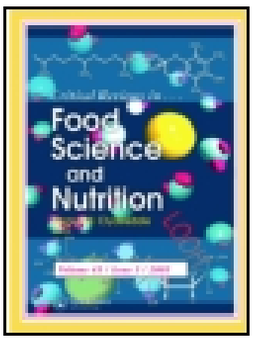

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Taste Loss in the Elderly: Possible Implications for Dietary Habits

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ABSTRACT

Aging may coincide with a declining gustatory function that can affect dietary intake and ultimately have negative health consequences. Taste loss is caused by physiological changes and worsened by events often associated with aging, such as polypharmacy and chronic disease. The most pronounced increase in elderly people's detection threshold has been observed for sour and bitter tastes, but their perception of salty, sweet and umami tastes also seems to decline with age. It has often been suggested that elderly people who lose their sense of taste may eat less food or choose stronger flavors, but the literature has revealed a more complicated picture: taste loss does not appear to make elderly people prefer stronger flavors, but nutrition surveys have pointed to a greater consumption of sweet and salty foods.

Real-life eating habits thus seem to be more influenced by other, social and psychological factors. Elderly gustatory function is worth investigating to identify dietary strategies that can prevent the consequences of unhealthy eating habits in the elderly.

This paper discusses age-related changes in taste perception, focusing on their consequences on food preferences, and pointing to some strategies for preserving appropriate dietary habits in elderly people.

Key words

Taste loss, elderly, food preferences, dietary habits

1. INTRODUCTION

Aging may be associated with an impaired nutritional and health status (Ahmed et al., 2010). A declining gustatory function is very common in the older population and may affect their dietary intake, with negative consequences on their health. Taste loss is caused by multiple factors, including physiological changes such as a taste receptor cells dysfunction, difficulties in maintaining oral health, and a declining olfactory function. Although there is no general consensus on the idea that an impaired chemosensory perception is an effect of aging *per se*, it is commonly accepted that it is exacerbated by events associated with aging such as poor general health, a greater use of drugs, and diseases (De Boer et al., 2013). Researchers are still debating on the extent and type of taste loss experienced by the elderly, but among all the tastant compounds, sour and bitter tastes seem to be the most affected. There are reports of a declining perception of salty and sweet flavors with aging too, though this has not always been confirmed, while all studies on the topic have reported an increase in the detection threshold for umami (Methven et al., 2012).

Whether these physiological changes in taste perception could affect food preferences is also still being debated (de Jong et al., 1999). Controversial results have been reported after investigating the taste preferences of elderly people as regards sweet and salty tastants (Lampure et al., 2015; Dejerlein et al. 2014), but many authors have found them less interested in more sour and pungent flavors (Duffy et al.,1995). Possibly as a consequence of this situation, it seems to be common for elderly people to consume less fruit and vegetables, and to prefer sweeter, softer foods, suggesting that real-life food choices are based on a complex interaction of other sensory

properties, such as visual appearance and texture, as well as social factors such as convenience and price (Locher et al., 2009).

A declining taste perception and possible shift towards unhealthy eating habits could have serious health consequences because it could raise the risk of diet-related diseases (Imoscopi et al., 2012). For instance, a weaker perception of salty flavors may induce people to season their food with excessive amounts of salt, raising the risk of cardiovascular disease, or the risk of obesity and metabolic/cardiovascular diseases may increase due to a stronger preference for sweet foods. The risk of changes in taste perception having harmful health consequences imposes the need to identify appropriate compensatory strategies for promoting healthy eating habits in the elderly.

The present study thus aimed to describe the age-related changes occurring in taste perception, focusing on their possible consequences on food preferences and suggesting some strategies for preserving an adequate dietary intake in elderly people.

2. CAUSES OF TASTE LOSS IN THE ELDERLY

Physiological changes

Several physiological factors are associated with an impaired gustatory function in older people. Here we discuss the three most important changes taking place in the process of healthy aging that affect taste perception: a declining chemosensory perception, increasing difficulties in maintaining oral health, and changes in olfactory function.

