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MARBLING

The role of marbling in the eating experience of beef and other red meats is well established. However, I get the impression that claims about the benefits of marbling are quoted often without sufficient scientific support. These may confuse the consumer and, in the end, work against the efforts to promote marbling as a quality trait in beef and other red meat species. This is a short but certainly not comprehensive discussion about marbling and an attempt to provide some facts around certain issues about marbling.

Marbling is the fine, evenly distributed flecks of fat found through the muscle. While fat in the form of phospholipids is found within muscle tissue (cell membranes), marbling fat occurs in the spaces between muscle bundles. It is one of the three fat depots of the carcass, the other two being subcutaneous fat – on the surface of the carcass and intermuscular fat found between major muscle groups.

It is also important to note that these fat depots are laid down in a different sequence during the animal's life. Intermuscular or seam fat is normally deposited at a higher rate at first, followed by subcutaneous fat and then marbling fat.

However, deposition of fat depots in this order does not mean that one depot will stop being deposited when the

other accelerates its deposition but will rather continue to be laid down. These are, of course, important in the context of striving for optimum levels of marbling, also called the “taste” fat, because in most cases, it means that there is also an abundance of “waste” fat in the carcass when this point is reached.

Marbling contributes to the eating experience of red meat through positive effects on the consumer’s perception of tenderness, juiciness, and flavour. Some studies claim that marbling explains 20% to 35% of the variation in general eating quality, but others are more conservative stating figures of 10% to 15%.

These figures also vary, as they were measured using different levels of marbling. The mechanism involved in the improvement of tenderness is three-fold: Marbling fat reduces the bulk density of a steak, meaning there is less muscle structure (resistance) to bite through or to chew the meat.

Secondly, marbling fat has a lubricating effect, which stimulates salivation and enhances the perception of juiciness and flavour, contributing to the perception of better texture and the overall eating quality.

Thirdly, marbling fat is deposited in the connective tissue structure and reduces the connective tissue toughness as marbling increases. We have now mentioned the experience of tenderness, together with juiciness and flavour, and it is difficult to separate the three from each other when discussing marbling, as the effect is integrated.

It is, however, interesting to note that the positive effect of marbling on flavour and juiciness (taste panel scores) increases as the level of marbling increases, but there is a turning point or plateau at about 15% marbling fat. This is important when considering that breeds, such as pure and crossbred Wagyu, show marbling fat levels in the upper 20s and even 30s (%).

Certain studies indicate that a minimum level of marbling required to improve the flavour is 3%, and above 8% is required to show an effect on texture. Savell and Cross (1988), researchers from the USA, established a window of acceptability and report a dramatic increase in palatability scores by consumers when marbling increases from 0 to 3%. Between 3 and 6%, the increase in response is still positive but not as dramatic. Above 6 - 7%, the response to increasing levels of marbling tapered off further. In addition, above 7.3% of health-conscious consumers started to protest against too much visual fat, which they related to health problems.

Therefore, the window of acceptability for marbling was set at 3 - 7.3%. Fifteen percent marbling, as indicated earlier, may be recommended for niche markets, e.g., Eastern countries where eating culture concerning portioning and culinary methods differ from Western countries.

The quality of marbling, and contribution to eating quality, is not only defined by the level but also by the deposition pattern. Equal distribution of marbling as small flecks of fat across the steak surface area is most important. Large islands of fat may contribute to total fat or marbling level but are visually unappealing and cause inconsistent eating experience with either exposure to too much or too little fat.

The response of consumers to visual fat in raw steaks should carefully be considered, especially in certain Western markets. Consumers will often respond negatively when confronted with high levels of marbling in uncooked steaks. This response is driven by the negative connotation of visual animal fat. Consumer studies performed in the 90s in Australia

confirmed that consumers preferred beef with the lowest fat trim (subcutaneous fat) and, interestingly, marbling fat had a larger influence on the perception of "fatty meat" than fat-trim/subcutaneous fat thickness. Consumers responded consistently (linear scale) negative concerning "liking of raw appearance" and "expected eating quality" over ranges of marbling scores 1-3 (marbling fat 4 to 7%).

