Review of Flavor Differences in Meat and Meat Products

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ABSTRACT

Hundreds or even thousands of volatile compounds present in meat have been documented. However, the flavor of meats have not always been successfully reproduced. This is in part due to interaction of factors such as genetic (species, breed and sex), environment (age, feeding and stress), processing methods (formulation and thermal as well non-thermal processing), chemical and biochemical reactions present in meat. Species as well as type of feed are the most important factors influencing fresh meat flavor, while the flavor of processed meat is mostly determined by product formulation and cooking method.

INTRODUCTION

Flavor is one of the most important palatibility characteristics. The U.S. Society of Flavor Chemists in 1969 proposed the following definition on flavor: "Flavor is the sensation caused by those properties of any substance taken into the mouth which stimulate one or both senses of taste and smell, and also the general pain, tactile, and temperature receptors in the mouth". Odor and taste are the major contributors to flavor.

Taste is the sensation that foods and other chemicals elicit when they stimulate receptors in the taste buds (Shahidi et al., 1986). Amerine et al. (1965) defined odor as sensations perceived from responses of the olfactory nerve or first cranial nerve.

The study of meat flavor started in the early 1950's which exclusively devoted to the identification of the water soluble precursors of meat flavor. The development of more sophisticated instrumentation and better separation procedures, in the 1960's and early 1970's, enabled for the identification of the volatile compounds of meat flavor. Until recently a large list of volatile compounds present in the meat had been documented and some of these compounds are known to be important contributors to meat flavor, however, the flavor of meat can still not be precisely reproduced (Baines and Mlotkiewics, 1984).

Current interest in the composition of meat flavor is for the purpose of producing high quality extracts or synthesizing better meat flavors. These will be useful in application of the meat flavors to non-meat protein analogs, intensifying meat flavor in products made with extenders or in products whose flavor has been decreased due to processing, and in supplying a desirable flavor for use in other than meat products (Wasserman, 1979).

The objective of this paper is to review the major state of knowledge of the various factors that influence the flavor changes or differences in meat and meat products.

GENETIC FACTORS

Within the muscle foods, beef and pork are the easiest to identify and most preferred (Wasserman and Talley, 1968). Meat form *Bos taurus* is preferred to meat from *Bos indicus* (Ramsey et al., 1963). Since most of the flavor research to date has implicated the fat rather than the lean components (Sink, 1973), the species effect on the flavor of muscle foods is probably expressed through the genetic control of lipid composition and metabolism. Those lipids implicated are the fatty acids, triglycerides and phospholipids as well as steroids (Love and Pearson, 1971). Wilson et al., (1976) reported that the species heritability estimates for flavor range from zero to 0.58, with 0.25 – 0.30 being a reasonable value.

The effect of breed on the flavor of muscle foods is less widely recognized than that of species but the evidence suggests breed does exert some influence (Sink, 1979). Ziegler et al., (1970) have reported flavor preferences for beef from the British breeds compared to that from the

Continental breeds. In Chicken, breed apparently exerts little effect on flavor preferences (Larmond et al., 1970).

Colorado State researchers have demonstrated significant breed differences in the fatty acid/triglycerides composition of beef muscle, adipose and serum lipids (Hecker et al., 1975). However, it appears that the effect of breed is more pronounced at younger ages and on the unsaturated fatty acids (Sink, 1979).

In pork, there is a well-known flavor intensity difference between boars and barrows (Teague et al., 1964). Although flavor intensity differences between male and female chickens have not been observed, flavor preferences for the meat from male birds has been noted (Larmond et al., 1970). The effect of sex on the flavor of muscle food is obviously related to the genetic control of metabolic development and production of the steroid sex hormones and their influence on lipid composition and metabolism (Sink, 1979).

ENVIRONMENTAL FACTORS

Although the intensity of beef flavor is similar regardless of age, but greater flavor intensity is reported in meat samples from younger as compared to older sheep (Batcher et al., 1969). Fry et al. (1958) noted greater flavor intensity scores in meat from older rather than younger birds.