Impairment of chemosensory ability

A decreasing taste acuity was once thought to stem from an oral sensation impairment. The presence of taste receptor cells has been confirmed in the soft palate, larynx and epiglottis, as

well as on the dorsum of the tongue, the whole surface of which responds to all taste qualities - refuting the hypothesis of a "tongue taste map" (Duffy, 2007). An age-related reduction in the number of taste buds on the circumvallate papillae of the tongue has been documented microscopically (Shimizu, 1997); and, using a histomorphometric analysis, Kanoet et al. (Kanoet et al., 2007) demonstrated that elderly people have a significantly lower mean density of the taste buds on the laryngeal surface of the epiglottis (which contain up to 25% of all the taste cells) than younger people. As Fukunaga et al. hypothesized, another possible mechanism involved may be a shorter lifespan of the aging receptor cells, which would lead to a deterioration in somatosensory responses to tastants (Fukunaga et al., 2005).

Oral sensation results from a combination of the senses of taste and smell, and somatosensation (touch, temperature, pain). Tastants are molecules that, by stimulating the receptor cells, enable the sensation of the five essential tastes, i.e. salty, sweet, sour, bitter and umami (the meaty taste of certain amino acids) (Duffy, 2007). The perception of these five basic tastes has frequently been examined in elderly people, albeit with several discrepancies across studies due to the inclusion or exclusion of confounding factors, different age groups, and sensory testing methods. Data from a systematic review on 23 relevant articles indicated a general increase (decrease?) in people's taste detection threshold with aging that involved all five tastes, but the magnitude of this decline varies from one study to another (Methven et., 2012). Schiffman et al. measured the average decline in elderly subjects' taste threshold at 4.7, meaning that a 4.7-fold higher concentration of molecules is needed for them to detect and recognize a tastant (Schiffman, 2009). The most pronounced age-related changes have been observed for sour and bitter tastes, but there is evidence of older people's perception of salty and sweet flavors declining with age

too, whereas the detection threshold for umami increased in all studies.

- *Sour:* across the four studies analyzed by Methven et al. (Methven et a., 2012), older individuals had a mean 1.5-fold higher threshold for sour taste detection (citric or tartaric acid). This finding was consistent with the report from Nordin et al. (Nordin et al., 2007), who used "impregnated taste strips" to stimulate different tongue regions in young and elderly adults, and found an age-related loss that was more prominent in the identification of sour stimuli (citric acid).
- *Bitter:* most studies found an increasing threshold for bitter tastes with aging, albeit with a marked variability in the thresholds identified, probably due to the different tastant stimuli presented and to genetic differences in people's ability to detect the bitter flavor of phenylthiocarbamide or propylthiouracil (Duffy et al., 2004): when quinine derivatives were tested, the mean increase in the taste threshold with aging was reportedly in the range of 1.5- to 7.4-fold, whilst the change observed with caffeine seems to be smaller, ranging between 1.1- and 1.2-fold (Methven et al., 2012). Nordin et al. also found bitter taste detection impaired in older people (using quinine hydrochloride), albeit to a lesser degree than for sour flavors, but the age-related effect might have been greater if they had investigated the bitter-sensitive region of the circumvallate papillae (Nordin et al., 2007).
- *Sweet:* according to Methven et al., the sucrose detection threshold became a mean 1.5 times higher with aging (Methven et al., 2012). A limited number of studies investigated sweet tastes and no clear pattern of age-related decline in sucrose identification emerged. When testing aspartame, some researchers clearly found no differences in tastant recognition between different age groups (Mojet et al., 2005, Easterby Smith et al., 1994).

