of these nutrient/indices can allow the user to establish target maximum consumption limits. With maximums in place, the nutritionist can then use a linear or binary optimizer to determine the lowest cost of feeding strategy, incorporating expected performance outcomes in growth, lean percentage and feed conversion to more precisely represent the financial outcome of the optimum cost solution.

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