The effect of age on the flavor of meat is probably through changes in metabolism, especially of the amino acids, proteins and nucleotide and related changes in muscle pH (Tuma et al., 1963). Age changes in lipid composition and metabolism have also been reported (Hecker et al., 1975).

Borger et al, (1973) reported that the amount and type of protein in the diet has little effect on flavor, while the amount and type of lipid does affect the flavor. Lambs fed with a legume diet had a more intense flavor in their meat than those fed with a grass ration (Cramer et al., 1967). In beef, the flavor of meat from animals fed with the grain ration was preferred (Moody, 1976).

The nutritional effects on the flavors of muscle foods are probably expressed through alterations in the digestion and metabolism of lipid, especially the short-chain, branched-chain and unsaturated fatty acids. This is especially true in the ruminants and to a lesser extent in monogastric (Sink, 1979).

Purdue researchers have shown that a 10-second electrical shock prior to slaughter can improve the flavor of lamb chops (Bramblett et al., 1963). There is no generallized agreement regarding the manner in which environmental stress exerts its effect on the flavor of muscle foods. However, one important metabolic aspect is its influence on muscle glycolysis (Sink, 1979).

PROCESSING METHODS

Post mortem attempts at improving tenderness through electrical stimulation also improve the flavor of beef but not that of lamb or goat meat (Savell et al., 1977). Tuma et al. (1973) found frozen pork had a lower flavor preference score than does fresh pork. The freezing systems such as liquid nitrogen or freon, evidently have little effect on flavor (Tuma et al., 1973). Apparently, length of frozen storage time except under selected conditions and packaging system have little effect on flavor acceptability (Sink, 1979).

Method of boning, mechanical tenderization, comminution, or forming do not affect either flavor intensity or preference of further processed meat products (Randalls and Larmond, 1977). However, the addition of various ingredients through formulation, curing and smoking does affect the flavor. The work of Schwartz and Mandigo (1976) has shown the addition of salt improved the flavor of restructured pork. The addition of sodium tripolyphosphate to restructured pork apparently has little influence on the flavor of the products. Cooking temperature or method of roasting does not appear to influence flavor acceptability of beef and lamb (Tuma et al., 1973). Similarly, no flavor differences in broilling or microwave cooking pork were noted (Montgomery et al., 1977).

Although the various mechanical treatments per se do not significantly affect the flavor of muscle foods, further processing operations related to changing the chemical composition of final product play a key role on maintaining flavor stability (Sink, 1979).

A characteristic odor developed in meat products which are sterilized by irradiation is called irradiated odor (IO). This off-odor has been described as being metallic, sulfide, wet dog, wet grain, goaty and burnt (Batzer et al., 1959). Huber et al. (1953) found that irradiation in frozen state (– 35°C) resulted in less IO than if it done at a higher temperature (5°C). They also indicated that IO development to be strongly affected by the presence of oxygen. Therefore, they suggested that residual oxygen should be reduced to less than 0.5%

saturation in order to minimized IO. This can be accomplished by either vacuum packaging or stripping with an inert gas. Huber et al. (1953) assumed that the off-odor was the result of free radical oxidation which was initiated by the radiation process.

Application of spices such as pepper, mace, allspice, turmeric, celery, thyme, onion and sage reduced IO in meats. The common antioxidants such as ascorbic acid, gallic esters and polyphenols were also found to effective. A single high dose of radiation for a short time was found to result in less off-odor than several lower doses for longer time (Huber et al., 1953). Merrit et al. (1975) suggested that irradiation under vacuum at about 4.5 – 5.6 Mrads and at temperature of –40°C resulted in an acceptable irradiated meat products.

The off-flavor which develops during canning, frequently called as a retort flavor, has only received minor attention. Brennan and Bernhard (1964) identified hydrogen sulfide, methanethiol, ethanethiol, propanethiol and butanethiol in the headspace of retorted beef. They suggested that these last two compounds are being responsible for typical retort flavor.

Persson and von Sydow (1974) showed that a decrease in headspace volatiles and taste panel criticisms of retort aroma as higher temperatures (121°C, 131°C) were used for achieving sterility of thin beef sections. This effect was not exist if the beef was processed in cans or in thick sections. They also reported that the addition of certain amino acids (L-arginine and L-lysine) to the beef prior to processing reduced the retort odor.

