

Marbling and Pork Tenderness

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What importance do consumers place on palatability, in general, and tenderness, in particular?

Consumers ideally desire attractive, economically priced products with desirable color, which are nutritious and healthy, tender, juicy, and flavorful, with no fat or additives. At the point of purchase, consumers visually assess meat products for size, shape, color, fat to lean and lean to bone ratio, texture, and cost per serving (McGill, 1981). They then base their purchasing decision on a balance of these factors, determined by past personal experience, which they perceive will provide assurance of maximum eating satisfaction. Unless meat products pass this initial evaluation, further evaluation will not proceed. Once a product has been purchased, consumers respond to aromatic, taste, and mouthful sensations during consumption, which result in hedonic or value judgments, based upon past personal experience.

The priority consumers place upon palatability, in general, and tenderness, in particular, is influenced by economic, social, and environmental factors, but palatability and tenderness are always important considerations. The social and economic climate may markedly influence the importance attached to palatability and tenderness. For example, a restaurant patron consuming an expensive entree has higher expectations regarding tenderness and palatability, than the same consumer, when consuming a product purchased at a bargain price and prepared in the home. Consumers also have different expectations and priorities for different products and products from different species. Since tenderness has generally not been a concern with pork, lamb and processed products when proper preparation procedures were employed, flavor and juiciness usually were given a higher priority than tenderness. However, with beef steaks and roasts, tenderness usually receives the highest priority.

Although marbling or the intermingling of fat with lean, has been equated with palatability and tenderness for years, increasing concerns regarding animal fat in the diet has caused the perceived health benefit from fat reduction to receive greater importance than assurances of tenderness or palatability. Consequently, consumers now demand minimal visual fat, while still desiring a palatable product, making it difficult to satisfy their requirements. On the other hand, consumers have clearly demonstrated a preference for intramuscular fat when rating pork in blind taste tests (NPPC 1996).

Glossary

Chronological age - The age of an animal in days.

Intramuscular fat - Fat deposited within a muscle.

Marbling - Fat intermingled with the lean within a muscle, or visible intramuscular fat.

Palatability - The satisfaction derived from eating.

Physiological maturity - The physiological state of maturation of an animal.

Plane of nutrition - The energy content of an animal's diet.

Tenderness - The ease with which a product is penetrated, fractured, and broken down during mastication.

Video image analysis - Analysis of photographic images with the assistance of a computer to determine the number, size, shape, and dispersion of particles.

Because of the negative correlation between carcass lean and intramuscular fat, selection for lean composition in the past has resulted in great reductions in marbling. However, the correlation is not very high. This means that selection for both traits should result in an ability to increase marbling while reducing external fat.

Convenience of preparation is of paramount importance to a steadily increasing portion of the consuming public, with more single parent households, more families with two working parents, an aging population, and more single and retired people. Although convenience of preparation takes precedence over tenderness and palatability, to these consumers, all products must provide at least an acceptable degree of eating satisfaction.

Economics often dictate how tenderness and palatability are prioritized. For example, consumers on a tight budget may be able to purchase twice as many servings by selecting cuts with a lower degree of tenderness and palatability assurance or ground products with built in tenderness. However, all products must provide at least an acceptable degree of eating satisfaction.

Consequently, the bottom line is: tenderness and palatability are very important to consumers, irrespective of economic, social, and environmental influences.

What is the relationship of fat and marbling to tenderness and palatability?

Following an extensive literature review, it was concluded marbling or intramuscular fat was usually positively related to and accounted for 12-14% of the variation in all beef palatability traits (Jeremiah et al., 1970). Following a later extensive literature review it was concluded fatness contributed to meat quality, but neither the amount of intramuscular fat nor the overall degree of fatness were major determinants of palatability, or precise indicators of eating quality (Jeremiah, 1978). Moreover, it has been reported a 30 unit increase in marbling was required to produce a single unit increase in beef tenderness (Crouse et al., 1978). However, it has been demonstrated 8mm of subcutaneous fat in combination with a small degree of marbling will provide 90% acceptance of beef palatability (Jeremiah 1997). Pork carcasses have been observed to contain substantial variability in both carcass and palatability traits (De Vol et al., 1988). Hodgson et al. (1991) observed the highest ratings for overall palatability from pork chops with bright color (high reflectance at 685nm), low moisture content (70.1%), high intramuscular fat content (9.1%), low protein content (19.4%), high marbling scores, and low cooking losses (25.9%); additionally, DeVol et al. (1988) reported, intramuscular fat was most highly related to tenderness and shear force values ($r=0.32$ and -0.29 , respectively) of all the traits which they evaluated. Ramsey et al. (1990) also reported marbling was negatively related to shear force values ($r= 0.35$) and van der Wal et al. (1992) reported marbling was significantly related to intramuscular fat. Jones et al. (1994) reported marbling was negatively related to the incidence of pale, soft, exudative (PSE) pork, but inherent muscle quality has been reported not to be related to tenderness or overall palatability of pork (Jeremiah 1983; 1984). Eikelenboom (1996) reported that sensory tenderness, juiciness and flavor were moderately related to intramuscular fat. They suggested that intramuscular fat is related to the eating quality of pork, but they also suggested that intramuscular fat is less important than ultimate pH of the meat for the eating quality of pork. Other workers have failed to observe a relationship between fatness or the amount of intramuscular fat to tenderness and/or overall palatability in pork, it can be concluded marbling maybe is positively related to palatability, but it is unlikely that it accounts for more than a small amount of variation in any palatability trait. Bejerholm and Barton-Gode (1986) identified a threshold value of 2% intramuscular fat for optimal tenderness. According to a U.S. study (De Vol et al., 1988), the threshold level was 2.5-3%.

