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THE UNIVERSITY OF ALBERTA

RELATIONSHIPS OF TASTE PERCEPTION AND DIETARY INTAKE: COMPARISON OF ELDERLY AND YOUNG MEN

BY

CHRISTINA LAI YEE KO

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

IN

FOODS AND NUTRITION

FACULTY OF HOME ECONOMICS

EDMONTON, ALBERTA
(FALL 1988)

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Relationships of taste perception and dietary intake: Comparison of elderly and young men" submitted by Christina Lai Yee Ko in partial fulfilment of the requirements for the degree of Master of Science in Foods and Nutrition.

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Date: June 24/88

ABSTRACT

Suprathreshold taste perception and nutrient intakes of thirty elderly (70-79 years) and thirty young (20-29 years) men in the community were examined. Relationships between these taste and nutrient parameters were studied.

Magnitude estimation was used to measure perceived intensity and pleasantness of suprathreshold concentrations of sourness and saltiness in aqueous and food systems. A combination of dietary recall (one day) and food records (three days) was used to quantitatively assess dietary intakes.

For sourness and saltiness in both systems, the mean slopes of taste intensity functions of the elderly were significantly flatter ($p<0.001$) than those of the young. The taste intensity slopes for the elderly and young, respectively, were as follows: for sourness: aqueous (0.34, 0.68), food (0.21, 0.46) and for saltiness: aqueous (0.39, 0.63), food (0.29, 0.47). Within each age group and taste quality, the slopes were flatter for the food systems than the aqueous systems.

For the elderly, the energy intake was lower ($p<0.001$) and the index of overall nutritional risk (percent risk of deficiency for 12 nutrients) was higher ($p<0.05$) than for the young. For the elderly, nutrients at greatest risk of deficiency were: folacin (50%), calcium (34%), vitamin A (26%), zinc (16%), vitamin D (8%) and protein (8%).

For the elderly, many significant Pearson, partial and/or canonical correlations between taste and nutrient parameters were noted. Partial correlations (controlling for previous smoking and medication) between taste intensity slopes and the index of overall nutritional risk were significant for the elderly. For the elderly, stepwise multiple regression analysis revealed the following predictors of taste intensity slopes: for sourness in aqueous system, percent risks of deficiency for riboflavin and folacin; for sourness in food system, index of overall nutritional risk. For saltiness the significant predictors were in aqueous system, vitamin A risk; in this food system, protein risk. Thus, results of this study suggest relationships between suprathreshold taste intensity and nutrient intakes in elderly men, especially for protein, folacin, riboflavin, vitamin B_6, vitamin A and iron.

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1. INTRODUCTION

Scientific, economic, and social changes in this century have resulted in a dramatic increase in the elderly, a high health risk group. This growing number of elderly is rapidly escalating the financial burden on governments and individuals for long-term health care. Many older people complain of a diminution of taste or of taste disturbances. Such disturbances have clinical significance because they may result in decreased food intake and thus threaten the nutritional status of the individual. In order to ensure that nutritionally adequate diets are consumed by the elderly, research on the interrelationships of taste perception and nutrition in the elderly must be conducted.

The objectives of the present study are to measure suprathreshold taste perception and nutrient intake in free-living elderly and young men in order to:

1. compare suprathreshold taste perception between elderly and young men
2. compare suprathreshold taste perception between aqueous and food systems
3. examine the relationships between suprathreshold taste perception and nutrient intake within each age group.

Research findings on taste perception should facilitate appropriate dietary modifications for optimal nutritional well-being and should be useful in planning and preparing food and food products for the older person.

2. LITERATURE REVIEW

Taste deficits in the elderly have been documented by the elderly (Cohen and Gitman, 1959 and Kamath, 1982). As well, more elderly than young subjects comment on a loss in accuracy of food recognition (Schiffman, 1977).

Taste buds are located in the oral cavity on the tongue, palate and pharynx (Henkin and Christiansen, 1967a) and are mounted on peg-like projections called papillae. Three types of papillae (fungiform, foliate and vallate) bear taste buds (Altner, 1981). The fungiform papillae are found over the anterior two-thirds of the dorsal surface of the tongue (Van Haesendonck, 1986) and their number is estimated to be 150 to 400 (Amerine et al, 1965). The foliate papilliae, which are less prominent in adults than in children, are arranged as closely packed folds on the back edges of the tongue. About half of all taste buds are located on the few (7-12 in adults) vallate papillae which are located in a V-shaped zone at the back of the tongue (Altner, 1981). Taste buds of the fungiform papillae are innervated by a branch (the chorda typmpani nerve) of the facial nerve, whereas those of the foliate and vallate are innervated by the glossopharyngeal nerve.

Each taste bud contains taste sensory cells as well as supporting and basal cells. The normal average lifespan of a taste bud is 10 days (Beidler and Smallman, 19[illegible]). Survival of taste buds depends on the integrity of the taste nerves which maintain these buds and induce their development and regeneration. Taste sensory cells are replaced by those derived from basal cells; old synapses between afferent nerve fibers and old cells are disrupted and new synapses are formed. Degeneration of taste buds occurs when taste nerves are cut (Oakley, 1970).

Taste buds on the different regions of the mouth vary in response to the four basic taste qualities (salty, sour, sweet and bitter). On the tongue, the tip is particularly sensitive to sweetness, the middle parts of the outer edges are most responsive to sourness, and the edge of the tongue that overlaps these two regions is most strongly stimulated by saltiness. Bitter stimuli affect strongly the receptors near the base of the tongue. Some studies have suggested that the palate is also sensitive to sour and bitter tastes (Collings, 1974 and Henkin and Christiansen, 1967a). Taste is initiated when chemical stimuli in solution come in contact with the membranes of taste cells. It is generally postulated that weak and reversible binding of the stimulus to the taste cell membrane produces a depolarization and/or conformational change which, in turn, causes the release of a synaptic transmitter that activates axon endings (Biedler, 1978 and Oakley, 1986). Specific receptors in the taste cell membranes determine the ability to discriminate taste qualities. For sourness, the taste sensation is elicited by the hydrogen ion. The higher the hydrogen ion concentration, the stronger the sour taste sensation (Guyton, 1981). The salty taste is stimulated by ionized salts and the magnitude of taste sensation depends on the type of salt. Although saltiness is mainly elicited by salt cations, anions can also contribute by either enhancing or inhibiting the stimulation (Guyton, 1981). Taste effect is obtained as a result of the stimulation of many taste buds from which the impulses are transmitted across a synapse to the central nervous system by way of several cranial nerves (Altner, 1981).

Sensory coding for taste quality and concentration has been studied by the analysis of single taste nerve fibers. It is generally believed that a taste quality is mediated by a small number of taste fibers that are narrowly tuned to that particular taste quality rather than by a large population of taste neurons transmitting a particular pattern of activity (Altner, 1981 and Oakley, 1986). For intensity, psychophysical magnitude estimates have been used to recorded neural response (ie. a taste solution that produces a large neural response also produces a large psychophysical response) (Oakley, 1986). The physiology of central processing of taste sensory input is still unresolved, however, the medulla oblongata thalamus and cerebral cortex are believed to be involved (Altner, 1981 and Oakley, 1986).

Whether the number of taste buds decreases with age is not clear. No age-related alterations in taste bud numbers were found in the fungiform papillae (Arvidson, 1979). However, the number of taste buds in the foliate papillae was reported to increase and then decrease with age, to numbers in the elderly of slightly below those of juvenile levels

(Mochizuki, 1939). The number of taste buds in the vallate papillae was reported to decrease with age (Arey et al, 1935). In addition to changes in the number of taste buds, age-related alterations in cell receptor membranes and in the central nervous system can also occur (Mistretta, 1984).

Most results on age-related changes in taste function have been obtained by measurement of taste thresholds and are conflicting. Most researchers have reported results for groups of combined males and females. For saltiness, age-related increases in threshold values have been documented (Balogh and Lelkes, 1961; Bartoshuk et al., 1986; Cooper et al., 1959; Murphy, 1979; Grzegorczyk et al., 1979 and Weiffenbach et al., 1982). In one study (Baker et al.,1983), the NaCl detection threshold increased with age in a log linear relationship. In contrast, other researchers were unable to find significant age-related differences in salt thresholds (Hermel et al., 1970). For sourness, researchers reported taste thresholds to increase with age (Bartoshuk et al., 1986; Cooper et al., 1959; Glanville et al., 1964, Hermel et al., 1970 and Murphy, 1979). Murphy (1979) observed that the increase in sour taste threshold was more gradual than those of other modalities. Cooper et al. (1959) noted that sour thresholds were not significantly increased until after the age of 60. Glanville et al. (1964) reported that the age-related rate of decline of sour taste sensitivity in males was four times that observed in females. Weiffenbach et al. (1982), however, observed no significant age-related changes in threshold for sourness. For sweetness, taste threshold has been found in some studies to be significantly increased with age (Balogh and Lelkes, 1961; Bartoshuk et al., 1986; Cooper et al., 1959; Hermel et al., 1970; Moore et al., 1982 and Murphy, 1979), while another study reported no significant changes with age (Weiffenbach et al, 1982). For bitterness, increased threshold values due to age had been demonstrated (Bartoshuk et al., 1986; Cooper et al., 1959; Glanville et al., 1964; Hermel et al., 1970; Murphy, 1979 and Weiffenbach et al., 1982). However, Kaplan et al. (1965) attributed the age-related changes in bitterness sensitivity to the cumulative effects of smoking.

While taste thresholds measure the perceived threshold concentration of tastants, suprathreshold tests determine the taste responses to above-threshold tastant concentrations typical of tastant concentrations encountered in foods (Bartoshuk, 1978). Early studies of age effects on suprathreshold taste perception were conducted by Byrd and Gertman (1959) and Cohen and Gitman (1959) using taste identification tests. These researchers found no age-related differences in the ability to correctly identify suprathreshold concentrations of the four basic tastants (salty, sour, sweet and bitter) in aqueous solutions. Little and Brinner (1984) measured suprathreshold taste perception of saltiness in a food system (tomato juice) using category scaling. These researchers found no significant effect for age or sex in the taste intensity perception of saltiness.

Magnitude estimation has been used to measure the way that perceived intensity grows with tastant concentration. Magnitude estimation (ME) (Stevens, 1957) is a ratio-scaling technique in which individuals assign any number to the perceived intensity of stimuli so that the ratio of the numerical subjective assessments reflect the ratios of the perceived magnitude of the stimuli (Moskowitz, 1977).

Magnitude estimation has an advantage over category scaling. The ME scale is continuous and unlimited so the subject can assign numbers without restrictions to reflect his true perception of the stimuli (Moskowitz, 1977).

According to Steven's Power Law, perceived intensities are a power function of the stimulus magnitude (Stevens, 1957); described by the following function: $S = kC^n$

where S = perceived intensity (taste magnitude)

C = stimulus magnitude (tastant concentration)

n = power exponent (value depends on substance tasted and the conditions of tasting)

k = constant for the system chosen

When the log of Steven's power function is taken, the resultant formula:

$$\log S = \log k + n \log C$$

describes a straight line of the slope n in the plot of logS vs logC. When the exponent $n = 1$, the perceived magnitude varies directly with the physical magnitude of the stimulus. When each individual assigns numbers based upon his own frame of reference, normalization of data is needed to bring the ratings into a common scale. Usually, no normalization is used when a fixed standard (reference) assigned with a fix number (modulus) is used. Stevens (1957) suggested that for ME data, log values of the data are normally distributed. The geometric mean has been traditionally used as the most appropriate measure of central tendency in log data that are distributed normally (Moskowitz, 1977). Some researchers (Marks, 1974 and Stevens, 1975), do not permit zero and negative ratings because the calculation of the geometric mean would not be feasible with zeros. Zero ratings can be adjusted relative to the individual's lowest nonzero rating to allow for the calculation of the geometric mean (Moskowitz, 1970a and 1970b).

Cowart (1981) and Weiffenbach et al. (1986) found that perceived intensities of the four basic tastes increased more slowly with concentration for the elderly than for the young (ie. the elderly had flatter psychophysical functions for taste than did the young). Hyde and Feller (1981) reported that the age effect on taste intensity scaling function for men was the greatest for bitter, marginal for sour and least for sweet and salty stimuli.

Magnitude estimation can also be used to scale pleasantness responses. McDaniel and Sawyer (1981) and Moskowitz and Sidel (1971) compared the use of ME with the use of the 9-point hedonic scale for rating preference. These researchers found ME to be equally (Moskowitz and Sidel, 1971) and more (McDaniel and Sawyer, 1981) sensitive than the 9-point hedonic scale, in that the ME technique resulted in more statistically significant differences. Other researchers (Giovannni and Pangborn, 1983 and Moskowitz, 1976) have found ME to be a reliable and useful procedure for measuring taste hedonics.

Aqueous solutions have been used by most researchers when studying age-related differences in taste perception and preference. However, in everyday situations, complex stimuli in foods are encountered. Cardello et al. (1979), Moskowitz et al. (1974) and Pangborn and Pecore (1982) showed that taste responses differ depending on the media (model or food) carrying the tastant. Therefore, there is a need to study the taste responses to tastants in both model and food systems in order to determine whether findings in the former apply to the latter.

Gender differences in taste perception have been investigated. Cohen and Gitman (1959) found that for the four basic tastes, elderly males had significantly higher incidences of taste errors than elderly females. Fikentscher et al. (1977) found that men after the age of 40 years were less able to recognize sourness, saltiness, sweetness and bitterness in aqueous system than their female counterparts. As well, elderly men had higher thresholds for sourness (Glanville et al., 1964 and Weiffenbach et al., 1982) and for saltiness (Greger and Geissler, 1978) compared to those of elderly women. However, other researchers found no significant gender differences in taste threshold (Cooper et al.,1959, Grzegorzyk et al.,1979 and Murphy, 1979) and suprathreshold taste intensity measurements (Hyde and Feller, 1981 and Weisfuse et al., 1986) in the elderly.

One factor thought to affect taste perception in the elderly is the wearing of dentures (Kamath, 1982). Hermel et al. (1970) studied the ability of subjects to identify the 4 basic taste qualities. These researchers reported an improvement in taste identification with the removal of dentures. Henkin and Christiansen (1967b) found that detection thresholds for sourness and bitterness were higher in subjects who wore dentures than in those who did not. However, Bartoshuk et al. (1986) reported lower detection threshold values for bitterness in subjects who wore dentures than in those who did not. No effect due to dentures was found for detection threshold measurements for NaCl (Baker et al.,1983 and Henkin and Christiansen, 1967b) and for sucrose (Henkin and Christiansen, 1967b and Moore et al.,1982).

Smokers often complain of taste impairment (Peterson et al., 1968). Some researchers have shown higher taste thresholds for saltiness (Baker et al., 1983) and for bitterness (Krut et al.,1961 and Peterson et al.,1968) among smokers as compared to nonsmokers. Kaplan et al. (1965) suggested that age and sex-related differences in taste sensitivity for quinine could be accounted for by the effects of smoking. In contrast, Redington (1984) showed no significant difference in the way smokers and nonsmokers rated the intensity and pleasantness of sweet, salty and bitter tastes and Grzegorczyk et al. (1979) found no relationship between smoking and NaCl taste detection thresholds.

Various drugs can also alter taste function. Potassium iodide and bromide-containing medications are excreted by the salivary glands and thus cause a salty bitter taste in the mouth (Hartshorn, 1977). Penicillamine and thiamozole affect taste indirectly by forming complexes with zinc and copper (Henkin et al., 1967 and Hanlon, 1975). Certain anticholesteremic, antihypertensive, antirheumatic and antiflammatory agents have also been reported to modify taste (Schiffman, 1983).

Information on age-related alterations in taste preference is limited. Murphy (1986) reported that the elderly (sex not specified) consistently rated citric acid in aqueous solutions and lemon-flavored beverages as more pleasant that did the young subjects. Laird and Breen (1939) found that older men (50 to 68 years) had a greater preference for sourness in pineapple juice than did younger men (18 to 40 years). However, Cowart (1981) found no systematic age-related changes in sour pleasantness ratings in aqueous solutions for males. For saltiness, Cowart (1983) observed that men after the age of 40 years showed a shift in peak preference towards more concentrated NaCl aqueous solutions. Murphy (1986) also noted that the elderly (males and females) rated the high concentrations of NaCl in aqueous solution and vegetable juice as more pleasant than did young (male and female) subjects. For sweetness, Murphy (1986) reported that elderly rated the high sucrose concentration in aqueous solution and in lemon-flavored beverage more pleasant than did younger subjects. However, Enns et al. (1979) found no age-related differnces in sucrose hedonic ratings among males. In contrast to Murphy (1986), Cowart (1981) observed that among males, the elderly group found the high sucrose concentration in aqueous solution less pleasant than did younge age groups. For bitterness, no systematic age-related changes in pleasantness ratings were found among males (Cowart, 1981).

The pattern of taste intensity and taste pleasantness responses differ (Giovanni and Pangborn, 1983; Moskowitz, 1976 and Trant and Pangborn, 1983). Lundgren et al. (1978) identified four types of h donic responses (monotonic decrease, parabolic function, monotonic increase and horizontal line) which could be used to classify subjects depending on their pleasantness responses.

Taste perception has been suggested to be a powerful motivator of feeding and drinking (Brightman, 1977). Mattes (1985) looked for relationships between taste function and dietary intake in adults. He found no significant correlation between the measures of taste function (sweet and bitter taste perception, intensity and preference) and five intake parameters (intakes of calories, protein, fat, and calories from foods classified as having the sour and the bitter taste qualities). Henkin et al. (1971) studied adult patients with hypogeusia (taste diminution) and dysgeusia (taste distortion). They (Henkin et al., 1971) reported that dysgeusia prompted a change in normal dietary habits such that certain foods (eg. meat, fish, poultry, eggs) were avoided. Mattes-Kulig and Henkin (1985) found that energy intake decreased significantly as the severity of dysgeusia increased but was unaffected by hypogeusia. As well, these researchers found that more than half of all patients with dysgeusia exhibited at least one anthropometric measurement indicating nutritional risk (triceps skinfold measurement below the 15th percentile, arm muscle circumference below the 15th percentile, body weight below 90% of ideal body weight, or acute weight loss of greater than 5% of usual weight).

Among the nutrients, the role of vitamin and minerals in taste sensory function has been studied most extensively for zinc and vitamin A. A few workers have investigated the influence that niacin, vitamin B_6 and vitamin B_{12} status may have on taste function (Bray, 1976, Greeley and Gniecko, 1986 and Green, 1971).

Zinc may play many roles in taste function. Zinc is a cofactor of many metalloenzymes (Parisi and Vallee, 1969) and is required for the metabolism of nucleic acids and synthesis of protein (Mills et al., 1969 and Prasad, 1967). Parakeratosis and hyperkeratosis of the oral membranes and tongue of zinc-deficient rats have been found (Osmanski and Meyer, 1969). Zinc is part of a metalloprotein (gustin) found in the saliva surrounding taste buds (Henkin et al., 1975). Decreased concentrations of gustin in saliva are found in patients with hypogeusia (Shatzman and Henkin, 1981). Zinc is found in taste bud receptors and has been thought to be involved in taste transduction (Law and Henkin, 1983). Zinc is also found in peripheral and cranial nerves (Henkin et al., 1979). An indirect mechanism by which zinc may be involved in taste function is that of the synthesis of retinol-binding protein which transports vitamin A from its storage site in the liver to peripheral tissue (Smith et al., 1974). Zinc is necessary to maintain normal vitamin A concentrations in plasma (Smith et al., 1973).

Researchers (Atkin-Thor et al., 1978, Hambidge et al., 1972, Henkin and Bradley, 1970, Henkin et al., 1971, Schechter et al., 1972 and Shatzman and Henkin, 1981) have shown improvement in taste acuity after zinc supplementation in patients with taste abnormalities. Despite the strong evidence for zinc involvement in taste function, researchers have not been able to find a relationship between taste deficits and poor zinc status in the elderly. No significant correlation was found between detection and recognition thresholds for sweetness or saltiness and zinc intake in groups of elderly men and women (Bales et al., 1986, Greger and Geissler, 1978, Greger and Sciscoe, 1977 and Hutton and Hayes-Davis, 1983). For elderly men, Greger (1977) found no correlation between NaCl and sucrose taste thresholds and nutrient intake, but a significant relationship between sucrose taste detection threshold and hair zinc levels was observed. Greger and Geissler (1978) reported that zinc supplementation did not significantly affect taste acuity in either men or women. However, these researchers noted that before zinc supplementation, males had significantly higher NaCl recognition thresholds than the females but after zinc supplementation, the improvement in taste acuity (no significant) noted in the males resulted in similar taste thresholds between genders.

One function of vitamin A is to maintain epithelial tissues in a healthy state (Wolbach and Howe, 1925). Bernard and Halpern (1968) and Bernard et al. (1961) studied the taste preferences of rats depleted of vitamin A by dietary restriction. These researchers found keratinization (hornlike degeneration) of the tongue, including the pore area of the taste buds, in vitamin A defi ient rats. In rats, normal taste responses to NaCl and quinine solutions were lost as a result of vitamin A depletion and were re ored after vitamin A supplementation (Bernard and Halpern, 1968 and Bernard et al., 1961). In huma s, impairment of taste and abnormal hedonic responses were observed in children who were found to be vitamin A deficient and in men i whom vitamin A deficiency was experimentally produced (es and Hodges, 1980).

The role of vitamin B_6 in taste has not been established. However, neurological damage as well as changes in the mouth and tongue (eg. glossitis, filiform hypertrophy) have been observed in humans with experimentally induced vitamin B_6 deficiency. As well, vitamin B_6 deficiency has been associated with some endocrine (hormonal) abnormalities (Hsu, 1963). Hormonal factors have been suggested to play a role in taste in both males and female humans (Mattes et al., 1986) and in animals (Richter, 1939). In vitamin B_6 deficient rats, altered preference and intake of salty, sweet and bitter taste solutions were demonstrated (Chan and Kare, 1979, Grewack et al., 1977 and Greeley and Gniecko, 1986). In humans, taste loss has been reported in patients with toxicity of 5-thiopyridoxine, an antirheumatic drug which possesses antivitamin B_6 action (Huskisson et al., 1980).

Glossitis and neurological damage have been observed in vitamin B_{12} deficiency (Herbert, 1975). A possible relationship between taste function and vitamin B_{12} has been suggested by Bray et al. (1976) who studied vitamin B_{12} absorption and taste preference in obese patients before and after jejunoileostomy. These researchers noted decreased vitamin B_{12} absorption, reduced pleasantess ratings for high sucrose and glucose concentrations in solution as well as altered taste preference in patients after jejunostomy. Whether vitamin B_{12} status and taste function are related is not clear and needs further research.

Some diagnostic signs of niacin deficiency are oral lesions and glossitis (Goldsmith et al., 1952). Frosti g and Spies (1939) and Green (1971) observed hypogeusia and dysgeusia in individuals with subclinical deficiency of niacin. The administration of niacin supplements resulted in the disappearance of these taste abnormalities (Green, 1971). However, the administration of tryptophan (precursor of niacin) alone can also correct niacin deficiency symptoms (Bean et al., 1951). Therefore, the adequacy of niacin intake cannot be assessed without the consideration of the amount of tryptophan in the diet (Horwitt, 1980).

Inadequate dietary intake in the elderly has been well documented. Although energy requirements decrease with advancing age as the result of age-related declines in basal metabolic rates and physical activity (Watkin, 1982), nutrient requirements do not decrease with age (Bureau of Nutritional Sciences, Department of National Health and Welfare, 1983). A national survey of the Canadian population, Nutrition Canada, 1973 (Department of National Health and Welfare, 1973), found that elderly men (65+ years) had mean folacin and calcium intakes of less than the recommended levels. In addition, nearly one-quarter to one-third of the general Canadian population of elderly men had less than adequate intakes of riboflavin, iron, thiamin and vitamin A intake (Department of National Health and Welfare, 1973). Other studies of elderly men have also reported nutrient intakes of less than the recommended levels, suggesting that this group of individuals is susceptible to nutritional deficiencies. The findings of these studies are summarized in Table 1.

Since the elderly have been found to have impaired taste function and are often nutritionally at risk, questions regarding relationships between sensory taste changes with age and inadequate nutrient intake arise. The objective of the present study is to investigate relationships between taste perception and nutrient intake in elderly and young men.

Table 1: Nutrient intake of free-living elderly men

Author	Age (yr)	N[1]	Kcal	Protein (g)	Calcium (mg)	Iron (mg)	Vit.A (I.U.)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Vit.C (mg)	Others/comments
Brown et al., 1977	72-90	9	2166	73	665	14.7	6249	1.22	1.45	15.5	161	
Kohrs et al., 1980	59-99	31	2178	85	1014	13.3	10518	1.26	2.19	17.2	132	
Kohrs et al., 1978	59+	35	2342	88	1095	15.0	11645	1.4	2.3	19.7	135	
Garry et al., 1982	60+	125	2171 (71)*	83 (11)	(55)	(6)	(86)	(27)	(16)	(0)	(7)	folacin:(86) zinc:(91) Vit.B6:(94) Vit B12:(42) *% of subjects whose intakes are below RDA
Grotkowski & Sims, 1978	62+	15	1801	80	79.	4.5	5043	1.34	1.78	16.2	110	
Yearick et al., 1980	66-96	25	2177	94	973	14.9	9047	1.33	2.12	18.2	107	
Vir & Love, 1979	65-91	10 5	2552 1715	72 56	1000 668	12.2 9.3	 757	1.30 .71	1.36 1.03		32 28	Vit.B6: 1.25 Vit.B6: .91
Leichter et al., 1978	76.7 74.2	51 23	1867 1679	73 63	859 616*	11.1 10.7	5150 4468	1.0 .9	1.7 1.5	15.0 13.5	65 78	single men married men: *value is significantly lower than those for single men
Guthrie et al., 1972	60+	40	1681	67	568	11.6	2999	1.0	1.3	51		
Joering, 1971	45-90	30	1280	61	537	10.5	4429	.73	1.15	10.0	44	
Nutrition Canada, 1973[2]	65+	881	2056	72	709	13	1113 R.E.	1.08	1.77	28 N.E.	85	folacin: 151 mcg

[1] number of subjects

[2] (Canada. Bureau of Nutritional Sciences, Department of National Health and Welfare. 1973.)