LIPID OXIDATION

The off-flavor which occurs on cooked meats during refrigerated storage is generally called as warmed-over flavor (WOF) (Tim and Watts, 1958). Presumably, WOF develops due to the oxidation of the intramuscular phospholipid fatty acids. Oxydation proceeds very rapidly following heating of the meat due to denaturation of the heme-proteins and destruction of cellular structure, therefore, facilitating the mixing of cellular constituents (Pearson et al., 1977).

The reaction is probably catalyzed by both heme and non-heme iron. Non-heme iron is of substantially more important in promoting WOF development in most meat products than the heme catalysts. WOF can be inhibited by the use of metal chelators such as polyphosphate, citric acid, ascorbic acid and EDTA (Pearson et al., 1977).

Intact raw chicken meat is quite stable to oxidation. However, in the mechanically deboned chicken and turkey lipid oxidation is a substantial flavor deterioration (Reineccius, 1979). Oxidation of the deboned meat presumably is enhanced due to cellular destruction permitting the mixing of cellular constituents, incorporation of bone marrow and, therefore, heme pigments more effectively catalyzes the reactions (Froning and Johnson, 1973).

The use of 0.01% (fat basis) Tenox II extended the flavor stability of deboned chicken from 6 days to 15 days during refrigerated storage (Moerck and Ball, 1974). The catalytic effect of home compounds is dependent on the ratio of polyunsaturated fatty acids to hemo-proteins (Lee et al., 1975). This ratio normally exists in deboned meat at the optimum for catalysis of lipid oxidation. Centrifugation of the deboned meat and removal of significant proportion of heme catalysts, therefore yielding a product more stable to oxidation.

BACTERIAL GROWTH

Bacteria utilizing a carbohydrate as the main carbon source do not usually produce metabolic products having very offensive flavors. However, utilization of amino acids and other compounds containing nitrogen or sulfur often results in the formation of unpleasant metabolites odor (Gill, 1983).

In aerobic microfloras, the only microorganisms likely to be present in numbers sufficiently high to play a part in meat spoilage are the pseudomonads and the *Moraxella/Acinetobacter* group. The latter group utilizes amino acids as preferred substrates when growing on meat and might be the major determinants of meat spoilage. However, these organisms do not appear to produce significant amount of highly offensive metabolic by-products (Lerke et al., 1965).

The onset of aerobic spoilage is a function of the metabolism of pseudomonads. Initially these bacteria utilize glucose and do not produce offensive odor. When the available glucose becomes insufficient to meet the bacterial demand, the microbes begin to utilize amino acids. The pH of the meat then rises due to ammonia production (Lea et al., 1969). Other undesirable products, such as organic amines and sulfides which have unpleasant odor are formed. The onset of spoilage is, therefore, rapid in normal pH meat stored in air once glucose has been effectively depleted at the meat surface (Gill, 1983).

If the conditions within a pack are anaerobic, the microflora is usually dominated by *Lactobacillus* species. These microflora were able to produce short-chain fatty acids which have objectionable odor (Sutherland et al., 1975). On the pH of 6.0 and above, *A. putrefaciens* can become of critical importance. Under anaerobic conditions, this organism produces a significant amount of H_2S and the meat is rapidly spoiled because of the development of green sulfmyoglobin as a result of a combination of H_2S with the meat pigments (Gill and Newton, 1979).

SUMMARY

Variety of factors are known to influence the flavor of muscle foods, but not single factor or group of factors can be assigned as the principal affector. In fresh muscle foods, genetic as well as environmental factors are probably the most important. Of the genetic factors, there is a little doubt that species exerts the most pronounced effect on flavor. The effect of feeding are the most important of the environmental factors influencing flavor. Method of handling the carcass and freezing can affect the flavor of fresh muscle foods. In further processed muscle foods, flavor is mostly affected by those factors which influence product composition (i.e.: formulation) heating methods and cooking temperatures. Aerobic spoilage are usually dominated by pseudomonads, whereas anaerobic spoilage are usually dominated by lactobacilli.

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