UNDERSTANDING CARCASS FAT QUALITY: WHAT NUTRITIONISTS NEED TO KNOW

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INTRODUCTION

The cost associated with feeding pigs to a suitable market weight has increased as a result of competition for corn by the ethanol industry. Therefore, it has become necessary for live production systems to investigate alternatives to high-priced corn. Much of this research has focused on utilization of co-products of the ethanol industry; most specifically, feeding dried distillers grains with solubles (DDGS). Changes in the fatty acid profile of pork originating from pigs fed greater than 20% DDGS in the diet can occur due to the relatively high concentration of unsaturated fat present in DDGS (Whitney et al., 2006).

Fat present within and around muscle tissue plays a vital role in the ultimate assessment of meat quality as it influences product appearance, oxidative stability, palatability, texture, and healthfulness (Nishioka and Irie, 2006). The old meat science mantra that "Fat = Flavor" has been proved many times in research projects evaluating the level of marbling in high quality chops and steaks. Indeed, the quality and fatty acid profile of adipose tissue present in muscle foods contributes to the palatability and distinctiveness of meat; it's what makes pork taste like pork and beef taste like beef. So it goes, as alterations in the fat profile are generated that differ from what has become gastronomically acceptable or characteristic to a given meat product, the level of acceptance of that product to the consumer will likely be compromised. Those responsible for dietary formulation of livestock feeds must therefore consider the lipid source if they are truly concerned with the ultimate eating quality of the final meat product. This concern is of great importance with regard to nonruminant species of livestock. Dietary fat is saturated prior to absorption in tissue from ruminant species due to actions of rumen physiology. In contrast, fatty acids present in nonruminant diets can be directly incorporated into tissue making it much more likely to alter the fatty acid profile of pork by dietary manipulation (Azain, 2001).

The flavor of a meat product is the most important criteria for repeated purchase of that particular product; if it tastes good to you, you are more likely to buy it again. However, the most important criteria for the initial purchase decision (made at the retail case) is the visual appearance of that product (Brewer and McKeith, 1999); if it looks "off" to you, it will not be placed in your grocery cart. The ultimate success of the pork industry therefore comes down to 1) consumers like the appearance of pork (they buy it) and 2) they like the taste of the pork (they buy it often).

Wood (1984; as cited by Hugo and Roodt, 2007) described high quality pork carcass fat as firm and white and poor quality fat as soft, oily, wet, grey, and floppy and indicated that flavor was also important when describing good and poor quality fat. The focus of this paper will be on how carcass fat influences the "quality" of pork and pork products. The assumption will be made that the audience has an understanding of the role dietary feedstuffs play in carcass fat manipulation and will highlight how alterations to standard fat composition influence pork processing, acceptability to the industry, and acceptability to the consumer.

ASSESSMENT OF FAT QUALITY

The National Pork Board provides a standard reference guide for evaluation of pork quality. Although the Pork Composition and Quality Assessment Procedures (NPB, 2000) are most often cited for evaluation of carcass composition and lean quality, it contains standard references for the procedures to analyze fat quality. According to this reference guide, quality U.S. pork has been characterized as possessing < 15% polyunsaturated fatty acids, > than 15% stearic acid (C18:0), and an iodine value (IV; further described below) < 70 mg iodine/ 100g of fat (citing Lea et al., 1970). Pork fat with > 14% linolenic acid (C18:2) has been associated with soft fat and the percentage of stearic acid (C18:0) is generally accepted to be the most important indicator of optimum pork fat "quality". As previously stated, the level of pork fat saturation is largely impacted by the concentration of unsaturated fatty acids present in the swine diet and by the backfat thickness (in general, as backfat thickness decreases, pork fat becomes softer and less cohesive).

The Pork Composition and Quality Assessment Procedures (NPB, 2000) lists melting point, iodine number (value), and fatty acid profile analysis as three analytical determinants of pork fat quality. A fourth technique, the "belly flop" or "belly bend" methodology for belly fat quality assessment is a technique that has been referenced in the literature since the publication of the NPB Procedures manual.

