Food Acceptability and Nutritional Status: Considerations for the Aging Population in the 21st Century

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By the turn of the century there will be considerable shifts in demographics and life-style (1–3), and the most significant change will be the massive increase in our aging population. The elderly have special sensory and nutritional needs that must be taken into account as we plan for better nutrition in the 21st century. The senses of taste and smell decline with advancing years, and these chemosensory losses can lead to inadequate intake, especially in sick elderly people (4–7). Designing foods that will be acceptable from a sensory standpoint and which also meet the nutritional needs for older persons will be a major challenge in the future.

The number of people who will have chemosensory losses in the 21st century will be staggering because of the projected growth in the absolute and relative size of the older populations. Worldwide, the number of persons age 60 years or more is expected to increase from 376 million in 1980 to 1.121 billion in 2025 (2). Thus the proportion of the total world population age 60 or more will increase from 8.5% to 13.6% during that period. There is a difference in the projected proportions of the population that will be elderly in developed (industrialized) and developing (non-industrialized) countries. At the present time, the number of people 60 years and older are approximately evenly divided between developed and developing countries. By 2025 only 28% of the world’s population who are 60 years or more will reside in currently industrialized countries, i.e., 72% will reside in developing countries.

Worldwide, in 1985 there were 290 million persons age 65 years or over (3). This included 17 million in Africa, 31 million in North America, 18 million in Latin America, 133 million in Asia, 62 million in Europe, 2.1 million in Oceania (Australia, New Zealand, Melanesia, Micronesia, and Polynesia), and 27 million in the former USSR. Most of the 290 million persons in this age range have some chemosensory losses (4–7).

In the USA, the increase in the older segment of the population has been far more rapid than the growth of the rest of the population. In 1900, only three million
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TABLE 1. Actual and projected growth of the older population, 1990–2050

<table>
<thead>
<tr>
<th>Year</th>
<th>Total population</th>
<th>65 years and over</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All ages</td>
<td>Number</td>
</tr>
<tr>
<td>1900</td>
<td>76,303</td>
<td>3,084</td>
</tr>
<tr>
<td>1930</td>
<td>122,775</td>
<td>6,634</td>
</tr>
<tr>
<td>1960</td>
<td>179,323</td>
<td>16,560</td>
</tr>
<tr>
<td>1990</td>
<td>249,657</td>
<td>31,697</td>
</tr>
<tr>
<td>2020</td>
<td>296,597</td>
<td>51,422</td>
</tr>
<tr>
<td>2050</td>
<td>309,488</td>
<td>67,411</td>
</tr>
</tbody>
</table>

Data adapted from Schick FL (8)

Americans were 65 years of age or over constituting 4.0% of the population (see Table 1, data from Schick, ref. 8). By 1990, 31.7 million Americans, or 12.7% of the population, were 65 years or more. By the year 2050, 67.4 million Americans or 21.8% of the USA population, will be at least 65 years of age; that is, approximately one in every five Americans. In addition, the segment of the population from 55 to 64 years is also expanding in the USA, and this group also has been found to have some chemosensory losses. By 2050, one in three persons will be 55 years or older.

The over age 85 population is the fastest-growing age group in the USA (2). This so-called “very old” group is expected to triple in size between 1990 and 2020 and increase sevenfold by 2050. Elderly women greatly outnumber elderly men. In 1984, there were only 40 men for every 100 women among those 85 years and over. Few persons in the “very old” segment have adequate senses of taste and smell, and thus they have reduced sensations from food. The chemosensory losses in the very old also predisposes them to hazards from leaking gas, spoiled food, and other environmental hazards.

The design of foods for the elderly that compensates for their chemosensory losses and also meets their physiological needs presents new challenges and opportunities for the food industry in the 21st century. Elderly people have increased incidences of cardiovascular disease, hypertension, mineral loss, and nutrient malabsorption, in addition to reduced kidney function and decreased bowel function. Thus medical foods or foods that are nutrient-dense and nutrient-free (e.g., without fat) will play a greater role in the future.