What is marbling and how is it measured?

Marbling is the intermingling of fat with lean in a muscle, and therefore, is intramuscular fat deposited around or between fascial or muscle fiber bundles. Intramuscular fat is usually quantitated chemically, while marbling is usually visually assessed subjectively. For research and carcass grading purposes, it is essential to make assessments under standardized conditions. The surfaces of freshly cut muscles, which have been exposed to air for at least 15 minutes, should be used. Care should be taken to ensure the meat surface is illuminated with at least 100lux of incandescent lighting. Subjective assessment of marbling requires judgment, since several variables can influence the final assessment. Marbling can either be coarse (large deposits), or fine (small deposits) and its distribution can be even, covering the entire muscle, or uneven, covering only portions of the muscle. Overall marbling scores encompasses size, number, and distribution of fat particles, with large particles receiving only slightly more credit than small particles and

large particles immediately adjacent to the subcutaneous or intermuscular fat receiving no credit. Five levels of marbling are illustrated in Figure 1, and represent the minimum degree of marbling for each level. Muscle surfaces can be compared to these photo-graphic standards. Generally the marbling score is based upon the standard with just slightly less marbling than the sample. In borderline situations, the size and distribution of fat particles is taken into consideration. Large, coarse particles and/or uneven distribution usually result in downgrading to the next lower level.

Visible marbling scores usually reflect the intramuscular fat contents at left.

Devoid	1.0 - 2.5%
Traces	2.5 - 4.0%
Slight	4.0 - 5.0%
Small	5.0 - 6.5%
Modest	6.5 - 7.5%
Moderate	7.5 - 8.5%
Abundant	> 8.5%

Guidelines for visual assessment of pork marbling have been clearly outlined (Jones et al., 1992). More recent research indicates greater accuracy of marbling assessment can be achieved through computer assisted video image analysis (Scholtz et al., 1995). The new NPPC visual standards published by the National Pork Producers Council (NPPC, 1998) on

marbling relate subjective standards to objective measures. The table at right demonstrates this relationship.

NPPC Marbling Standards	
Marbling Score	Intramuscular Fat Content (%)
1	1
2	2
3	3
etc.	etc.

What factors influence marbling?

The best available evidence indicates marbling level is determined by genetics, chronological age and/or physiological maturity, plane of nutrition, duration of feeding high energy diets, and undoubtedly other less well defined factors.

Traditionally, it has been believed marbling was coincidental with higher degrees of carcass fatness. However, recent research, with both beef and pork have shown only 1-3% of the variation in marbling is accounted for by subcutaneous fat thickness (Jones et al., 1992). Consequently, no amount or duration of high energy feeding prior to slaughter will increase marbling score if an animal has a genetic predisposition for a very low degree of intramuscular fat deposition. Since breeds vary genetically in marbling, selection can be used to enhance marbling. Considerable interest presently exists in estimating marbling in live breeding animals, for this purpose, using real-time ultrasound but these techniques are currently being perfected and are not yet readily available commercially.

Could and should marbling be enhanced?

Past research has made it obvious marbling can be increased through genetic selection and the use of extended, limited feeding periods. Jeremiah et al. (1992) observed a clear discrimination on the part of consumers to higher degrees of marbling in beef at the point of purchase, but a clear preference for higher degrees of marbling at the point of consumption. NPPC has recognized the same phenomenon in pork (NPPC, 1997). Consequently, it may be possible to educate consumers as to the beneficial effects of marbling on palatability, in which case, it is maybe advantageous to increase marbling, depending upon the economics involved. Consumers should be advised, even though the chemical fat content of meat cuts increase with visible marbling, the implications on caloric content are relatively minor. For example, a 100gm cut (cooked weight) with a slight degree of marbling contains approximately 63 calories from fat, while a similar cut with a small degree of marbling contains 69 calories (Jones et al., 1992).

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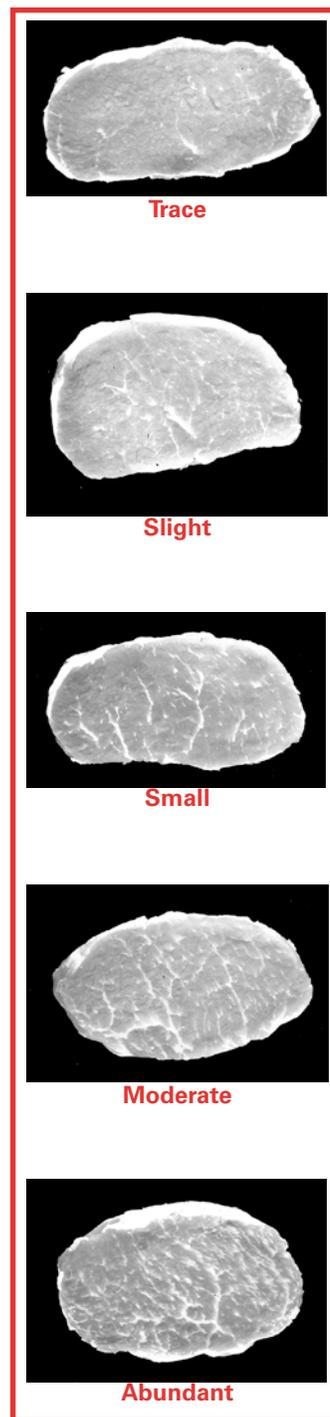


Figure 1. Five levels of marbling in pork steaks cut near the tenth rib. Source: Jones et al. 1992; photos courtesy of W.M. Robertson.

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