Melting point

Soft pork fat will often possess a lower melting point which can effectively melt as a result of the heat of friction during grinding or chopping. The fat will then smear over the surface of the processed meat product generating a product that is less visually appealing. Knowledge of the melting point of the fat is especially important when manufacturing emulsified products such as bologna or frankfurters. Meat batter temperature must be more closely monitored when soft fat is used in emulsified pork products to avoid smearing and a reduced product yield. The advantages of the melting point analytical procedure are 1) it can be used as an indication of fat quality and degree of fatty acid saturation and 2) is relatively simple and cost effective. The disadvantages are 1) it cannot determine the degree of unsaturation in the fat and 2) fatty acid profile cannot be determined (NPB, 2000).

Iodine number (value)

Iodine number or value (IV) is a measure of the number of fatty acid double bonds in a lipid sample expressed as the grams of iodine absorbed per 100 g of sample. A lower number indicates that lipid sample contains more saturated fatty acid (fewer double bonds); therefore IV has rapidly become a standard analytical tool for establishing a threshold of acceptability for pork fat firmness. According to NPB (2000), the advantages of the IV analysis is that it provides an overall indication of fatty acid unsaturation. The disadvantages are 1) di-unsaturated fatty acids such as linolenic acid (C18:2) absorb twice as much iodine as a monounsaturated fatty acid such as oleic (C18:1) which elevates the iodine number, 2) the differential amount of polyunsaturated fatty acids cannot be distinguished from the IV, and 3) the chemicals used in the analysis are considered hazardous and may require a more sophisticated means of disposal.

An iodine value of 70 has been frequently cited as the threshold level of acceptability for pork fat (>70 is too soft). Hugo and Roodt (2007) provide an excellent review of iodine value criteria. In their review paper, they cite research indicating that pork backfat used for manufacturing "firm-cutting" sausage should have an IV < 60. Many researchers cite Lea et al. (1970) and (or) Barton-Gade (1987) as the origin of the 70g/ 100g of sample threshold, however, Hugo and Roodt (2007) cite many other authors who agree with this threshold value. That said, care must be taken when adhering to a strict line of demarcation when considering any biological system. As pointed out above, iodine numbers are subject to bias based on the specific fatty acid profiles within the tissue being measured. Furthermore, different laboratories may employ different analytical means for reporting IV which confounds cross-lab comparisons and may result in "rejection" of a pork belly/ bacon product. A graphical depiction of potential analytical bias is shown in Figure 1. These data were generated from research conducted within Farmland Foods and show iodine values calculated from bellies representing two different analytical techniques. The "lab test" (crossed line) refers to the standard g iodine absorption/ 100g of tissue analytical procedure and the "GC values" line refers to IV calculated from actual fatty acid profile analysis conducted by gas chromatography (GC; further described below). The regression lines are plotted across incremental levels of DDGS inclusion in the diet of finishing pigs. Figure 1 clearly illustrates that at lower levels of inclusion of DDGS, the lab test generates an over estimation of IV compared to the GC procedure. If we consider the GC methodology to be a more accurate approximation of polyunsaturated fatty acid profile (soft fat), we may make the mistake of labeling individual bellies as unacceptable at a level of DDGS inclusion well below 10% using the IV of 70 as the cut-off point.

