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Meat flavor precursors and factors influencing flavor precursors—A systematic review

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ABSTRACT

Flavor is the sensory impression sensed by taste and smell buds and is a leading factor determining the meat quality and purchasing decision of the consumer. Meat flavor is characteristic of volatiles produced as a result of reactions of non-volatile components that are induced thermally. The water soluble compounds having low molecular weight and meat lipids are important precursors of cooked meat flavor. The Maillard reaction, lipid oxidation, and vitamin degradation are leading reactions during cooking which develop meat flavor from uncooked meat with little aroma and bloody taste. The pre-slaughter and postmortem factors like animal breed, sex, age, feed, aging and cooking conditions contribute to flavor development of cooked meat. The objective of this review is to highlight the flavor chemistry, meat flavor precursors and factors affecting meat flavor precursors.

Contents

1. Introduction

The meat purchasing decision of consumers is influenced by quality characteristics of meat and they prefer tender meat and meat products with natural taste and flavor (Reicks et al., 2012). Flavor is the sensory impression of a food sensed by taste and smells buds. Flavor after tenderness is one of the principle factors involved in a consumer's meat purchasing decision (Sitz, Calkins, Feuz, Umberger, & Eskridge, 2005). Meat flavor is a combination of taste and odor; however mouth feel and juiciness of meat also affect the individual flavor perception (Farmer, 1992; Robbins et al., 2003). Fats and low molecular weight water-soluble compounds constitute the most important precursors of cooked meat flavor (Resconi, Escudero, & Campo, 2013). The taste of cooked meat is due to the non-volatile constituents of fresh meat that are essential flavor precursors and taste contributors (Chen & Ho, 1998). The reaction between reducing sugars and amino acids acts

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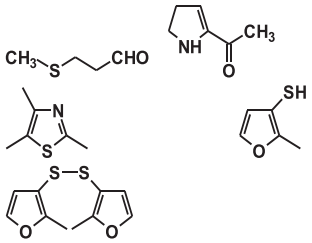
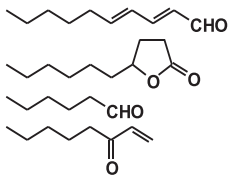
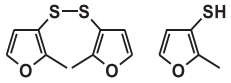
Table 1
Flavor forming precursors, reaction and flavoring compounds.
Source: Framer (1999).

Flavor precursor	Thermal reactions	Flavoring compounds
Sugars, nucleotides, free amino acids, peptides	Maillard's reaction	
Lipids, fatty acids	Oxidation	
Thiamine	Degradation	

as the principal pathway in the formation of cooked meat aroma compounds (Farmer & Mottram, 1990; Mottram & Nobrega, 2002). Cysteine and methionine are considered the largest contributors to meat flavor development (Werkhoff et al., 1990). Vitamin degradation during cooking, lipid oxidation, interaction of lipid-oxidized products with the products of Maillard's reaction and the reactions that are induced thermally as a result of heating during Maillard's reaction produce the volatile flavor components responsible for the characteristic aroma and flavor of cooked meats (MacLeod, 1994). The volatile flavor components are organic in nature (pyrazines, aldehydes, acids, ketones, hydrocarbons, esters, alcohols, nitrogen and sulfur-containing compounds) and they have low molecular weight (Landy, Courthaudon, Dubois, & Voilley, 1996). The volatility of these compounds varied based on variation in their chemical structures. Generally lipids influence the production of aromatic flavor compounds, greatly among all food constituent as they reduce the vapor pressure of most flavor compounds (Rabe, Krings, & Berger, 2003) but most aroma compounds are also lipophilic in nature (Kinsella, 1990) so fats reduce their volatility. Pre- and post-harvest factors influencing meat flavor are animal breed, sex, diets, chiller aging, meat pH, meat composition and cooking conditions (Ames, Guy, & Kipping, 2001; Domínguez, Gómez, Fonseca, & Lorenzo, 2014a, 2014b). So meat flavor is the result of thermally induced chemical reactions of non-volatiles toward the formation of volatile compounds.