3. METHODOLOGY

3.1 Selection of Subjects

Two groups of caucasian males, one group consisting of 30 elderly men (70-79 years) and the other consisting of 30 young men (20-29 years) were chosen for the present study according to the following criteria:

1) Free-living residents of the greater Edmonton area for over six months
2) Ambulatory and having no known history of serious metabolic disease
3) Not following a special therapeutic diet
4) Able to communicate in English
5) Willing and available to participate in the study

A random sample of the population of Edmonton was chosen by Alberta Hospitals and Medical Care from names of appropriate individuals registered with the Alberta Health Care Insurance Plan. Letters recruiting participants for the study (Appendix 1) were sent to 176 individuals from each of the two age groups. Individuals indicating an interest in the study were interviewed by the researcher. The subject profile questionnaire (Appendix 2. Part I) was used to determine if the individual was suitable for the study. For the elderly, 18 men (10%) indicated they were interested in the study and 15 (9%) actually participated in the study. For the young, 9 men (5%) showed interest in the study and 3 (2%) were enrolled.

Other methods of recruiting subjects were employed in order to obtain additional individuals for the study. Potential volunteers were recruited through friends, and several organizations and events, including the Strathcona Place Society, the Society for the Retired and Semi-Retired and the University of Alberta 1985 Spring Session for Seniors. In these cases, individuals were contacted through letters requesting participants (Appendix 3). The subject profile questionnaire described earlier was used to determine the eligibility of all volunteers for the study. As a result, an additional 15 elderly men and an additional 27 young men were enrolled to provide a total of 30 subjects for each age group. Further subject profile information such as socioeconomic status, drug usage, smoking habits, alcohol consumption pattern and demographic data was obtained from subjects by completing the questionnaire (Appendix 2, Part II).

The research proposal for this study was reviewed and approved by the Ethical Review Comittee on Human Research. Written consent was obtained from each subject (Appendix 12).

Data collection took place between March 1985 and January 1986. For each subject, five interviews, of approximately one to two hours each in length, were required to collect quantitative data concerning taste perception and dietary intake. Table 2 presents the protocol for data collection. All subjects were individually interviewed by the researcher. Collection of data took place at the home of

Table 2: Protocol for Data Collection

Interview		Taste Perception Evaluation	Dietary Assessment
1	signing of consent form, complete questionnaire, orientation to magnitude estimation	taste quality I	
2		taste quality I	24-hour recall; instruction on completing food record
3		taste quality I taste quality II	review food record (one day)
4	taking anthropometric measurements	taste quality II	
	presentation of token of appreciation	taste quality II	review food records (two-days)

the subject, at the Department of Foods and Nutrition, University of Alberta, at the Strathcona Place Society, or at the Society for the Retired and Semi-Retired.

3.2 Collection of Taste Perception Data

Suprathreshold taste perception was tested using the technique of magnitude estimation (ME) (Moskowitz, 1983). In using ME, each subject is allowed to assign any non-negative number to describe a series of sensory stimuli so that the ratios of the numbers assigned reflect the ratios of sensory perception. A fixed standard and fixed modulus method of ME was used (Moskowitz, 1977). A reference sample, within the usual suprathreshold range, was pre-assigned a number (10) and used as a reference to which other samples in the series could be compared. To avoid gustatory fatique, only the sour and salty taste modalities were assessed.

a) Sample Preparation

Aqueous solutions and simple foods containing sour and salty modalities at six suprathreshold concentrations per series were prepared. Water solutions and apple drinks contained concentrations of 3, 6, 12, 18, 24 and 36 mM citric acid (CA). Water solutions and chicken broths contained concentrations of 20, 40, 80, 160, 320 and 640 mM sodium chloride (NaCl). The lowest concentrations of NaCl and CA used were higher than the reported detection thresholds measured in the elderly (Langan and Yearick,1976; Grzegorczyk et al., 1979; Weiffenbach et al., 1982; Hutton and Hayes-Davis, 1983).

At least every month throughout the study, new batches of samples (1500ml of the reference samples and 500 ml of other concentrations) were prepared. Appropriate amounts of food-grade CA (Allen and Hanburys® U.S.P. hydrous granular CA) were added to double-distilled deionized water and to General Foods® reduced acid apple drink. The low-acid fruit drink, obtained courtesy of General Foods® Ltd., Cobourg, Ontario, initially had 10% apple juice, 0.063% (weight/volume) malic acid and a Brix value of 10.7°. Each time a new batch of CA samples (solutions and drinks) was prepared, the total acidity of each stimulus concentration was checked using the titration method of Ruck (1956) to ensure that the acid content was as intended.

Windsor® table salt (composition presented in Appendix 4) was added to double-distilled deionized water and to Stafford® Low Sodium Chicken Broth to achieve the desired NaCl concentrations. The chicken broth had an initial concentration of 0.3% (weight/volume) NaCl when reconstituted at a constant proportion of 50 gm per liter of boiled tap water (as suggested by instructions on product use). The reconstituted soup was strained to ensure a clear broth.

Taste samples were dispensed into 20 ml glass vials sealed with screw caps and frozen at -15 + 5°C until needed. Samples frozen for more than 4 months were analyzed for CA content by a titration method (Ruck, 1956) and for the level of NaCl by the Volhard Chloride method (Hillebrand and Lundell, 1953). Freezing had no significant effect of the composition of the tastants.

For evaluation by subjects, samples were brought to and maintained at appropriate temperatures. Aqueous solutions were served at room temperature (20 ± 3°C) while food samples were presented at the temperature at which they are normally consumed. The apple drink was maintained at 12 ± 2°C by immersing the samples in about 1 cm of cold (12 ± 3°C) water chilled with a reusable Ice Pack® placed in a 24 x 33 cm aluminum tray. The chicken broth samples were maintained at 60 ± 5°C in a closed water bath double-boiler system using two Corningware® casserole dishes fitted with one lid and placed on top of a heated Salton® Electric Hotray.

For presentation to subjects, samples were dispensed in 10 ml quantities into 30 ml plastic Medicups®. References were marked with "R" and test samples were coded with 3-digit random numbers. Score sheets (Appendix 5) were labelled with the sample random numbers in the order to be tested. A modification of Hyde and coworkers' (1981) sequence order was used to present the six test samples of each series in a partially randomized order (Appendix 6) such that no two consecutive samples differed in concentration by greater than four-fold. Consecutive evaluation of samples of extreme concentrations was avoided to reduce order effects due to adaptation to higher concentrations. Double-deionized water (20 ± 2°C), stored in glass bottles, was available ad libitum for rinsing. Styrofoam cups marked "WATER" and "WASTE" were provided for fresh rinsing water and expectorated waste, respectively.

b) Orientation to Magnitude Estimation

Each subject was instructed in the method of ME before his first taste test. The objectives of the orientation were to ensure reliable data collection through the development of an understanding of the use of numbers and ratios in quantifying perceptual differences. During the orientation, the subject was trained in the use of ME through a series of exercises involving judgments of various lengths of lines and areas of shapes, respectively (Appendix 7). After the completion of the exercises, the results were checked to ensure that the participant had used the method correctly.

c) Sample Evaluation

Subjects were asked to refrain from eating, drinking (except water) and smoking for at least one hour before the taste tests. The wearing of dentures was according to usual eating habits, ie. if the individual usually ate with his dentures on, he would be tested in the same manner. Prior to tasting, the salivary pH of each subject was measured (using pH paper for pH range 3 to 8, supplied by Micro Essential Laboratory, Ltd) and recorded.

All subjects were tested individually. Each subject was instructed to taste but not swallow the samples. When tasting, the participant was asked to empty the contents (10 mls) of the Medicup® into his mouth, to swoosh the sample around and hold for about 3 seconds. All samples were expectorated. The perceived intensity and pleasantness of the sample were rated numerically according to instructions given in Appendix 8. The researcher recorded the subject's response regarding the perceived intensity and pleasantness on the scorecard (Appendix 8). To eliminate any aftertaste, the participant was instructed to rinse with water ad libitum before and in between samples. All rinse water was expectorated. Time lapses of at least 20 seconds between samples and of 3 to 5 minutes between media within a session were required.

Taste perception for saltiness and sourness was evaluated in six separate sessions (3 sessions for each taste modality) for each individual. In the first 3 sessions, half of the participants in each age group were assessed for salty taste while the other half were tested for sour perception. Replicates for each taste modality took place on separate days.

Within each taste session, 2 series of the same modality were presented: the aqueous solution and the simple food. For each series, a total of 8 samples were presented. The reference was introduced twice, once before the first unknown and again before the fourth unknown to remind the subject of the reference's intensity and pleasantness. A hidden reference sample was also presented as an unknown for evaluation.

Information concerning factors influencing taste perception (eg. dentures, use of table salt, smoking habits and alcohol consumption patterns) was obtained from the subject profile questionnaire (Appendix 2, Part II).

To convert the raw data into a form appropriate for statistical analyses, magnitude and pleasantness estimates of each subject were reordered using the computer. Profile information was coded for statistical correlation.

3.3 Assessment of Dietary Data

Four days of dietary intake were assessed quantitatively for each subject. The method used was a combination of the 24-hour recall and the dietary record. All dietary data were collected by the one researcher who was trained in the Nutrition Canada techniques of quantitative dietary assessment (Department of National Health and Welfare, 1973) using food models; dietary interviews were conducted using a standardized procedure (guidelines appear in Appendix 9). Four days of intake were assessed; three weekdays and one weekend day were chosen to represent weekdays and weekend days in their true proportion. For each subject, dietary data were collected at the second, third and fifth interviews (Table 2).

Initially, a twenty-four hour recall of food intake was obtained. During the interview, recalled dietary information was recorded on a dietary intake form (Appendix 10). Each subject was asked to itemize, in chronological order, all foods and beverages consumed on the preceding day, beginning when the subject awakened. The items were reviewed with the subject to estimate quantities consumed and to obtain detailed descriptions of food items, including methods of preparation. Portion sizes were estimated by the use of food models (constructed according to Nutrition Canada specifications) and by the observation of dishes and utensils used in subjects' homes. Skilled probing during the interview helped to ensure completeness of information. In the case of married men, wives were often consulted for recipes and details about food items. Instructions were provided on the proper way to complete the food records. A food record form (Appendix 11, Part I) was given to the subject for completion on the day preceding his next interview. A sample food record (Appendix 11, Part 2) was provided as a guide for the subject. During the next visit (third interview), the completed record was reviewed with the subject. At the end of the fourth interview, blank food record sheets for two days were given to the subject to be completed for the two days prior to the final visit. In general, a total of three days of food records was collected. For ten of the young subjects, four days were not adequate to describe usual food intake. For nine of these subjects, dietary intake was assessed for five days; for one subject, dietary intake was assessed for seven days. All completed food records were reviewed with the subject. Other pertinent information concerning nutrient intake was obtained, eg. the use of vitamin/mineral supplements. If a vitamin/mineral supplement was used for a period of over six months, the following information was obtained: brand name, nutrient composition, intake frequency and dose. Additional information concerning food preparation and food habits was obtained from the subject profile questionnaire (Appendix 2, Part II).

The daily nutrient intake of each subject was computed in the following way: all recorded food items were coded by the researcher using coding procedures standardized in the Department of Foods and Nutrition. After verification, the data were then transferred to computer tape for the computation of nutrient intake by the main-frame computer at the University of Alberta.

The nutrient data base used was the Canadian Nutrient File (Bureau of Nutritional Sciences. Department of National Health and Welfare, 1985), a data bank based on United States Department of Agriculture Handbook No. 456 (Adams, 1975) into which Canadian food composition data had been incorporated to provide a total of over 3000 food items. Values for zinc were also incorporated into the data base from various sources: Revised Agricultural Handbook No. 8 (Consumer and Food Economics Institute, 1976-1983); Murphy et al. (1975); Freeland-Graves et al. (1980); Freeland and Cousins (1976); Lawler and Klevay (1980); and McNeill et al. (1985). Values for dietary fiber and cholesterol were incorporated into the nutrient base from Southgate's tables (Paul and Southgate,

1978) and from the Nutrition Coding Center, Minneapolis (Feeley et al., 1972). Volumes of food were converted by computer programs to weig which were then used for computation of nutrient content. For each subject, average daily nutrient intakes, with and without vitamin/mineral supplements, were determined for the four-day period. The following mean daily nutrient intakes were calculated: energy, protein, fat, cholesterol, total carbohydrate, dietary fiber, sugar, starch, thiamin, riboflavin, niacin, folacin, vitamin B_6, vitamin B_{12}, ascorbic acid, vitamin A, vitamin D, calcium, phosphorus, iron, zinc, sodium, and potassium. Mean daily nutrient densities (intakes per 1000 kcals) were computed for each individual.

Daily food intakes we e also classified into the ten food groups previously used for the Nutrition Canada data (Bureau of Nutritional Sciences, Department of National Health and Welfare, 1977). These ten food groups (Davenport, 1964) were: 1) dairy products; 2) meat, poultry, fish and eggs; 3) cereal products; 4) fruit and fruit products; 5) vegetables; 6) fats and oils; 7) nuts and legumes; 8) foods primarily sugar; 9) beverages and soft drinks; and 10) miscellaneous (includes food group combinations, soups, condiments and items not classified elsewhere).

Nutrient intakes were also evaluated for the probability of risk that the observed intake was inadequate for the corresponding individual (Anderson et al., 1982). A software package designed by Dr. G.H. Beaton, University of Toronto, for an Apple IIe micro-computer was used for this purpose (Beaton, 1984). For each subject, an index of overall nutritional risk was calculated as the average of the percent risk of deficiency for 12 nutrients (protein, thiamin, riboflavin, folacin, vitamin B_6, vitamin B_{12}, vitamin A, vitamin D, ascorbic acid, calcium, iron and zinc).

3.4 Anthropometric Measurements

For each subject, measurements of height, weight, triceps skinfold thickness, arm circumference and elbow breadth were collected. Throughout the study, the same set of equipment was used to obtain anthropometric measurements; the set included the following: portable spring scale ("SECA", distributed by Precision Scale Ltd Co.), Lange skinfold calipers, metal calipers, and steel measurement tape. Anthropometric measurements were performed on subjects wearing light indoor clothing with shoes removed.

For height measurement, the subject was asked to stand against a flat surface, with heels, buttocks, shoulders and head against the vertical surface. A right angle metal headpiece was levelled horozontally, brought to the crown of the head and used as a guide to mark the height on the vertical surface. A metal tape was then used to measure the distance from the floor to the mark on the vertical surface. Frame size was determined using elbow breadth measurements and categories specified in "The 1983 Metropolitan Height and Weight Tables" (Metropolitan Life Insurance Co., 1983). With the use of sliding calipers, the greatest breadth across the elbow joint was measured with the right arm in the following position: extended forward perpendicular to the body; bent so that the angle at the elbow forms 90°; and fingers pointing up with dorsal part of wrist toward the researcher. Relative body weight (RBW) was determined using the height and frame size measurements of each subject and the desirable body weight tables prepared by Metropolitan Life Insurance Company (Metropolitan Life Insurance Co., 1959).

Left upper arm circumference was measured with a non-stretching tape at a point halfway between the tip of the elbow and the acromial process of the scapula, with the arm hanging relaxed. The mid-arm triceps skinfold measurement was taken along the posterior midline of the unclothed arm. With the arm hanging relaxed, the skinfold over the triceps muscle was grasped at the point one centimeter above the midpoint.

Mid-arm muscle circumference was determined using the following equation:

$$\text{arm muscle circumference (cm)} = \text{arm circumference (cm)} - (0.314 \times \text{triceps skinfold thickness (mm)})$$

For each subject, triceps skinfold measurement, mid-arm circumference and mid-arm muscle measurement were also expressed as percentage of standard values using sex and age specific 50th percentile reference values for the Canadian population (Jette, 1983).

For each subject, the theoretical basal energy requirement (BER) was calculated using the Harris-Benedict equation (Harris and Benedict, 1919):

BER (males) = 66.47 + 13.76(W) + 5.00(H) - 6.76(A)

(where W=Weight in kg; H=Height in cm; and A=Age in years)

3.5 Data Analysis

3.5.1 Taste Perception Data

Taste intensity and pleasantness perception were measured by ME. Although zero ratings are usually not allowed, zero ratings were permitted when a subject could not detect the presence of the tastant in the samples or if the sample was perceived to be extremely unpleasant. In this study, these zero ratings were replaced by a number derived from multiplying the lowest estimate (other than zero) ever given by the subject for an intensity or pleasantness rating for the specific tastant by 0.1 (Moskowitz, 1970a and 1970b). Twenty of the 4,320 intensity ratings were zeros (given by 3 elderly and 3 young subjects). Forty-six of the 4,320 pleasantness ratings were zeros (given by 4 elderly and 13 young subjects).

Intensity Data

Taste intensity responses for each of the sixty (60) subjects were examined by analyzing the ratings given to the six tastant concentrations of each of the taste qualities (sourness, saltiness) in each of the two systems (aqueous, food). For data analyses, individual mean magnitude estimates were transformed to logarithms to linearize the relationships between ratings and actual concentrations. For sourness, the six CA concentrations of 3, 6, 12, 18, 24 and 36 x10-3M are equal to -2.5, -2.2, -1.9, -1.8, -1.6 and -1.4M in log values; for saltiness, the six NaCl concentrations of 20, 40, 80, 160, 320 and 640 x10-3M are equal to -1.7, -1.4, -1.1, -0.8, -0.5 and -0.2M in log values.

For each of the two age groups, mean values of the 3 responses (replicates) per subject for each intensity measurement were computed and used for the estimation of mean group values for statistical analyses. The average group values presented in the tables are geometric means calculated as antilogarithms of the average log of mean individual intensity estimates. For each concentration of each tastant quality in each system, log mean intensity estimates were compared between the elderly and young men using analyses of variance (ANOVA). For each concentration of each tastant quality in each age group, log mean intensity estimates for aqueous and food systems were analyzed by ANOVA. Log mean intensity estimates of all six concentrations were used in ANOVA to determine the interaction effects of concentration with either age or medium. Coefficients of variation were calculated to study the interindividual consistency in mean intensity ratings for each of the six concentrations. To determine whether variances within groups were homogeneous, the test for homogeneity of variance was applied.

Indices of taste perception were obtained by regressing mean taste intensity ratings on the six CA and six NaCl concentrations. For each of the sixty (60) subjects, linear regression coefficients (slopes) were computed for each of the four combinations of tastant and system: CA in aqueous and in food systems, and NaCl in aqueous and in food systems. Slopes and intercepts were also calculated using normalized values (ie. mean individual magnitude estimates of intensity were normalized to the reference concentration modulus of 10). However, the conclusions were essentially the same for the normalized values as for the non-normalized data and therefore, results presented are derived from analysis using non-normalized data.

Pleasantness Data

Except for regression analysis (ie. taste pleasantness on concentration) which were not calculated, the same statistical analyses used for the intensity data were applied to the pleasantness data.

3.5.2 Dietary Data

For each of the 60 subjects (30 elderly and 30 young), the dietary intakes for 23 nutrients were obtained for each recalled or recorded day. For each subject, the daily nutrient intake with and without vitamin/mineral supplements was computed by averaging across the intake of the number of days studied. Mean nutrient intakes with and without supplements, percent risks of nutrient deficiency with and without supplements, and nutrient density without supplements were compared between the elderly and young using the Student's t-test.

3.5.3 Subject Profile Data

For each subject, data on previous smoking habits and medication were collected from the profile questionnaire. Subjects were classified into groups according to previous smoking habits as follows: never smoked, smoked lightly (one to 11 cigarettes per day), smoked moderately (12-24 cigarettes per day) and smoked heavily (25 or more cigarettes per day). Information about drugs taken per individual at the time of the study was used to classify subjects for the use of antihypertensives, cardiovascular drugs, and analgesics. Cardiovascular drugs included cardiotonic, antiarrythmic, antianginal and coronary vasodilator agents. Elderly subjects were classified according to wearing of dentures as follows: no dentures, partial dentures, one arch, and both arches. Height in centimeters was used as a variable in the statistical analyses for the study of interrelationships between taste perception data and dietary parameters.

3.5.4 Relationships Between Taste Perception Data and Dietary Data

The interrelationships between taste perception data and nutrient data were evaluated. Using the scatterplot technique (Chenier, 1980 and Cleveland and Kleiner, 1975), mean individual slopes of taste intensity functions for CA and NaCl in aqueous and food systems were plotted against mean individual percent risks of nutrient deficiency.

Pearson correlation coefficient were calculated between mean taste intensity slope values and 1) average nutrient intake, and 2) average percent risk of nutrient deficiency. Partial correlation coefficients were computed between mean taste intensity slopes values and 1) average nutrient intake, and 2) average percent risk of nutrient deficiency by controlling for Calories, protein, previous smoking habits, medication, dentures and height.

For each age group, stepwise multiple regression analysis was applied to the data to describe the relationship between each taste intensity function and dietary intake. The average slopes of taste intensity functions for sourness and saltiness in aqueous and food systems (dependent variable) were each regressed on the following independent variables: 1) selected demographic variables (previous smoking, medication, height and dentures) and 2) the risks of nutrient deficiency (index of overall nutritional risk, protein, riboflavin, folacin, vitamin B_{12}, vitamin B_6, ascorbic acid, vitamin A, vitamin D and calcium) and 3) nutrient intakes (Calories, protein, thiamin, riboflavin, folacin, vitamin B_{12}, vitamin B_6, ascorbic acid, vitamin D, calcium, iron zinc and dietary fiber).

Stepwise multiple regression was calculated using the linear model $Y = B_0 + B_1X_1 + B_2X_2 + \ldots B_kX_k + e$ where Y = the dependent variable, B_0 = the constant, B_k = the partial regression coefficient of X_k, X_k = independent variable and e = a random error term. Independent variable(s) are entered into the equation in order of the highest partial correlation coefficient between that variable and the dependent variable. The additional percent of total variance accounted for by an independent variable is conditional to the preceding independent variables entered into the equation. That is, X_1 is entered into the equation first and the variance of Y accounted for by X_2 is additional to the variance of Y explained by X_1. Part of the predicting effect of X_1 may be removed when X_2 enters the equation if X_1 and X_2 are correlated. To gain insight into possible relationships from stepwise multiple regression, the critical F-value for entry into the regressions was set at the significance level of $p<0.100$. Though each variable entered into the equation met the $p<0.100$ criteria, each variable was not significant at the $p<.05$ level.

Canonical correlations were calculated to determine the relationships between multiple measures of taste intensity response for sourness and saltiness and dietary intake variables (mean nutrient intake and mean percent risk of nutrient deficiency).

4. RESULTS

4.1 Subject Characteristics

The characteristics of the elderly and young groups are given in Table 3. Each group was comprised of thirty men. The mean age of the elderly was 73.2 years while that of the young was 24.7 years. The elderly men were significantly shorter ($p<0.001$) than the young. No significant difference was found in body weights between the two age groups.

For the elderly, the mean value for mid-arm muscle circumference was significantly lower ($p<0.01$) and the mean value for triceps skinfold thickness was significantly greater ($p<0.01$) than those for the young. Compared to reference values for the Canadian population (Jette, 1983), the mean mid-arm muscle circumference measurements were 104 and 105 percent and the mean triceps skinfold thickness values were 132 percent and 110 percent, respectively, of the corresponding standards for elderly and the young.

Subject profile data including demographic factors as well as some variables affecting taste perception and dietary intake collected from the subject profile questionnaires are shown in Table 4. Information on the use of vitamin/mineral supplements and medications is given in Table 5. Nine (30%) of the elderly subjects and 7 (23%) of the young subjects used vitamin/mineral supplements regularly. Of the regular supplement users in the elderly group, 2 (22%) took only one supplement while 3 (33%) took five or more supplements. Of

Table 3: Characteristics of the elderly and young groups

Characteristics	Elderly	Young
Number of subjects	30	30
Age (years)	73.2 ± 0.5[1]	24.7 ± 0.5***
Height (cm)	173.3 ± 1.0	179.0 ± 1.1***
Weight		
(kg)	76.0 ± 1.7	76.5 ± 1.5
(RBW[2])	111.8 ± 2.1	107.3 ± 1.7
MAC[3]		
(cm)	30.4 ± 0.5	30.8 ± 0.4
(% of standard MAC)	105.8 ± 1.7	101.8 ± 1.5
MAMC[4]		
(cm)	26.0 ± 0.4	27.7 ± 0.4**
(% of standard MAMC)	103.8 ± 1.8	104.8 ± 1.5
TSF[5]		
(mm)	13.9 ± 0.8	9.8 ± 1.0**
(% of standard TSF)	132.0 ± 7.8	110.4 ± 10.8

[1] Mean ± standard error of mean
[2] Relative Body Weight
[3] Mid-Arm Circumference
[4] Mid-Arm Muscle Circumference
[5] Triceps Skinfold Thickness
,* Significant at $p<0.01$, 0.001 respectively

Table 4: Subject profile data

Profile	Elderly[1]	Young[1]
Education		
up to grade 6	6[2]	0
grade 7 to grade 12	5	3
career preparation	9	6
post-secondary	10	21
Income (self and spouse)		
less than $20,000	12	17
greater than $20,000	17	12
not released	1	1
Present Smoking Habit		
never	28	26
light (1 cigarette/day)	0	2
moderate (12 cigarettes/day)	1	1
heavy (25+ cigarettes/day)	1	1
Previous Smoking Habit		
never	13	26
light (1 cigarette/day)	5	1
moderate (12 cigarettes/day)	3	2
heavy (25+ cigarettes/day)	9	1
Alcohol Consumption		
none	18	2
occasional	8	19
regular (1 drink/day)	4	2
frequent (greater than one drink/day)	0	7
Dentures		
none	12	29
partial	1	0
upper or lower arch	7	1
both arches	10	0
Company at Meals		
alone	4	7
one other peson or more	26	23
Salt Added at Table		
none	15	16
small	8	10
fair	6	4
a lot	1	0

[1] n=30

[2] Number of individuals

Table 5: Vitamin/mineral supplement use and medication use among subjects

Supplement/Medication	Elderly[1]	Young[1]
Vitamin and Mineral Supplement Use		
regular use	9[2]	7
irregular use	4	3
Product Use		
single nutrient product	8	5
multiple vitamin	5	2
multiple vitamin + minerals	4	6
All medications	18	3
Antihypertensives	8	0
Cardiovascular drugs	6	0
Analgesics	5	0

[1] n=30
[2] Number of individuals

the regular supplement users in the young group, 2 (29%) took only one supplement while another 2 (29%) took three or more supplements. The elderly used the single nutrient supplement most frequently [8 (89%) of the regular supplement users] while the young used the multivitamin/mineral supplement most frequently [6 (86%) of the regular supplement users]. For the elderly, the most commonly used single nutrient supplement was vitamin E [8 (89%) of regular supplement users]. For the young group, the most common single nutrient supplement was vitamin C [4 (51%) of regular supplement users]. The number of medications taken per individual at the time of the study ranged from zero to nine different drugs. The more commonly used medications for the elderly were antihypertensives, taken by eight subjects, cardiovascular drugs, taken by six subjects (one individual was using as many as five), and analgesics, taken by five subjects.

