White Paper

A Brief Overview of Factors Affecting Lamb Flavor

Prepared for the Lamb Industry Roadmap Product Characteristics Team

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Meat produced by sheep of various ages has a distinctive, species-specific aroma and flavor profile that some consumers find objectionable, particularly when some of the characteristic flavor notes are overly intense. Because these flavor notes intensify as animals become older, the term "mutton flavor" is commonly used to describe the strong, objectionable flavor that can be present in ovine meat, regardless of the age of the animal from which the meat originated (Sink and Caporaso, 1977). Another distinctive flavor that can negatively affect consumer acceptance of lamb products has been identified in cooked meat of pasture-finished lambs and characterized as "pastoral flavor" (Young et al., 2003).

Wong et al. (1975a, b) determined that 8- to 10-carbon, branched chain fatty acids (**BCFA**) found in ovine adipose tissue, specifically 4-methyloctanoic acid (**MOA**) and 4-methylnonanoic acid (**MNA**), were primary contributors to the distinctive flavor of ovine meat and that increased concentrations of these fatty acids were associated with greater intensities of flavors described as "muttony" and "goaty". The link between sheep meat flavor intensity and concentrations of MOA, MNA, and another BCFA, 4-ethyloctanoic acid (**EOA**), has been confirmed by others (Young et al., 1997; Watkins et al., 2010) and it is now accepted that these 3 compounds are largely responsible for the strong flavor and aroma generally characterized as mutton flavor (Watkins et al., 2014).

Concentrations of BCFA, which occur as triglycerides in ovine fat, gradually increase with animal age. Correspondingly, the smallest amounts of BCFA normally are found in adipose tissue of lambs less than 1 year old, whereas intermediate BCFA levels usually are observed in sheep 1 to 2 years of age, and the greatest concentrations typically are observed among sheep 2 years old and older (Watkins et al., 2010). It is noteworthy, however, that changes in BCFA with

increasing age are influenced by other factors, one of which is sexual maturation of male lambs (Sutherland and Ames, 1996; Young et al., 2006).

Sutherland and Ames (1996) compared fatty acid composition of adipose tissue samples from wethers and rams slaughtered at 12 and 30 weeks of age. In that study, BCFA concentrations did not differ for wethers and rams slaughtered at 12 weeks (before sexual maturity); however, at 30 weeks of age (when the animals were sexually mature), rams had much greater concentrations of MOA and MNA (Sutherland and Ames, 1996). Between 12 and 30 weeks of age, MOA (the main contributor to mutton flavor) increased 13 fold in rams, but only 1.3 fold in wethers (Sutherland and Ames, 1996). Young et al. (2006) reported similar findings, showing that differences in BCFA concentrations between wethers and rams became greater as age increased, with the most pronounced differences between the 2 sex classes occurring among animals 13 months old or older.

Branched chain fatty acids are formed from methylmalonate produced by propionate metabolism in the liver or other tissues (Schreurs et al., 2008). Because feeding grain-based diets to sheep increases the amount of propionate formed in the rumen, fat of grain-finished lambs normally contains more BCFA compared with fat of lambs of the same age finished on pastures (Young et al., 2003). However, meat from grain-fed lambs often has a milder aroma and flavor with fewer objectionable flavor notes compared with meat from pasture-fed lambs (Rousset-Akrim et al., 1997; Young et al., 2003). Moreover, there is general agreement in the literature that meat from lambs grazing legume pastures (particularly white clover or alfalfa) or those grazing forage rape has a stronger flavor and aroma and a greater incidence of off-flavors than meat from lambs finished on grass pastures (Cramer et al., 1967; Shorland et al., 1970; Nicol and Jagusch, 1971; Park et al., 1972a; Park et al., 1972b; Wheeler et al., 1974; Notter et al., 1991; Channon et al., 2003).

The comparatively strong flavor of meat produced by some pasture-fed lambs has been described as “sheepy”, “gamey”, “barnyard”, “animal”, “fecal”, “grassy”, and “milky” (Schreurs et al., 2008). These flavor notes, collectively categorized as pastoral flavor (Schreurs et al., 2008), have been attributed to increased concentrations of indoles and, to a lesser extent, methylphenols found in fat tissue of pasture-finished lambs (Young et al., 2003; Watkins et al., 2013).