2. Meat flavor chemistry

Meat cooking results in the formation of characteristic meat aroma through thermally induced reactions as shown in Table 1. Lipid oxidation, Maillard's reaction, interaction of lipid oxidation products with Maillard's reaction products, and vitamin degradation are thermally induced reactions producing volatile flavor components responsible for the characteristic cooked meat aroma (MacLeod, 1994). The volatile flavor components have low molecular weight and are organic in nature (Landy et al., 1996). A variety of chemical structures is observed in volatile flavor compounds that have been identified in thousands of numbers including aldehydes, acids, ketones, hydrocarbons, alcohols, nitrogen and sulfur-containing compounds (Ba, Oliveros, Ryu, & Hwang, 2013; Lorenzo & Domínguez, 2014; Machiels, Istasse, & van Ruth, 2004; Rochat & Chaintreau, 2005). Meat flavor and palatability are influenced by fat content; the fatty flavor of beef preferred by US consumers increases with the increase in intramuscular fat (IMF) content (Miller, Moeller, Goodwin, Lorenzen, & Savell, 2000) and the minimum IMF level for US consumer acceptance and preference is approximately 3% to describe slightly intense fat flavor (Miller, 2001). The volatiles derived from lipid sources are believed to be responsible for species specific flavor, as higher unsaturated fatty acid differences in fatty acid deposition of ruminants and non-ruminants (Calkins & Hodgen, 2007), produce more volatile carbonyls (major lipid degradation products) in these species (Perez-Alvarez, Sendra-Nadal, Sanchez-Zapata, & Viuda-Martos, 2010). Although a small proportion of fatty acids are oxidized, they can be sufficient to alter flavor significantly (Belitz, Grosch, & Schieberle, 2009). The degree of unsaturation in IMF is important as it determines overall concentration of volatiles from lipid oxidation (Specht & Baltes, 1994). Most of the aroma compounds recognized in cooked meat are the result of Maillard's reaction (Bailey et al., 1994). The precursors formed from 1-deoxysones interact with products of the Strecker reaction resulting in numerous aromatic compounds. Thermal degradation of thiamin produces a number of sulfur compounds like thiol, sulfides and disulfides (Grosch, 2001) which themselves smell or contribute to the development of cooked meat aroma (Kerscher & Grosch, 1998). The aromatic phenolic compounds in the meat of ruminants come directly from plants or they are products of rumen microbial fermentation (Ha & Lindsay, 1991) or formed by tyrosine microbial metabolism (Schreurs, Lane, Tavendale, Barry, & McNabb, 2008). Phenols and hydrogen sulfide react to form thiophenols responsible for meat aroma (Ha & Lindsay, 1991).

3. Meat flavor precursors

The flavor precursors contributing to basic tastes (sweet, salty, bitter and sour) of cooked meat are the non-volatile constituents (sugars, peptides, amino acids, inorganic salts and organic acids) of fresh meat (MacLeod, 1994) and flavor enhancers, inosine 5′-monophosphate, guanosine 5′-monophosphate and monosodium glutamate give 'umami' taste (Maga, 1987). Most meat flavor precursors responsible for producing meat flavor are water soluble in nature (Koutsidis et al., 2008). Meat peptides and free amino acids have a role in contributing taste during aging (Spanier et al., 2004) and/or cooking (Spanier, Flores, McMillin, & Bidner, 1997). Dry-cured hams have high amounts of free amino acids and peptides (Toldra, Flores, & Sanz, 1997; Bermúdez, Franco, Carballo, Sentandreu & Lorenzo, 2014) and these compounds are taste-active that strongly influence the final flavor. Lipid oxidation is one of the main causes of meat quality deterioration during storage and processing (Gray, Gomoa, & Buckley, 1996; Morrissey, Sheehy, Galvin, & Kerry, 1998) but is essential for the development of the typical meaty aroma of many meat products (Shahidi, Rubin, & D'Souza, 1986). Glycolysis, proteolysis and lipolysis result in production of a large number of non-volatile compounds which are important in contributing to meat flavor and mostly endogenous enzymes are responsible for such reactions (Toldrá & Flores, 2000). The reducing sugar content of beef is increased significantly when cattle are fed with concentrate feed during aging resulting in increased concentration of free sugar such as ribose (Koutsidis et al., 2008) which reacts with free amino acids to produce flavor through Maillard's reaction. The production of volatile flavor precursors can be enhanced through supplementation of fats in animal diet which directly affects the fatty acid composition of animal fat (Elmore et al., 2005; Elmore, Mottram, Enser, & Wood, 2000). The intramuscular triglycerides and structural phospholipids are the main components of meat lean tissues. Meat with subcutaneous fat, either cooked or uncooked, contain lipid derived volatiles in larger amounts except for the grilled meat where severe conditions give off Maillard-derived volatiles (Mottram, 1985). Lipids play multiple roles in meat flavor development; they act as solvent for volatile compounds produced during processing (Moody, 1983) and products of lipid thermal oxidation give distinct flavors after reacting with components of lean meat tissues (Mottram & Edwards, 1983).