4.2 Taste Perception

4.2.1 Taste Intensity Data

Age Differences:

The average slopes and intercepts of the taste intensity functions for sourness and saltiness for the elderly and the young groups are presented in Table 6. Significant age-related differences were determined from ANOVA.

For sourness and saltiness in both aqueous and food systems, the average slopes and intercepts of the taste

Table 6: Mean slope and intercept values of sour and salt taste qualities for the elderly and young groups

Taste Quality	System		Elderly[1]	Young[1]
Sourness	Aqueous	Slope	0.34 ± 0.03[2]	0.68 ± 0.05***
		Intercept	1.70 ± 0.06	2.34 ± 0.10***
	Food[3]	Slope	0.21 ± 0.03	0.46 ± 0.05***
		Intercept	1.40 ± 0.06	1.90 ± 0.10***
Saltiness	Aqueous	Slope	0.39 ± 0.04	0.63 ± 0.04***
		Intercept	1.45 ± 0.04	1.67 ± 0.04***
	Food[4]	Slope	0.29 ± 0.03	0.47 ± 0.04***
		Intercept	1.33 ± 0.03	1.52 ± 0.03***

[1] n=30
[2] Mean ± standard error of mean
[3] Apple drink
[4] Chicken broth
*** Significant at $p<0.001$

intensity functions differed significantly ($p<0.001$) between the two age groups. The taste intensity slopes for the elderly and the young groups, respectively, were as follows: for sournes aqueous (0.34, 0.68), food (0.21, 0.46) and for saltiness: aqueous (0.39, 0.63), food (0.29, 0.47). For the elderly, the slopes of all of the taste intensity functions were significantly flatte[illegible] those of the young group.

Group geometric means the intensity estimates for each citric acid (CA) concentration are shown in Table 7. For the CA aqueous solutions, the elderly judged the two lowest concentrations (3mM, $p<0.001$ and 6mM, $p<0.01$) to be significantly more intense than did the young. However, the elderly rated the two highest concentrations of CA in aqueous solution to be significantly less intense (24mM, $p<0.05$ and 36mM, $p<0.001$) than did the young. Similar patterns of age-related differences were also noted in the sour food system. For apple drink samples, the elderly group rated the lowest CA concentration (3mM) to be significantly stronger ($p<0.001$) and the two highest CA concentrations to be significantly less intense (24mM, $p<0.001$ and 36mM, $p<0.001$) than did the young. Mean group taste intensity functions (log estimates) for CA in aqueous and food systems for both age groups are plotted in Figure 1. For sourness, ANOVA of the log mean individual taste intensity estimates did not indicate any significant age-related main effects; however, significant ($p<0.001$) age x concentration interactions were found for both the aqueous and food systems.

Figure 1: Log intensity estimates of citric acid in aqueous and food systems

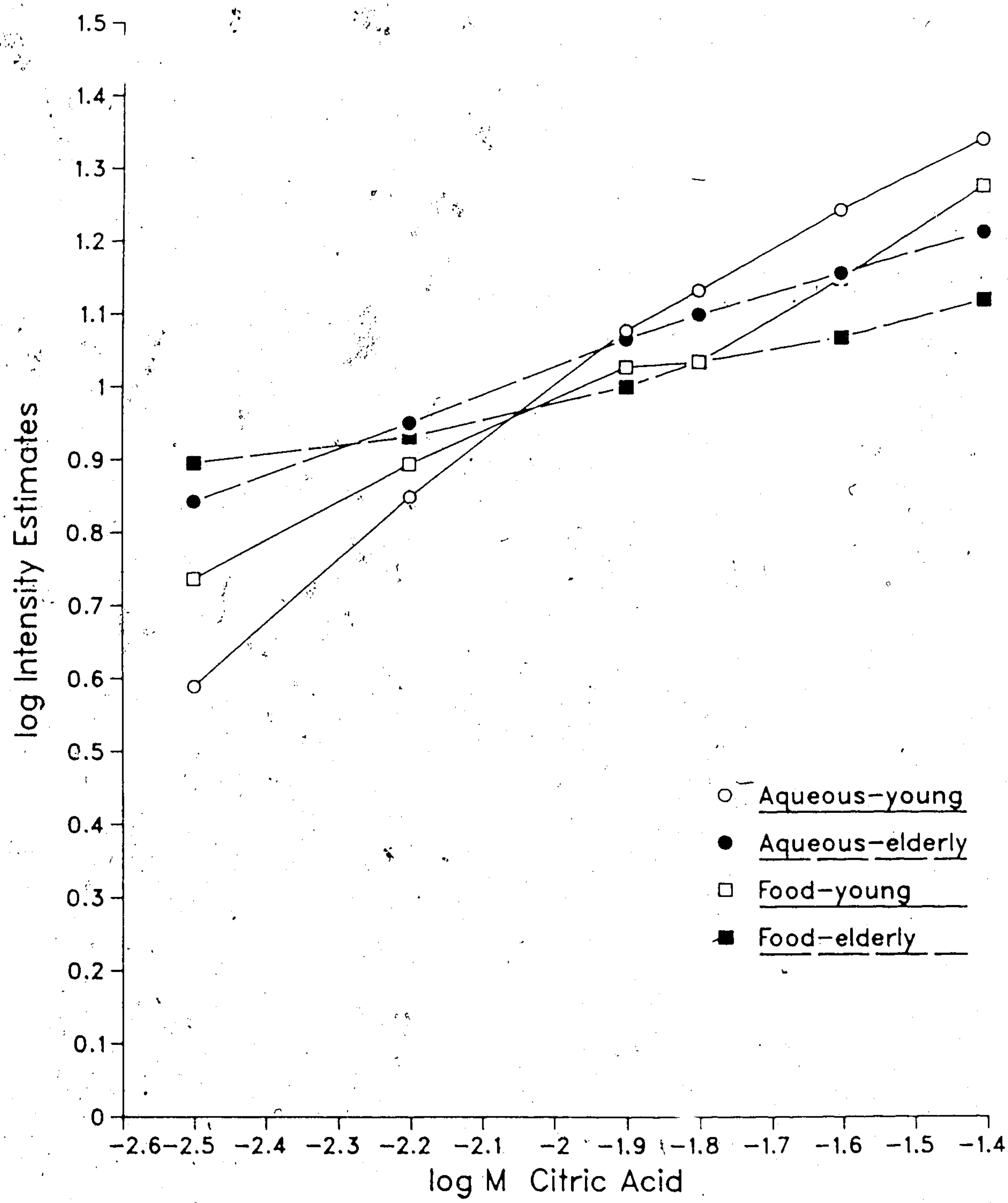


Table 7: Geometric means of intensity estimates for different concentrations of citric acid in aqueous and food systems for the elderly and young groups

Citric Acid (mM)	Aqueous		Food	
	Elderly[1]	Young[1]	Elderly[1]	Young[1]
3	7.0 (0.4)[2]	3.9*** (0.4)	7.9 (0.3)	5.4*** (0.4)
6	8.9 (0.4)	7.1** (0.4)	8.5 (0.4)	7.8 (0.4)
12	11.6 (0.5)	11.9 (0.6)	10.0 (0.3)	10.6 (0.4)
18	12.5 (0.8)	13.5 (0.6)	10.8 (0.4)	10.8 (0.4)
24	14.2 (1.0)	17.4* (1.0)	11.6 (0.5)	14.0*** (0.6)
36	16.2 (1.1)	21.7*** (1.3)	13.1 (0.7)	18.8*** (1.0)

[1] n=30

[2] Standard error of mean

*,**,*** Significant at $p<0.05$, 0.01, 0.001, respectively

Group geometric means of the intensity estimates for each sodium chloride (NaCl) concentration in each system are given in Table 8. For NaCl aqueous solutions, the elderly subjects rated the lowest concentration (20mM) to be significantly stronger ($p<0.001$) and the higher concentrations (160mM, $p<0.01$, 320mM, $p<0.05$ and 640mM, $p<0.05$) to be significantly less intense than did the young group. For the NaCl food system, the elderly group judged the lowest concentration (20mM) to be significantly stronger ($p<0.01$) and the higher concentrations (160mM, 320mM and 640mM) to be significantly less intense ($p<0.01$) than did the young subjects. Figure 2 presents the group taste intensity functions (log estimates) for saltiness in aqueous and food systems. Although ANOVA of the log mean taste intensity estimates for saltiness showed no significant main effect for age in either system, significant ($p<0.001$) age x concentration interactions were found for both the aqueous and food systems.

System Differences (Aqueous vs. Food Media):

Mean slopes and intercepts of the taste functions for sourness and saltiness in aqueous and food systems appear in Table 9. For both the elderly and young groups, the slopes of taste intensity functions for CA in aqueous solutions were significantly higher ($p<0.01$) than those for the food system. In addition, when subjects from both the young and elderly groups were combined, the average slope of the CA aqueous

Table 8: Geometric means of intensity estimates for different concentrations of sodium chloride (NaCl) in aqueous and food systems for the elderly and young groups

NaCl (mM)	Aqueous		Food	
	Elderly[1]	Young[1]	Elderly[1]	Young[1]
20	6.0 (0.4)[2]	3.2*** (0.4)	7.6 (0.4)	5.1** (0.5)
40	7.6 (0.4)	6.7 (0.4)	8.4 (0.3)	7.5 (0.4)
80	11.1 (0.4)	12.1 (0.5)	10.1 (0.4)	10.7 (0.3)
160	12.8 (0.6)	15.5** (0.8)	11.5 (0.5)	13.3** (0.4)
320	18.2 (1.5)	22.7* (1.4)	15.6 (0.9)	19.4** (0.8)
640	23.5 (3.0)	30.6* (1.8)	20.6 (1.7)	27.0** (1.7)

[1] n=30
[2] Standard error of mean
*,**,*** Significant at p<0.05, 0.01, 0.001, respectively

Figure 2: Log intensity estimates of sodium chloride in aqueous and food systems

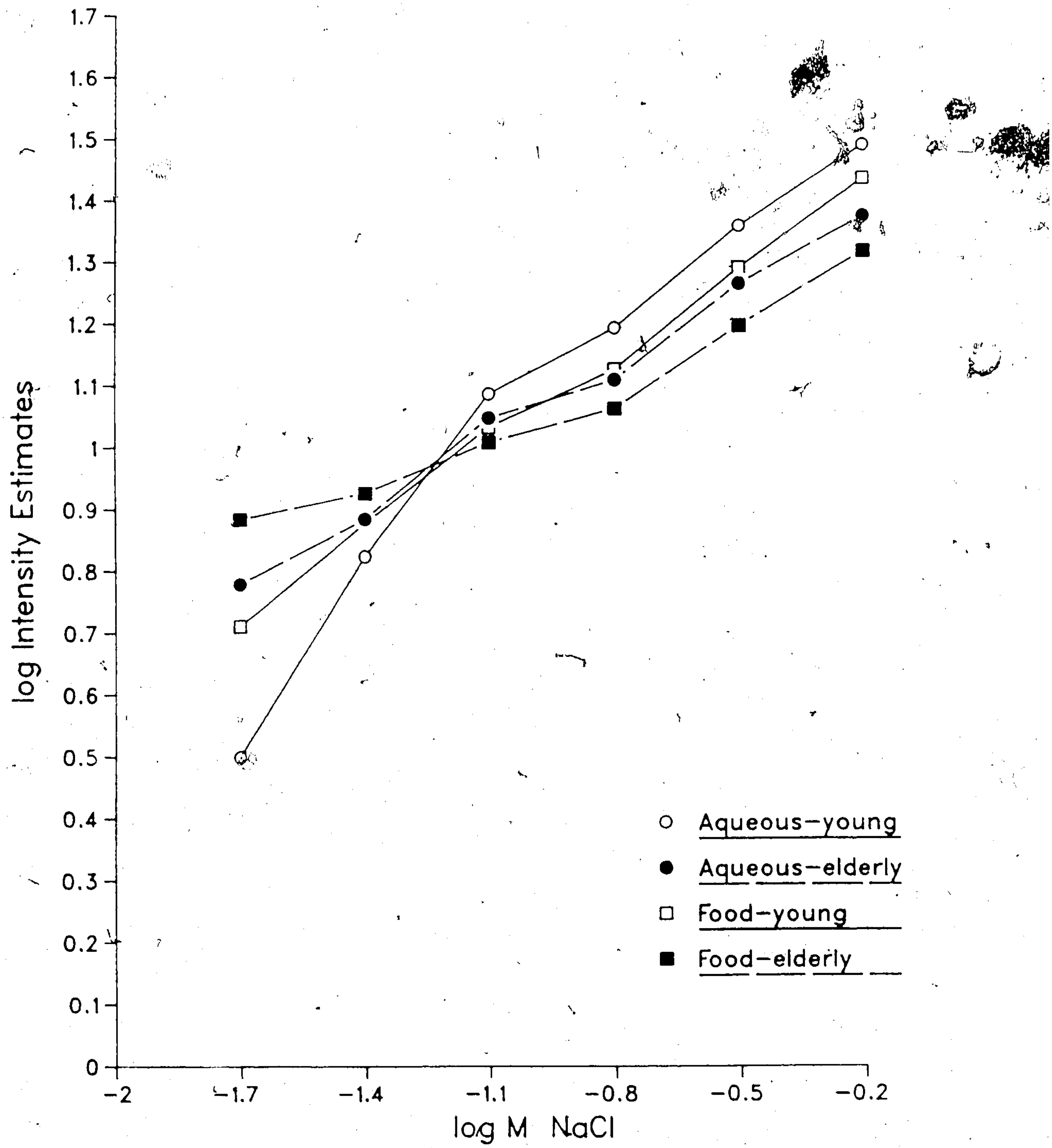


Table 9: Mean slope and intercept values of sour and salt taste qualities for aqueous and food systems

Taste Quality	Age Group		Aqueous	Food[1]
Sourness	Elderly[2]	Slope	0.34 ± 0.03[3]	0.21 ± 0.03**
		Intercept	1.70 ± 0.06	1.40 ± 0.06***
	Young[2]	Slope	0.68 ± 0.05	0.46 ± 0.05**
		Intercept	2.34 ± 0.10	1.90 ± 0.10**
Saltiness	Elderly	Slope	0.39 ± 0.04	0.29 ± 0.03*
		Intercept	1.45 ± 0.04	1.33 ± 0.03*
	Young	Slope	0.63 ± 0.04	0.47 ± 0.04**
		Intercept	1.67 ± 0.04	1.52 ± 0.03**

1 Apple drink for sourness; chicken broth for saltiness
2 n=30
3 Mean ± standard error
*, **, *** Significant at $p<0.05$, 0.01, 0.001, respectively

solution (0.51) was significantly steeper ($p<0.001$) than that of the food system (0.33).

Group geometric means of intensity estimates for CA in aqueous and food systems (Table 10) show that the four highest CA concentrations (12mM, 18mM, 24mM and 36mM) were perceived by both the elderly and the young to be significantly less intense in the food than in the aqueous system (Table 10). When the data of the young and elderly groups were combined, the average intensity estimates for the CA concentrations ranging from 12mM to 36mM showed significant differences due to media, with the corresponding concentration of sourness in apple drink samples being judged as less intense than that in the aqueous solutions. The lowest CA concentration (3mM) was rated to be significantly more intense ($p<0.05$) in the food system than in the aqueous system by the young and age-combined groups. For sourness, ANOVA did not show any significant main effect for medium in both the elderly and young subjects. However, medium x concentration interactions for sourness were significant ($p<0.001$) in both age groups (Figure 1).

For both the elderly and young groups, the mean group slope of the intensity functions for saltiness in the food system were flatter than those in the aqueous system (Table 9). When the data for the two age groups were combined for analysis, the average slope of the taste intensity function for the NaCl food system (0.[illegible]) was significantly flatter ($p<0.001$) than that of the aqueous system (0.51).

Table 10: Geometric means of intensity estimates for different concentrations of citric acid for aqueous and food systems

Citric Acid (mM)	Aqueous Elderly	Young[1]	Combined[2]	Food Elderly[1]	Young[1]	Combined
3	7.0 (0.4)[3]	3.9 (0.4)	5.2 (0.3)	7.9 (0.3)	5.4* (0.4)	6.6* (0.3)
6	8.9 (0.4)	7.1 (0.4)	7.9 (0.3)	8.5 (0.4)	7.8 (0.4)	8.1 (0.3)
12	11.6 (0.5)	11.9 (0.6)	11.7 (0.4)	10.0** (0.3)	10.6* (0.4)	10.2*** (0.2)
18	12.5 (0.8)	13.5 (0.6)	12.9 (0.5)	10.8* (0.4)	10.8*** (0.4)	10.7*** (0.3)
24	14.2 (1.0)	17.4 (1.0)	15.8 (0.7)	11.6** (0.5)	14.0** (0.6)	12.9*** (0.4)
36	16.2 (1.1)	21.7 (1.3)	18.6 (0.9)	13.1** (0.7)	18.8* (1.0)	15.8** (0.7)

[1] n=30
[2] n=60
[3] Standard error of mean
*,**,*** Significant at p<0.05, 0.01, 0.001, respectively, between systems within the same age group

Group geometric means of intensity estimates for the different NaCl concentrations in each system are given in Table 11. The lowest NaCl concentration (20mM) was perceived to be significantly more intense in the food than in the aqueous samples by both the elderly ($p<0.05$) and the young ($p<0.01$) subjects. The young group also judged concentrations of 80mM, 160mM and 320mM NaCl, respectively, in the food system to be significantly less intense ($p<0.01$, $p<0.01$, and $p<0.05$, respectively) than those in the aqueous systems. When the data of the young and the old subjects were combined for analysis, the two lowest NaCl concentrations in the food were rated as being significantly more intense (20mM, $p<0.001$ and 40mM, $p<0.05$) than those in the aqueous samples. At concentrations of 80, 160 and 320 mM NaCl, respectively, the age-combined data indicated significantly lower intensity ratings for the chicken broth than for aqueous solutions. ANOVA of log mean intensity estimates for saltiness did not show a significant main effect for medium in the elderly group, but did show a significant ($p<0.05$) effect for medium in the young group. Each age group had significant medium x concentration interaction effect for saltiness ($p<0.001$) (Figure 2).

4.2.2 Taste Pleasantness Data

Age Differences:

Group geometric means of pleasantness estimates for sourness and saltiness in both systems for both age groups are presented in Tables 12 and 13. For sourness, the only

Table 11: Geometric means of intensity estimates for different concentrations of sodium chloride (NaCl) for aqueous and food systems

NaCl (mM)	Aqueous			Food[1]		
	Elderly[2]	Young[2]	Combined[3]	Elderly[2]	Young[2]	Combined[3]
20	6.0 (0.4)[4]	3.2 (0.4)	4.4 (0.3)	7.6* (0.4)	5.1** (0.5)	6.3*** (0.4)
40	7.6 (0.4)	6.7 (0.4)	7.1 (0.3)	8.4 (0.3)	7.5 (0.4)	7.9* (0.3)
80	11.1 (0.4)	12.1 (0.5)	11.5 (0.3)	10.1 (0.4)	10.7** (0.3)	10.5** (0.2)
160	12.8 (0.6)	15.5 (0.8)	14.1 (0.5)	11.5 (0.5)	13.3** (0.4)	12.3** (0.3)
320	18.3 (1.5)	22.7 (1.4)	20.4 (1.0)	15.6 (0.9)	19.4* (0.8)	17.4** (0.6)
640	23.5 (3.0)	30.6 (1.8)	26.9 (1.8)	20.6 (1.7)	27.0 (1.7)	23.4 (1.2)

[1] Chicken broth
[2] n=30
[3] n=60
[4] Standard error of mean
*,**,*** significant at $p<0.05$, 0.01, 0.001, respectively, between systems within the same age groups

Table 12: Geometric means of pleasantness estimates for different concentrations of citric acid in aqueous and food systems for the elderly and young groups

Citric Acid (mM)	Aqueous		Food	
	Elderly[1]	Young[1]	Elderly[1]	Young[1]
3	8.3 (0.5)[2]	10.6* (0.6)	[illegible].3 (0.3)	8.1 (0.5)
6	9.2 (0.3)	9.6 (0.5)	9.7 (0.3)	9.2 (0.4)
12	7.0 (0.5)	8.5 (0.4)	9.3 (0.3)	[illegible].1 (0.3)
18	6.8 (0.5)	7.2 (0.3)	9.3 (0.3)	10.0 (0.3)
24	5.7 (0.6)	4.8 (0.6)	9.0 (0.4)	9.0 (0.4)
36	4.8 (0.6)	3.1 (0.8)	7.7 (0.6)	6.4 (0.7)

[1] n=30
[2] Standard error of mean
* Significant at $p<0.05$

Table 13: Geometric means of pleasantness estimates for different concentrations of sodium chloride (NaCl) in aqueous and food systems for the elderly and young groups

Sodium Chloride (mM)	Aqueous		Food	
	Elderly[1]	Young[1]	Elderly[1]	Young[1]
20	9.6 (0.4)[2]	10.3 (0.9)	8.3 (0.4)	6.6 (0.5)
40	9.2 (0.4)	9.9 (0.5)	8.9 (0.3)	8.3 (0.4)
80	9.2 (0.4)	8.0 (0.4)	10.5 (0.3)	10.8 (0.3)
160	8.5 (0.5)	6.9 (0.5)	9.8 (0.5)	10.[illegible] (0.5)
320	6.0 (0.8)	4.4 (0.6)	7.4 (0.8)	7.4 (0.8)
640	4.6 (0.9)	2.2** (0.6)	5.0 (0.7)	3.8 (0.8)

[1] n=30
[2] Standard error of mean
** Significant at $p<0.01$

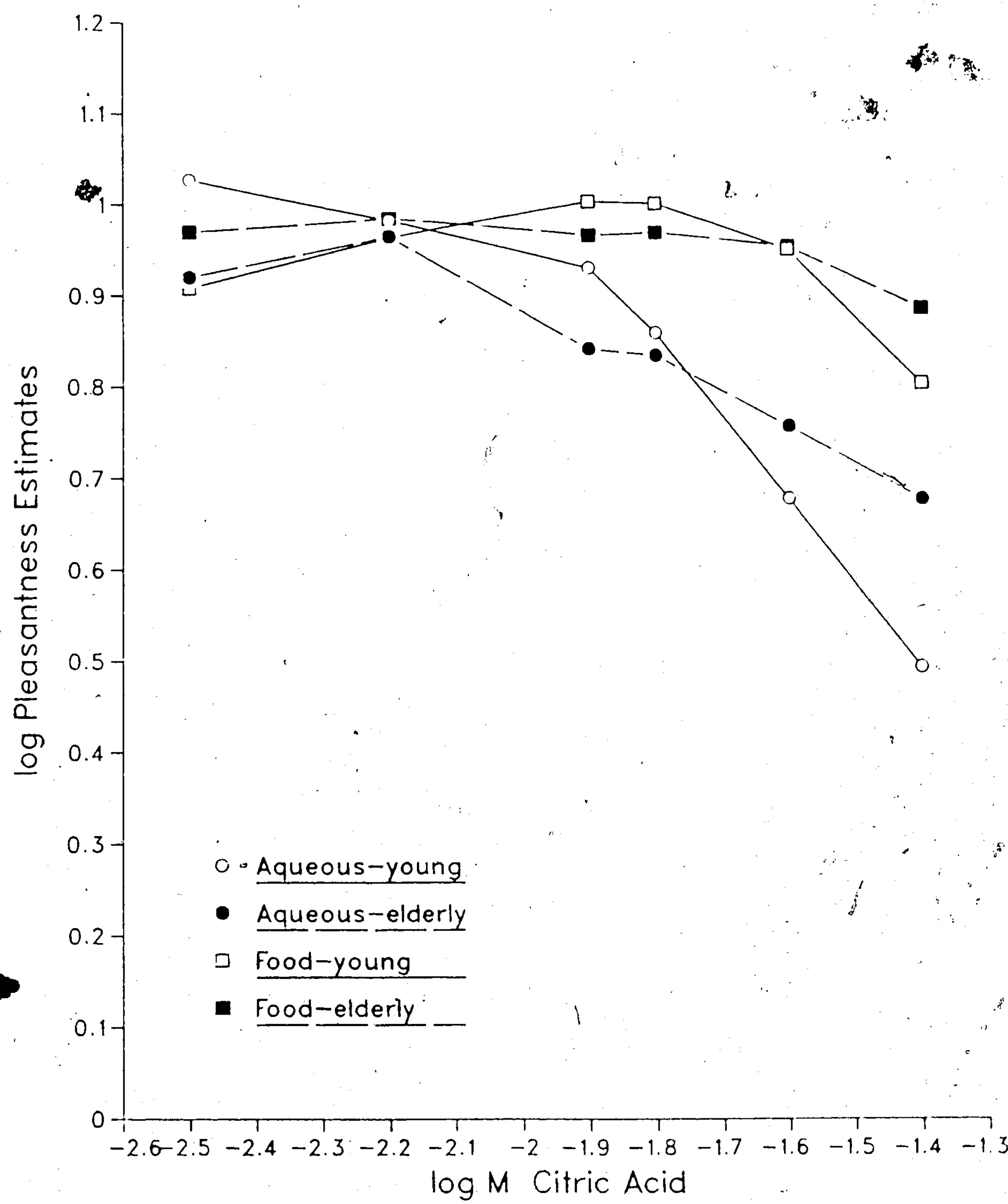
significant age difference determined was for the lowest CA concentration (3mM) in aqueous system which the elderly perceived as significantly less pleasant ($p<0.05$) than did the young subjects (Table 12). For the CA aqueous solutions, the elderly group preferred the 6mM concentration while the young rated the lowest concentrations (3mM) as most pleasant.