On fat-trim, there was no negative response between 2- and 5-mm fat cover, and a negative response was recorded only when fat thickness increased from 5 to 10 mm. Consumers believed that lean trim meat does not only look more appealing but will also taste better.

Interestingly, this negative response made a 180° turn when consumers tasted meat without being exposed to the raw cuts. Consumer panel MQ4 scores (used in Australia as a collective response to tenderness, juiciness, flavour, and overall liking) showed a 4 - 8% increase in overall score, even with a small range of marbling levels from score 0 (no marbling) to 3 (5.4 – 7.0%). This corresponds to the study by Savell and Cross in the USA.

The composition of fat is important when considering the nutritional value and contribution to the health status of the consumer. Saturated fatty acids (SFA), commonly associated with animal products, are often blamed for their contribution to health problems such as cancer, diabetes, and heart disease.

However, today we know that the SFA's, stearic acid and palmitic acid (comprising about 45% of the total fatty acids (FA) of muscle), does not raise plasma cholesterol, while the SFA, myristic acid, does but only comprise about 3% of the total muscle FA.

Mono-unsaturated fatty acids (MUFA) and poly-unsaturated fatty (PUFA) are generally regarded as "healthier" fatty acids. Any fat, also in meat, consists of different proportions of these three groups of FA (apart from other co-structures of fat) which give the fat its unique physical (e.g., melting point) chemical and nutritional characteristics.

The composition of animal fat in terms of the said fatty acids may also vary across animals within the breed, between breeds and feeding regimes, but only to a limited extent across fat type/depot, viz, marbling, subcutaneous fat and seam fat (intermuscular). Therefore, the claim often made that marbling fat is healthier than another fat (in the same animal) is not true.

True marbling fat is high in SFA and MUFA (almost in equal proportions) just like subcutaneous and seam fat. In most cases, high levels of marbling are associated with high levels of the specific MUFA, oleic acid (30-40%, particularly if it was associated with high levels of grain feeding). Oleic acid (MUFA) levels are followed by slightly lower levels of SFA's, palmitic (~30%) and stearic acids (~15%). PUFA are generally represented in much lower levels in any animal fat compared to PUFA and SFA, and this fact also applies to marbling fat.

PUFA mostly presents itself in phospholipids as part of cell walls. For this reason, the proportion of PUFA's within muscle decreases (diluted) as the marbling level increases, because of the decrease in the contribution of FA in the cell walls.

When considering these facts, an article in a local Sunday newspaper in October 2018 stating that Wagyu meat has higher levels of omega 3 and 6 PUFA's than salmon (fish) is quite off the mark. When meat is trimmed clean of external fat, higher marbling means that total fat intake increases, both SFA and MUFA, and that could (potentially) become a health concern.

As stated earlier, some American studies showed that

maximum marbling levels of 6 to 7% are about the upper limit for compliance with dietary and health guidelines. These recommendations must be considered in the context of portion size and other factors, but it is also important to note that products currently on the shelf may exceed 30% marbling.

When considering the effect of diet on PUFA and the different types of PUFA (omega 3 and 6), grass-feeding will cause a favourable (health-wise) increase in omega 3 to omega 6 PUFA ratio, but once again the favourable effect of this change will be diluted at high levels of marbling, because an increase in marbling fat coincides with the increase in mainly MUFA, but also SFA's at the cost of PUFAs.

Quite interesting information was found in a local study where beef steaks with very high (30%), medium (4.5%) and low (2.5%) muscle fat/marbling were analysed for the contribution of types of fatty acids on a weight basis. This (weight basis) contrasts with presenting FA values on a percentage basis, which often look very impressive, but does not give an account of the actual intake of FA when consuming a 200 or 300 g steak.

The study showed that consuming the very highly marbled steak would result in about six times higher total fat intake compared to the medium marbled steak. This ratio also translated into more or less six times higher intake of MUFA and SFA. Consequently, the "bad" SFA, myristic acid, but also the "good" SFA's palmitic and stearic acid were just below or above six times higher levels, and the "friendly" MUFA, oleic acid, slightly higher than six times in highly marbled steaks.