ANATOMY OF TASTE AND SMELL

In order to understand the chemosensory losses that occur with age it is helpful to have an understanding of the anatomy of taste and smell (4,9). The sense of taste is mediated by taste buds that are situated in small protrusions called “papillae” on the surface of the tongue. Taste buds are also found in the throat on the larynx, pharynx, and epiglottis as well as in the first one-third of the esophagus. Taste buds
consist of approximately 50 cells arranged like orange segments (see Fig. 1). These cells are formed in the epithelium surrounding the bud and are replaced every ten to ten and a half days. This renewal process is affected by normal aging, diseases, drugs, nutritional and hormonal status, radiation, and other conditions that interfere with normal cell division (mitosis). The number of buds and papillae tend to decline during the aging process. However, recent data (7) suggest that decrements in taste perception in the elderly are related more to losses of receptors on the membrane of taste cells than to the reduced number of taste cells.

The receptors for smell are bipolar neurons situated in the upper portion of the nasal cavity (Fig. 2). Olfactory cells such as taste cells are constantly being replaced, although the turnover time for olfactory cells averages 30 days. The olfactory receptor neurons project to the olfactory bulbs through a small bone called the cribriform plate (Fig. 3). The olfactory bulbs that are located in the anterior portion of the brain contain groups of cells called glomeruli. During the aging process, many glomeruli degenerate, and the bulb actually looks moth-eaten. Functional changes in smell are presumed to be related in part to these anatomical losses (6,9).

Neurons project from the bulb to the so-called "old brain." This area of the brain
not only processes olfactory information but also is involved in determining our emotions, i.e., the parts of the brain that subserve olfaction and emotions overlap anatomically. The “old brain,” which is “old” in an evolutionary sense, consists of the hippocampus, amygdala, and the prepyriform cortex. These areas are especially vulnerable to aging; in fact, neurons in these areas exhibit the first degeneration found in the brain as it ages (4,6,9).

The vulnerability of the olfactory cortex is due in part to its easy access by viruses and pollutants which are transported from the nose up the olfactory pathways into the brain causing direct damage (10). In addition, the “old brain” was the first cortex to evolve and is architecturally different and more vulnerable to aging than later-evolved cortical areas. The vulnerability of the olfactory cortex has been linked to Alzheimer’s disease, a dementing illness of old age. One theory of the cause of Alzheimer's disease is that it begins in the nose as a result of breathing aluminosilicates which are transported into the hippocampus, amygdala, and prepyriform cortex. Aluminosilicates and other pollutants may be responsible in part for the degenerative development of neurofibrillary tangles and senile plaques that invade these areas of the brain in normal aging and excessively in Alzheimer’s disease.

CHEMOSENSORY LOSSES WITH AGE

Perceptual losses in the senses of taste and smell occur during the aging process (5–7). These losses result not only from anatomic changes that occur during normal aging but also from certain diseases, pharmacologic and surgical interventions,
radiation, and environmental pollutants. Diminished taste and smell acuity in elderly persons can lead to reduced enjoyment from food and can even result in depression. In elderly patients, reduced chemosensory input can contribute to anorexia, weight loss, and malnutrition. It is crucial that we find practical means for treating elderly persons with chemosensory losses, especially because the aged portion of the population is increasing so rapidly.

Perceptual Losses in Taste

Losses in taste sensitivity have consistently been reported in the elderly and are usually classified as follows: ageusia (absence of taste), hypogeusia (diminished sensitivity of taste), and dysgeusia (distortion of normal taste). Hypogeusia is found in most elderly persons, and the losses occur at both threshold and suprathreshold concentrations (7). For example, the taste thresholds for amino acids, sweeteners, and salts are on average 2 to 2.5 times higher in the elderly than the young. However, thresholds that are over 20 times higher for the elderly have been reported for sodium citrate, sodium sulfate, and sodium tartrate (11).

Taste losses can be both an advantage and a disadvantage for good nutritional status in the elderly. Increased thresholds for bitter-tasting amino acids such as methionine can be an advantage because the taste of foods that are nutritionally fortified with these amino acids may be less objectionable. However, increased thresholds for sweet and salty tastes are clearly a disadvantage. Increased thresholds for sweeteners make the elderly vulnerable to any adverse effects that result from ingestion of sugar or sodium saccharin (personal clinical observation). Sensory losses for the taste of NaCl could lead to increased salt consumption which is contraindicated for persons with hypertension and heart disease.