Group pleasantness functions (log mean individual pleasantness estimates) for sourness in each system are plotted in Figure 3. The hedonic curve for the sour aqueous system for the elderly group shows a peak at 6mM CA while the curve for the young group exhibits two decreasing monotonic trends of which the steeper decline occurs after the 12mM CA concentration. For sourness in the food system, the elderly group exhibited a relatively flat curve with a downward trend at the highest CA concentrations. The young subjects generated a parabolic relationship between pleasantness ratings and CA concentrations in apple drink (Figure 3) and preferred the middle concentrations (12mM and 18mM).

For sourness in both the aqueous and food systems, no significant main effect for age was determined in mean pleasantness response. Age x concentration interactions were significant in both the sour aqueous ($p<0.01$) and food ($p<0.05$) systems.

For saltiness in aqueous and food systems (Table 13), the only significant age difference in mean group pleasantness estimates was found at the highest NaCl concentration (640mM) in aqueous solutions. For the elderly,

Figure 3: Log pleasantness estimates of citric acid in aqueous and food systems



the most preferred NaCl concentrations in aqueous solutions were in the range of 20-160mM. For the young, the most preferred NaCl concentrations in aqueous solutions were 20-40mM. Both age groups chose 80-160mM NaCl in the chicken broth to be most pleasant.

Figure 4 shows the group functions of log pleasantness estimates for saltiness for the two systems. For the aqueous system, the average pleasantness function of the elderly showed a relatively flat curve for the first four NaCl concentrations and then a sharp decline thereafter. The pleasantness function of the young showed an almost monotonic decreasing trend in hedonic response with increasing NaCl concentrations in aqueous solution. For the NaCl food system, both age groups demonstrated parabolic pleasantness functions which peaked at 80-160mM NaCl.

ANOVA of log mean individual pleasantness estimates showed a significant main age effect ($p<0.05$) and an age x concentration interaction ($p<0.001$) for the aqueous system, but no significance for the food system (Figure 4).

System Differences (Aqueous vs Food Media):

For both age groups, there were significant differences in mean group sourness pleasantness ratings between aqueous and food systems (Table 14). Both the elderly and young subjects judged CA concentrations 12mM and higher to be significantly more pleasant in the apple drink than in comparable aqueous solutions. The young group also rated the lowest CA concentration (3mM) in the food system to be

Figure 4: Log pleasantness estimates of sodium chloride in aqueous and food systems

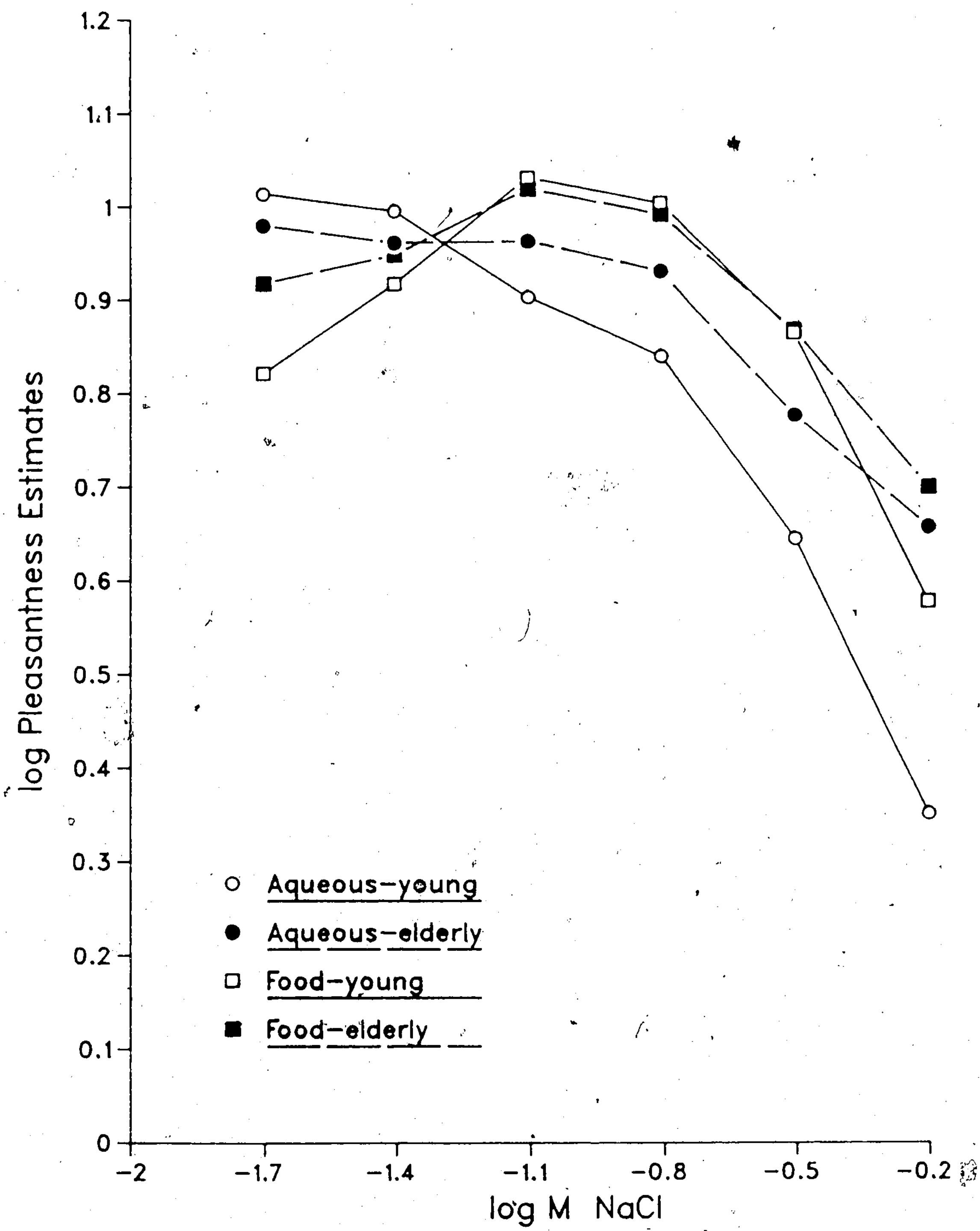


Table 14: Geometric means of pleasantness estimates for different concentrations of citric acid for aqueous and food systems

Citric acid	Aqueous			Food		
(mM)	Elderly[1]	Young[1]	Combined[2]	Elderly[1]	Young[1]	Combined[2]
3	8.3 (0.5)[3]	10.7 (0.6)	9.3 (0.4)	9.3 (0.3)	8.1** (0.5)	8.7 (0.3)
6	9.2 (0.3)	9.6 (0.5)	9.3 (0.3)	9.7 (0.3)	9.2 (0.4)	9.3 (0.2)
12	7.0 (0.5)	8.5 (0.4)	7.8 (0.3)	9.3** (0.3)	10.1** (0.3)	9.8** (0.2)
18	6.8 (0.5)	7.2 (0.3)	7.1 (0.3)	9.3** (0.3)	10.0*** (0.3)	9.8*** (0.2)
24	5.7 (0.6)	4.8 (0.6)	5.2 (0.4)	9.0** (0.4)	9.0*** (0.4)	8.9*** (0.3)
36	4.8 (0.6)	3.1 (0.8)	3.9 (0.5)	7.7* (0.6)	6.4*** (0.7)	7.1*** (0.5)

[1] n=30
[2] n=60
[3] Standard error of mean
*, **, *** significant at $p<0.05$, 0.01, 0.001, respectively, between systems within the same age group.

significantly less pleasant ($p<0.01$) than in the aqueous system. When the two age groups were combined for analyses, significant differences in group pleasantness estimates due to media were found for CA concentrations 12mM and higher. For both groups, pleasantness functions for the CA aqueous system showed a greater downward trend with increasing concentration than did the CA food system (Figure 3). For the elderly, peaks for mean CA pleasantness ratings in food system included higher concentrations (3-24mM) than that in the aqueous system (6mM). For the young, peaks for mean CA pleasantness ratings were found at higher CA concentrations (12-18mM) in food system than those in aqueous system (3-6mM).

A significant main effect for medium was found in the mean individual pleasantness response to sourness for both the elderly ($p\leq0.05$) and young ($p<0.001$) subjects. As well, a significant ($p<0.001$) medium x concentration interaction for mean individual CA pleasantness ratings was observed for the two age groups (Figure 3).

Mean pleasantness estimates for saltiness in aqueous and food systems are presented in Table 15. For the elderly, group pleasantness ratings for 20mM and 80mM NaCl in the food system were significantly ($p<0.05$) lower and higher, respectively, than that in the aqueous system. For the young group, significant media differences were found for concentrations across the entire suprathreshold range; compared to the group pleasantness estimates for the

Table 15: Geometric means of pleasantness estimates for different concentrations of sodium chloride (NaCl) for aqueous and food systems

NaCl	Aqueous			Food		
(mM)	Elderly[1]	Young[1]	Combined[2]	Elderly[1]	Young[1]	Combined[2]
20	9.6 (0.4)[3]	10.3 (0.9)	10.0 (0.5)	8.3* (0.4)	6.6* (0.5)	7.4** (0.3)
40	9.2 (0.4)	9.9 (0.5)	9.6 (0.3)	8.9 (0.3)	8.3* (0.4)	8.5* (0.2)
80	9.2 (0.4)	8.0 (0.4)	8.5 (0.3)	10.5* (0.3)	10.8*** (0.3)	10.7*** (0.2)
160	8.5 (0.5)	6.9 (0.5)	7.8 (0.4)	9.8 (0.5)	10.1*** (0.5)	10.0*** (0.3)
320	6.0 (0.8)	4.4 (0.6)	5.1 (0.5)	7.4 (0.8)	7.4*** (0.8)	7.4** (0.6)
640	4.6 (0.9)	2.2 (0.6)	3.2 (0.6)	5.0 (0.7)	3.8* (0.8)	4.4 (0.5)

[1] n=30
[2] n=60
[3] Standard error of mean
*, **, *** Significant at $p < 0.05, 0.01, 0.001$, respectively, between systems within the same age group.

corresponding NaCl concentrations in aqueous system, those for the food system were significantly lower for the two lowest NaCl concentrations (20mM and 40mM) and significantly higher for the four higher levels (80mM and above). For the elderly, peaks for mean NaCl pleasantness ratings in aqueous system included lower NaCl concentrations (20-160mM) than those in food system (80-160mM). For the young, peaks for mean NaCl pleasantness ratings in aqueous system were found at lower NaCl concentrations (20-40mM) than those in food system (80-160mM). When the data of the two age groups were combined for analyses, significant media differences were found in the average pleasantness estimates for all the NaCl concentrations except 640mM NaCl.

For both the elderly and young subjects, the group pleasantness functions of saltiness in the food system showed parabolic relationships while those in the aqueous system demonstrated flat and downward trends (Figure 4).

For NaCl log mean individual pleasantness estimates, there were no significant main effects for either medium or medium x concentration interactions for the elderly. For the young subjects, a significant main effect for media ($p<0.01$) as well as a significant medium x concentration interaction ($p<0.001$) were found for the saltiness log pleasantness data.

4.2.3 Subject Profile Data

For each age group, the effects of demographic factors (smoking, alcohol consumption, denture wearing, salivary pH and level of income) on slopes of taste intensity functions for sourness and saltiness in aqueous and food systems were examined. For the elderly, ANOVA showed only a significant effect of previous smoking on the mean individual intensity slopes of sour aqueous solutions. Elderly subjects with a history of light smoking had higher mean CA aqueous taste intensity slopes than those for the elderly with a history of heavy smoking. For the young subjects, none of the demographic factors mentioned above had a significant effect on the taste intensity slopes of the functions studied.

4.3 Dietary Intake Data

4.3.1 Dietary Intake

Table 16 presents the average values of dietary energy intake and calculated basal energy requirement for the two age groups. The elderly had a mean daily energy intake of 2040 kilocalories, which was significantly less ($p \leq 0.001$) than that of the young group (2651 kilocalories). Mean energy intake for the elderly (26.9 kilocalories per kilogram body weight) was significantly less ($p \leq 0.001$) than that for the young (34.9 kcals/kg). For the elderly group, the average energy intake was 138 percent of the mean theoretical basal requirement as compared to 144 percent for the young group.

The average proportions of energy derived from protein, fat, carbohydrate and alcohol for the elderly and young are tabulated in Table 17. For the elderly group, an average of 14% of energy was derived from protein, 36% from fat and 48%

Table 16: Dietary energy intakes and basal energy requirements of the elderly and young groups

	Elderly[1]	Young[1]
Mean Energy Intake		
kcal/day	2040	2651***
kcal/kg	26.9	34.9***
Calculated BER[2]		
kcal/day	1484	1847***
Energy Intake		
% of BER	138	144

[1] n=30
[2] Basal Energy Requirement (calculated for actual weight)
*** Significant at $p<0.001$

Table 17: Dietary sources of food energy as a percentage of energy intake for the elderly and young groups

Nutrient	Elderly[1]	Young[1]
	% of Kcal	% of Kcal
Protein	14.0 ± 0.4	14.8 ± 0.3
Fat	36.1 ± 0.7	36.2 ± 0.8
Carbohydrate	48.5 ± 0.9	45.8 ± 1.0*
Alcohol	1.4 ± 0.4	3.3 ± 0.6*

[1] n=30

* Significant at $p < 0.05$

from carbohydrate. For the young group, the average proportions of energy derived from protein, fat and carbohydrate were 15%, 36% and 46%, respectively.

Table 18 presents mean group daily nutrient intakes (diet only). Mean intakes of the following nutrients were found to be significantly lower for the elderly than for the young: Calories ($p<0.001$), protein ($p<0.001$), total fat ($p<0.001$), total carbohydrate ($p<0.01$), starch ($p<0.001$), riboflavin ($p<0.001$), preformed niacin ($p<0.001$), vitamin B_6 ($p<0.05$), calcium ($p<0.001$), phosphorus ($p<0.001$), sodium ($p<0.001$) and zinc ($p<0.001$). For the elderly, mean intakes of folacin (188 mcg) and calcium (794 mg) were below the recommended levels of 205 mcg and 800 mg, respectively. For the young, mean intakes of all nutrients exceeded recommended levels.

Table 19 shows that the use of vitamin/mineral supplements increased mean group daily intakes of some nutrients. For the elderly, the mean intakes for folacin and calcium were increased to levels above recommendations (213 mcg and 847 mg, respectively). For the elderly, the average intakes of thiamin, riboflavin, vitamin B_6 and vitamin B_{12} were dramatically increased by supplement use and reached levels of 706%, 555%, 527% and 405% of recommendations, respectively.

Averages tend to obscure the range in individual nutrient intakes. Mean percent risk of inadequate intake was calculated using the computer program "Probability Assessment

Table 18: Mean daily nutrie[illegible] ntake (diet only) for the elderly and young g[illegible]oups

Nutrient	Elderly[1]	Young[1]
Energy (kcal)	2040 ± 75[2]	2651 ± 86***
Protein (g)	72 ± 3	100 ± 4***
Fat		
Total (g)	84 ± 4	108 ± 4***
Cholesterol (mg)	392 ± 25	426 ± 37
Carbohydrate		
Total (g)	255 ± 11	308 ± 12**
Dietary Fiber (g)	21 ± 2	20 ± 2
Sugar (g)	126 ± 7	135 ± 8
Starch (g)	110 ± 6	152 ± 6***
Thiamin (mg)	1.54 ± 0.11	1.80 ± 0.10
Riboflavin (mg)	1.61 ± 0.08	2.11 ± 0.11***
Preformed Niacin (mg)	18 ± 1	24 ± 1***
Vit B6 (mg)	1.6 ± 0.1	1.8 ± 0.1*
Vit B12 (mcg)	3.4 ± 0.5	4.5 ± 0.4
Total Folacin (mcg)	188 ± 12	220 ± 14
Ascorbic Acid (mg)	124 ± 13	144 ± 11
Vit A (RE)	1072 ± 112	1189 ± 93
Vit A (IU)	5807 ± 570	6998 ± 812
Vit D (IU)	217 ± 18	221 ± 23
Calcium (mg)	794 ± 57	1154 ± 87***
Phosphorus (mg)	1321 ± 75	1766 ± 89***
Iron (mg)	15.4 ± 0.8	17.3 ± 0.7
Sodium (mg)	2606 ± 139	3578 ± 173***
Potassium (mg)	2954 ± 219	3315 ± 157
Zinc (mg)	9.7 ± 0.5	12.5 ± 0.5***

[1] n=30
[2] Mean ± standard error of the mean
*,**,*** Significant at $p < 0.05, 0.01, 0.001$, respectively

Table 19: Mean daily nutrient intake (diet plus vitamin/mineral supplements) for the elderly and young groups

Nutrient	Elderly[1]	Young[1]
Energy (kcal)	2042 ± 76[2]	2651 ± 86***
Protein (g)	73 ± 3	100 ± 4***
Fat		
Total (g)	84 ± 4	108 ± 4***
Cholesterol (mg)	391 ± 25	426 ± 37
Carbohydrate		
Total (g)	255 ± 11	308 ± 12**
Dietary Fiber (g)	21 ± 2	20 ± 2
Sugar (g)	126 ± 7	135 ± 8
Starch (g)	110 ± 6	152 ± 6***
Thiamin (mg)	5.79 ± 1.96	2.21 ± 0.22
Riboflavin (mg)	5.66 ± 1.95	2.60 ± 0.24
Preformed Niacin (mg)	32 ± 8	26.0 ± 1.6
Vit B_6 (mg)	5.8 ± 2.0	2.2 ± 0.2
Vit B_{12} (mcg)	8.1 ± 2.8	5.2 ± 0.5
Total Folacin (mcg)	215 ± 20	226 ± 15
Ascorbic Acid (mg)	213 ± 42	178 ± 20
Vit A (RE)	1484 ± 342	1341 ± 113
Vit A (IU)	7157 ± 1324	7614 ± 907
Vit D (IU)	282 ± 43	253 ± 27
Calcium (mg)	847 ± 79	1158 ± 88*
Phosphorus (mg)	1403 ± 136	1771 ± 89*
Iron (mg)	17.2 ± 1.8	17.7 ± 0.6
Sodium (mg)	2607 ± 139	3578 ± 173***
Potassium (mg)	2958 ± 219	3315 ± 157
Zinc (mg)	13.3 ± 2.7	12.9 ± 0.6

[1] n=30
[2] Mean ± standard error of the mean
*, **, *** Significant at $p < 0.05$, 0.01, 0.001, respectively

of Nutrient Intake" (by Dr. G.H. Beaton). Table 20 presents these probability estimates of nutrient deficiencies. For the elderly group, nutrients at the greatest risk of deficiency (diet only) were folacin (49.7%), calcium (34.1%), vitamin A (26.2%), zinc (16.5%), vitamin D (8.0%), and protein (7.8%). For the young group, nutrients at the greatest risk of deficiency (diet only) were: folacin (33.3%), vitamin A (17.7%), calcium (13.8%) and vitamin D (8.8%). The use of vitamin/mineral supplements by subjects did not alter mean percent risk estimates to any great extent for either age group. For both diet alone and diet plus supplements, the elderly, compared with the young, had significantly higher index of overall nutritional risk ($p<0.05$) and higher percent risk of deficiency for the following nutrients: zinc ($p<0.01$), protein ($p<0.05$) and calcium ($p<0.05$). For diet plus supplement, the significant difference in percent risk of vitamin B_6 appeared because supplement intake reduced one young subject's percent risk from 26% (diet only) to 0% (diet plus supplement).

Presented in Table 21 are nutrient densities (mean intake per 1000 kilocalories (diet only)). All mean nutrient density values, except that for folacin in the elderly group, exceeded those calculated from Recommended Nutrient Intakes (RNI). The nutrient density of folacin was 92 mcg per 1000 kcals for the elderly which is less than 96-102 mcg per 1000 kcals calculated from the RNI for this age group. The densities for the following nutrients were significantly

Table 10: Mean percent risk[1] that observed intake is below requirement for the elderly and young groups

Nutrient	Elderly[2] Diet only	Elderly[2] Diet plus Supplements	Young[2] Diet only	Young[2] Diet plus Supplements
	(%)	(%)	(%)	(%)
Index of Overall Nutritional Risk[3]	12.4 ± 1.9[4]	11.7 ± 2.0	6.3 ± 1.4*[5]	5.9 ± 1.4*[6]
Protein	7.8 ± 3.4	7.8 ± 3.4	0.0 ± 0.0*	0.0 ± 0.0*
Thiamin	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Riboflavin	0.3 ± 0.2	0.3 ± 0.2	0.0 ± 0.0	0.0 ± 0.0
Vitamin B_6	0.0 ± 0.0	0.0 ± 0.0	1.2 ± 0.8	0.5 ± 0.2*
Vitamin B_{12}	3.4 ± 1.8	3.1 ± 1.8	0.0 ± 0.0	0.0 ± 0.0
Total Folacin	49.7 ± 7.3	46.0 ± 7.4	33.3 ± 6.9	31.1 ± 6.8
Ascorbic Acid	2.3 ± 1.4	1.6 ± 1.3	0.3 ± 0.3	0.3 ± 0.3
Vitamin A	26.2 ± 6.7	26.1 ± 6.7	17.7 ± 5.7	16.0 ± 5.6
Vitamin D	8.0 ± 4.3	5.3 ± 3.5	[illegible]	8.6 ± 4.7
Calcium	34.1 ± 7.0	33.6 ± 7.0	[illegible]	13.6 ± 5.4*
Iron	0.0 ± 0.0	0.0 ± 0.0	[illegible]	0.0 ± 0.0
Zinc	16.5 ± 5.2	16.5 ± 5.2	0.7 ± 0.4**	0.6 ± 0.4**

1 Microcomputer software package "Probability Assessment of Nutrient Intake by GH Beaton".

2 n=30

3 Calculated from sum of risk of deficiency for 12 nutrients (protein, thiamin, riboflavin, folacin, ascorbic acid, vit B_6, vit B_{12}, vit A, vit D, calcium, iron and zinc) divided by 12

4 Mean ± standard error of the mean

5 Significant difference between young and old for mean percent risk (diet only)

6 Significant difference between young and old for mean percent risk (diet plus supplements)

*,** Significant at $p < 0.05$, 0.01, respectively

Table 21: Mean daily nutrient intake (diet only) expressed as nutrient density (per 1000 Kcals)

Nutrient	Elderly[1]	Young[1]
Energy (kcal)	1000	1000
Protein (g)	35.9 ± 1.1[2]	37.4 ± 0.9
Fat		
Total (g)	41.1 ± 0.9	40.7 ± 0.9
Cholesterol (mg)	195 ± 13	160 ± 11*
Carbohydrate		
Total (g)	124 ± 2	116 ± 3*
Dietary Fiber (g)	10.0 ± 0.6	7.5 ± 0.6**
Sugar (g)	61 ± 3	51 ± 2***
Starch (g)	54 ± 2	58 ± 2
Thiamin (mg)	0.75 ± 0.03	0.68 ± 0.03
Riboflavin (mg)	0.79 ± 0.03	0.79 ± 0.03
Vit B6 (mg)	0.77 ± 0.04	0.70 ± 0.03
Vit B12 (mcg)	1.7 ± 0.2	1.7 ± 0.1
Total Folacin (mcg)	92 ± 5	83 ± 4
Ascorbic Acid (mg)	62 ± 7	55 ± 4
Vit A (RE)	517 ± 45	452 ± 36
Vit A (IU)	2800 ± 233	2671 ± 327
Vit D (IU)	107 ± 43	82 ± 8*
Calcium (mg)	386 ± 21	428 ± 26
Phosphorus (mg)	646 ± 24	664 ± 24
Iron (mg)	7.6 ± 0.2	6.6 ± 0.2**
Sodium (mg)	1276 ± 50	1362 ± 62
Potassium (mg)	1435 ± 73	1248 ± 40*
Zinc (mg)	4.8 ± 0.2	4.7 ± 0.1

[1] n=30

[2] Mean ± standard error of the mean

*,** Significant at $p < 0.05$, 0.01, respectively

greater for the elderly than for the young: cholesterol ($p<0.05$), total carbohydrate ($p<0.05$), dietary fiber ($p<0.01$), sugar ($p<0.001$), vitamin D ($p<0.05$), iron ($p<0.01$), and potassium ($p<0.05$). Despite the significant age-related differences found in mean intake values (diet only) for protein, fat, starch, riboflavin, niacin, vitamin B_6, calcium, phosphorus, sodium, and zinc (Table 18), densities of these nutrients in diet were basically the same for the elderly as for the young.

Food intakes of the subjects were also assessed in terms of average quantities of foods consumed in each food group (shown in Table 22). Both age groups have lower intakes of meat, poultry, fish and eggs, vegetables and foods primarily sugar, and higher intakes of fruit and fruit products food groups than their average Canadian counterparts. Mean intakes of dairy products for the elderly and young were similar to the reported values for the general Canadian population. Compared to the average Canadian, the elderly group consumed less cereal products and the young group consumed more. The consumption of the following food groups was significantly lower for the elderly than for the young: dairy products ($p<0.05$); meat, poultry, fish and eggs ($p<0.01$); and cereal products ($p<0.05$).

4.3.2 Subject Profile Data

Relationships between dietary parameters (percent risk of nutrient deficiency) and several subject profile characteristics were examined. For the elderly, users of

Table 22: Mean daily intake of food groups

Food group	Elderly[2]	Young[2]	NUTRITION CANADA[1] Elderly[3]	NUTRITION CANADA[1] YOUNG[4]
	(g)	(g)	(g)	(g)
Dairy Products	272 ± 31[5]	437 ± 60*	273	420
Meat, Poultry, Fish, Eggs	135 ± 7	175 ± 12**	162	285
Cereal Products	256 ± 18	323 ± 21*	314	300
Fruit and Fruit Products	340 ± 44	298 ± 31	165	244
Vegetables	213 ± 17	253 ± 18	242	344
Fats	33 ± 2	31 ± 3	24	33
Nuts and Dried Legumes	7 ± 3	11 ± 2	8	15
Food Primarily Sugar	46 ± 7	37 ± 4	56	64
Miscellaneous[6]	81 ± 18	101 ± 23	108	132
All Foods (total)	1383	1666	1352	1837

1 Food Consumption Patterns Report. Nutrition Canada.
2 n=30
3 National group: males from 20 to 39 years old
4 National group: males over 65 years old
5 Mean ± standard error of the mean
6 Include mixtures of food groups, soups, condiments and items not classified elsewhere
*,** Significant at $p < 0.05$ and 0.01, respectively, between elderly and young

vitamin/mineral supplements (n=9) had significantly lower ($p<0.05$) risk of zinc deficiency (from diet alone) than nonusers (n=21). Neither economic status nor education were significantly associated with risks of nutrient deficiency for the elderly. For the young, there was a significant relationship between higher levels of education and lower risk of vitamin A ($p<0.01$) and calcium ($p<0.05$) deficiencies.