However, due to the dilution effect of marbling, despite the higher total fat (and FA) in higher marbled steaks, the PUFA ratio was only three times higher. Interestingly, the favourable PUFA, CLA, was also almost six times higher, but long-chain PUFA's, known for many health benefits, were undetectable in highly marbled steaks.

Although many secondary factors play a role when considering health guidelines for fat consumption, the rule of thumb states that not more than 30% of total calories consumed per day should be from fat and not more than 10% from SFA.

Considering these guidelines, consuming a 200 g highly marbled steak will mean that the daily quota for calories from any fat has been reached, and the proportion from SFA's has been exceeded. We may, therefore, need to re-consider the way highly marbled beef is consumed and scale down on portion size like in Eastern cultures.

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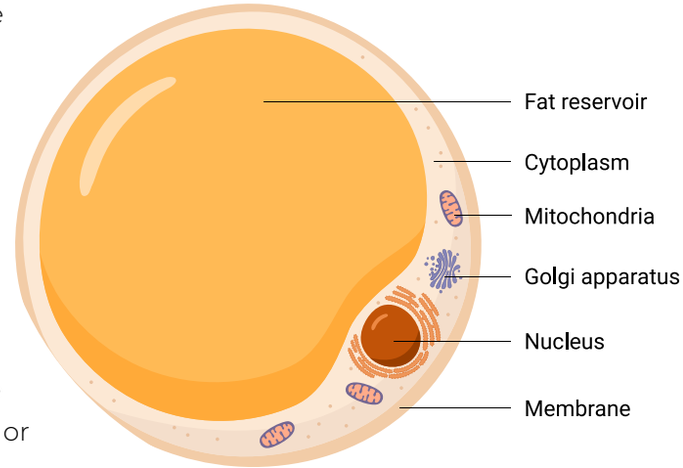

Just a short note on where marbling fat comes from and what factors are involved in its expression. Marbling fat, as it is seen in steaks, are mature adipocytes, in other words, a cell specialised solely for the storage of fat. Adipocytes develop from pre-adipocytes, which in turn develop by differentiation from multipotent stem cells. Multipotent means the cells can develop into several cell types such as cartilage, muscle, or fat cells.

Various factors could influence the initial and subsequent development of stem cells into adipocytes and the subsequent "filling" of adipocytes to appear as marbling fat in the final product. For a given weight and time on feed, heifers will have higher marbling than steers, which in turn have more than bulls. Calves castrated just after birth will have higher marbling than those castrated at weaning.

The use of implants and beta-agonists will also influence

marbling. While the results of various studies are not conclusive, there is strong evidence that implants and, more so, beta-agonists (salbutamol, zilpaterol) will inhibit the deposition of muscle fat.

Interestingly, one study showed that steers implanted with oestrogens had lower marbling scores than those implanted with androgenic or combination implants. It seems that early life restriction of nutrients, e.g., protein restriction prenatal and preweaning, will increase adipocyte numbers and, therefore, the potential to marble. Weight loss later in life, followed by weight gains, has a compensatory or accelerated effect on the filling of adipocytes, therefore higher marbling occurs in such cases.

Factors that influence the growth (filling) of mature adipocytes (marbling fat cells) are mostly genetics and nutrition. The right genetics will provide an animal with a predisposition to lay down marbling fat. Extended periods on high energy diets will lead to the expression of marbling, and this will take place at a higher rate/level in animals with marbling genetics. Those without the predisposition will show a proportionally higher increase in subcutaneous fat.

Multiple genes influence marbling, and the effect of each gene is small in relation to the total variation in the trait. However, it is possible to locate regions (QTL) on a chromosome that are associated with differences in the marbling phenotype. Furthermore, with whole-genome mapping, genes with specific effects on marbling are identified and selected.

In summary,

marbling certainly contributes to good eating quality. However, consumers need to be educated to accept that visual fat in the form of marbling, translates to good eating quality, but always within certain limits. Consumption of steaks with extreme levels of marbling should signal health threats.

Marbling fat is not healthier than other fat in the same animal, and consumers should be guided by recommended calorie intake in the form of fat when selecting marbled steak portions. ■