- *Salty:* data from the previously-mentioned meta-analysis clearly showed a decline in the perception of salty flavors too, with a mean 2-fold increase in the perception threshold with old age (Methven et al., 2012). A study by Drewnowski et al. reported contradictory results, however. Older and younger individuals did not differ in their salt perception when assessing sodium chloride solutions or salted chicken broth (Drewnowski et al., 1996). In short, salty taste perception does not seem to be the quality most affected in the elderly.
- *Umami:* despite the shortage of studies investigating umami perception, there is a general consensus on the age-related decline in this capacity. Methven et al. reported a mean 2.2-fold increase in the threshold with aging (Methven et al., 2012). A recent publication reports a specific decline in umami taste recognition identified in elderly individuals using a novel sensitivity test, while the other four basic tastes were preserved (Satoh -- Kuriwada, 2010). The role of umami taste is currently attracting interest because it promotes the secretion of saliva, which is important to gustatory function (Sasano et al., 2014).

Difficulties in maintaining oral health

Saliva plays an essential part in oral functions such as swallowing and speech, and also in taste sensitivity. First, salivary flow enables tastants to be solubilized by means of interactions with components of saliva and transported to taste receptor sites. Then saliva stimulates the taste receptors, and responses to the tastants depend on the sensitivity of these saliva-adapted receptors. Finally, saliva protects the receptor cells from damage, preserving taste acuity (Matsuo, 2000). The physiological aging process coincides with a degeneration of the salivary gland parenchyma and a reduction in salivary output. These changes are not clinically relevant *per se*, but may reinforce the effect of other xerostomic factors such as drug therapies that have a

deleterious effect on taste sensation (Gueiros et al., 2009).

Edentulism is also increasingly frequent with advancing age, and most studies report that tooth loss peaks already at around 65 years of age. Edentulism represents the final stage of periodontal disease and caries, and plays a part in affecting food preferences. Chewing and swallowing difficulties may induce elderly people to restrict their diet to softer foods and to avoid harder textures, such as fruit and vegetables, with negative consequences on their nutritional status (Gil Montoya et al., 2015).

Olfactory function

An impaired olfactory acuity seems to be even more pervasive with aging than taste loss. A recent report from Toussaint et al. (Toussaint et al., 2014) indicates a higher prevalence of olfactory impairment among older individuals (mean age 80.9 years): they found a higher prevalence of anosmia (46.4% vs 0.3%) and hyposmia (46.4% vs 31.6%) than in younger adults (mean age 67.1 years). On the other hand, they found no association between olfactory function and nutritional status using the mini nutritional assessment (after correcting for confounders). These findings are consistent with several other papers (Smoliner et al., 2013; Mackai Sim et al, 2006), and suggest that a decline in sense of smell may represent a cofactor, along with other impairments, in worsening nutritional status in the elderly. In a recent longitudinal study, Gopinath et al. found that the diet in older women with severe olfactory loss was of markedly worse quality than in those with only a mild impairment after a 5-year follow-up. This could be because elderly people with a mild or moderate olfactory deficit may still use compensatory strategies such as a higher intake of foods with other sensory qualities, i.e. sweets and fats, to preserve an adequate nutritional status (Gopinath et al., 2015). The issue remain debatable,

however, and warrants further investigation in larger cohort studies on older individuals to rule out possible confounding factors, such as behavioral variables.

Other causes of taste loss in the elderly

In addition to physiological changes, comorbidities and the related polypharmacy are the most common causes of the age-related decline in gustatory function (Imoscopi et al., 2012). Healthy elderly people are frequently exposed to chronic, non-debilitating diseases such as gastroesophageal reflux, influenza, diabetes, and/or to mild cognitive impairment or smoking habits, which are often reported to cause taste perception dysfunctions. According to a recent study, community-dwelling elderly are likely to be taking an average of 4.4 different drugs (Morin et al., 2015). Numerous drugs that are often used by the elderly, such as NSAIDs/corticosteroids, antibacterial agents and antihypertensives, can affect taste acuity by impairing the function of the taste buds or the neurons involved in the transduction of flavor stimuli (Imoscopi et al., 2012).

