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Review

The taste of fat

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ABSTRACT

For many years, fat in meats have been considered to convey quality although variations in the amounts of fat were often poorly correlated with eating qualities. The contribution of fat to taste is equally controversial, because a specific 'fat taste' perception had not been characterized.

The innate attraction for fats may be due to one or more of orosensory, post-ingestive and metabolic signals. This literature review suggests that taste of lipids, particularly of oxidized PUFAs and their esters, may derive from a specific fatty acid perception mechanism in human lingual papillae. Interactions of the CD36 scavenger system with the many compounds derived from fats in cooked and processed meats offer an explanation for the variety of flavors and off-flavors found in meats. The genetic variations in the presence of receptor proteins could be one of the factors related to the differences in fat preferences in different countries and between genders.

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1. Introduction

Fat in meat and meat products is usually associated with high quality and some fat is thought essential for cooking and to maintain good eating quality. However, many consumers also believe that excess fat consumption will increase their risk of cardiovascular diseases. This review looks at 'taste' as a generic term in appreciation and in flavor in relation to recent research into lipid receptor mechanisms, which show that variations in oxidised-lipid binding to lingual receptors may be responsible for some of the differences in appreciation of meat quality.

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2. Fat quality and consumer preferences

The evaluation of fat by the consumer comprises elements of the fat itself (its amount and quality), as well as the consumer's sensory capacities, cultural background and concerns about environmental and ethical considerations in meat production. The content and types of fat in meat, in relation to eating quality, have been studied systematically for more than 3 decades as they impact on meat production. They mainly concern variations in 'neutral lipids' as oppose to the phospholipids, present mainly in membranes. The fat content of meat from most species is important in appearance and some research approaches linked intuitively the content of fat with a role in texture, comprising tenderness and juiciness, and in flavor. Because of the concerns over potential health risks from consumption of animal fats, many animal production and husbandry methods, such as the production of entire male animals, breeds and crosses and the use of implants, aim at reducing fat content in meats.

The importance of fat content to the appearance and choice of meat is incontrovertible and many reports have shown the relationships in meats from different species. In a recent study of over 12,000 consumers from 23 countries, the amount of pork backfat and colour of the lean were the most important factors, with marbling and drip less important (Fig. 1). The majority of consumers, particularly in Poland, Finland and Mexico, preferred low fat cover. The majority of Irish consumers preferring light red, lean pork, with no marbling and no drip, and Australian consumers, light red, lean pork, again with no marbling. However, many Korean, Japanese and Taiwanese consumers preferred the more marbled and fatter pork. The results of a self-reported questionnaire showed that most socio-economic factors and eating habits were related to choice of subcutaneous fat cover but few factors were common across countries. Gender had the most consistent influence and, in all but one of the countries, a greater proportion of women than men chose the pork with less fat cover (Ngapo, Martin, & Dransfield, 2007b). In beef, the majority of British consumers preferred lean ribs and, from 1982 to 2002, about a quarter of all consumers had shifted their preference towards leaner beef (Ngapo & Dransfield, 2006). The consistency of fatty tissue in pork is also an important quality component and may lead to a soft and unsightly product (Enser, Dransfield, Jolley, Jones, & Leedham, 1984). The ratio of stearic to linoleic acid was the best discriminator of fat firmness in which about half the lipid in pig backfat triglycerides present as linoleic acid (Wood et al., 1978).

In relation to meat production, early American work (Luckett, Bidner, Icaza, & Turner, 1975) showed that 60–70% of consumers who rated rib-eye, found no or slight preference related to marbling and, although lower grading (leaner) carcasses gave less tender meat, it was thought that this was due their more rapid cooling. In another study, conducted over a 3-year period on meat from 500 steers, it was concluded that USDA quality (largely based on differences in fat cover) grades were of minimal value in predicting tenderness (Champion, Crouse, & Dikeman, 1975). In pigs, only about 10% of the variation in tenderness was accounted for by variations in lean or fat content and increases in fat content of pigmeat up to 2.5% increased quality but there was no relationship above this value (Kirkgaard, Moller, & Wismer-Pederson, 1979). In cooked beef, perception of flavor appears to differ across countries, possibly related to the different cooking methods (Dransfield et al., 1984). In sheep fed different dietary oil sources (Nute et al., 2007), lamb flavor was best correlated with phospholipid fatty acid linolenic acid (C18:3n-3) but accounted for only 25% of the variation in sensory ratings.

So, in general, fat content in meats appears to relate strongly to appearance and choice but fat content in raw meats relates weakly to eating quality.