4.4 Relationships Between Taste Perception and Dietary Intake

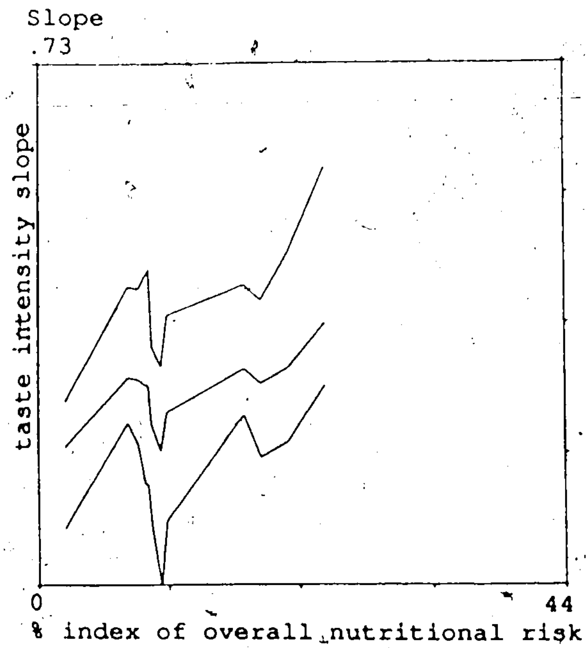
4.4.1 Graphical Presentation of Taste Intensity Slopes vs. Nutritional Risk

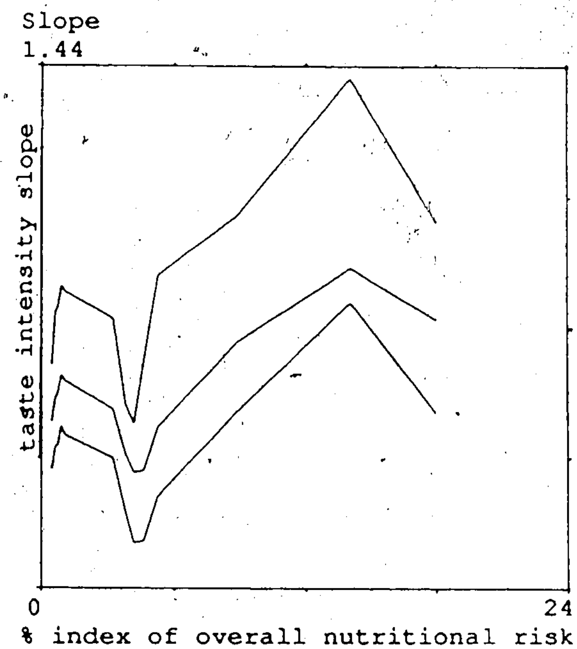
Figure 5 and 6 present scatterplots of individual slopes of taste intensity functions (sourness and saltiness in aqueous and food systems) versus the individual indices of overall nutritional risk for the elderly and the young. Figure 7 and 8 present scatterplots of taste intensity slopes for sourness and saltiness (aqueous and food systems) versus percent risk of zinc deficiency for the elderly and the young. Appendix 13 shows scatterplots of the taste intensity slopes for the tastants in each system versus the percent risk of deficiency for the following nutrients: folacin, vitamin A and calcium. On all the scatterplots presented the slope of taste intensity is represented by the Y-axis and the percent risk of nutrient deficiency (or index of overall nutritional risk) is represented by the X-axis. With the scatterplot graphical technique, three curves of moving

Figure 5: Graphical presentations[1] of slope of taste intensity vs. index of overall nutritional risk: Sourness

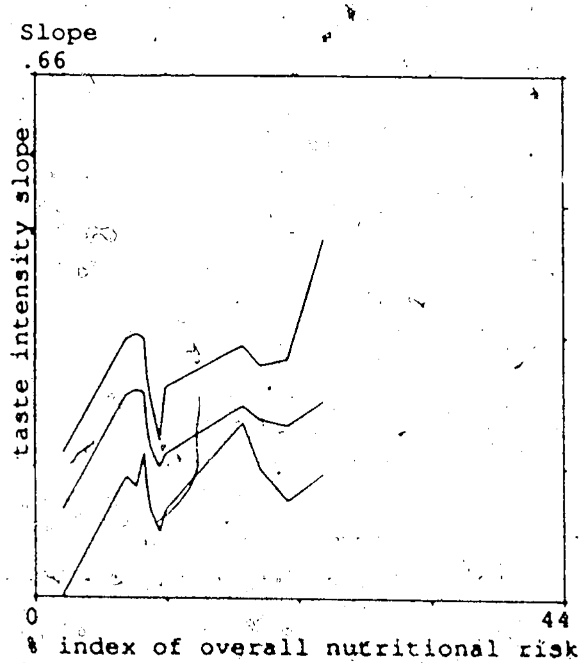
Elderly | Young

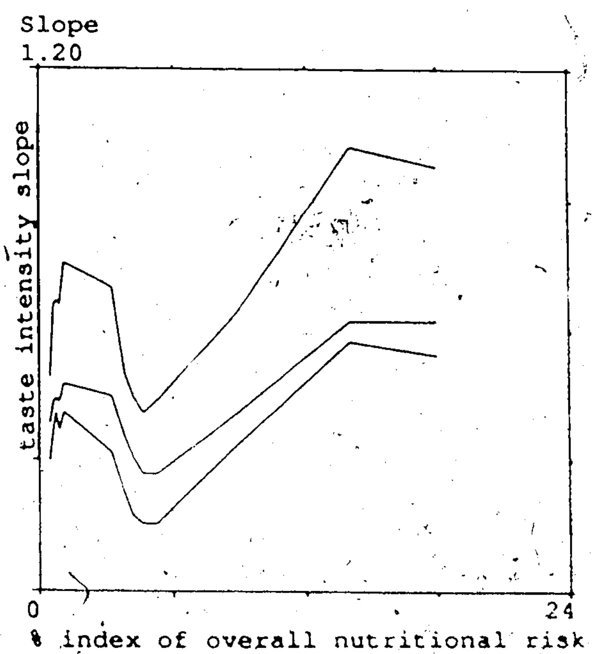
Aqueous





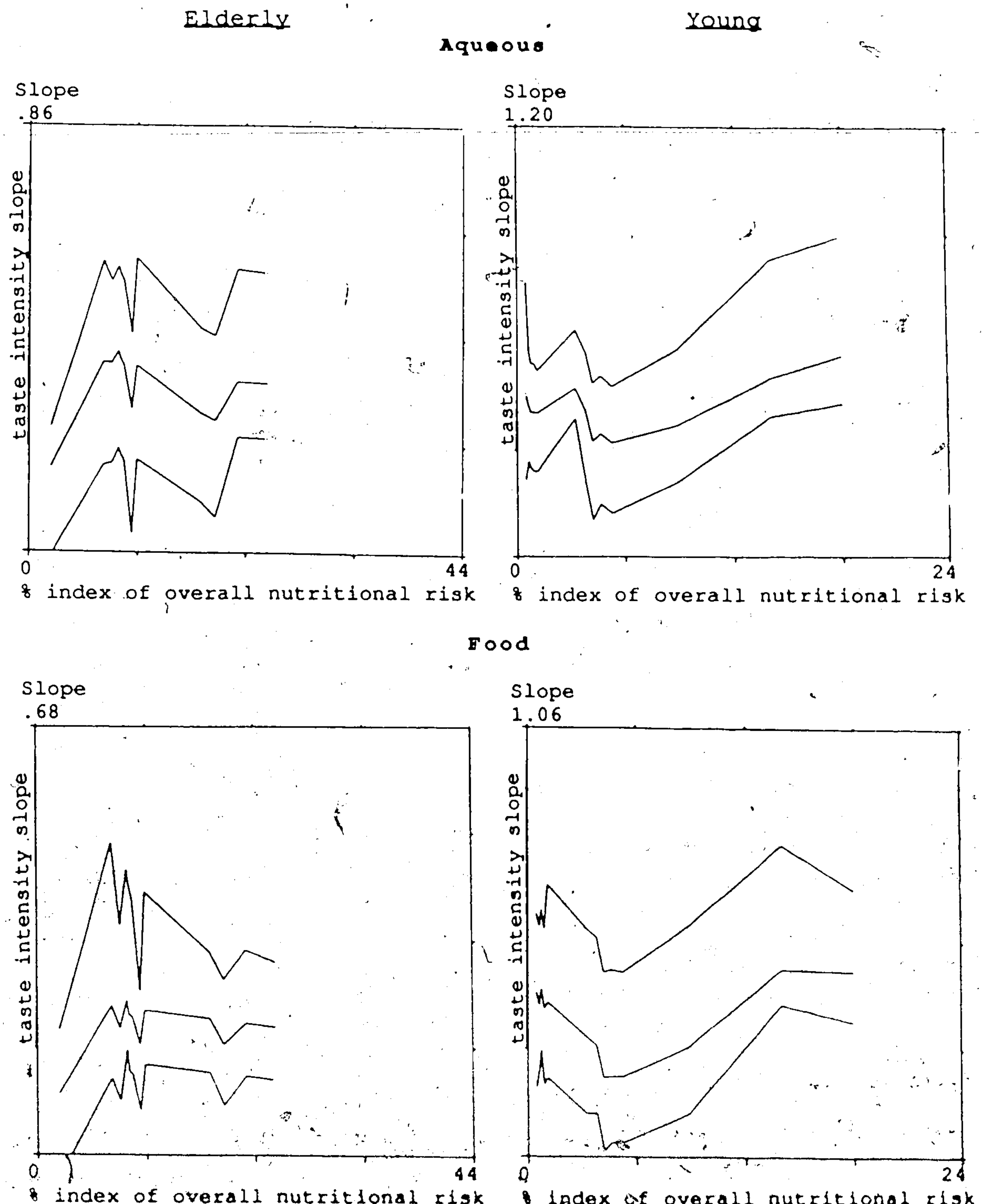
Food





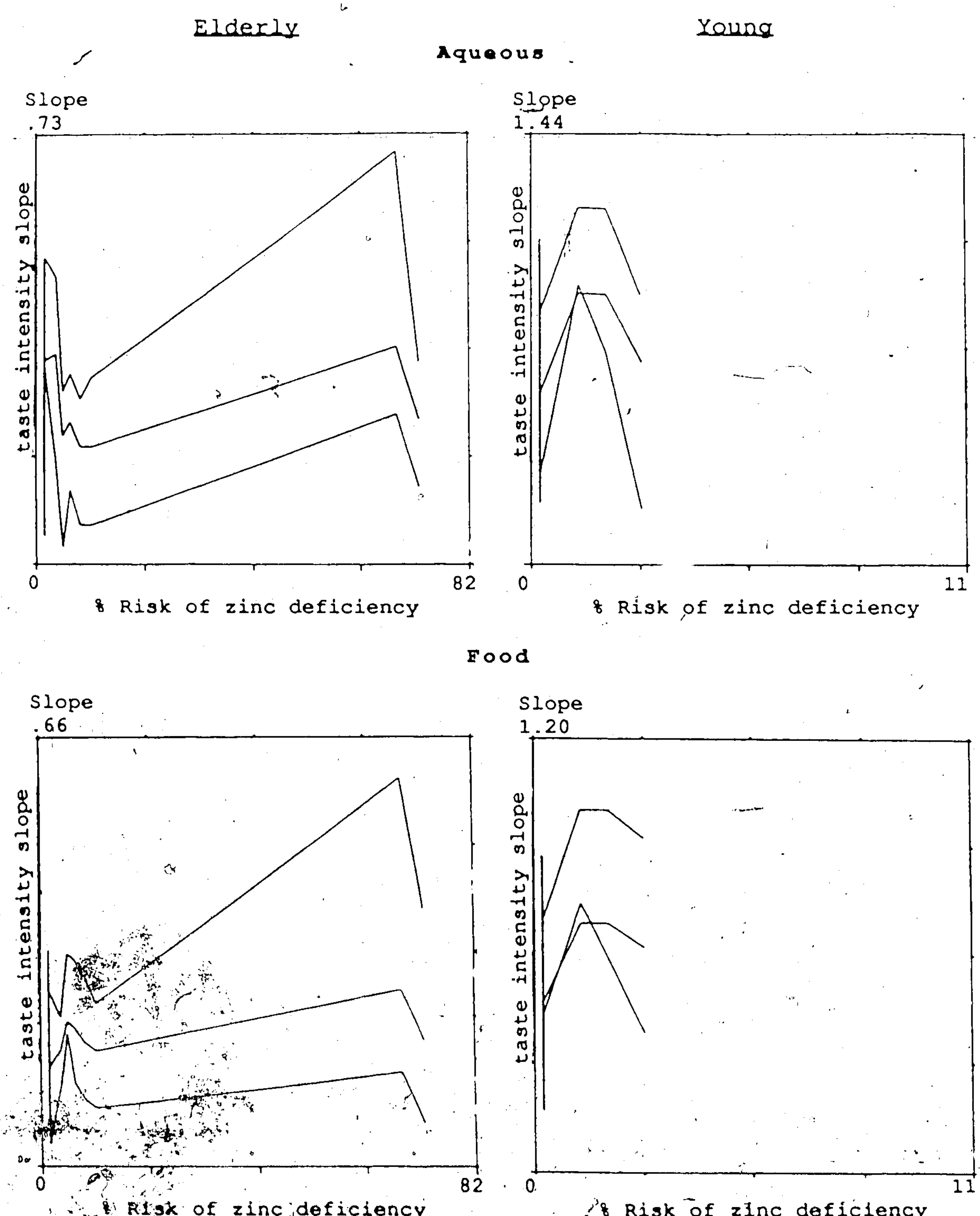
[1]showing upper semi-midmean, midmean, and lower semi-midmean

Figure 6 : Graphical presentations[1] of slope of taste intensity vs. index of overall nutritional risk: Saltiness



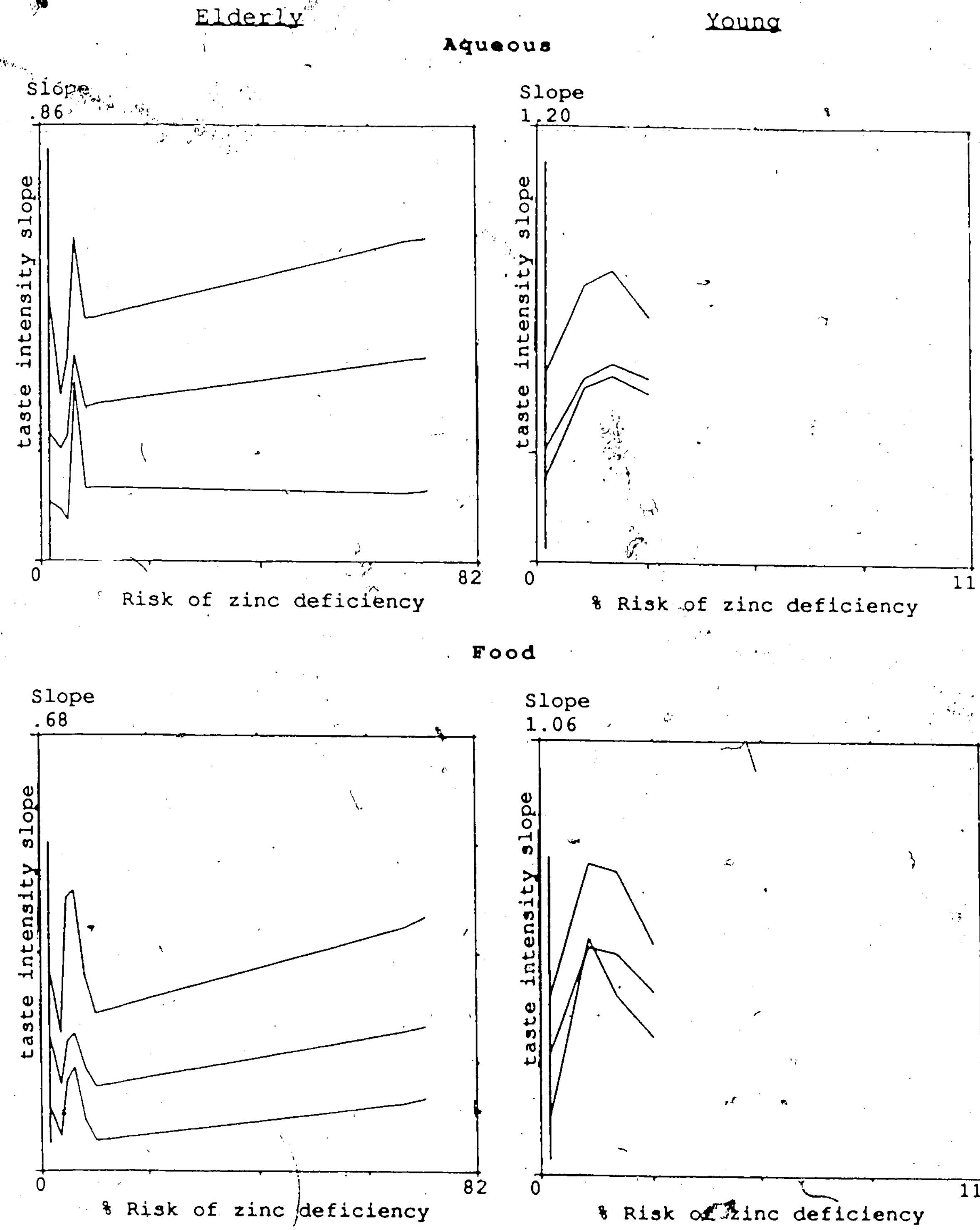
[1]showing upper semi-midmean, midmean, and lower semi-midmean

Figure 7: Graphical presentations[1] of slope of taste intensity vs. percent risk of zinc deficiency: Sourness



[1] showing upper semi-midmean, midmean, and lower semi-midmean

Figure 8 : Graphical presentations[1] of slope of taste intensity vs. percent risk of zinc deficiency: Saltiness



[1]showing upper semi-midmean, midmean, and lower semi-midmean

statistics are plotted which show the midmean, lower semi-midmean and upper semi-midmean (Cleveland and Kleiner, 1975).

For the elderly, there was a tendency for the index of overall nutritional risk to increase with an increase in the taste intensity slope for sourness (Figure 5) in both aqueous and food systems but not for saltiness (Figure 6). For the young, the index of overall nutritional risk tended to increase with an increase in the taste intensity slope for both sourness and saltiness in both aqueous and food systems. For the elderly, the trend for the percent risk of zinc deficiency to increase with taste intensity slope was greater for sourness in both aqueous and food systems than for saltiness in both systems (Figure 7 and 8). For the young, no overall trend was seen between risk of zinc deficiency and slopes of taste intensity for sourness and saltiness in both systems.

4.4.2 Taste Perception Versus Dietary Intake Data:

Table 23 presents the results of Pearson correlation analyses comparing individual slopes of taste intensity (tastants in each system) and 1) individual percent risks of nutrient deficiency (diet only) and 2) individual mean nutrient intakes (diet only). In Table 23, Pearson correlation coefficients are shown only for the statistically significant relationships. Appendix 14 Parts I and II present all Pearson correlation coefficients comparing taste intensity slopes and nutrient parameters (diet with and without supplements). Significant correlations between taste

Table [illegible]: Pearson correlation coefficients: slope of [illegible] sity vs percent risk of nutrient deficiency and nutrient intake (diet only)

Dietary Parameter	Sourness: Aqueous Elderly[1]	Sourness: Aqueous Young[1]	Sourness: Food Elderly	Sourness: Food Young	Saltiness: Aqueous Elderly	Saltiness: Aqueous Young	Saltiness: Food Elderly	Saltiness: Food Young
I. Correlation between slopes of taste intensity vs percent risk of nutrient deficiency:								
Index of Overall Nutritional Risk	0.44[2]*	[illegible]	[illegible].54**	NS	NS	NS	NS	NS
Protein	NS	[illegible]	[illegible]5*	NS	NS	NS	0.41*	NS
Thiamin	--	[illegible]	[illegible]	--	--	--	--	--
Riboflavin	0.51**	[illegible]	[illegible]	NS	NS	NS	NS	NS
Folacin	NS	[illegible]	[illegible]	NS	NS	NS	NS	NS
Vit B_{12}	0.41*	[illegible]	[illegible]	0.46*	NS	0.50**	NS	NS
Vit B_6	NS	[illegible]	[illegible]	NS	NS	NS	NS	NS
Vit C	NS	[illegible]	[illegible]	NS	NS	NS	NS	NS
Vit A	NS	[illegible]	[illegible]	NS	0.38*	NS	NS	NS
Vit D	NS	[illegible]	[illegible]	0.40*	NS	NS	NS	NS
Calcium	NS	[illegible]	[illegible]	NS	NS	NS	NS	NS
Iron	--	[illegible]	--	--	--	--	--	--
Zinc	NS	[illegible]	NS	NS	NS	NS	NS	NS
II. Correlation between slopes of taste intensity vs nutrient intake:								
Calories	NS	NS	-0.39*	-0.37*	NS	-0.41*	NS	-0.42*
Protein	NS	NS	-0.48*	-0.39*	NS	-0.44*	NS	-0.43*
Thiamin	NS	NS	-0.47**	NS	NS	NS	NS	NS
Riboflavin	NS	NS	-0.48**	-0.37*	NS	-0.39*	NS	NS
Folacin	-0.43*	NS	-0.47**	NS	NS	NS	NS	NS
Vitamin B_{12}	NS	NS	NS	NS	NS	-0.37*	NS	NS
Vitamin B_6	NS	NS	-0.46**	-0.42*	NS	NS	NS	-0.46**
Vitamin C	NS	NS	NS	NS	NS	NS	NS	NS
Vitamin A	NS	NS	-0.38*	NS	NS	NS	NS	NS
Vitamin D	NS	NS	NS	NS	NS	NS	NS	NS
Calcium	NS	NS	-0.41*	NS	NS	-0.39*	NS	NS
Iron	NS	NS	-0.56***	NS	NS	NS	NS	NS
Zinc	NS	NS	NS	NS	NS	NS	NS	NS
Dietary Fiber	-0.41*	NS	-0.51**	NS	NS	NS	NS	NS

1 n=30
2 Only significant correlation coefficients are listed
*, **, *** Significant at $p \leq 0.05$, 0.01, 0.001, respectively.
-- designates no correlations made due to singularity of variable (zero risk of this nutrient for all subjects).

intensity slopes and percent risk of nutrient deficiency (diet only) will be discussed. For the elderly, significant positive Pearson correlations were found between CA aqueous system taste intensity slopes and the index of overall nutritional risk and the percent risk of deficiency for the following: riboflavin and vitamin B_{12}. For the young, significant positive Pearson correlations were noted between CA aqueous system taste intensity slopes and percent risk of deficiency for vitamin B_{12} and vitamin D. For the elderly, significant positive Pearson correlations were found between CA food system taste intensity slopes and the index of overall nutritional risk and the percent risk of deficiency for the following: protein, riboflavin, folacin and vitamin B_{12}. For the young, significant positive Pearson correlations were observed between CA food system taste intensity slopes and percent risk of deficiency for vitamin B_{12} and vitamin D. For the elderly, a significant positive Pearson correlation was found between NaCl aqueous taste intensity slopes and percent risk of vitamin A deficiency. For the young, a significant positive Pearson correlation was noted between NaCl aqueous system taste intensity slopes and percent risk of vitamin B_{12} deficiency. For the elderly, a significant positive Pearson correlation was found between NaCl food system taste intensity slopes and percent risk of protein deficiency. For the young, no significant Pearson correlations were observed between NaCl food system taste intensity slopes and percent risks of nutrient deficiency.

Significant Pearson correlations between individual taste intensity slopes and individual mean nutrient intake (diet only) (Table 23) were also found. For the elderly, significant negative Pearson correlations were found between CA aqueous system taste intensity slopes and folacin intake as well as dietary fiber intake. For the young, no significant Pearson correlation was observed between CA aqueous system taste intensity slopes and nutrient intake. For the elderly, significant negative Pearson correlations were noted between CA food system taste intensity slopes and intakes of Calories, protein, thiamin, riboflavin, folacin, vitamin B_6 and vitamin A as well as intakes of calcium, iron and dietary fiber. For the young, significant negative Pearson correlation coefficients were found between CA food system taste intensity slopes and intakes of Calories, protein, riboflavin and vitamin B_6. For the elderly, no significant Pearson correlations were found between NaCl aqueous system taste intensity slopes and nutrient intakes and between NaCl food system taste intensity slopes and nutrient intakes. For the young, significant negative Pearson correlations were noted between NaCl aqueous system taste intensity slopes an[illegible]es of Calories, protein, riboflavin, vitamin B_{12} [illegible]m. As well, significant negative Pearson correla[illegible]s in the young were noted between NaCl food system taste intensity slopes and intakes of Calories, protein and vitamin B_6. In general, a greater number of significant correlations were noted between taste and dietary parameters for the elderly than for the young.