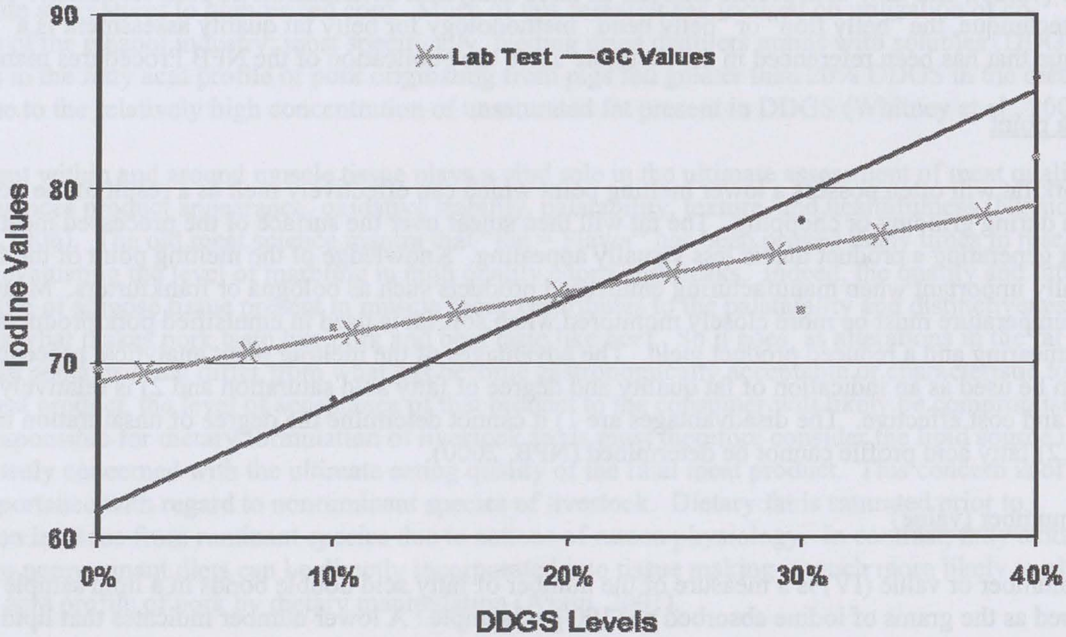

Figure 1. Iodine values calculated from bellies representing two different analytical techniques obtained from internal research at Farmland Food. The "lab test" (crossed line) refers to the standard g iodine absorption/ 100g of tissue analytical method and the "GC values" line refers to IV calculated from actual fatty acid profile analysis conducted by gas chromatography (GC). The regression lines are plotted across incremental levels of DDGS inclusion in the diet of finishing pigs.

Gas chromatography: Fatty acid profile

Using GC equipment, fatty acids possessing different chain lengths or differing degrees of saturation can be distinctly identified because each fatty acid moves through the gas column of the GC at a different rate (NPB, 2000). Iodine number can be calculated from the GC fatty acid profile (as referred above). The advantage of this methodology is that the precise fatty acid profile can be obtained which may be of interest if the researcher wishes to compare accumulation or disappearance of specific fatty acids due to treatment effects. The disadvantage of this method is that it requires use of highly sophisticated, technical equipment. The cost of purchase may be cost prohibitive.

Belly flop/ belly bend

This very applied means of assessment cuts right to the functionality and physicality of the fresh pork belly. The technical application of this procedure varies across institutions that apply it. The basic concept is that the level of flex in the fresh pork belly is determined by placing the center of the belly on a rod, dowel, or PVC pipe and measuring the "flop" or "bend" of the belly (Figure 2). Rentfrow et al. (2003) found belly flex to be highly correlated to total unsaturated fatty acids ($r = 0.50$; $P < 0.001$) yet the authors concluded that greater fresh belly flex (soft bellies) had no adverse effects on belly/ bacon processing quality parameters. The advantages of the belly flop procedure are 1) it is in inexpensive and easily accomplished, 2) it is an appropriate means of distinguishing "soft" bellies, and 3) it is related to the degree of unsaturation of the belly fatty acid profile. The disadvantages are 1) it does not quantify any chemical nature associated with "soft" fat and 2) it may not be relevant with regard to prediction of further processing characteristics of bacon such as smokehouse yield, high-speed sliceability, or bacon slice shatter score.