Suprathreshold losses, such as those at threshold levels, are not uniform across compounds. For example, the decrements in perceived intensity for suprathreshold concentrations of two amino acids (glutamic acid and aspartic acid) are relatively larger than for other amino acids. The loss of the taste of glutamic acid may be due to reduced binding of glutamate to gustatory receptors on the tongue; reduced glutamate binding has been observed in the brain in Alzheimer’s disease (7). Identification tasks indicate that elderly people also have reduced ability to recognize common tastes.

The taste losses that are found in the elderly have been shown to result from various causes. These include normal aging, a wide range of diseases, and many drugs (4,5,10).

Perceptual Losses of Smell

During the aging process, there is a decline in olfactory sensitivity that generally begins in the 60s—although it can begin earlier—and becomes more severe in persons over 70 years of age. Olfactory losses are classified as anosmia (absence of smell),
hyposmia (diminished sensitivity of smell), and dysosmia (distortion of normal smell). These losses have been quantified using a variety of measurement techniques (see Table 2). Elderly people have raised thresholds for a wide range of odors including foods, purified odorants, and coal gas. For food flavors such as cherry, grape, and lemon, the thresholds are at least 11 times higher on average than in young college students (5).

Like taste, losses in olfactory sensitivity have both advantages and disadvantages. The diminished sensitivity to food odors can result in reduced appreciation of food and may even lead to malnutrition (4). However, loss of perception of compounds such as steroids that have urinolike odors is clearly an advantage. Elderly patients in nursing homes do not complain about urinous odors, perhaps because they do not detect them.

Olfactory losses can result from a variety of causes including normal aging, diseases, and drugs (4,5,9). Losses that for a small portion of the population occur in the 40s and 50s are usually caused by viruses, environmental exposure, or drugs.

**TREATMENT OF AGE-RELATED ODOR LOSSES WITH FLAVOR ENHANCEMENT**

Commercial flavors have been added to foods during and after preparation as a practical means of counteracting chemosensory losses in the elderly. That is, simulated carrot flavor can be added to carrots; simulated beef flavor can be added to beef; bacon flavor can be added to vegetables; or cheese flavor can be added to soups. Flavors are mixtures of odorous molecules that can be obtained directly from natural products, or they can be synthesized after chromatographic and mass spectrographic analysis of natural products.
The addition of flavors to foods for sick elderly people has been found to increase appetite, reverse the effects of anorexia, and significantly improve nutritional status (4,12). For healthy elderly people, some enhanced foods are rated as more pleasant and are eaten in greater amounts than unenhanced foods. In addition, small improvements are seen in the immune status of healthy elderly persons who eat flavor-enhanced food.

Flavor (Odor) Enhancement of Food for Sick Elderly People

Flavor amplification is used extensively at Duke University Medical Center and in a local North Carolina nursing home to promote weight gain and improve protein status in elderly persons who have reduced dietary intake (less than 80% of the US Recommended Daily Allowance), are below average weight for height and age, have clinical manifestations of malnutrition, and/or have had a recent weight loss of 6% or more. In sick patients, addition of flavors to foods in a clinical setting significantly increases food intake and body weight. It also improves plasma protein levels including somatomedin-C/insulin-like growth factor 1, albumin, and transferrin, and increases T-lymphocyte counts from abnormal values to the normal range. In addition, muscle strength improves as measured by hand grip-strength using a Jamar hand dynamometer (Asimow Engineering Co-Therapeutic Equipment, Clifton, NJ) and pinch-strength using a pinch gauge (Therapeutic Equipment, Clifton, NJ).

The use of flavor-amplified foods in sick elderly people has been very successful in a clinical setting over the last 20 years although no controlled studies have been performed. Controlled studies have been difficult because the patient's medical and surgical conditions have tended to be unique. In general, all of the foods at a meal have been flavor-enhanced in the hospital and nursing home settings, especially for patients for whom taste and smell acuity was found to be reduced. A review of our clinical records of 300 patients over a 20 year period indicates that 90% of persons receiving flavor-enhanced foods gained weight and showed some improvement in nutritional status.