Partial correlation coefficients (Table 24) were obtained by controlling for previous smoking habits and medication. Table 24 shows comparisons between slopes of taste intensity for sourness and saltiness in aqueous and food systems and 1) individual percent risk of nutrient deficiency (diet only) and 2) individual mean nutrient intakes (diet only). (Appendix 14 Parts III and IV gives all partial correlation coefficients between taste intensity slopes and nutrient parameters for diet with and without supplements.) Significant partial correlations between taste intensity slopes and percent risk of nutrient deficiency (diet only) were noted. For the elderly, significant positive partial correlations were found between CA aqueous system taste intensity slopes and index of overall nutritional risk and percent risk of deficiency for riboflavin, folacin and vitamin B_{12}. For the young, significant positive partial correlations were observed between CA aqueous system taste intensity slopes and percent risk of deficiency for vitamin B_{12} and vitamin D. For the elderly, significant positive partial correlations in the elderly were noted between CA food system taste intensity slopes and index of overall nutritional risk and percent risk of deficiency for protein, riboflavin, folacin and vitamin B_{12}. For the young, positive partial correlations were found between CA food system taste intensity slopes and percent

Table 24: Partial correlation coefficients: slope of taste intensity vs percent risk of nutrient deficiency and nutrient intake (diet only)

Dietary Parameter	Sourness: Aqueous Elderly[1]	Sourness: Aqueous Young[1]	Sourness: Food Elderly	Sourness: Food Young	Saltiness: Aqueous Elderly	Saltiness: Aqueous Young	Saltiness: Food Elderly	Saltiness: Food Young
I. Correlation between slopes of taste intensity vs percent risk of nutrient deficiency:								
Index of Overall Nutritional Risk	0.53[2]**	NS	0.56**	NS	0.43*	NS	0.38*	NS
Protein	NS	NS	0.46*	NS	NS	NS	0.43*	NS
Thiamin	--	--	--	--	--	--	--	
Riboflavin	0.56**	NS	0.54**	NS	NS	NS	NS	NS
Folacin	0.43*	NS	0.41*	NS	0.45*	NS	0.47*	NS
Vit B_{12}	0.47*	0.49**	0.40*	0.47*	NS	0.51**	NS	NS
Vit B_6	NS	NS	NS	NS	NS	NS	NS	NS
Vit C	NS	NS	NS	NS	NS	NS	NS	NS
Vit A	NS	NS	NS	NS	0.48**	NS	NS	NS
Vit D	NS	0.49**	NS	0.38*	NS	NS	NS	NS
Calcium	NS	NS	NS	NS	NS	NS	NS	NS
Iron	--	--	--	--	--	--	--	--
Zinc	NS	NS	NS	NS	NS	NS	NS	NS
II. Correlation between slopes of taste intensity vs nutrient intake:								
Calories	NS	NS	-0.39*	NS	NS	-0.43*	NS	-0.40*
Protein	NS	NS	-0.50**	NS	NS	-0.46*	NS	-0.39*
Thiamin	NS	NS	-0.48**	NS	NS	NS	-0.39*	NS
Riboflavin	NS	NS	-0.54**	NS	NS	NS	NS	NS
Folacin	-0.55**	NS	-0.50**	NS	-0.38*	NS	-0.38*	NS
Vitamin B_{12}	NS	NS	NS	NS	NS	NS	NS	NS
Vitamin B_6	NS	NS	-0.50**	-0.39*	NS	NS	NS	-0.44*
Vitamin C	NS	NS	NS	NS	NS	NS	NS	NS
Vitamin A	NS	NS	-0.38*	NS	-0.38*	NS	NS	NS
Vitamin D	NS	-0.37*	NS	NS	NS	NS	NS	NS
Calcium	-0.40*	NS	-0.46*	NS	NS	NS	NS	NS
Iron	-0.42**	NS	-0.59***	NS	NS	NS	-0.43*	NS
Zinc	NS	NS	-0.38*	NS	NS	NS	NS	NS
Dietary Fiber	-0.49**	NS	-0.53**	NS	NS	NS	NS	NS

[1] n=30
[2] Only significant correlation coefficients are listed
*, **, *** Significant at $p<0.05$, 0.01, 0.001, respectively
-- designates no correlations made due to singularity of variable (zero risk of this nutrient for all subjects)

risk of deficiency for vitamin B_{12} and vitamin D. For the elderly, significant positive partial correlations were found between NaCl aqueous system taste intensity slopes and index of overall nutritional risk and percent risk of deficiency for folacin and vitamin A. For the young, a significant positive partial correlation was noted between NaCl aqueous system taste intensity slope and percent risk of vitamin B_{12} deficiency. For the elderly, significant positive partial correlations were found between NaCl food system taste intensity slopes and index of overall nutritional risk and percent risk of deficiency for protein and folacin. For the young, no sigificant partial correlations were observed between NaCl food system taste intenstiy slopes and percent risk of nutrient deficiency.

Significant partial correlations between individual taste intensity slopes and individual mean nutrient intakes (diet only) (Table 24) were also obtained. For the elderly, significant negative partial correlations were found between CA aqueous system taste intensity slopes and intakes of folacin as well as intakes of calcium, iron and dietary fiber. For the young, a significant negative partial correlation was observed between CA aqueous system taste intensity slopes and intake of vitamin D. For the elderly, significant negative partial correlations were revealed between CA food system taste intensity slopes and intakes of Calories, protein, thiamin, riboflavin, folacin, vitamin B_6 and vitamin A as well as intakes of calcium, iron, zinc and dietary fiber. For the young, the only significant negative partial correlation observed was between CA food system taste intensity slopes and intakes vitamin B_6. For the elderly, significant negative partial correlations were found between NaCl aqueous system taste intensity slopes and intakes of folacin and vitamin A. For the young, significant partial correlations were observed between NaCl aqueous system taste intensity slopes and intakes of Calories and protein. For the elderly, significant negative partial correlations in the elderly were noted between NaCl food system taste intensity slopes and intakes of thiamin and folacin as well as intake of iron. For the young, significant negative partial correlations were found between NaCl food system taste intensity slopes and intakes of Calories, protein and vitamin B_6. Thus, again, a greater number of significant correlations were noted between taste and dietary parameters for the elderly than for the young.

Table 25 presents the canonical correlations for the multiple measures of individual mean sour and salty taste intensity slopes and 1) individual percent risk of nutrient deficiency (diet only) and 2) individual nutrient intake (diet only). (Appendix 14 Part V gives canonical correlations for multiple measures of taste intensity slopes and nutrient parameters from diet with supplements.). For the elderly, significant canonical correlations were observed between CA taste intensity slopes and index of overall nutritional risk and percent risk of deficiency for protein,

Table 25: Canonical correlation: slope of sourness and saltiness taste intensity vs. nutrient risk and nutrient intake (diet only) for the elderly and the young

Nutrient Parameter	Sourness		Saltiness	
	Elderly	Young	Elderly	Young
I. Nutrient risk:				
Index of overall nutritional risk	0.56**	0.33	0.28	0.26
Protein	0.46*	0.24	0.41	0.07
Thiamin	--	--	--	--
Riboflavin	0.58**	0.06	0.10	0.14
Folacin	0.40	0.33	0.37	0.17
Vit B_{12}	0.45*	0.51*	0.05	0.57**
Vit B_6	0.10	0.14	0.24	0.29
Vit C	0.14	0.24	0.22	0.07
Vit A	0.36	0.18	0.39	0.10
Vit D	0.28	0.49*	0.02	0.35
Calcium	0.34	0.29	0.03	0.23
Iron	--	--	--	--
Zinc	0.33	0.21	0.13	0.09
II. Nutrient intake:				
Calories	0.39	0.39	0.21	0.45*
Protein	0.49*	0.40	0.23	0.48*
Fat	0.34	0.35	0.17	0.28
Carbohydrate				
Total	0.33	0.29	0.23	0.31
Dietary Fiber	0.52*	0.26	0.23	0.11
Thiamin	0.47*	0.35	0.38	0.31
Riboflavin	0.50*	0.37	0.07	0.39
Vit B_6	0.46*	0.43	0.35	0.46*
Vit B_{12}	0.30	0.37	0.35	0.39
Folacin	0.51*	0.28	0.27	0.30
Vit C	0.18	0.07	0.16	0.16
Vit A	0.38	0.17	0.36	0.33
Vit D	0.29	0.37	0.08	0.20
Calcium	0.41	0.33	0.14	0.39
Iron	0.56**	0.30	0.27	0.26
Zinc	0.36	0.33	0.12	0.38

-- indicates no canonical correlations made due to singularity of variable (no risks of deficiency for this nutrient for all subjects)

*,** significant at $p<0.05$ and 0.01, respectively

medication, dentures and height) were used as independent variables (predictors). Only those independent variables with a significant ($p<0.05$) contribution to the variance of taste intensity slopes will be discussed. For risk estimates, the nutrients that made a significant contribution to the variance of taste intensity slopes will be noted. For sourness for the elderly, all independent variables included in the equations for taste intensity in aqueous and food systems, respectively, accounted for 43% and 29% of total variance. For the elderly, percent risk of riboflavin deficiency accounted for 26% of total variance in CA aqueous system taste intensity slopes and percent risk of folacin deficiency contributed an additional 9% to the total variance after percent risk of riboflavin deficiency and smoking had been entered into the equation. For the elderly, the index of overall nutritional risk accounted for the entire 29% of total variance in CA food system taste intensity slopes. For the young, all independent variables entered into the equations for taste intensity for CA in aqueous and food systems, respectively, accounted for 42% and 44% of the total variance. For the young, mean percent risk of vitamin B_{12} contributed to 23% of total variance in CA aqueous system taste intensity slopes while percent risk of vitamin B_{12} deficiency predicted 21% of the total variance in CA food system taste intensity slopes.

For saltiness for the elderly, all independent variables entered into the equations for taste intensity slopes in

Table 26: Stepwise regression equations for sour and salty taste intensity slopes (Y), standard error of the estimate (S), and coefficient of multiple determination (R^2) for the elderly and the young (percent risk of nutrient deficiency from diet only)

Parameter	Equation[1]	S	R^2
I. Sourness			
A. Elderly:			
Slope of Sourness in Aqueous System	Y=.315 + .063(Riboflavin Risk)*** - .047(Previous Smoking)** + .001(Folacin Risk)**	.12	.43***
Slope of Sourness in Food System	Y=.109 + .008(Index of overall nutritional risk)***	.13	.29***
B. Young			
Slope of Sourness in Aqueous System	Y=-2.871 + .849(Vit B_{12} Risk)*** + .020(Height)***	.23	.42****
Slope of Sourness in Food System	Y=-2.549 + .765(Vit B_{12} Risk)*** + .017(Height)** - .122(Previous Smoking)**	.23	.44***
II. Saltiness			
A. Elderly:			
Slope of Saltiness in Aqueous System	Y=.323 + .003(Vit A Risk)*** - .043(Medication)** + .001(Folacin Risk)	.17	.40***
Slope of Saltiness in Food System	Y=-1.383 + .003(Protein Risk)** + .009(Height)	.13	.28**
B. Young			
Slope of Saltiness in Aqueous System	Y=.610 + .568(Vit B_{12} Risk)***	.18	.25***
Slope of Saltiness in Food System	Y=-1.465 + .011(Height)*	.21	.10*

[1] variables entered into equations at $p<0.10$

*, **, ***, **** significant at $p<0.10$, 0.05, 0.01 and 0.001, respectively

riboflavin and vitamin B_{12}. For the young, significant canonical correlations were found between CA taste intensity slope and percent risk of deficiency for vitamin B_{12} and vitamin D. For the elderly, no significant canonical correlations were observed between NaCl taste intensity slopes and percent risk of nutrient deficiency. For the young, a the only significant canonical correlation found was between NaCl taste intensity slopes and percent risk of vitamin B_{12} deficiency.

Significant canonical correlations were also found between taste parameters and nutrient intake. For the elderly, significant canonical correlations were noted between CA taste intensity slopes and intakes of protein, thiamin, riboflavin, vitamin B_6 and folacin as well as intakes of dietary fiber and iron. For the young, no significant canonical correlations between CA taste intensity slopes and nutrient intake were found. For the elderly, no significant canonical correlation were observed between multiple measures of NaCl taste intensity slopes and nutrient intake. For the young, significant canonical correlations were found between NaCl taste intensity slopes and nutrient intakes of Calories, protein and vitamin B_6.

Table 26 presents stepwise multiple regression equations for the the elderly and the young for slopes c⁼ taste intensity functions for CA and NaCl in aqueous and food systems. Mean percent risks of nutrient deficiency (diet only) and subject profile variables (previous smoking habits, aqueous and food systems, respectively, accounted for 40% and 28% of the total variance. In the elderly group, percent risk of vitamin A deficiency explained 15% of the total variance in NaCl aqueous system taste intensity slopes, while the percent risk of protein deficiency explained 17% of the total variance in NaCl food system taste intensity slopes. For the young, all independent variables entered into the equations for taste intensity slopes for NaCl in aqueous and food systems, respectively, accounted for 25% and 10% of the total variance. In the young group, percent risk of vitamin B_{12} accounted for 25% of total variance in NaCl aqueous system taste intensity slopes. In contrast, no percent risk of nutrient deficiency was included in the equation predicting NaCl food system taste intensity slopes for the young.

Table 27 presents stepwise multiple regression equations calculated using nutrient intake rather than percent risk of nutrient deficiency. For the elderly and the young, the slopes of taste intensity functions for CA and NaCl in aqueous and food systems and individual mean nutrient intakes (diet only) and selected subject profile variables were used. Nutrient intakes that made a significant contribution to the variance of mean individual taste intensity slopes will be considered. For the elderly, all independent variables entered into the equations for both CA aqueous and CA food systems taste intensity slopes accounted for 31% of the total variance. In the elderly group, folacin intake explained 19% of total variance in CA aqueous system taste intensity

Table 27: Stepwise regression equations for sour and salty taste intensity slopes (Y), standard error of the estimate (S), and coefficient of multiple determination (R^2) for the elderly and the young (nutrient intake from diet only)

Parameter	Equation[1]	S	R^2
I. Sourness			
A. Elderly:			
Slope of Sourness in Aqueous System	Y=.657 − .001(Folacin Intake)*** − .044(Previous Smoking)**	.14	.31***
Slope of Sourness in Food System	Y=.514 − .020(Iron Intake)***	.13	.31***
B. Young:			
Slope of Sourness in Aqueous System	Y=−2.097 + .019(Height)** − 2.5×10^{-4}(Caloric Intake)**	.25	.29**
Slope of Sourness in Food System	Y=−1.941 − .217(Vit B_6 Intake)** + .016(Height)** − .108(Previous Smoking)*	.24	.37***
I. Saltiness			
A. Elderly:			
Slope of Saltiness in Aqueous System	Y=.480 − .057(Dentures)**	.19	.14**
Slope of Saltiness in Food System	Y=−1.738 − .013(Height)** + .127(Vit B_6 Intake)** − .039(Cardiovascular Drugs)*	.13	.37***
B. Young:			
Slope of Saltiness in Aqueous System	Y=1.005 − .004(Protein Intake)**	.19	.19**
Slope of Saltiness in Food System	Y=−1.575 − .336(Vit B_6 Intake)*** + .015(Height)*** + .016(Dietary Fiber Intake)*** − 1.8×10^{-4}(Caloric Intake)** + .037(Vit B_{12} Intake)*	.15	.58****

[1] variables entered into equations at $p<0.10$

*,**,***,**** significant at $p<0.10$, 0.05, 0.01 and 0.001, respectively

slopes, while iron intake predicted 31% of the total variance in CA food system taste intensity slopes. For the young, all independent variables entered into the equations for taste intensity slopes for CA aqueous and CA food systems, respectively, accounted for 29% and 37% of the total variance. In the young group, height was entered into the equation preceded by Calorie intake; Calorie intake accounted for an additional 16% of total variance in CA aqueous system taste intensity slopes. Vitamin B_6 intake accounted for 17% of the total variance in CA food system taste intensity slope for the young.

For saltiness in the elderly group, all independent variables (subject profile variables and nutrient intakes) entered into the equations for taste intensity slopes in aqueous and food systems, respectively, accounted for 14% and 37% of total variance. For the elderly, none of the nutrient intake variables were entered into the equation predicting for NaCl aqueous system taste intensity slopes. In the elderly group, height was included in the equation before vitamin B_6 intake which contributed an additional 14% of total variance in NaCl food system taste intensity slopes. For the young, all independent variables entered into the equations for taste intensity slopes for NaCl in aqueous and food systems, respectively, accounted for 19% and 58% of total variance. In the young group, protein intake accounted for the entire 19% of the total variance in NaCl aqueous system taste intensity slopes. For the young, vitamin B_6 intake accounted for 21% of the variance, while dietary fiber intake and caloric intake, respectively, accounted for an additional 10% and 5% of total variance in NaCl food taste intensity slope.

Certain subject profile factors were found to be significant predictors of taste intensity slopes when used as independent variables (along with percent risk of nutrient deficiency) in stepwise multiple regression analyses. For the elderly, the following variables made significant contributions to the total variance in taste intensity slopes: previous smoking (34% for CA in aqueous system) and medication (32% for NaCl in aqueous system). For the young, the following variables made significant contributions to the total variance in taste intensity slopes: previous smoking (44% for CA in food system) and height (42% and 35% for CA in aqueous and food systems, respectively).

When regression equations were calculated using nutrient intake rather than percent risk of nutrient deficiency, subject profile data were again found to be significant predictors of taste intensity slopes. For the elderly, the following variables made significant contributions to the total variance in taste intensity slopes: previous smoking (31% for CA in aqueous system); dentures (14% for NaCl in aqueous system); and height (15% for NaCl in food system). For the young, height significantly accounted for 13%, 30% and 35% of total variances in taste intensity slopes for CA in aqueous, CA in food and NaCl in aqueous systems, respectively.

5. DISCUSSION

5.1 Recruitment of Subjects

An attempt to recruit a random sample of subjects from the Alberta Health Care Insurance Plan files yielded 50% of the elderly group and 10% of the young group. In order to meet the requirement of thirty participants for each age group, additional volunteers were obtained through contacts with friends and senior groups. Coleman and Krondl (1981) had also documented difficulties in recruiting a random sample of free-living elderly. In their study, 48.5% of the original objective of 400 subjects was obtained.

5.2 Taste Perception

In the present study, ME was used to assess taste perception at suprathreshold concentrations similar to the tastant levels normally found in foods. Average group taste intensity slopes for sourness and saltiness in both aqueous and food systems were flatter for the elderly than for the young men. It is possible that these differences in the use of ME by the elderly and the young may contribute to this finding. Stevens et al. (1984) postulated that young persons would use wider ranges of numbers. Restriction in the range of numbers used could result in flatter taste response slopes. Moskowitz (1977) described the regression effect as a bias that occurs when ME users restrict the range of numbers they assign to stimuli as a result of conservatism. This regression effect might occur more in the elderly, who are likely to be more conservative than the young. Robinson (1976) suggested that the regression bias could be reduced by the use of appropriate numerical examples given as part of the instructions for the use of ME. In the present study, an orientation to ME was given to each subject. During this training session, subjects were encouraged to use a wide range of numbers and it was emphasized that the use of very large as well as decimal or fractional estimates was permissible as long as the ratio of the numbers reflected their perceived sensation. In addition, hidden references were incorporated into each of the three replicates evaluated by each subject.

The slope of taste intensity function describes the relationship between perceived intensity and tastant concentration. In the present study, all group slope values of taste intensity functions (each tastant in both systems) for the elderly subjects were significantly lower ($p<0.001$) than those for the young subjects. This effect of age on suprathreshold taste perception agrees with the results of other researchers. Cowart (1983) and Weiffenbach et al. (1986) have also found the slopes of CA and NaCl taste intensity functions (in aqueous systems) to be flatter for the elderly than for the young. In the present study, the group CA intensity slopes of elderly and young for the aqueous system were 0.34 and 0.68, respectively, and those for the food system were 0.21 and 0.46, respectively. For saltiness, the group slopes of taste intensity of elderly and young for the aqueous system were 0.39 and 0.63, respectively; and those for the food system were 0.29 and 0.47, respectively. The group CA and NaCl aqueous taste intensity slopes obtained for the elderly in this study were comparable to the corresponding slopes reported for elderly men (Weisfuse et al., 1986), but somewhat lower than those reported for combined male and female elderly groups (Cowart, 1983 and Weiffenbach et al., 1986). Variations in taste intensity slopes among studies could reflect methodological differences. Intensity ratings assigned to tastant stimuli could be influenced by the range of concentrations presented to the subject (McBride, 1982 and McBride, 1985). The choice of internal standards could also have affected the range of numbers assigned by subjects (Moskowitz, 1983). In addition, separate randomization of the lowest concentrations and highest concentrations would be required to avoid adaptation effects (Hyde et al., 1981). Subject characteristics (eg. denture wearing, smoking, medication) could also account for the variations in the intensity slope values reported by different researchers.

In the present study, ratios of the group taste intensity slopes generated by the young men to those produced by the elderly men were as follows: CA aqueous system, 2.00; CA food system, 2.19; NaCl aqueous system, 1.62; and NaCl food system, 1.62. Comparison of these ratios shows that the effects of age on suprathreshold taste perception are less pronounced for saltiness than for sourness. These results differ from those of Cowart (1983) and Weiffenbach et al. (1986), who show similar taste intensity slope ratios of the young to the elderly for the two taste qualities. These researcher also reported lower CA and NaCl slope ratios (young/elderly) than those observed in the present study.

In the present study, group intensity ratings assigned to the high tastant concentrations (above 24mM CA for sourness and above 160mM NaCl for saltiness in both systems) were significantly lower in the elderly than those in the young. The intensity estimates given to the low tastant concentrations (3mM CA for sourness and 20mM NaCl for saltiness in both systems) were significantly higher in the elderly than in the young. Similar results were found by Bartoshuk et al. (1986) who reported that group taste intensity ratings for the elderly tended to rise above those for the young at low CA and NaCl concentrations and drop below those for the young at high CA and NaCl concentrations.

The present study demonstrated differences due to system (ie. aqueous and food) when the same suprathreshold tastant concentrations were judged by the subjects. For the elderly, group slopes of intensity functions were significantly higher ($p<0.05$) in the aqueous than in the food system for both sourness ($p<0.01$) and saltiness ($p<0.05$). For the young, slopes of taste functions were also higher in the aqueous than in the food system for both sourness ($p<0.01$) and saltiness ($p<0.01$). Intensity ratings assigned to high concentrations (above 12mM CA for sourness and 80-320 mM NaCl for saltiness for n=60) were lower in the food system than those in the aqueous system. Intensity ratings assigned to the low concentrations (3mM CA for sourness and 20mM NaCl for saltiness for n=60) were significantly higher in the food than in the aqueous system.

In general, there were no significant age-differences in the group pleasantness ratings for the suprathreshold concentrations of tastants used in this study. For the elderly and young, the most preferred CA concentrations in aqueous solution were 6mM and 3mM, respectively, and those in food system were 3-24mM and 12-18mM, respectively. For the elderly and the young (sex combined groups), Cowart (1983) and Murphy (1986) found that the most preferred CA concentrations in aqueous solution were in the range of 1.6mM to 3.2mM and 0.6mM, respectively. Murphy (1986) observed that the most preferred CA concentration in lemon-flavored beverage were 1mM for the elderly and the range of 0.6-2mM for the young. In the present study, plots of group pleasantness ratings for sourness in aqueous solution for the elderly demonstrated a plateau at 6mM CA while those for the young showed a negative monotonic trend. Negative monotonic trends for plots of CA aqueous pleasantness ratings for both the young and elderly have been documented by Cowart (1983) and Murphy (1986). For sourness in the apple drink, the elderly in the present study demonstrated a flat curve with slight monotonic trend while the young generated a parabolic relationship (peak at 12-18mM CA) between pleasantness ratings and sour tastant concentrations. These findings differ from those of Murphy (1986) who noted that the hedonic functions for sourness in lemon-flavored beverage yielded a parabolic curve for the elderly and a flat curve that descends at high concentrations for the young.

In the present study, the most preferred NaCl concentrations in aqueous system for the elderly and the young were 20-160mM and 20-40mM, respectively. For both age groups, the most preferred NaCl concentrations in food system were 20-160mM. Cowart (1983) reported that the most preferred NaCl concentrations in aqueous system for the elderly and the young were 100mM and 50mM, respectively. Murphy (1986) observed that for both the elderly and the young, the most preferred NaCl concentration in aqueous system was 50mM and the most preferred NaCl concentrations in vegetable juice were 100mM to 200mM. These differences in hedonic ratings for NaCl concentrations between studies may be due to the differences in the range in stimulus concentrations employed (McBride, 1985) and the different food systems used (Murphy, 1986). In the present study, for both the elderly and young, the group hedonic ratings across NaCl concentrations in aqueous system were negatively monotonic, while those in food system were parabolic. Others (Cowart (1983) and Murphy (1986)) have also observed negative monotonic trends in pleasantness ratings for NaCl in aqueous system in both elderly and young subjects. Pangborn (1970) showed that although most of her subjects demonstrated a negative monotonic hedonic curve for NaCl in aqueous solutions, two other types of pleasantness responses (parabolic and positive monotonic) were found among some individuals. Similar to the present study, Murphy (1986) also found parabolic pleasantness responses to NaCl in food system (vegetable juice) for both the elderly and the young.

In the present study, significant differences in group hedonic responses between the aqueous and food systems were found. For both age groups, pleasantness ratings for CA concentrations above 12mM in the food were significantly higher than those in the aqueous system. For both the elderly and young, plots of these group pleasantness ratings for sourness revealed flatter curves for the food system than for the aqueous system, with a tendency for the preferred concentrations to be higher for the food than for the aqueous system. Murphy (1986) reported that CA pleasantness ratings for the aqueous system were monotonic (for both elderly and young) and those for food system (lemon-flavored beverage) were parabolic (for the elderly) and flat (for the young). In the present study, significant medium effects on CA pleasantness ratings were found for both the elderly ($p<0.05$) and the young ($p<0.001$) subjects.

For saltiness, media differences in pleasantness ratings for each of the six NaCl concentrations were more obvious for the young than for the older subjects. Hedonic curves for saltiness were monotonic for the aqueous system and parabolic for the food system, with a tendency for the most preferred

NaCl concentrations to be higher for the food than for the aqueous system. Bertino et al. (1982) and Murphy (1986) also noted NaCl pleasantness curves to be monotonic for the aqueous system and parabolic for the food system. In the present study, significant differences in mean individual NaCl pleasantness ratings due to medium effects were found for the young ($p<0.01$) but not for the elderly. Differences in hedonic response between aqueous and food systems have also been reported by other researchers (Moskowitz et al., 1974 and Murphy, 1986).

5.3 Dietary Intake

In this study, a combined dietary recall (one day) and food record (three days) was employed to assess the dietary intake of each subject. Kohrs et al. (1980) used the combined recall and food record method to overcome problems encountered when one relies on the elderly to remember all foods consumed. Gersovitz et al. (1978) postulated that elderly subjects would keep a more valid food record if they had prior experience with the dietary recall. In the present study, food intake was evaluated on 3 separate occasions (one-day dietary recall, one-day food record and two-day food record). These assessments provided ample opportunities to obtain important details regarding the food products used and the methods of food preparation. Throughout the study, one trained foods and nutrition researcher collected all the dietary data and coded each food item for computer analysis using standardized coding rules. Food models (prepared according to Nutrition Canada specifications) and a dietetic scale, when necessary, were used to provide precision in estimating food portions. Food records were reviewed with the subject each time in order to collect all pertinent information regarding the foods consumed. The amount of information obtained through skilled probing in dietary recalls has been found to be significant in the elderly, especially among men (Campbell and Dodds, 1967). In the present study, information egarding the participant's food consumption pattern was collected during the initial 24-hour recall and was used in subsequent food records to probe for forgotten details. The use of more than one dietary assessment method and the evaluation of more than one day's intake in the present study allowed for the collection of reliable quantitative dietary data.