The main contributors to pastoral flavor of lamb have been identified as 3-methylindole (skatole) and indole (Young et al., 1997, 2003). These compounds are formed in the rumen from degradation of the amino acid tryptophan and accumulate in adipose tissue when excessive amounts are absorbed into the circulatory system (Schreurs et al., 2008; Watkins et al., 2013). Lush pastures, high in readily digestible protein and comparatively low in energy (such as legume pastures), have been shown to result in the greatest formation of indoles in the rumen (Schreurs et al., 2007, Watkins et al., 2003). The presence of 3-methylindole in adipose tissue imparts an "animal" or "fecal" odor (i.e., the odor of confined livestock) to cooked meat (Young et al., 1997, 2003) that appears to be universally disagreeable to consumers (Prescott et al., 2001; Watkins et al., 2013). Young et al. (1997) concluded that the characteristic species flavor of lamb and mutton is linked specifically to BCFA, but that this basic sheep-like flavor is exacerbated by the presence of pasture-derived 3-methylindole and alkyl phenols, such as 4-methylphenol, ultimately producing a strong, unpleasant flavor (Priolo et al., 2001).

Studies that have examined breed effects on lamb flavor characteristics have produced inconsistent results (Duckett and Kuber, 2001). Cramer et al. (1970) compared the flavor of meat produced by Rambouillet, Targhee, Columbia, and Hampshire lambs and reported that among-breed differences in meat flavor intensity paralleled differences in wool fineness – increased wool fineness was associated with more intense meat flavor. Based on these findings, they concluded that mutton flavor was most detectable in meat from finewool breeds of sheep (Cramer et al., 1970). Similarly, Safari et al. (2001) reported a stronger meat flavor for straight-bred Merino lambs compared with Border Leicester × Merino crossbred lambs. In contrast, other reports suggest that breed has no effect on lamb flavor (Dransfield et al., 1979; Crouse et al., 1981; Snowder and Duckett, 2003). In a more recent study, Shackelford et al. (2012) compared sensory properties of lamb produced by progeny of several different sire breeds, including Dorper, Dorset, Finnsheep, Katahdin, Rambouillet, Romanov, Suffolk, Texel, White Dorper, and Composite (1/2 Columbia, 1/4 Suffolk, 1/4 Hampshire). When compared at the same age, lamb flavor intensity scores were greater for progeny of Katahdin, Romanov, and Texel sires than for progeny of Suffolk, Composite, and Rambouillet sires; however, it was noted by the researchers that the observed breed differences in lamb flavor intensity were relatively small (Shackelford et al., 2012). Collectively, results of breed comparisons suggest that genetic effects on lamb flavor are minor, compared with the effects of other factors such as age, sex, and diet.

Research conducted to date has identified several production-level factors that might be managed systematically to influence lamb flavor characteristics. However, production targets, based on consumers' preferences for particular lamb flavor characteristics, have not been clearly defined for U.S. markets. Research in other countries has demonstrated that consumers differ in their acceptance of various sheep-specific meat flavor notes depending upon past eating experiences (Sanudo et al., 2000; Prescott et al., 2001). Consumers who are accustomed to eating lamb or mutton with a particular flavor profile seem to prefer ovine meat products with a familiar flavor (Sanudo et al., 2000; Prescott et al., 2001). On the other hand, consumers who seldom eat lamb or mutton tend to exhibit the greatest aversion to sheep-specific meat flavor notes, sometimes finding even mildly detectable levels of theses flavors unacceptable (Prescott et al., 2001; Watkins et al., 2013).

In an interesting experiment, Prescott et al. (2001) spiked bland beef samples with varying levels of BCFA and 3-methylindole (none, low, or high) to create flavors normally associated with ovine meat. The spiked samples then were evaluated by 2 different untrained consumer panels. One panel consisted of Japanese consumers who were unaccustomed to eating lamb or mutton, whereas the other panel consisted of New Zealand consumers who were familiar with the characteristic flavor of lamb. Japanese consumers showed an aversion to any detectable amount of BCFA and, among these consumers, flavor desirability decreased linearly as BCFA concentration increased. In contrast, New Zealand consumers, who were accustomed to eating lamb, showed a preference for samples with a low level of BCFA, but disliked samples with the high BCFA level. Both groups of consumers disliked the flavor of samples with the high level of 3-methylindole. Results of this study demonstrate clear differences between diverse consumer groups in preferences for lamb flavor. Anecdotal evidence suggests that similar preference differences, stemming from diverse cultural backgrounds and differing levels of familiarity with lamb flavor, also may exist among American consumers.

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