3. FROM TASTE LOSS TO HEALTH STATUS

Worsening sense perception thresholds may modify elderly people's food choices and have negative consequences on their health. A poor-quality diet can lead to suboptimal levels of nutritional biomarkers, and this can negatively affect the quality of life and functional independence of older adults. A substantial body of literature has focused on the possible health consequences of age-related loss in sensory perception, hypothesizing that people who lose their sense of taste may eat less or choose foods with stronger flavors (Kremer et al., 2007), with a consequent deterioration in their health and nutritional status. On the other hand, observational studies on older people have reported very different laboratory-tested food preferences and 'real-

life' food choices from what might be expected in association with taste loss: the elderly's liking for sweet and salty flavors does not seem to change, and the prevalence of sweet and salty foods increase in their daily food choices. So, to date, a clear causal relationship between taste loss and eating behavior is still lacking, partly because of the many other social and psychological determinants potentially involved (Figure 1).

Assuming that elderly people generally eat what they like, and that their preferences might be affected by changes in their sensory perception, we tried to clarify the effect of taste loss on health status by analyzing their taste preferences and 'real-life' food choices, seeking possible links between them.

From taste perception to food preferences

It is generally assumed that age-related taste loss can modify food preferences. Such modifications in people's tastes have been assessed with forced-choice food preference questionnaires (Locher et al., 2009; Lampurè et al., 2015), or tests with ascending concentrations of tastants in solutions (Van der Meij et al., 2015), or in foods (Mojet et al., 2005), and their extent largely varies according to different studies. Although the sweet taste threshold rises with age (Methven et al., 2012), not all authors found an age-related preference for higher concentrations of sugar in these studies. In one recent study, the liking for sweet-tasting foods was even lower in older than in younger participants; the authors suggested that younger people developed a greater preference for sweet foods because of a greater exposure to them (Lampure et al., 2015). Murphy and Withee showed that elderly people who had difficulty in detecting salty flavors developed a stronger preference for salty foods (Murphy et al., 1986). This strong positive association between older age and a liking for salt was in agreement with the findings of

a recent study (Lampurè et al., 2015), although most studies observed no such significant changes in people's preferred NaCl concentrations in foods (Mojet et al., 2004), and some studies (Rolls, 1999; Goncalves et al., 2014) even reported a preference for lower salt concentrations in chicken or vegetable soup. Most clinical and laboratory studies found that enhancing the flavor of food with sodium salt of amino acid glutamic acid (monosodium glutamate?) (umami) can improve food palatability, satisfaction and salivation in the elderly (Schiffman, 2000; Van der Meij et al., 2015). Finally, Duffy et al. (Duffy et al., 1995) found a lower preference for food with a predominantly sour/bitter or pungent taste (e.g. citrus fruits, vegetables) in elderly people with smell and taste dysfunction.

From food preferences to food choices

Sensory liking is believed to have a major impact on people's real-life food choices and consequently on their health status, but there is often a large gap between older adults' food preferences and food choices. Mojet and al. emphasized the limited relevance of assessing preferences of tastants dissolved in water to test the real-life perception of taste in complex food systems (Mojet et al., 2004). Sensory liking also interacts with a large number of social and psychological determinants of dietary behavior.

A significant prevalence of sweet (often soft and palatable) foods in the diet of older people has been reported in most nutritional surveys. So factors like the soft texture of a food, sensory appeal, convenience and price could also play a part in making people increase their consumption (Lampurè et al., 2015) even though their preference for sweet foods (as tested) remained unchanged.