Flavor Enhancement of Food in a Retirement Community

The only controlled study on flavor enhancement of food for elderly persons was done with healthy elderly individuals living in a retirement community who attended meals at a cafeteria. In this study, one or two foods were targeted for enhancement at each meal, and flavor amplification increased food intake of some of the targeted foods. This finding was based on an extensive study of 39 elderly Caucasian subjects (mean age = 84.6 years, SD = 5.0) who were divided into two groups. The mean age of the 17 subjects (16 female and 1 male) in group 1 was 85.7 years, SD = 3.8; the mean age of the 22 subjects (19 female and 3 male) in group 2 was 83.8 years, SD = 5.6. All subjects were independent residents at the Methodist Retirement Home in Durham, North Carolina; they had permission to participate in the study.
from their family physicians. Subjects were not prescreened for nutritional status although the dietitian at the Home indicated that each participant had some eating problems over the last year (e.g., did not feel like eating because a close friend died; did not eat after taking a new medication).

The subjects were divided into two matched groups. Group 1 received food that was unenhanced by flavor for the first 3 weeks, and food that was enhanced by flavor for the second three-week period. For group 2 the order was reversed. Six flavors were utilized throughout the study: roast beef, ham, natural bacon, prime beef, maple, and cheese. The flavors were selected by an older panel (over 60 years of age) of the Flavor Extract Manufacturers Association (FEMA). The levels of flavors that were added were determined in pretesting at the Methodist Retirement Home. The foods to which the flavors were added included: soups, gravies, eggs and egg substitutes, vegetables, grits, stews, sauces, pancakes, oatmeal, and macaroni. One or two foods were flavored at each meal.

Six types of measurements were obtained during the six week study. Traditional nutritional indices including biochemical and anthropometric measurements were obtained at the beginning of the study, at the end of 3 weeks, and at the end of six weeks. Taste and smell were also assessed and grip strength measurements were obtained. Food consumption (plate wastage) was determined for every meal for five days of the week.

The biochemical measures were: somatotelin-C/insulin-like growth factor 1, transferrin, total T- and B-lymphocytes, and routine blood chemistries including albumin and creatinine. The anthropometric measures were weight, stature, midarm circumference, and triceps skinfold thickness. Taste thresholds for NaCl and sucrose were determined using the triadic comparison method; odor thresholds for benzaldehyde, geraniol, and citralva were determined as well. The functional measurements were handgrip-strength and pinch-strength. Handgrip strength was determined using a Jamar hand dynamometer; pinch strength was measured with a pinch gauge. Plate wastage was determined by ten persons. Nine of the ten persons had no knowledge of the foods that were amplified. One person had knowledge of the foods to be amplified on some occasions.

Taste detection thresholds for elderly subjects in this study were found to be 3 to 10 times higher than those for young subjects (normative data collected in our laboratory were used for comparison). Olfactory detection thresholds for benzaldehyde, geraniol, and citralva were 3–60 times higher than for young controls. Elderly people ate significantly more of the foods that were flavor-enhanced with roast beef, ham, or bacon flavor (see Fig. 4). Persons with greatest olfactory losses (those with detection thresholds for odors above the median values) ate the most flavor-enhanced food. However, these increases did not alter the overall energy or nutrient intakes. This suggests that when only one or two foods are flavored at a meal, elderly people increase their intake of foods that “taste better” due to flavor enhancement and reduce intake of less flavorful foods so as to maintain a relatively constant intake of energy and nutrients. The diets were fairly well balanced although they tended to be low in fiber, pantothenic acid, calcium, copper, magnesium, potassium,
FIG. 4. Percent increase in consumption relative to unenhanced food for six flavors.

selenium, and zinc in both the unenhanced and enhanced conditions. All biochemical measures were within the normal range both prior to the study and the enhanced and unenhanced conditions. This suggests that there was less malnutrition in elderly people living in this retirement community than we originally presumed.

