

Nutritional Manipulation of Pork Quality: Current Opportunities

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■ Introduction

The pork industry is naturally segmented into producers, packers and retailers. The question is what can producers do to produce pigs that will yield pork that *consistently* meets market demands? What are market demands? Previous demands for leaner meat have driven the reduction of fat in pork and consumer demand for “normal” pork has driven selection of pigs without the halothane gene and now the RN gene. Current demands are for “normal” pork to meet domestic and export consumption and to meet specialized markets (ex. darker-firmer pork, highly marbled pork or organic pork). Markets drive demand and demand is the impetus for change but opportunities for change may not always be easily identified or implemented and may require integrated industry approaches. Quality pork is the combined result of genetics, nutrition, production management, transportation, slaughter, processing and retailing practices, and each share responsibility in the quality of the final product.

Most nutritional manipulations will, therefore, not be magic bullets that lead to complete resolution of pork quality defects or unfettered production of “enhanced” quality pork. With the understanding that certain risks are involved in achieving desired outcomes for nutritional manipulations, there are a number of promising nutrients that have been shown to positively affect pork quality. The subject of nutritional manipulation of meat quality has recently been reviewed (ex. Pethick et al. 1997, Pettigrew and Esnaola 2001, Rosenvold and Anderson 2003) and a factsheet on the subject has been published by the National Pork Producers Council (Ellis and McKeith 1999; www.porkscience.org/documents/Other/qnutritinfluences.pdf). For this presentation I've taken the liberty of extensively citing Pettigrew and Esnaola (2001) in addition to reports published subsequent to this review. This presentation will consider only a few of the more extensively investigated nutrients.

■ Nutrients Modifying Pork Quality

Protein and Amino Acids

Feeding protein or amino acid deficient diets increases marbling. In 18 trials reviewed by Pettigrew and Esnaola (2001) marbling increased 0.4 points on a 5 point scale or by 1.4% intramuscular fat. The problem is that growth performance was also impaired and carcass fatness was increased. Cisneros et al. (1996) investigated feeding higher levels of leucine (the only amino acid that can be used exclusively for fat synthesis) and found numeric trends for reduced growth rate (-8%) and increased intramuscular fat (+0.6%). Comparable effects have now been confirmed in a follow up study by Hyun et al. (2003). These effects may be due to leucine impairing utilization of other amino acids sharing the same transport system, or may be linked in some way to leucine inducing protein synthesis (Lynch 2001).

Chromium

Chromium potentiates the action of insulin and may play a role in increasing rates of lean deposition. Chromium was originally reported to increase leanness in pigs by Page et al. (1993). Pettigrew and Esnaola (2001) reviewed the effects of Cr –picolinate in 27 studies when fed at 200 ppb. Average backfat depth was reduced by 1.5 mm, the proportion of carcass lean was increased by 1.5% and loin eye area increased 2 cm². Eighteen of these 27 studies showed numerical improvements but only 8 were statistically significant. Out of 10 additional studies where Cr was fed at different levels or in a different form, 8 showed no improvement in carcass composition. Two further studies have since been completed using market weight hogs and these indicate Cr may interact with dietary energy level (low energy yielded negative results and high energy positive results). Shelton et al. (2003) showed Cr increased loin area for high energy diets (+4.5 cm²) and decreased area for low energy diets (-2.87 cm²) but in a second experiment increases in loin area were not significant when feeding high energy diets. Responses seen by Mathews et al. (2003) were also only numeric for reductions in backfat.

The effects of Cr on aspects of pork quality beyond lean and fat deposition have been intermittent and not covered in this presentation, but a series of experiments conducted at Louisiana State University has recently been reviewed by Southern (2001) and readers are directed there for further coverage. Pettigrew and Esnaola (2001) have also indicated that for research in this area to advance, measurement of Cr levels in whole diets and assessment of Cr availability will be necessary. In addition, it might also be important to consider to what extent Cr may be interacting with other dietary minerals.

Betaine

Methionine is an essential amino acid and aside from its requirement for protein synthesis, it is a methyl group donor in a number of essential reactions (ex. DNA and choline synthesis). Betaine donates methyl groups to regenerate methionine and also assists in maintaining osmotic balance. Adding betaine to swine diets has shown some potential to increase carcass leanness and/or growth performance but Pettigrew and Esnaola (2001) indicate that results have been erratic. More recently, Lawrence et al. (2002) found variable responses may in part be due to gender, with barrows showing better responses than gilts. In addition, Schrama et al. (2003) indicated responses during restricted feeding or when feeding low energy diets might be due to reduced energy requirements for maintenance (-5.5%). Further definition of conditions is still needed to determine when addition of betaine to the diet would be of practical benefit. It would certainly be of interest to determine if betaine has any effects when feeding the relatively low energy barley/wheat diets typical to Western Canada.