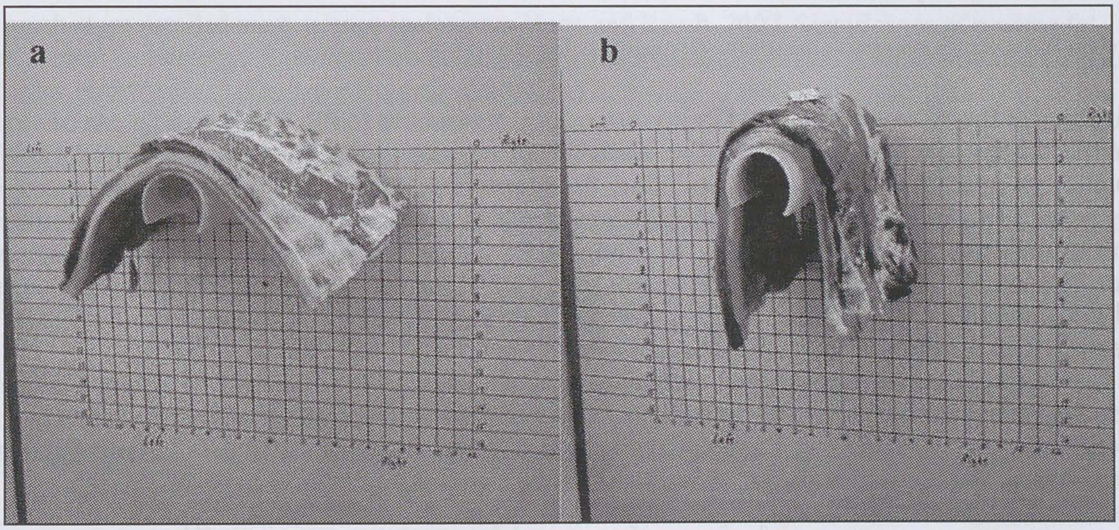

Figure 2. Evaluation of the Belly Flop/ Belly Bend technique of determining fresh pork belly softness showing firm (a) vs. soft (b) bellies.

PORK BELLIES/ BACON

According the USDA National Nutrient Database for Standard Reference the average total lipid (fat) value per 100g of edible portion for pork, fresh, belly, raw is 53% and pork, cured, bacon, raw is 45% (http://www.nal.usda.gov/fnic/foodcomp/search/). This is a good place to start this segment of the discussion since alterations to carcass fat will be most noted in this fatty, high-value cut of pork. Soft fat associated with bacon processing has the potential for problems when you consider the common industry practice of high-speed slicing of bacon slabs. This is particularly important considering the average slicing yield for retail bacon is nine slices per inch and food service is 13 slices per inch (Mandigo, 1998). Firmer fat is an insurance policy that facilitates more even slicing and improves definition of the slices in the vacuum package (NPB, 2000). Soft bellies have the potential to produce bacon slices that flatten together or fold, can appear wet or oily, are more prone to more rapid spoilage (rancidity through oxidation), and the soft fat may be more likely to separate from the lean in the bacon slice (NPB, 2000). All these defects create an undesirable presentation that may be rejected by consumers at the point of purchase. Also, prior to slicing, slabs of bacon are "pressed" to a more uniform shape to facilitate more rapid and consistent movement through the slicer. Softer bacon slabs may be more prone to fold during pressing which produces irregular strips of bacon. There is a reason that I am writing that the soft fat of fresh bellies <u>may</u> generate these quality defects. It is because several industry contacts state that soft bellies are not a problem going through the slicer. This is because the majority of bacon processors place bacon slabs in a tempering cooler (-4° C) to facilitate optimal pressing and slicing. The -4° C chill placed on the bacon slab effectively alleviates the slicing problems associated with soft fat.