The only pertinent statistical change in these healthy elderly people was a slight improvement in immune status as determined by lymphocyte measurements in the flavor-enhanced condition (Table 3). No changes were found in anthropometric measurements, taste and smell assessments, or grip strength throughout the study. These data suggest that the elderly subjects in this retirement home were not particularly malnourished; however, they did eat more flavor-enhanced food and this could have

<table>
<thead>
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<th>Blood values and normal values</th>
<th>Baseline</th>
<th>Unenhanced</th>
<th>Enhanced</th>
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<tbody>
<tr>
<td>Total Lymphocytes (800–3200/mm³)</td>
<td>1877.7(669.6)</td>
<td>1776.9(560.4)</td>
<td>2094.7(673.5)</td>
</tr>
<tr>
<td>Total B Cells (63–547/mm³)</td>
<td>129.7(132.8)</td>
<td>131.1(113.9)</td>
<td>159.5(129.3)</td>
</tr>
<tr>
<td>Total T Cells (750–2285/mm³)</td>
<td>1601.4(487.5)</td>
<td>1500.4(465.1)</td>
<td>1752.9(561.3)</td>
</tr>
<tr>
<td>% Lymphs HLA-DR + Antigen marker on all B-lymphocytes and activated T-lymphocytes (6.4–20.5)</td>
<td>18.00(5.79)</td>
<td>13.56(5.32)</td>
<td>14.66(4.85)</td>
</tr>
<tr>
<td>% Leu12(CD19) + Lymphs</td>
<td>6.41(4.59)</td>
<td>7.19(4.09)</td>
<td>7.41(4.23)</td>
</tr>
<tr>
<td>B-lymphocyte marker (6.4–21.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Leu5B(CD2) + Lymphs</td>
<td>82.97(5.95)</td>
<td>84.34(5.16)</td>
<td>83.50(5.79)</td>
</tr>
<tr>
<td>T-lymphocyte marker (57.0–93.0)</td>
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improved their T-lymphocyte counts, because chemosensory stimuli may release endorphins that subsequently improve immune status (see 13–15).

Legal Aspects and Safety of Flavors

In addition to the biochemical, anthropometric, and nutritional data given above, a review of published reports also suggests that addition of flavors to foods is a safe procedure (16). The potential hazards from foods, ranked from greatest to least risk, are the following: microbial contaminants (e.g., pathogenic microorganisms), poor nutrition (e.g., excess fat or alcohol), environmental contaminants (e.g., DDT, lead, cadmium), natural toxicants (e.g., glycoalkaloids, nitrosamines), pesticide residues (e.g., halogenated hydrocarbons), and food additives (e.g., ascorbic acid, tocopherols, BHA, bisulfites, β-carotene, flavorings). A further examination of food additives reveals that some additives may even prevent diseases such as cancer (e.g., β-carotene, ascorbic acid, and tocopherols). Other food additives such as bisulfites can produce adverse reactions such as asthma and dermatitis in some individuals (unpublished double-blind study in patients at Duke University Medical Center). Volatile flavors are not known to have negative effects at the levels used.

The amount of flavor presently consumed by the average person per day is quite small. In Germany, for example, 15% of the food consumed per capita is flavored. The amount of flavoring to which such an individual is exposed is 8.5 g per year or approximately 25 mg per day. These 25 mg consist of hundreds of different types of molecules so that the impact of any one molecule on metabolism is probably insignificant. When flavor levels are increased to treat feeding problems associated with aging or obesity, the exposure is still minimal.

There are four multinational groups that have been concerned with safety of flavors: Council of Europe, European Community (EC), Codex Alimentarius Commission established by FAO/WHO, and the International Organization of the Flavor Industry (IOFI). The Council of Europe has published a useful reference guide, the "Blue Book," which provides safety-in-use information on flavoring agents. EC directives have been published and the listed substances are characterized by E-numbers: E100-199 (colors), E200-299 (preservatives), E300-399 (antioxidants), and E400-499 (emulsifiers, stabilizers, thickeners, and gelling agents). Natural aromatic products that contain "active principles" such as coumarin and safrole are restricted. Maximum limits are a national prerogative of member states and are not prescribed in EC directives.