In contrast with taste preferences probably propending for a lower salt content, older men and women were both found to exceed the recommended intake of sodium (Deierlein et al., 2014). These data collected from a nutritional survey in the USA were reiterated in an Italian population study, in which from 72% to 97% of elderly people exceeded the recommended sodium intake (Correa Leite et al., 2003). Although more and more studies are now focusing on elderly people's liking for MSG added to food to enhance its flavor (Schiffman, 2000), to our knowledge, no observational studies on food choices have reported a higher consumption of umami-flavored foods, which are considered as savory and meaty. Contrasting findings on the consumption of foods with a mainly sour or bitter taste (e.g. citrus fruits, vegetables) have emerged from the few studies available. In agreement with other authors (Deierlein et al., 2014; Zhu et al., 2010), Duffy et al. found a lower consumption in fruits and vegetables in the elderly. It is worth noting that a recent British nutritional study on 4252 elderly people made the point that the negative association between age and daily fruit and vegetable intake was strongest for lower social classes, lower pensions, and then a lower formal education (Atkins et al., 2015). On the other hand, the daily consumption of fruit and vegetables proved sufficient in most of the elderly rural population in Northern and Southern Italy (Correa Leite et al., 2003), and seemed to remain much the same over a 10-year longitudinal study on community-dwelling people (Toffanello et al., 2010).

From food choices to health consequences

Possible consequences of excessive amounts of sugar in food include hyperglycemia, obesity and related metabolic and cardiovascular diseases (Imoscopi et al., 2012). On the other hand, sweet foods ensure a high calorie intake that could be useful in undernourished elderly people.

A high sodium intake is associated with hypertension, stroke, left ventricular hypertrophy, kidney disease (Deierlain et al., 2014). It can also protect against age-related hyponatremia, which is common in older adults (Miller, 1998) due to changes in the regulation of water homeostasis. Recent data have confirmed that hyponatremia in the elderly population is associated with multiple clinically significant outcomes relating to neurocognitive effects and falls, osteoporosis, bone fractures, hospital readmissions, and the need for long-term care (Cowen et al., 2013).

Finally, a reduction for various reasons in the intake of vegetables and citrus fruits and juices could lead to a loss of their protective effects against ischemic heart disease (Genkinger et al., 2004) and the risk of ischemic stroke (Joshipura et al., 1999). A consequently low fiber and water intake can also exacerbate syndromes typical of geriatric age like constipation and dehydration.

4. STRATEGIES

Although there is still no clear correlation between old people's taste loss and their eating habits, several nutritional compensatory strategies might be adopted to overcome certain erroneous eating habits, such as a low fiber intake, a high consumption of sweet foods rich in saturated fats and cholesterol, or and an excessive salt intake. Some studies have documented an inverse association between the quality of older people's diet and the incidence of IADL-related difficulties. To be specific, the so-called Mediterranean-style diet - characterized by an abundance of fruit and vegetables, pulses and unrefined cereals, with olive oil as the main source of fat, a moderate consumption of dairy products, fish and poultry, and a paucity of red meat and sweets - is associated with better scores in the physical functioning, general health, and vitality

domains (Gopinath et al., 2014). In several studies, the Mediterranean-style diet has been associated with healthy aging and a lower incidence of chronic diseases such as neoplasms, cardiovascular diseases and dementia (Yannakoulia et al., 2015).

As far as fruit and vegetables are concerned, efforts to increase their consumption in older people may be warranted. Since the elderly remain responsive to the sensory properties of food, such as texture and visual appeal, studies have shown that increasing the variety of their diet, offering them more types of food, with more color and texture variations, is an effective strategy for increasing their fiber intake (Van der Meij et al., 2015). Cooking methods, respecting seasonality and preferring ripe products could enhance the flavor and reduce the bitterness of fruit and vegetables, improving their intake by elderly people. Preferring ripe fruits, which have a higher water content, may also help to prevent the harmful consequences of dehydration and constipation. Efforts could be made to remove barriers to food selection such as price and convenience. For the time being, unhealthy eating patterns cost less because their low dietary quality stems from the abundance of foods high in fat and sugar associated with a paucity of fruit and vegetables (which are increasingly expensive).