The characteristic meat flavor (see review, Mottram, 1998) is produced during cooking by a complex series of reactions that occur between non-volatile components of lean and fatty tissues. Currently, over 1000 volatile compounds have been identified. Early work suggested that the species differences in flavor are largely explained by differences in lipid-derived volatile components. Several hundred volatile compounds derived from lipid degradation have been found in cooked meat. These include aliphatic hydrocarbons, aldehydes, ketones, alcohols, carboxylic acids and esters. Some aromatic compounds, especially hydrocarbons, have also been reported, as well as oxygenated heterocyclic compounds such as lactones and alkylfurans. In general these compounds result from the oxidation of the fatty acid components of lipids. Exposure to air, storage and heating can cause oxidation of lipid and give rise to 'stale', 'sulphur-rubbery' and 'rancid' off-flavor development including the so-called 'warmed-over flavor' (see review by Byrne & Bredel, 2002). The autoxidation of lipid is the major source of warmed-over-flavor, although reactions involving proteins and heterocyclic compounds may be implicated in the loss of desirable meaty characteristics.

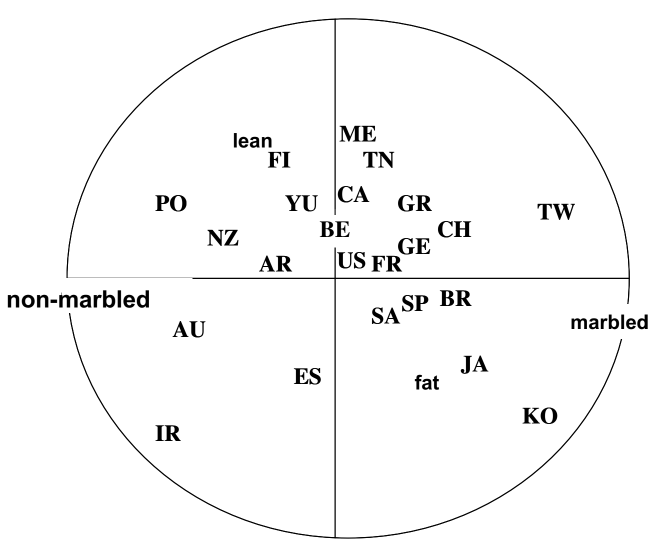

Fig. 1. Fat preferences of different populations. Populations from different countries, a total of 12,590 people from 23 countries, chose photographs of pork chops that had been systematically produced to show variations in fat cover, colour of lean, marbling and drip. The figure shows the relationship (correspondence analysis) between the country and their preference for fat/lean and marbled/non-marbled meat. AU, Australia; AR, Argentina; BE, Belgium; BR, Brazil; CA, Canada; CH, China; ES, Estonia; FI, Finland; FR, France; GE, Germany; GR, Greece; IR, Ireland; JA, Japan; KO, Korea; ME, Mexico; NZ, New Zealand; SA, South Africa; SP, Spain; PO, Poland; TN, The Netherlands; TW, Taiwan; US, United States; YU, Yugoslavia. Adapted from Ngapo, Martin, & Dransfield, 2002, 2007a.

3. Gustatory mechanisms

Gustation (informally often referred to as 'taste' or 'flavor perception') is a form of direct chemoreception in the taste bud that is bathed in saliva and therefore tastant solubility in water will play a role in its perception. The taste bud is composed of sensory taste cells surrounding a central pore, and has several layers of support cells on the outer region of the taste bud (Fig. 2). Taste cells in humans are found on the surface of the tongue, along the soft palate, and in the epithelium of the pharynx and epiglottis (Margolskee, 1993). The superior laryngeal branch of the vagus nerve innovates the epiglottis and larynx and the posterior one-third of the tongue. Different sensory signals from ortho-nasal, retro-nasal odour and gustatory receptors may integrate in the higher centers to give 'flavor' cognition.

There are five well-recognized taste sensations: salty, sour, bitter, sweet and umami and much is now known of the physiology and molecular mechanisms for these basic tastes (for a recent review see: Chandrashakar, Hoon, Ryba, & Zuker, 2006). They are designed to signal both the presence of desirable (salts, carbohydrates and proteins) and harmful (acid and bitter) compounds. Arguably the simplest receptors found in the mouth are the salt (NaCl) and sour (H^+) receptors. An ion channel in the taste cell wall allows ions to enter the cell that causes depolarization of the cell, and opens voltage-regulated Ca^{2+} gates, flooding the cell with ions and leading to neurotransmitter release. The other tastes, bitter sweet and umami involve different G-protein coupled receptor proteins. There are many different classes of bitter compounds and humans can distinguish between the many types of molecule