So if this soft fat is not an issue with regard to bacon processessing, why is there such a large focus placed on, for example, the use of DDGS in finishing swine rations relative to changing the fat profile of bellies/ bacon? For one, the "defects" are passed on to the consumer when they open the package. Once removed from the confines of the vacuum pack, the slices appear wet and oily, the fat separates from the lean, and, now exposed to oxygen, is more prone to rancidity. Furthermore, alteration of the fatty acid profile may change the flavor profile of the bacon in those products that have a more mild cure. Fatty acid profile alterations may not be the only fat-related factors to influence flavor. Fat soluble flavenoids, ethanol processing byproducts, and other volatiles may be incorporated into the fat tissue along with the lipid from the dietary source.

<u>SAUSAGES AND OTHER PROCESSED PORK PRODUCTS</u>

According to Pork Composition and Quality Assessment Procedures (NPB, 2000), soft fat can become a problem for sausage manufacturers. Proper aesthetic composition of many sausages requires the ability to visualize fat particles in the final product. Since the fatty acid profile of soft fat is more unsaturated, it may possess a more transparent (or in some cases yellow) appearance which makes discerning the fat particles difficult. It is common practice to grind trim for sausage and (or) emulsified pork products at cold temperatures, however, soft pork will often have a lower melting point which may essentially melt and smear throughout the product during grinding or later during slicing. Transparent fat and (or) fat smearing is an aesthetic defect that consumers will avoid.

The same potential for altering the shelf-life and flavor profile of processed meat products exists as was described for bacon. There is opportunity to mask potential flavor changes with the addition of spices, preservatives, and (or) antioxidants. That said, there are a growing number of consumers seeking "natural" meat products who may purposefully avoid any processed meat containing preservatives or any other additive they consider un-natural.

<u>FRESH PORK LOINS</u>

The principal criteria for fresh pork loins qualifying for the high quality Japanese export market are 1) a sufficient degree of marbling, 2) a firm boneless loin, and 3) a darker, redder lean color. Two (if not all three) of these criteria are influenced by soft fat. The level of unsaturation will be effective at the muscle cellular level and may influence the firmness of the boneless loin when the Japanese inspector evaluates the loin firmness by grasping it in the middle and allowing it to drape over his/her hand. Soft fat will influence the firmness of the loin where seam fat is present; giving way to separation between the fat seams from the lean muscle. With regard to marbling, the transparency of unsaturated fat may make visualization of marbling more difficult and may give the cut surface of the loin chops a more soft and oily appearance.

Since the longissimus dorsi muscle is on average a lean primal cut, the affects of soft fat on flavor profile are less pronounced than in bacon or sausage. Even so, there is still greater potential for more rapid development of rancidity in pork loin chops possessing a higher degree of unsaturated fat. Genetic lines of swine more prone to high intramuscular fat deposition may be more susceptible to undesirable flavor modification and reduced shelf-life as a result of feeding such unsaturated feedstuffs as DDGS.

TAKE-HOME MESSAGE

The ultimate decision to purchase any pork product is made at the retail level. Soft, smeared, oily, wet, or grey/ transparent appearing pork products will never find their way into the consumer's grocery cart. Current industry practices can correct for the undesirable processing characteristics of soft fat. Bacon slicing can be improved by tempering bacon slabs to minus 4°C. Shelf life of pork products containing more unsaturated fat can be extended through the addition of antioxidants and preservatives in the ingredient formulation. However, as consumers become more label savvy, they may avoid purchase of products containing these additives as they are perceived as un-natural. Products marketed to consumers as being "naturally" higher in unsaturated fat or higher in omega-3 fatty acids may have initial appeal for addition to a "healthier" diet. Yet, if these pork products do not taste like what consumers have come to recognize as pork they may be less inclined to purchase them on a repeated basis.

SUGGESTED READING

For a much more detailed meat science review, see Hugo and Roodt. 2007. Significance of porcine fat quality in meat technology: A review. Food Reviews International. 23:175-198. Available online at http://www.informaworld.com/smpp/content~content=a772854208~db=all~jumptype=rss.

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