The Codex Committee on Food Additives is a subsidiary body of the Codex Alimentarius Commission established in 1963 by FAO and WHO to develop international food standards. The safety of food additives is determined by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) which reports to the Codex Committee. The food additives evaluated by JECFA include flavors. Eighty-seven flavoring substances have been reviewed by JECFA. Due to the large number of flavors used in foods, JECFA now classifies materials in decreasing order of potential
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risk (see Volume XIV of the Codex Alimentarius Commission). The International Organization of the Flavour Industry (IOFI) represents 20 national organizations of flavor manufacturers. It has published a booklet entitled "Basic Features of Modern Flavor Regulations." This booklet details various systems for identifying flavors but strongly advocates a system based on toxicological findings and human experience of long history-of-use. There is extensive national legislation on flavors. The definitions of flavors accepted by JECFA are: natural flavoring: obtained exclusively from a natural source; nature-identical flavoring: chemically identical to a natural substance but synthesized or isolated from raw materials; and artificial flavoring substances: not identified yet in natural products.

Each country has its own regulations on use of flavors and labeling. In the United States, the 1958 food additive amendment exempted substances that fall into the category "Generally Regarded As Safe" (GRAS). The Flavor and Extract Manufacturers’ Association (FEMA) Expert Panel was formed in response to this provision (17). This panel of experts confers GRAS status based on chemical identity, purity, structural analogy, natural occurrence in food, concentration of the chemical in food and in the total diet, toxicity and metabolism in animals, and where possible, metabolism in man. Safety evaluations for FEMA are carried out by a nonindustry related expert panel of scientists. Lists of GRAS substances are published by FEMA and in the Federal Register.

FURTHER RESEARCH IN TASTE ENHANCEMENT FOR THE ELDERLY

Research on the taste-enhancement properties of chemicals may ultimately lead to useful means of treating taste losses in elderly subjects. Four classes of pharmacologic agents have been found to enhance taste perception (18): methyl xanthines (including caffeine, theophylline, and theobromine), 5' nucleotides, inosine, and bretylum tosylate. Although several of these agents are not practical potentiators, their use in experimental studies has provided insight into means for modulating taste intensity.

Methyl Xanthines

Caffeine, theophylline, and theobromine are methyl xanthines that are found in coffee, tea, and chocolate respectively. Methyl xanthines exert their pharmacologic effects by blocking adenosine receptors that mediate a range of biologic processes. For example, the binding of adenosine to its receptors on the heart slows sinus rate and leads to atrioventricular block, vasodilatation, and hypotension. Methyl xanthines can also bind to adenosine receptors and antagonize the effects of adenosine. In taste, adaptation of the anterior tongue to low concentrations of methyl xanthines (10 uM to 10 mM) for four minutes enhances the taste of artificial sweeteners that have bitter components such as sodium saccharin (18). Caffeine slightly but significantly potentiates the salty tastes of both NaCl and KCl. However, sweeteners
without bitter components such as sucrose and aspartame are not enhanced by methyl xanthines. It is hypothesized that methyl xanthines potentiate certain tastes by increasing cAMP (cyclic adenosine monophosphate) inside the cells. These enhancements were found on small areas of the dorsal tongue surface. However, drinking coffee or other caffeine-containing substances does not seem to enhance taste significantly.

5'-Nucleotides

5'-Ribonucleotides, including inosine-5'-monophosphate (IMP) and guanosine-5'-monophosphate (GMP) have been known for some time to enhance the taste of monosodium glutamate. Recently, these compounds have also been shown to enhance the sweet tastes of aspartame and sucrose. However, sweeteners with bitter components such as sodium saccharin as well as salty, sour, or bitter tastes are unaffected by 5'-ribonucleotides (18).

Inosine

Inosine is a metabolite of both inosine monophosphate (IMP) and adenosine. When the tongue is adapted to inosine, the tastes of sucrose, aspartame, and sodium saccharin are enhanced. Inosine has no potentiating effect on any tastants that are known to be enhanced by caffeine (18).