Promoting the consumption of sweet, ripe fruit could also be a valid strategy for replacing the consumption of sweet snacks rich in saturated fats and cholesterol. A future challenge could be to develop innovative soft, sweet and palatable snacks with a healthy nutritional profile (a high water and fiber content and a low fat content) and make them readily available to elderly people.

Finally, several studies support reducing dietary salt intake to lower blood pressure and prevent deaths due to stroke or cardiovascular disease. Analyzing older people's food preferences, it has been reported that a 30% salt reduction in soups can be achieved without affecting perceived

saltiness and liking among the elderly, considering the reported mean baseline sodium content. (Goncalves et al., 2014). Maintaining the target consumption recommended by the World Health Organization (WHO) of less than 2,000 mg of sodium a day could avoid the negative effects of an excessive dietary intake and it could very likely be achieved in the elderly without influencing their liking for their food.

In conclusion, more and more studies are focusing on elderly people's food choices and how they influence their health status. Although taste loss may affect food preferences, real-life dietary habits seem to be influenced more by other, social and psychological factors. Exactly how much taste loss might influence food preferences is still unclear, but changes in the elderly's gustatory function, and their tendency to dislike bitter and sour flavors, and to opt for sweet foods, might be taken into account when devising some diet-improving strategies. A target dietary pattern rich in water and fiber, with a low fat content, such as the Mediterranean-style diet, could be recommended for elderly people to prevent the consequences of unhealthy dietary habits.

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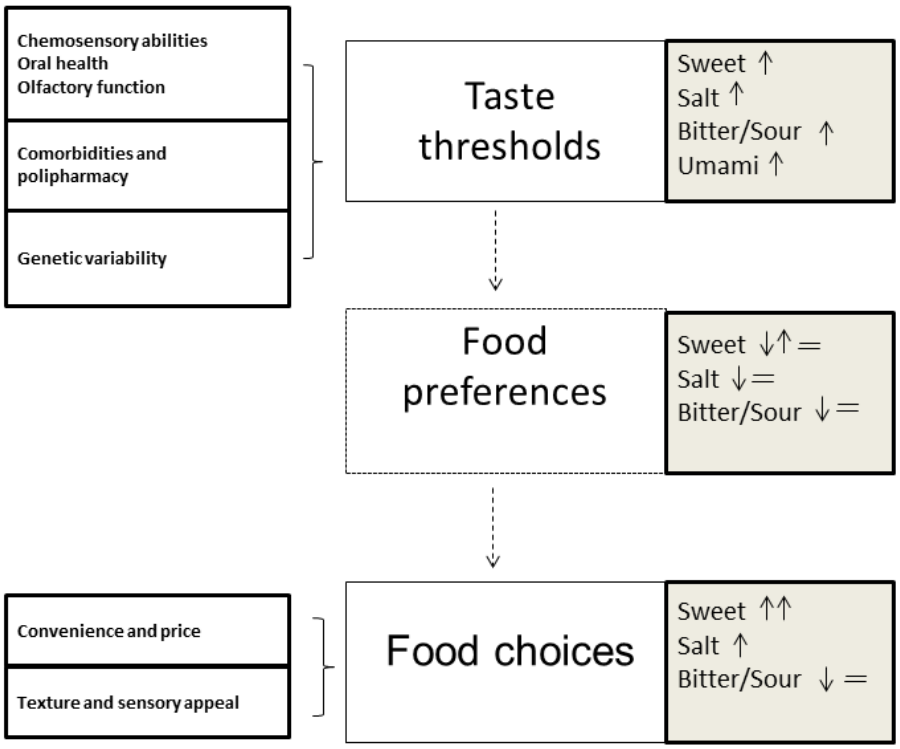

Figure 1. Comparison between older adults' taste thresholds, food preferences and food choices: possible relationships and cofactors.