The large number of individuals needed for this study placed limitations on the number of days of dietary intake practically possible to assess. The four days of food intake (three week days and one weekend day) were assessed in order to obtain a representative estimation of usual intake. Researchers (Houser and Bebb, 1981 and Richard and Roberge, 1982) have recommended the inclusion of weekend days and week days in their true proportion in order to obtain representative dietary data. McGee et al. (1982) examined the dietary intakes of 329 men using data on 7 consecutive days and found significant differences between days of the week. These researchers (McGee et al., 1982) observed greater absolute intakes of Calories, protein, carbohydrate, fat and alcohol on weekends than on weekdays. Richard and Roberge (1982) also found increases in Calorie and alcohol intake on weekend days when compared to weekdays. In the present study considerable fluctuations were found in the dietary data of ten of the young men. Therefore, assessments of food intake of five days for 9 of these subjects and 7 days for the remaining one subject were necessary to obtain representative estimates of usual intake.

Two groups of researchers (Joer et al., 1983 and Young et al., 1953) compared 7-day food records with recorded intakes of 28 days and both observed the 7-day intake to be sufficient in estimating the nutrient consumption of groups of subjects. Young et al. (1953) found the pattern of food intake for a group of males and females aged 23 to 50 years to be stable enough that even less than 7 days' record could be used to estimate group intakes with little loss in precision. Cellier and Hankin (1963) and Marr (1971) also advocated the use of four-day records. Moreover, results of Gersovitz et al. (1978) indicated that a decline in accuracy of food records would occur if kept for longer than four days. Balogh et al. (1971) used the method of random repeated 24-hours recalls. These researchers found 4 recalls were adequate for appropriate representation of certain nutrients (eg. Calories), however, greater numbers of days of intake were needed for other nutrients. Vitamin A, ascorbic acid and calcium had the greatest variability in the diet (Joer et al., 1983 and Young et al. 1953). The assessment of dietary vitamin A status is especially difficult because this nutrient is found in relatively high concentrations in a few selected foods. Hunt et al. (1983) studied the components of variance in dietary data in a population of healthy free-living elderly. His results showed great increases in interindividual variations in cases where supplement intake was large in comparison to diet (ie. B-complex vitamins, ascorbic acid and zinc). If nutrient intake values were to be correlated with biological parameters such as taste perception, a high level of accuracy would be required to maximize statistical power and avoid false negative correlation (Hunt et al., 1983).

A method has been developed by Dr. Beaton (University of Toronto) to analyse dietary data with a statistical approach. Beaton's software package, "Probability Assessment of Nutrient Intake", has been designed to calculate percent risk of nutrient deficiency. This method takes into consideration that the Recommended Nutrient Intakes (RNI) exceed the actual requirement of almost all individuals and that the probability of an inadequate intake for a person ingesting the recommended level of a nutrient would be $P \leq 0.025$ (Anderson et al., 1982). The lower the intake is in relation to the RNI, the greater the probability that this intake is insufficient to meet the individual's actual requirement. Remarkable agreement between estimates of inadequate intakes of iron using the probability method and the incidence of nutrient inadequacy estimated from biochemical measurements of this nutrient has been demonstrated (Beaton, 1974).

In general, analyses of the dietary data collected in the present study revealed that the elderly group had a poorer mean intake than did the young group. Energy consumption in the elderly was significantly lower than that in the young. In the diet of the elderly group, the nutrients at risk of deficiency were: folacin (50%), calcium (34%), vitamin A (26%), zinc (16%), vitamin D (8%) and protein (8%). In the diet of the young subjects, the nutrients at risk of deficiency were: folacin (33%), vitamin A (18%), calcium (14%) and vitamin D (9%). The elderly had a significantly lower ($p<0.001$) protein intake than the young. It was surprising to find that some of the elderly men had poor intakes of protein; 40% of the elderly subjects were at risk of protein deficiency. Similar results have been found in studies involving healthy, free-living elderly subjects. Garry et al. (1982) and Munro (1987) found 11% and 12-15% of their elderly men, respectively, to have protein intakes below the recommended levels. Guthrie et al. (1972) reported that 32% of their elderly men had intakes of protein below two-thirds the recommended level. Nutrition Canada reported that for the senior men (65+ years), poor protein intakes were found in 25 percent and serum protein levels classified "at risk" were found in 6 percent.

For the elderly in the present study, the nutrient with the greatest risk of inadequacy was folacin (50%); 77% of the elderly men were at risk for folacin deficiency. Elsborg et al. (1983) and Garry et al. (1982) have reported that high proportions of their elderly subjects (86% and 100%, respectively) consumed less than the recommended level of folacin intake. Yearick et al. (1980) measured serum folate concentrations and found 15% of the tested elderly subjects to be in the deficiency range, but no correlation between serum folate and dietary folate was observed. Webster and Leeming (1979) reported that 24% of their free-living elderly subjects had subnormal erythrocyte folate levels Rosenberg et al. (1982) suggested that the elderly poor was a group at high risk of folate deficiency.

For the elderly in the present study, the risk of inadequacy for vitamin A was 26%; 60% of elderly men wer at risk of vitamin A deficiency. In the literature, 13 to 20% of elderly men have been reported to consume less than two-thirds of the recommended intake for vitamin A (Garry et al., 1982, Vir and Lov 979 and Yearick et al., 1980). However, Baker et al. (1979) found adequate serum vitamin A levels in his free-living elderly sample.

For the elderly in the current study, the mean intake of calcium (794 mg) was below the recommended level and was significantly less than that of the young (1154 mg). The mean daily intake of dairy products of the elderly was significantly less than that of the young.

In the present study, the mean index of overall nutritional risk was significantly higher for the elderly (12.4%) than for the young (6.3%). Twenty-seven (90%) of the elderly man had an index of overall nutritional risk greater than zero.

Vitamin/mineral supplementation raised the average intake of some nutrients to levels well above the recommended level, however, mean values of percent risk of deficiency underwent little change. These findings indicate that individuals taking supplements were not the ones who had high risks of deficiency for the particular nutrients. Similar results were documented by Garry et al. (1982) who found that the elderly who took supplements generally had higher nutrient intakes than those not taking the supplements.

5.4 Relationship Between Taste Perception and Dietary Intake

In the present study, significant Pearson, partial and canonical correlations were found between taste intensity slopes and dietary data for the elderly. In addition, nutrient variables entered into stepwise multiple regression equations were significant in predicting taste intensity slopes.

In Pearson and partial correlations, taste intensity slopes for CA and NaCl in aqueous and food systems were significantly correlated with percent risk of deficiency for a greater number of nutrients for the elderly than for the young. In addition, for the elderly, the index of overall nutritional risk was consistently correlated with taste intensity slopes for CA and NaCl in aqueous and food systems in partial correlation. For the elderly, significant partial correlations between taste intensity slopes and percent risk of nutrient deficiency included those of the following: for CA aqueous system: folacin, vitamin B_{12} and riboflavin; for CA food system: folacin, protein, vitamin B_{12} and riboflavin; for NaCl in aqueous system: folacin and vitamin A; and for NaCl in food system: folacin and protein. For the young, significant partial correlations included those between taste intensity slopes (for CA in aqueous and food systems and NaCl in aqueous system) and percent risk of vitamin B_{12} deficiency and those between taste intensity slopes (for CA in aqueous and food systems) and percent risk of vitamin D deficiency.

The Pearson and partial correlations for taste intensity slopes and nutrient intakes indicated a greater number of significant correlations for the elderly than for the young. For the elderly, the significant partial correlations found between taste intensity slopes and nutrient intake included the following: for CA in aqueous system: folacin, calcium, iron and dietary fiber; for CA in food system: folacin, vitamin A, zinc, protein, vitamin B_6, thiamin, riboflavin, Calories, calcium, iron and dietary fiber; for NaCl in aqueous system: folacin and vitamin A; and for NaCl in food system: folacin, thiamin and iron. For the young, significant partial correlations included those between taste intensity slopes (for CA and NaCl in food system) and vitamin

B_6 intake, those between taste intensity slopes (for NaCl in both aqueous and food systems) an protein and Calories, and those between taste intensity slopes (CA in aqueous system) and vitamin D.

For the elderly, there were a greater number of significant canonical correlations than for the young between the multiple measures of CA taste intensity slopes and the dietary parameters of percent risk of nutrient deficiency and nutrient intake. For the elderly, the index of overall nutritional risk was significantly correlated with the multiple measure of CA taste intensity slopes. For the elderly, significant canonical correlations were found between CA taste intensity slopes and percent risk of deficiency for vitamin B_{12}, protein and riboflavin. For the young significant canonical correlations were found between CA and NaCl taste intensity slopes and percent risk of vitamin B_{12} deficiency, and in addition, between CA and vitamin D.

For the elderly, significant canonical correlations were found between CA taste intensity slopes and intakes of protein, vitamin B_6, thiamin, riboflavin, folacin, iron and dietary fiber. For the young, significant canonical correlations were found between NaCl taste intensity slopes and intakes of protein, vitamin B_6 and Calories.

Stepwise multiple regression equations were calculated to explore the contribution of dietary and subject profile data to the prediction of taste intensity slopes for sourness and saltiness in aqueous and food systems. Percent risk of nutrient deficiency (diet only) and/or selected variables entered into the equations accounted for the following variances in taste intensity slopes for the elderly and the young, respectively: CA in aqueous system, 43% and 42%; CA in food system, 29% and 44%; NaCl in aqueous system, 40% and 25%; and NaCl in food system, 28% and 10%. For the elderly, the index of overall nutritional deficiency was significant in predicting CA food system taste intensity slopes while risk of protein deficiency was significant in predicting NaCl food slopes. In addition, for the elderly, percent risks of deficiency for riboflavin and folacin, and for vitamin A, contributed significantly to the total variance in taste intensity slopes for CA in aqueous system and for NaCl in aqueous system, respectively. For the young, the percent risk of vitamin B_{12} deficiency was significant in predicting taste intensity slopes for CA in both systems and NaCl in aqueous system.

Dietary intakes of nutrients and/or selected subject profile variables entered into the stepwise multiple regression equations accounted for the following variances in taste intensity slopes for the elderly and the young, respectively: CA in aqueous solution, 31% and 29%; CA in food system, 31% and 37%; NaCl in aqueous solution, 14% and 19%; and NaCl in food system, 37% and 58%. For the elderly, intakes of folacin, iron and vitamin B_6 were among the factors which contributed significantly to the total variance of taste intensity slopes for CA in aqueous and food systems and NaCl in food system, respectively. For the young, intake of vitamin B_6 was the factor which significantly contributed to the total variance of taste intensity slopes for both CA and NaCl in food system. For NaCl in food system in the young group, dietary fiber and Caloric intake were also important.

In the present study, all the measures of taste intensity and the index of overall nutritional risk were significantly correlated. Mattes-Kulig and Henkin (1985) studied the energy and nutrient consumption of patients with dysgeusia (taste distortion). These researchers also reported a progressive decrease in nutrient intake relative to the recommended intakes as the severity of dysgeusia increased.

For the elderly in the current study, percent risk of protein inadequacy was significantly correlated with CA food and NaCl food system taste intensity slopes in partial correlation and with the multiple measure of CA taste intensity slopes in canonical correlation. Percent risk of protein deficiency in the elderly also made a significant contribution to the total variance in the stepwise regression equation for the NaCl food system. One of the surprising findings of this research was that 40% of the elderly subjects were at risk of protein deficiency. Protein is a source of amino acids required for the synthesis of new protein in the tissue maintenance and growth. Thus, protein is required for the replacement of tissues with high turnover rates, such as taste cells.

In the present study, the risk of folacin deficiency (diet only) and dietary folacin intake for the elderly were consistently significantly correlated (partial correlation) with taste intensity slopes for both CA and NaCl in both aqueous and food systems. As well, dietary folacin intake was significantly correlated with the multiple measure of CA taste intensity slopes in canonical correlation. In stepwise multiple regression equations, risk of folacin deficiency and daily folacin intake made significant contributions to the total variance in CA aqueous system taste intensity slopes. For the elderly, mean intake of folacin was below the recommended level. In the current study, folacin was the nutrient at greatest risk of inadequacy for the elderly; 77% of the elderly men were at risk for folacin deficiency. No documented research regarding the relationship between taste function and folacin status has been found. However, taste function involves the tongue, oral structures and the associated nervous system. Folic acid is required for cell division, therefore, a deficiency of this nutrient could affect cells with rapid turnover rates, such as taste cells. Folic acid deficiency has also been documented to be associated with neurological deficits (Fox et al., 1975 and Meindok and Dvorsky, 1970).

In the elderly, percent risk of riboflavin inadequacy was significantly correlated with CA aqueous and CA food systems taste intensity slopes in partial correlation and with the multiple measure of CA taste intensity slopes in canonical correlation. Also, riboflavin intake was significantly correlated with CA food taste intensity slopes in partial correlation and with the multiple measure of CA taste intensity slope in canonical correlation. In addition, percent risk of riboflavin deficiency accounted for a significant contribution to the total variance of the multiple regression equation for the CA aqueous system. For the elderly, dietary thiamin intake was significantly correlated with CA food and NaCl food system taste intensity slopes in partial correlation and with multiple measure of CA taste intensity slopes in canonical correlation. No documented research regarding the relationship between taste function and riboflavin and thiamin has been located. However, the clinical manifestations of riboflavin deficiency include stomatitis and glossitis (Sebrell and Butler, 1938). As well, symptoms of thiamin deficiency (beri-beri) include peripheral neuropathy (Victor and Adams, 1961).

For the elderly in the present study, dietary vitamin B_6 intake was significantly correlated with CA food system taste intensity slopes in partial correlation and the multiple measure of CA taste intensity slopes in canonical correlation. In stepwise multiple regression, dietary vitamin B_6 intake was significant in predicting NaCl food system taste intensity slopes. For the elderly, the percent risk of vitamin B_{12} deficiency was significantly correlated to

CA aqueous and CA food systems taste intensity slopes in partial correlation and to the multiple measure of CA taste intensity slopes in canonical correlation. Possible relationships between taste function and vitamin B_6 (Huskisson et al., 1980) and vitamin B_{12} (Bray et al., 1976) in man have been suggested.

For the elderly in the present study, the percent risk of vitamin A deficiency was significantly correlated with NaCl aqueous taste intensity slopes (partial correlation) and dietary vitamin A intake was significantly correlated with CA food (partial correlation) and NaCl aqueous system (partial correlation) taste intensity slopes. In stepwise multiple regression equations, percent risk of vitamin A deficiency had a significant contribution to the total variance in NaCl aqueous system taste intensity slopes. Vitamin A deficiency had been associated with abnormal taste sensation in man (Hodges and Hodges, 1980 and Sauberlich et al., 1974). Vitamin A intake was lower than normal and inadequate in patients with dysgeusia (Mattes-Kulig and Henkin, 1985).

For the elderly in the present study, a greater number of correlations between dietary data and slopes of taste intensity functions were found for sour taste quality than for salt taste quality. Sour taste acuity had been reported to be affected by the wearing of dentures (Henkin and Christiansen, 1967b). However, in the present study, no correlation between denture wearing and taste intensity data for either sourness or saltiness was found.

For the elderly, previous smoking habits played a significant role in predicting taste intensity slopes for CA in aqueous system (stepwise multiple regression with percent risk of nutrient deficiency and nutrient intake). For the young, previous smoking habits played a significant role in predicting taste intensity slopes for CA in food system (stepwise multiple regression with percent risk of nutrient deficiency). For the elderly, medication in stepwise multiple regression equation contributed significantly to the total variance in taste intensity slopes for NaCl in aqueous system (stepwise multiple regression with percent risk of nutrient deficiency). Smoking had been demonstrated to affect taste acuity (Kaplan et al., 1965) and food preference (Perrin et al., 1961). Perrin et al. (1961) reported that a high proportion of smokers preferred salty and spiced foods. Baker et al. (1983) found that declines in taste acuity were associated with ill health. The use of medication to treat chronic diseases in the elderly may have direct and/or indirect effects on taste perception (Lambert, 1975, Wester, 1975 and Roe, 1985).

In summary, the present study revealed a number relationships between suprathreshold taste intensity perception and nutrient intakes in elderly men. Of special significance were the relationships found between taste intensity perception and the index of overall nutritional risk and dietary intakes of protein, folacin, thiamin, riboflavin, vitamin B_6, vitamin B_{12}, vitamin A, zinc and iron for the elderly. Despite the number of significant relationships found between taste perception and nutrient intake in the present study, further research is needed to more fully ascertain the nature and importance of these relationships.

6 CONCLUSIONS

Suprathreshold taste perception and nutrient intake were measured in 30 elderly men (70-79 years) and 30 young men (20-29 years). Relationships between taste intensity functions and nutrient intake were examined.

6.1 Taste Perception

Suprathreshold taste intensity and pleasantness ratings for sourness and saltiness in aqueous and food systems were measured using the method of magnitude estimation (ME). For sourness, samples containing citric acid (CA) in concentrations of 3, 6, 12, 18, 24 and 36 mM in aqueous solution and apple drink were assessed. For saltiness, samples containing sodium chloride (NaCl) in concentrations of 20, 40, 80, 160, 320 and 640 mM in aqueous solution and chicken broth were evaluated. The results of suprathreshold taste perception measurements are as follows:

Taste Intensity

1. The mean slopes of taste intensity functions for CA and NaCl in both aqueous and food systems for the elderly men were consistently flatter than for the young men. The slopes of taste intensity functions for the elderly and the young, respectively, were as follows: for CA in the aqueous system, 0.34 and 0.68 ($p<0.001$) and in the food system, 0.21 and 0.46 ($p<0.001$); for NaCl in the aqueous system, 0.39 and 0.63 ($p<0.001$) and in the food system, 0.29 and 0.47 ($p<0.001$).

2. Comparisons of taste intensity estimates for the six tastant concentrations were made between the elderly and the young. For both CA and NaCl in both systems, significant age x concentration interactions were found ($p<0.001$).
3. The elderly perceived the lowest CA and NaCl concentrations (3mM CA and 20mM NaCl) in each system to be significantly more intense than did the young. The elderly judged the two highest CA concentrations (24mM and 36 mM) and the three highest NaCl concentrations (160, 320 and 640mM) to be significantly less intense than did the young.
4. For both sourness and saltiness, slopes of taste intensity functions for the food systems were flatter than those for the aqueous system for both age groups. For sourness, the mean taste intensity slopes for the food system for the elderly and the young (0.21 and 0.46, respectively) were significantly flatter ($p<0.01$) than those for the aqueous system (0.34 and 0.68, respectively). For saltiness, the mean taste intensity slopes for the food system for the elderly and the young (0.29 and 0.47, respectively) were significantly flatter than those for the aqueous system (0.39 ($p<0.05$) and 0.63 ($p<0.01$), respectively).
5. Comparisons of taste intensity estimates for the six tastant concentrations were made between aqueous and food systems within each age group. For both CA and

NaCl, significant medium x concentration interactions were found ($p<0.001$) in both the elderly and young groups.

Taste Pleasantness

1. For each taste quality in each system, pleasantness ratings across the six tastant concentrations were compared between the elderly and the young. For CA pleasantness, significant age x concentration interactions were observed in both the aqueous ($p<0.01$) and food ($p<0.05$) systems. For NaCl pleasantness, significant age x concentration interactions were observed in the aqueous system only ($p<0.001$).
2. Age-related differences in the most preferred concentrations were observed for sourness in both systems but not for saltiness. For sourness, the most preferred CA concentrations were as follows for the elderly and the young, respectively: in aqueous system, 6mM and 3mM; and in food system, 3-24mM and 12-18mM. For saltiness, the most preferred NaCl concentrations were as follows for the elderly and the young, respectively: in aqueous system, 20-160mM and 20-40mM; and in food system, 80-160mM for both age groups.
3. For each taste quality, taste pleasantness ratings across the six tastant concentrations were compared between aqueous and food systems within each age group. For CA taste pleasantness, significant medium x concentration interactions ($p<0.001$ for both the elderly

and the young) as well as significant main effects for medium ($p<0.05$ for the elderly and $p<0.001$ for the young) were observed. For salty pleasantness ratings, a significant medium x concentration interaction ($p<0.001$) and a significant medium effect ($p<0.01$) were observed only for the young.

6.2 Dietary Intake

Quantitative assessment of dietary intake (four days) showed the following:

1. The mean energy intake was significantly lower ($p<0.001$) for the elderly (2040 kcals) than for the young (2651 kcals).
2. The mean daily intake (diet only) of the elderly was significantly lower than that of the young for the following nutrients: protein ($p<0.001$), fat ($p<0.001$), carbohydrate ($p<0.01$), starch ($p<0.001$), riboflavin ($p<0.001$), preformed niacin ($p<0.001$), vitamin B_6 ($p<0.05$), calcium ($p<0.001$), phosphorus ($p<0.001$), sodium ($p<0.001$) and zinc ($p<0.001$).
3. For the elderly, the mean daily dietary intakes of folacin (188 mg) and calcium (794 mg) were less than the recommended levels (RDNI).
4. The incidence of inadequate intakes was greater in the elderly than in the young. The index of overall nutritional risk was 12.4 percent for the elderly and 6.3 percent for the young. For the elderly, the

nutrients with the greatest mean percent risk of inadequacy were: folacin (50%), calcium (34%), vitamin A (26%), zinc (16%), vitamin D (8%) and protein (8%). For the young, the nutrients with the greatest mean percent risk of inadequacy were: folacin (33%), vitamin A (18%), calcium (14%) and vitamin D (9%).

6.3 Relationship Between Taste Perception and Dietary Intake

The interrelationships between taste perception and dietary intake for the elderly and the young were evaluated using Pearson, partial and canonical correlation analyses. In addition, stepwise multiple regression analysis was used to describe the relationships between slopes of taste intensity function and dietary intake.

1. Partial correlation analyses controlling for previous smoking habits and medication revealed a greater number of significant correlations between taste intensity slopes and percent risk of nutrient deficiency (diet only) for the elderly than for the young. For the elderly, partial correlation analyses showed significant positive correlations between slopes of all taste intensity functions (for each taste quality in each system) and the index of overall nutritional risk. For the elderly, significant positive partial correlations were noted between slopes of taste intensity and percent risk of deficiency for the following: for CA in aqueous system with folacin, riboflavin and vitamin B_{12}; for CA

in food system with folacin, riboflavin, vitamin B_{12} and protein; for NaCl in aqueous system with folacin and vitamin A; and for NaCl in food system with folacin and protein. For the young, taste intensity slopes for CA in aqueous and food systems and NaCl in aqueous system were significantly correlated (partial correlation) with the percent risk of vitamin B_{12} deficiency, and those for CA in both systems were significantly correlated with percent risk of vitamin D deficiency.

2. Partial correlation analyses revealed a greater number of significant correlations between CA aqueous and CA food systems taste intensity slopes and nutrient intake (diet only) for the elderly than for the young. For the elderly, significant negative partial correlations were noted between slopes of taste intensity for CA in aqueous system with intakes of folacin, iron, calcium and dietary fiber; for CA in food system with protein, folacin, thiamin, riboflavin, vitamin B_6, vitamin A, zinc, Calories, calcium, iron and dietary fiber; for NaCl in aqueous system with folacin and vitamin A; and for NaCl in food system with folacin, thiamin and iron. For the young, significant negative correlations were found for slopes of taste intensity for CA in aqueous and food systems with mean daily intakes of vitamin D and vitamin B_6, respectively. For the young, significant negative correlations were found for taste intensity slopes for NaCl in aqueous system with intakes

of Calories and protein and for NaCl in food system with intakes of Calories, protein and vitamin B_6.

3. Canonical correlations comparing multiple CA taste parameters and dietary parameters revealed a greater number of significant correlations for the elderly than for the young. For the elderly, CA taste intensity slopes and the index of overall nutritional risk was significantly significantly correlated. In addition, significant canonical correlations were noted between sour taste parameters and percent risks of protein, riboflavin and vitamin B_{12} deficiencies. For the elderly, sour taste parameters and mean daily intakes of folacin, protein, thiamin, riboflavin, vitamin B_6, iron and dietary fiber were significantly correlated. For the young, significant correlations were noted between the taste parameters and the following: percent risk of vitamin B_{12} deficiency (sourness and saltiness) and vitamin D (sourness); and mean daily intake of protein, vitamin B_6 and Calories (saltiness).

4. Multiple stepwise regression analyses were employed to determine the relative importance of dietary and subject profile factors in predicting taste intensity functions. For the elderly: for CA in aqueous system, the percent risks of riboflavin and folacin deficiencies were significant predictors; for CA in food system, index of overall nutritional risk was a significant predictor; for NaCl in aqueous system, vitamin A was important;

while for NaCl in food system, protein was significant. For the elderly, factors other than dietary variables that significantly predicted taste intensity slopes were: for CA in aqueous system, previous smoking habits; for NaCl in aqueous system, medication. For the young, the only percent risk of nutrient deficiency that significantly predicted taste intensity slopes was that of vitamin B_{12} for CA in both systems and NaCl in aqueous system. For the young, factors other than dietary variables that significantly predicted taste intensity slopes were: height for CA in aqueous system, and height and previous smoking habits for CA in food system. All considered factors together accounted for the following percentages of total variance in taste intensity slopes for the elderly and the young, respectively: CA in aqueous system, 43% and 42%; CA in food system, 29% and 44%; NaCl in aqueous system, 40% and 25%; and NaCl in food system, 28% and 10%.

