Fat in dairy diets and relationship to NRC 8 energy system

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I have previously compared how the NRC 8 derivation of fat contribution to energy differs from the previous NRC 7. One of the major advantages (my opinion) of NRC 8 handling of fatty acids is it is much simpler without "exceptions" for fat as a diet component and integrates more seamlessly with the energy system as a whole. Given that, explaining the complexities of the previous model that are not carried over into NRC 8 is probably not the best use of time or effort.

The new NRC deals with fatty acids per se and not gravimetrically determined ether extract or crude fat measurements. Fatty acids are measured individually, but in NRC 8 they are really handled as a sum of FA in most cases. Remember, that even when total FA is reported and FA shown as a proportion of total FA, the 'wet chemistry' analysis is done by measuring individual FA and then summing them. The 5 major individual fatty acids found in feeds (palmitic, C16:0; stearic, C18:0; oleic, C18:1; linoleic, C18:2 and linolenic, C18:3 are reported) and should be useful in evaluating and formulating diets even though they are not used in any of the model equations. When dealing with FA in diets, it is important to remember that when feeding a triglyceride, the mass of FA and glycerol released is greater than the original mass of triglyceride. FA content of feeds should be reported as the free fatty acid (protonated) weight regardless of its form in the feed, so the reported FA and glycerol released from a pure triglyceride is more than 100% of the original triglyceride weight. Also when adding or removing fat to a diet, other components (usually mostly starch) are altered reciprocally, and their effect in both the model equations and the cow must be recognized.

In the updated NRC, FA contribution to DE is slightly less than in NRC 7. Decreasing FA digestibility at higher levels of FA in the diet is ignored by the NRC 8 model even though evidence exists to show that it clearly exists for some FA sources. As increased diet FA usually relies on added fat supplements (both in research data and field use) some of this digestibility decline is captured implicitly in the (generally lower) digestion of FA supplements based on empirical measurement, but the model may underestimate FA digestion in lower level of a given FA supplement compared to higher levels of the same FA supplement. Nevertheless, a linear, 0 intercept model of FA digestion (including the ten classes of FA supplements formed according to their reported FA profile) fit the data well without bias for FA concentration or DM intake. This straight line (class adjusted) model also is consistent with a 0 intercept signifying no endogenous fecal FA secretion and subsequently true digestion equal to apparent digestion. FA effect on ME obtained from DE is through the combined diet methane production equation, and diet FA has a large negative effect in this equation which greatly enhances the DE to ME conversion efficiency when adding FA to a diet. While there are data to support a higher conversion of ME to NE for FA compared to other energy sources, however the effect is very small over the range of FA actually fed and the model converts diet ME to NE with the same efficiency (0.66) for all dietary energy source, including FA. Therefore some of the simplifications of the model may be slightly disconcerting in theory, but provide a simple model that fits the data as well as more complex constructions and with deviations in calculated energy supply that are not likely to be of a magnitude that is impactful, or even measurable, in practice.

I believe it is useful to pay attention to the 5 main individual fatty acids in the diet, and also to use milk infrared analysis that separates the shorter de novo milk fatty acids from exogenous dietary FA (sum of C4 to C14 milk fatty acids, C16 total milk, and C18 total milk fatty acids). Future nutrient models may better predict total FA digestion by directly measuring dietary fatty acids. In the current model FA composition is only incorporated by the classification of fat supplements. This probably helps account for possible detrimental effects of high levels of stearic and low levels of oleic acid to some extent, but not directly. The profile of diet FA is important also in differing effects on milk fat yield. In general adding any of these fatty acids to the diet results in partial transfer to the absorbed C16 or C18 to those FA secreted in milk (mostly as C16:0, C18:0 and C18:1) . But, adding linoleic acid to diets reduces de novo milk FA synthesis. Adding oleic or linolenic also reduces de novo milk fatty acid secretion. It is not really clear what stearic acid does, but adding palmitic acid does not reduce the combined mass of C4 to C14 secreted (although profile within that group changes, and more milk C16 is now derived from the exogenous C16:0 fed and less from synthesis of C16:0 by the mammary gland). At least part of the effect of linoleic is clearly due to production of bioactive FA with trans bonds in the rumen which are absorbed and inhibit milk fat synthesis. Some knowledgeable investigators believe that the effect of exogenous dietary FA to reduce shorter chain fatty acids in milk solely a substitution effect where the mammary gland is regulating total milk fat secretion so that longer chain exogenous FA displace de novo fatty acids. While this possible substitution effect cannot be totally discounted, in my opinion it does not fully explain the effect of oleic and linolenic acids, but I could be wrong. In any event, the effect of depressing mammary de novo FA is stronger for dietary linoleic than oleic and linolenic, not clear for stearic, and not existent for palmitic. To the extent that stearic acid would show the same effect as oleic and linolenic, the substitution model would make most sense, if dietary oleic and linolenic have stronger depressing effect than stearic, some sort of bioactive FA effect may explain that as it does the greater effect of linoleic over oleic and linolenic. While it is important to avoid extreme high levels of linoleic acid, both linoleic and linolenic are essential as absorbed nutrients and less that 10% of these dietary FA actually make it to the cow's tissues. I would be cautious of intentionally reducing linoleic acid much below 1% of diet dry matter.

Because adding dietary fat generally increases milk fat and milk lactose yield, not all of the increased energy density from adding fat contributes to improving energy balance in the cow. Also, any reduction in intake cause by fat addition (but not incorporated into model estimates of intake) will impact the benefit of FA to improved energy balance.