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Review Article

Nutrition and taste and smell dysfunction

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Abstract Food selection plays a pivotal role in maintaining adequate nutrient intake, thus elucidating drivers of food choice is a meaningful strategy to maintain health and manage disease. Taste and smell are key determinants of food choice and warrant careful consideration. In this review, we first discuss how sensory stimulation influences food selection and metabolism. We then review the evidence regarding the relationship between taste and smell dysfunction and food preferences and selection, with attention given to contexts of certain chronic diseases. We conclude with brief recommendations for the management of chemosensory disorders. While sensory abilities influence food selection, the effect of taste and smell dysfunction on long-term consumption patterns and health status must be considered in light of environment, exposure, and culture.

Introduction

Of the many interacting influences on food selection, sensory inputs are often the primary driver.[1] Sensory signals also affect the metabolism of ingested nutrients. Through these functions, the chemical senses (taste, smell and chemical irritation) play a role at all stages along the continuum from health to disease. Concurrently, the function of these sensory systems is modified by an individual's health status. The sensory properties of foods interact with the sensory capabilities of consumers to generate sensations that are measured by their detectability, intensity, quality, duration, and hedonic valence. The first four dimensions are the substrate for hedonic judgements and the latter exerts the most important influence on food choice under conditions of an available, varied diet.

Sensory influences on diet selection

In addition to serving as a warning system for potentially toxic substances, sensory systems may also have evolved as

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a way to detect energy and key nutrients.[2] Here, we review evidence surrounding the chemosensory detection of the macronutrients (carbohydrates, protein, and fat) and sodium, and their relation to nutrient and food selection.

Dietary carbohydrates are often consumed in the form of starch and sugars. Although increasing evidence indicates complex carbohydrates may be detected by the taste system,[3] sweetness is the sensory attribute most commonly associated with carbohydrates, and for which the most data are available. Sensitivity to sweetness is present in utero and influences sucking behavior in pre-term infants.[4,5] Despite the biological predisposition for sweet taste, the preference for and intake of sweetened foods depends heavily on culture.[6,7] Exposure, more than functional dimensions of sensory abilities such as threshold sensitivity or perceived intensity ratings, is related to sweet preferences. For example, frequent exposure to sweetened soft drinks increases the preferred sucrose concentrations among individuals who originally preferred lower concentrations.[8] However, relationships between exposure to selected sugary foods and acceptance cannot be generalized to all sweetened foods. Exposure to sugar-sweetened water during the first six months after birth is associated with greater intake of sweetened water at six months of age, but not with consumption of sugar-sweetened fruit drinks at two years of age.[9] Other studies have failed to find significant associations between intake of sweet foods and hedonic ratings of a test item.[10] Overall, the sweetness of some carbohydrate sources promotes intake of these compounds and foods that contain them, but there is no biological determinism that overwhelms dietary experience and cultural norms.

Intact proteins are generally weak chemosensory stimuli. Their constituent amino acids as well as short peptides have varied taste qualities.[11] Umami, best exemplified by mono-sodium glutamate, is considered by many as a basic or primary taste quality. The quality is sub-served by a unique receptor and is not replicated by other "primary" taste sensations. Although protein hydrolysates are generally regarded as unpalatable, their acceptance is heightened in populations with low or marginal protein status, suggesting the presence of a body or taste wisdom to ensure adequate intake.[12,13] Additionally, healthy individuals on low-protein diets show increased protein intake and preference for savory high-protein foods.[14] In some instances, savory taste modulates food preferences more than sweet taste.[15] Furthermore, preference for high protein foods decreases more following consumption of a savory meal rather than a sweet meal.[16] Together with sensory explanations for a protein-specific appetite, others have proposed that protein is the primary physiological signal driving total energy intake, a theory derived from observations of low variability in protein intake cross-culturally and within cultures over time. This view is termed the "protein leveraging hypothesis."[17] It is postulated that diets low in protein would be consumed in larger quantity to achieve a needed level of protein intake, and diets high in protein would be ingested in lower quantities as protein needs would be met more easily. However, several studies have directly tested this hypothesis and have not provided consistent support. Although some have demonstrated a change in energy intake in response to altered dietary protein, none has consistently shown a convergence towards an optimal level of protein intake when presented both higher and lower protein diets.[18–21] The taste of protein, i.e., amino acids and peptides, may serve more as a hedonic modifier than a fundamental controller of ingestive behavior.

Although increasing evidence suggests that fat is detectable via gustation as well as other sensory systems, data supporting a role for fat taste on dietary behavior is mixed.[22] The primary form of fat in the diet is triacylglycerol, a large molecule without documented efficacy as a taste stimulus. However, its constituent fatty acids are potent olfactory stimuli and effective, albeit more subtle, taste signals. Their chemosensory properties are generally unpleasant, and foods containing high quantities are rejected (except in selected cases where a liking develops through dietary exposure and cultural norms, e.g., appeal of strong cheeses). Thus, the food industry expends considerable effort to ensure fatty acids remain below detection levels so products are viewed favorably. In this regard, fat taste is a powerful determinant of intake. Early hypotheses held that the increasing fat content of breast milk over a feed was a cue used by nursing infants to terminate a feed. Evidence related to this view is mixed, but generally negative.[23–25] High fat foods are often viewed as desirable by consumers, but this is likely attributable to non-olfactory and gustatory properties. Rather, the contribution of triacylglycerols to the mouthfeel of foods (e.g., lubricity, creaminess) are primarily responsible for hedonic appeal. Some have suggested an association between low fat detection, high intake of fatty foods, and elevated BMI or disinhibited eating behavior.[26–30] However, findings from a recent meta-analysis do not support a relationship between fat detection or intensity ratings and body weight.[31]

Taste sensitivity to salt develops at approximately 4–6 months of age and generally elicits a positive response.[32,33] However, children quickly learn cultural norms regarding where sodium is appropriate in the diet.[34] Indeed, a twin study demonstrated that environment was more influential than genetics on salt taste.[35] Others have reported that dietary intake influences salt preferences, as reduced sodium intake lowered salt preferences independent of changes to salt taste detection.[36,37] Earlier work indicated increased or decreased dietary salt is associated with higher and lower preferred salt concentrations in foods, respectively.[36,38]

Salt taste has been proposed as a mechanism to regulate physiological needs for sodium. Sodium depletion increases salt sensitivity and preference for salty foods.[39,40] However, the association is not symmetrical: high levels of sodium consumption do not blunt preferences, and may even augment them.[38] Exercise may also alter sensory perception and preference for sodium.[41,42] However, a more recent placebo-controlled cross-over study failed to show an effect of encapsulated sodium or potassium supplementation on salt detection thresholds, or desire to eat salty foods.[43] Given the health concerns related to sodium intake, resolution of this mixed literature warrants further study. Taken together, current evidence suggests salt preferences are primarily determined by exposure, rather than innate sensory abilities.

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