Bretyllium Tosylate

Bretyllium tosylate is a quaternary ammonium compound that is used to control ventricular arrhythmias. When the tongue is adapted to bretyllium tosylate for four minutes, the taste of salt is enhanced. While the mechanism of this enhancement is not known, it is presumed to act by opening sodium channels in the taste cell to permit an influx of Na⁺ (18).

Safety Issues and Practical Limitations of Taste Enhancers

While each of the enhancers described above provides insight into the biochemical mechanisms that are involved in potentiation of taste, only IMP has been introduced into table food, specifically in combination with monosodium glutamate. Caffeine, inosine, and bretyllium tosylate are not practical enhancers because they require a four-minute adaptation period. Bretyllium tosylate is an antiarrhythmic drug and will never be used in food. Future research, however, will undoubtedly uncover probes that can be safely added to foods.
Texture Enhancement

The modulation of food texture by increasing crunchiness, chewiness, or crispiness can partially compensate for odor and taste losses in the elderly. However, this strategy is only helpful for persons without dentition problems. Texture enhancement can often be achieved with functional fiber which is helpful for gastrointestinal function in elderly people as long as there is adequate fluid intake.

CONCLUSION

The sensory properties of food along with its nutrient content will be especially important for the rapidly growing elderly population in the 21st century. Foods must be designed that compensate for the taste and smell losses that occur with age. Flavor, taste, and texture enhancers will be crucial in achieving this goal. Flavor enhancement will be especially helpful in improving nutrition and health in sick elderly persons.

REFERENCES

DISCUSSION

Dr. Ashwell: How much individual variation do you get in taste responsiveness? Can you correlate it with nutritional status?

Dr. Schiffman: There is a lot of variability in taste and smell sensitivity in elderly people. There is indeed a correlation with nutrition and many individuals with very poor nutritional status have no sense of smell at all. Unfortunately once the sense of smell is lost, flavor enhancement is no longer effective.

Dr. Dalmauserra: Have you done any studies on children?

Dr. Schiffman: Yes. Children with cancer develop aversion to tastes and smells, especially if they are receiving radiation or chemotherapy. However, children with other chronic diseases, such as heart disease, show improved nutrition when flavors are added to their food.

Dr. Tontisirin: What are the effects of temperature on taste sensation? And what about hot spices?

Dr. Schiffman: Temperature certainly has an effect. With taste the optimum temperature seems to be about 37°C and sensation declines on either side of this. Chili peppers are thought to deplete the neurotransmitters in nerves innervating the tongue. Chronic users can desensitize themselves to sensations from these peppers.

Dr. Viss: I thought that hypoguesia in severe protein malnutrition was due to zinc deficiency rather than to the protein deficiency. Have you examined zinc status?

Dr. Schiffman: Zinc levels are not generally low in the people I see with severe loss of taste. There have been double-blind studies of the effects of zinc on taste perception. For someone who is severely zinc deficient, zinc does improve taste perception; otherwise zinc is ineffective in restoring taste.

Dr. Viss: As far as we could measure it, severe kwashiorkor in central Africa is accompanied by zinc deficiency. We think that the hypoguesia that we observe in those cases is related more to zinc deficiency than to protein deficiency.

Dr. Buzina: How did you measure nutritional status in elderly people living at home?

Dr. Schiffman: We took anthropometric measurements and drew blood for estimation of albumin, somatotropin, C, T-lymphocytes, and a series of other biochemical measures.

Dr. Buzina: I was wondering about vitamin and mineral status.

Dr. Schiffman: We did not measure that, though according to the RDA the intake of certain vitamins was low.

Dr. Hulse: Studies in Canada show that among old people living alone the social aspects of eating may be overlooked. Lonely widows and widowers will resort to tea and toast rather than cook a balanced meal.

Dr. Schiffman: In the States there is a group of people who bring food into elderly people's homes and sit and talk with them. However, even so the food is often not eaten and there are complaints about it. When I gave a small group of these people flavors to enhance the food, they ate more and there were fewer complaints. I agree about the social aspect but failing taste and smell is a serious problem, too.