Magnesium

Shortly after slaughter, oxygen delivery to muscles ceases and anaerobic metabolism (glycolysis) is switched on to maintain energy levels and muscle function. Accelerated post mortem glycolysis while the carcass is still warm can lead to lactic acid build-up, pH drop and development of pale, soft, exudative (PSE) pork. Magnesium has the potential to reduce glycolytic rates triggered by stress hormones (catecholamines), and may also antagonize stimulation by calcium. Early work by Schaefer et al. (1993) showed feeding Mg-aspartate had the potential to reduce drip loss (-0.53%). In this study, a magnesium aspartate containing product was fed at a rate of 40 g per day but it only contained 1.3% Mg-aspartate. Subjective color, structure and 45 minute pH were, however, not affected by Mg. D'Souza et al. (1998, 1999) have since shown some remarkable effects of Mg on pork quality after feeding 40 g of a purer sources of Mg for 5 days. In these studies, Mg was fed at approximately ~64 fold greater levels than by Schaefer et al. (1993), and significant reductions in L* (lightness reduced 2.6 units) and drip loss (1.7%) were found. In addition, the incidence of PSE pork was 8% for boars handled gently, 33% for boars stressed by electric shock and 0% for boars fed supplemental Mg when either gently handled or shocked. Further work reported by Hamilton et al. (2002, 2003) has confirmed the work of D'Souza, and indicates beneficial effects of feeding Mg may be obtained for feeding Mg for 1 day at 1.6 g elemental Mg per day, and Mg-sulfate (a relatively inexpensive source of Mg) can be fed as a source of Mg. However, results were not consistent in some instances when feeding for 2 or 3 days. In addition, no one seems to have considered interactions with other dietary minerals (ex. calcium or phytate levels) and the need to ensure adequate but not over consumption of Mg should also be

considered (ex. six days prior to slaughter D'Souzas split pigs into pens of 3 and fed at 95% of ad libitum to maximize Mg intake for all pigs).

Creatine

Creatine can be synthesized from 3 amino acids (arginine, glycine and methionine) and when phosphorylated acts as a quick source of energy for muscle. Feeding creatine increases its level in muscle and can possibly delay anaerobic glycolysis, lactate production and pH drop after slaughter. Pettigrew and Esnaola (2001) indicated feeding creatine may have some potential to improve pork quality (increased ham pH at 45 min, reduced variability of L* (lightness)) based on preliminary reports but subsequent results indicate that the effects of creatine may not be consistent (Berg and Allee 2001, Stahl et al. 2001, Maddock et al. 2002, Berg et al. 2003, Stahl and Berg, 2003). Work in the area is ongoing to further define the conditions where creatine feeding might be warranted. Work of Berg et al. (2003) has now also indicated feeding lipoic acid might have some potential to control early reductions in muscle pH post-slaughter.

Vitamin E

The effects of vitamin E on pork quality have been thoroughly reviewed by Pettigrew and Esnaola (2001). In general, super-nutritional supplementation of vitamin E (100-200 mg/kg diet) has been found to increase the oxidative stability of pork. L* (lightness) and b* (yellowness) have not been influenced by vitamin E but a* (redness) has sporadically been increased by vitamin E. Vitamin E was reported to significantly reduce drip loss in 3 studies, nonsignificant improvements were found in a fourth study and no effects were found in a fifth. The sporadic nature of vitamin E effects may be related to the fatty acid composition of the diets fed, with greater levels of unsaturation showing greater responses. Supplementation of diets with vitamin E will, therefore, be of considerable value if and when designer pork products are developed with high levels of omega-3 fatty acids.

Conjugated Linoleic Acid (CLA)

Several studies to date have indicated consumption of CLA may help in the fight against many diseases including cancer. Early work feeding synthetic CLA to rodents also indicated CLA could reduce carcass fat, increase lean and possibly improve feed efficiency. We have recently reviewed the effects of feeding CLA on pork quality (Dugan et al. 2002) and a more comprehensive manuscript has now been submitted for publication to the *Amer J. Clin. Nutr.* In summary, out of 12 studies in which CLA was fed for extended periods (i.e. not slaughtering before 50 kg or starting on feed after 74 kg), feeding CLA decreased measures of body fat by 6.2-25% and increased lean by 2.3-9.7%.

CLA's effects on body composition have, however, been shown to interact with the level of dietary oil (Dugan et al. 2001, 2003). Some of the variation in responses might be related to the indices used for prediction/measurement of body composition since many use linear measurements rather than full carcass dissection or proximate analysis. Accelerated development/evaluation of carcass modifiers would, therefore, likely be possible if comprehensive measurements were used (ex. as in Dugan et al. 2001; Ostrowska et al. 1999).

In addition to CLA's effects on carcass composition CLA increased marbling fat in 3 out of 5 studies. In an extreme case, when feeding 5% dietary CLA, muscle marbling was increased 1.12% (Joo et al. 2002). Fatty acid saturation and/or firmness of backfat and/or bellies was also improved in 7 studies and this is likely due to the inhibition of the enzyme required to synthesize monounsaturates from saturates. At present, CLA is not available for inclusion in pig diets in Canada or the USA. BASF has the license to include CLA in animal feeds, and applications to do so have been made to regulatory authorities.

■ Conclusions

Nutritional means to manipulate meat quality are possible but in many instances more work needs to be done to ensure these are profitable in a commercial setting. Nutritional manipulations will only be used if producers receive a return on their investment. To do this would either require a quality based grading system or a way to certify and pay producers for using enhanced nutrition programs which, on average, produce pork of superior quality. In addition, segmentation of the industry is reflected in segmentation of research. Integration of industry efforts to solve problems and produce quality pork will, therefore, also need to be met by greater integration of genetics, nutrition and meat quality research.

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