5. For the elderly, nutrient intakes that were significant in predicting taste intensity slopes were: for CA in aqueous system, folacin; for CA in food system, iron; and for NaCl in food system, vitamin B_6. For the elderly, significant predicting factors other than nutrient intake were: for CA in aqueous system, previous smoking; for NaCl in aqueous system, dentures; and for NaCl in food system, height. For the young: for CA in aqueous system, Caloric intake was a signficant

predictor; for CA in food system, vitamin B_6; for NaCl in aqueous system, protein; and for NaCl in food system, vitamin B_6, Calories and dietary fiber. For the young, the significant predicting factor other than nutrient intake was height for CA in both systems and for NaCl in food system. All factors together accounted for the following percentages in total variance in taste intensity slopes for the elderly and the young, respectively: CA in aqueous system, 31% and 29%; CA in food system, 31% and 37%; NaCl in aqueous system, 14% and 19%; and NaCl in food system, 37% and 58%.

6. The index of overall nutritional risk was calculated for each individual as an average of percent risks of deficiency for twelve essential nutrients. For the elderly, the index of overall nutritional risk significantly predicted CA food system taste intensity slopes in a stepwise multiple regression equation, and was significantly correlated with all taste intensity slopes in partial correlation and with taste parameters for sourness in canonical correlation. For the young, no significant relationship were found between the index of overall nutritional risk and taste intensity slopes.

In conclusion, the findings of the present study indicate relationships between suprathreshold taste intensity perception and nutrient intakes in elderly men. Of special significance were the following nutrients: protein, folacin, riboflavin, vitamin B_6, vitamin A and iron.

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Appendix 1. Letter Sent by Alberta Hospitals and Medical Care Requesting Participation

Alberta Hospitals and Medical Care
Health Care Insurance Plan
118th Avenue and Groat Road,
Box 1360, Edmonton, Alberta,
Canada
T5J 2N3

March 15, 1985

Dear Sir/Madam:

The Department of Foods and Nutrition at the University of Alberta is studying the relationships between taste perception and the nutritional status of older men and women. They have approached the Department of Hospitals and Medical Care for assistance in recruiting people to participate in their study. The people selected include males and females in the 70-79 and 80+ age range plus control cases from the 20-29 age range.

The participant will be required to taste food samples and answer some questions about them. All samples will be foods consisting of commonly used ingredients. This information will be useful in developing, preparing and providing food of greater acceptability for elderly people.

Two researchers will make about five visits to collect the data. The participant will be asked to answer questions about food intake. Participants are free to refuse to answer any of the questions. All information given will be held in confidence and used only for research purposes. Any information on the outcome of the study will be provided to the participant as requested.

Your name has been included in a sample of the population taken from the Alberta Health Care Insurance Plan files. We shose people according to a pre-determined plan to include a broad range of people throughout the province.

If you are interested in participating in this study, which will begin soon and take an approximate period of one month, please complete the attached information sheet and return it in the enclosed postage-paid envelope. With your consent, a researcher will contact you at a later date to arrange for a personal interview.

continued ...

Appendix 1. continued

Should you have any questions about this study, please contact one of the persons at the following numbers:

Dr. Jaya Chauhan - 432-5239 or 465-5887
Ms Christina Ko - 439-4089
Ms. Susanna Ko - 439-5524

Thank you in advance for your participation.

Yours very truly,

A. V. Follett, M.D.
Senior Medical Consultant
Hospitals and Medical Care

....

NAME: ______________________ TELEPHONE: HOME: ____________
ADDRESS: ______________________ BUSINESS: ____________
____
____

I, the undersigned, agree to participate in the Taste Perception and Nutritional Status study to be carried out by the University of Alberta, Department of Foods and Nutrition. The survey information will be provided to a researcher of the University of Alberta whom I understand, through a pre-arranged appointment, will visit me.

SIGNATURE: ______________________ DATE: ______________

I do not wish to participate in the above study.

SIGNATURE: ______________________ DATE: ______________

continue ...

Appendix 2. Part I. Subject Profile Questionnaire

SUBJECT NO: ____________ DATE: ____________
NAME: ____________ ADDRESS: ____________
PHONE: ____________ HRS. TO AVOID CONTACTING: ____________
SEX: M ______ F ______ ETHNIC ORIGIN: ____________

I. Health Status

1. Would you say that your health in general is
   Very Good ___ Good (average) ___ Poor ___

2. Mobility of subject: Ambulatory ___ Non-ambulatory ___
   Limited (eg. with walker) ___ Other ___ (describe) _____
   ____

3. Have you had any medical condition within the past 5 years which has caused changes in diet or changes in exercise and activity patterns?
   Yes ___ No ___
   (If 'yes' please specify)
   a) Medical condition: Note unusual appearance of
      skin ____________ eyes ____________
      teeth ____________ hair ____________
      gums ____________ nails ____________
      lips ____________ legs ____________
   b) Diet change (eg. low cal, diabetic, Na restricted, modified fat, etc.)
   c) Activity change
   d) When did it occur?
      present ___ within past year ___ 1-5 years ago ___

4. Have you had a medical checkup in the last year?
   Yes ___ No ___

5. Have you had any illnesses in the past year?
   Yes ___ No ___
   anemia ____________ kidney ____________
   diabetes ____________ infections ____________
   liver ____________ colds ____________
   heart ____________ psychological illness ______
   allergy ____________ G.I. ____________
   other ____________

6. Name of doctor: ____________ Phone: ______

continued ...

7. During the past 6 months, have you regularly used any medication internally? (Drugs, pills, injections, hormones, tranquilizers, tonics, cough medicine, etc.)
   Yes ___ No ___
   (If yes, please specify)

   (If applicable) Does medication affect your appetite?
   Yes ___ No ___

8. Do you experience any problems with taste?
   Yes ___ No ___
   (If yes, please specify)

9. Do you experience any problems with smell?
   Yes ___ No ___
   (If yes, please specify)

10. Are you on a modified salt intake?
    Yes ___ No ___
    (If yes, please specify)

11. Do you add salt to your food at the table?
    Yes ___ No ___
    (If yes, please specify)
    Small amount ___ Fair amount ___ A lot ___

12. Are you taking any vitamin/mineral supplements?
    Yes ___ No ___
    (If yes, please specify)
    a) What brand?
    b) How often do you take?
    c) How many do you take each day?
    d) How many do you take each week?
    e) Were they prescribed by a physician?
    Yes ___ No ___

13. Do you drink alcoholic beverages?
    Yes ___ No ___
    (If yes, please specify)
    a) Usual type of beverage ________________
    b) No. of drinks per day ________________
    c) No. of drinks per week ________________

continued ...

Appendix 2. continued

14. Do you smoke?
Yes ___ No ___
Usually smoke:
cigarettes ___ pipe ___ cigar ___ other ___
(If cigarettes, please specify)
Usual number of cigarettes smoked per day ___________

15. In the past year, has your weight varied by 5 lbs or more either up of down?
Yes ___ No ___
(If yes, please specify)
a) How much weight did you gain or lose?
b) Any significant reason known for the change? (eg. illness, dieting)

16. Have you followed any type of a weight-reducing diet within the past year?
Yes ___ No ___
(If yes, please specify)
a) Name of diet
b) Duration

17. Do you wear dentures?
No ___ Upper arch only ___ Lower arch only ___
Both arches ___
(If applicable) How long have you been wearing dentures?
Do you wear dentures while eating?
Yes ___ No ___
(If no, please explain)

18. Do you have any difficulty in biting or chewing or swallowing severe enough to interfere with eating?
Yes ___ No ___
(If yes, please specify)
______ missing teeth
______ dentures do not fit
______ other

19. How would you describe your appetite?
Very good ___ Good (average) ___ Poor ___

continue ...

Appendix 2. continued

20. With whom are meals usually eaten?
Alone ___ Spouse ___ Friend ___ Family/Relative ___

21. How many people share your living quarters with you?
0 1 2 3 4 5 6 or more
(If applicable) What is their relationship to you?
(Check all that apply.)
spouse ___ son/daughter ___ other relatives ___
friend ___ boarders ___

22. Who usually prepares your food?
self ___ spouse ___ other household member ___
meals on wheels ___ other ___

23. Do you regularly miss any meals?
Yes ___ No ___
(If yes, what is your usual menu pattern?)

24. Do you have any food dislikes or foods that disagree with you? (Foods that give you gas pains, heartburn, diarrhea, constipation, other discomforts.)
Yes ___ No ___
(If yes, please specify)

25. Do you have any food allergies?
Yes ___ No ___
(If yes, please specify)

26. Do you a[illegible] eating an[illegible] foods?
Yes ___ No ___
(If y[illegible] please specify)

continue ...

Appendix 2. continued

II. Demographic Information

Finally, we would like to ask you some questions about yourself.

1. Birthdate ____________ Age ______ years.

2. What is the highest level of education you have completed? (Check all that apply.)
   - ___ elementary sch
   - ___ high school gr
   - ___ some high scho
   - ___ career training (e.g. trades, business school,
   - ___ armed forces)
   - ___ some university
   - ___ university degree
   - ___ no formal training

3. What is your marital status?
   - ___ single (never married)
   - ___ married
   - ___ divorced/separated
   - ___ widowed

4. Interviewer: indicate type of dwelling.
   - ___ single family house
   - ___ duplex
   - ___ condominium
   - ___ apartment
   - ___ rented room
   - ___ retirement community (eg. high-rise senior
   - ___ citizens apartments)
   - ___ institution
   - ___ other

5. What is your present yearly income? (self and spouse)
   - ___ less than $5,000
   - ___ $5,000 - $9,999
   - ___ $10,000 - $14,999
   - ___ $15,000 - $19,999
   - ___ $20,000 - $24,999
   - ___ $25,000 - $29,999
   - ___ $30,000 - $34,999
   - ___ $35,000 - $39,999
   - ___ $40,000 - $44,999
   - ___ $45,000 - $49,999
   - ___ $50,000 - $54,999
   - ___ $55,000+

6. Do you get any other form of nutritional support?

7. Contact: (one of the following)
   Relative of another generation ____________
   Previous employer ________ Pension Plan No. ________
   Driver's license ____________

continue ...

Appendix 3. Part I. Letter Requesting Elderly Participants

University of Alberta
Edmonton

Department of Foods and Nutrition
Faculty of Home Economics

The Department of Foods and Nutrition at the University of Alberta is beginning a study to investigate taste perception and the nutritional status of older men and women. Participants in the age range of 70-79 and 80+ are required for the study.

You will be required to taste food samples and answer some quesitons about them. All samples will be foods consisting of commonly used ingredients. This information will be useful in developing, preparing and providing food of greater acceptability for elderly people.

A food quality researcher will make several visits to collect the data. You will also be asked to answer questions about food intake. Participants are free to refuse to answer any of the questions. All information given will be held in confidence and used only for research purposes.

Any information on the outcome of the study will be provided as requested. Those interested in participating in the study, which will begin mid-February and take an approximate period of one month, should contact us at the following numbers:

Dr. Jaya Chauhan - 432-3828
Ms. Christina Ko - 439-4089
Ms. Susanna Ko - 439-5524

Your help in this research project would be greatly appreciated. Thank you.

Yours Truly,

Christina Ko
Foods and Nutrition Researcher

Appendix 3. Part II. Letter Requesting Young Participants

University of Alberta
Edmonton

Department of Foods and Nutrition
Faculty of Home Economics

Dear Friends;

The Department of Foods and Nutrition at the University of Alberta is studying the relationships between taste perception and the nutritional status of older men and women. Participants in the age range of 20-29 are required for comparison.

In this study you will be asked to participate in five interviews. A Foods and Nutrition researcher will ask you about your food intake. You will be asked to keep a record of what you eat and drink for four days.

You will also be asked to taste food samples and to answer some questions about them. All samples are foods with commonly used ingredients. This information will be useful in developing, preparing and providing food of greater acceptability for the elderly people.

Participants are free to refuse to answer any of the questions. All information given will be dept confidential and used only for research purposes. Any information on the outcome of the study will be provided as requested. If you are interested in participating in this study, please contact me at the following umbers:

Christina Ko - 432-5239 (O) 439-4089 (H)

Your help in this research project would be greatly appreciated. Thank you.

Yours Truly,

Christina Ko
Foods and Nutrition Researcher

Appendix 4. Analytical Composition of Windsor® Table Salt

Chemical Analysis*		Typical	Limits
Calcium Sulphate	$CaSO4$	0.16 %	0.4 % max
Calcium Chloride	$CaCl2$	0.04 %	0.4 % max
Magnesium Chloride	$MgCl2$	0.002 %	0.4 % max
Filter Pad - APHA Test		0.10 mg	0.3 mg max
Iron	Fe	1.0 ppm	2.0 ppm max
Copper	Cu	0.5 ppm	1.0 ppm max
Moisture	$H2O$	0.03 %	0.1% max
Net Salt-Dry basis	NaCl	99.8 %	99.6 % min

Added:

Yellow prussiate of soda-anti-caking agent		3.0 ppm	13.0 ppm max
Zeolex, free running agent		0.6 %	1.0 % max
Potassium iodide	KCl	0.013 %	0.010 % min
Invert sugar, iodide stabilizer		0.02 %	

* data provided by the Canadian Salt Company Limited, Windsor®, August, 1985

Appendix 5. Score card for taste assessment

NAME: DATE:

SUBJECT NO: SESSION:

SALIVARY pH:

Please taste each of the samples in the order indicated, rinsing with water to start and between samples. Do not swallow samples - just hold in mouth for 3 seconds. Taste the Reference (R) sample first. It has been assigned a score of 10. Assign the following samples numbers proportional to the Reference (R). If you think the sample is twice as salty in intensity to R, assign the number 20; similarly, if you think it is only half as pleasant as R, assign 5. Retaste R after the third sample.

Sample Code:	R				R			
Saltiness Water	10				10			
Pleasantness	10				10			

Comments:

Sample Code:	R				R			
Saltiness Soup	10				10			
Pleasantness	10				10			

Comments:

Appendix 6. Order of Sample Presentation

Subject No.	Session 1	Session 2	Session 3
1	123456*	213456	654213
2	213546	564213	124356
3	312465	123564	654321
4	465312	564321	213546
5	564231	213465	465312
6	654321	564312	213465
7	132456	213546	564213
8	213564	654213	123456
9	312456	645312	312465
10	465321	123465	654231
11	564312	213564	123465
12	645321	213546	564321
13	123546	312456	654312
14	213456	123456	132465
15	564321	654321	312456
16	645312	654312	132456
17	123564	564231	645312
18	213465	645321	213456
19	564213	132465	123564
20	654231	312465	123546
21	123465	654231	465321
22	654312	465312	564312
23	124356	465321	564231
24	654213	123546	645321
25	132465	124356	213564
26	213456	465312	123546
27	213465	654312	132456
28	564213	123465	213546
29	124356	654213	564231
30	312456	123456	654231

	Citric Acid (mM)	NaCl (mM)
*1 denotes solution at	3	20
2 denotes solution at	6	40
3 denotes solution at	12	80
4 denotes solution at	18	160
5 denotes solution at	24	320
6 denotes solution at	36	640

Note: Each subject received the same order of presentation for sour and salt qualities

Appendix 7. Orientation to Magnitude Estimation

Name ______________________________ Date ______________________

The following exercises acquaint you with Magnitude Estimation. In these exercises there are no limits to the positive numbers that you may choose.

1. Assuming the following lines each measure "100", put a cross on each line appropriate to the location of the corresponding number:

33 ____

25 ____

1 ____

91 ____

42 ____

5 ____

75.5 ____

66.6 ____

58 ____

82 ____

2. Give the first line a number to judge its length. Then assign the remaining lines numbers proportionate to the first line, eg. if a line is twice as long as the first line, give it a number twice as large; if a line is half as long, call it a number half as large. Don't hesitate to use decimals or fractions, and use numbers as large or small as you wish.

____

____

____

____

____

_____

continued ...

Appendix 7. continued

3. In the accompanying booklet are contained 9 shapes:
   a) assign a number to estimate the area of the first shape and without referring back to any shape, assign numbers to the area of each of the following shapes relative to the first. Numbers can be larger than, or fractions of, your first number, as you wish, and there is no "right" or "wrong" answer.

      1. ______________________
      2. ______________________
      3. ______________________
      4. ______________________
      5. ______________________
      6. ______________________
      7. ______________________
      8. ______________________
      9. ______________________

   b) give the first shape a number to estimate how much you like it. Without referring back to any shape, assign numbers to your degree of liking of each of the following shapes relative to the first. Again, use any numbers you like and, as it is your subjective judgements you are giving, there is no "right" or "wrong".

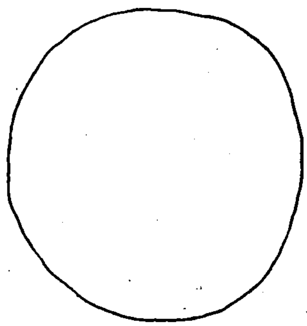
      1. ______________________
      2. ______________________
      3. ______________________
      4. ______________________
      5. ______________________
      6. ______________________
      7. ______________________
      8. ______________________
      9. ______________________

continued ...

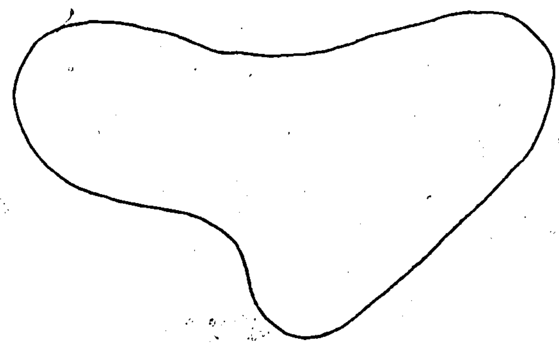
Appendix 7. continued

Shapes to be Evaluated for Orientation to Magnitude Estimation Exercise #3

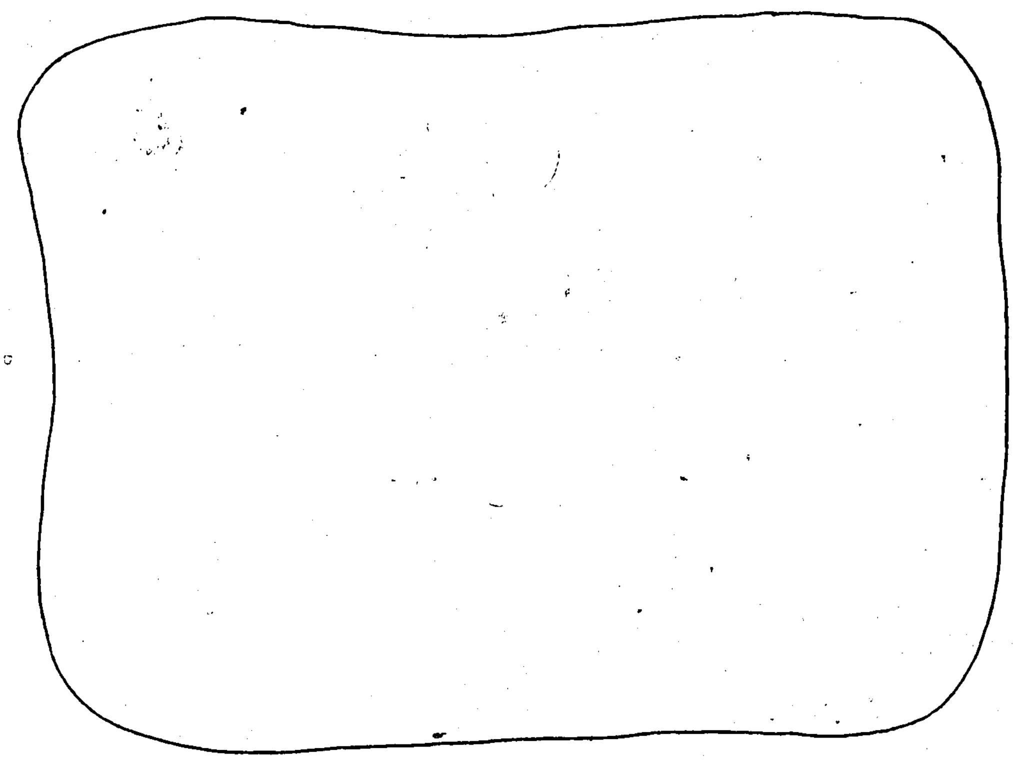
1.



2.



3.

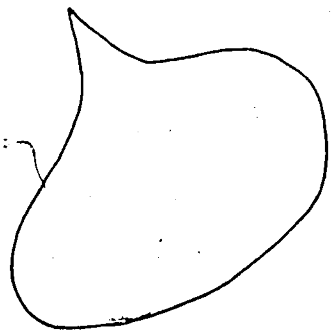


continued ...

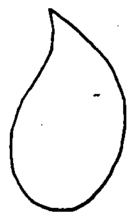
Appendix 7. continued

Shapes to be Evaluated for Orientation to
Magnitude Estimation Exercise #3

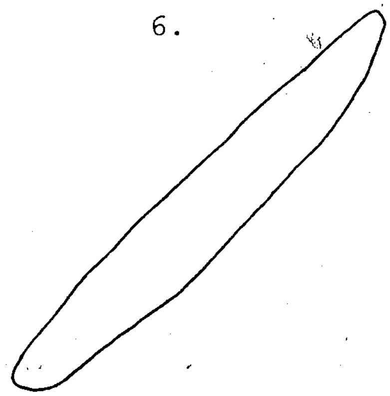
4.



5.

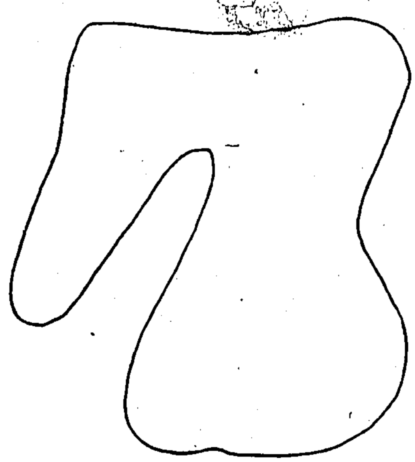


6.

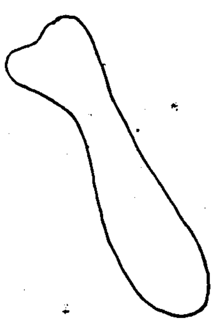


7.

8.



9.



Shape No.	Actual Ratios :	
	1. 1.0	6. 0.5
	2. 1.5	7. 0.01
	3. 9.4	8. 1.7
	4. 0.8	9. 0.3
		5. 0.2

continued ...

Appendix 8. Instructions for Tasting Procedures

"In this session, you will be rating the sourness (saltiness) and pleasantness of the samples placed before you. The first sample is the reference (R) which we have already assigned a number of 10 for the degree of sourness (saltiness) and pleasantness. When you taste the R, try to remember how sour (salty) and pleasant you perceive it to be and assign a number 10 to the level of these qualities. When you taste the next three samples, assign to each of them numbers according to how many times more or less sour (salty) and pleasant, or whether they are the same, when compared to the R. For instance, if you find a sample that is twice as sour (salty) as the R, assign it a number twice as big as 10, ie. 20. If you find a sample that is half as sour as the R, assign it the number 5. If you cannot taste any difference between a sample and the R, give the sample the same number as the R, ie. 10. Use the same procedure just described to rate the pleasantness of the samples. Except for negative numbers, feel free to use any number you wish, just as long as it reflects the magnitude of the intensity of sourness (saltiness) and pleasantness relative to the R. You will be given another R in the middle of the series to refresh your memory."

Appendix 9. Instructions for Dietary Interviews

The techniques of dietary interview employed will determine greatly the accuracy of the results obtained. It is essential that all interviewers utilize similar techniques to minimize bias. This is not to say that every interview should be exactly the same. Interviews may be modified according to the individual who is being interviewed. The interviewer should be able to judge the intelligence of the respondent and also how apprehensive he is about the interview itself.

The interview should be approached in a calm manner. Don't be in a hurry to pick up information because chances are some important food itams will be missed.

1. Greet the respondent warmly at the door. Identify yourself.
2. Establish rapport with the respondent before beginning the interview. Explain why you are there, how long you will be there, and the type of information you are seeking. Don't give too much information about the exact nature of the study however.
3. Arrange yourself in a seat beside th respondent and place the food model kit on the table beside you. It may be appropriate to have the suitcase on a small chair and food models can be extracted and placed on the table as required.
4. Be sincere and straightforward about the interview. Don't be machine-like. Ask questions as if you expect them to be answered.
5. Do not show surprise or disapproval of the respondent's replies, either by facial expression or tone of voice.
6. Listen carefully to the respondent's replies. You may get the answers to several questions at one time.
7. Repeat back what the respondent has told you to make sure you understand the information which has been reported.
8. Maintain a friendly manner but do not engage in small talk throughout the interview.
9. If an unexpected visitor interrupts your interview, come back another time. Don't try to finish the interview when you have lost the respondent's attention.
10. If the respondent appears to be ill, come back another time.

continue ...

Appendix 9. continued

Specific Points on Conducting the Dietary Interview

1. Do not refer to any meals in the day - such as breakfast, lunch and supper. Some people do not follow such a pattern. Simply ask for an account of all the food items consumed throughout the day. For example, ask "What was the first thing you did when you got up yesterday morning?". If the respondent says, "I had breakfast", then ask him what he had for breakfast.
2. Try having the respondent recall the activities of the previous days as these are often associated with food intakes.
3. Don't give negative or closed questions like: "Didn't you have anything else to eat last night?". Use open-ended questions such as: "Can you think of anything else you had to eat last night?".
4. After you have acquired a list of foods in the order of consumption, go back and enquire about the amounts. Place all appropriate food models of the same type on the table equidistant from the respondent (eg. all the glass models).
5. Ask the respondent if any of the models resenble the amount he had to eat. eg. In the case of a beverage, ask:
   i) from what type of container did you drink?
   ii) If he says, "a glass", then display all the glasses and ask which glass resembles the one he drank from.
   iii) Then ask how full that particular glass was.
   iv) Did he drink its entire contents?
6. Always recheck a day's intake but do not suggest foods unless absolutely necessary as this will introduce a bias into the results.
7. If the respondent cannot remember his intake for a particular day, then have his look into the cupboards or the refrigerator. This may help to jar his memory.
8. Although the subject should be interviewed alone where possible, a male respondent may require the help of his wife, especially if she had prepared the meals for him.
9. Remember to ask the respondent if he ate everything on his plate. Also enquire about second helpings.

Appendix 10. Sample 24-hour dietary recall sheet.

DIETARY RECALL

NAME:....................................

TIME OF DAY Enter Time from 00:01 to 24:00 in hours and minutes	FOOD CODE	FOOD OR DRINK	WORK AREA	AMOUNT CONSUMED		FOOD UNIT OR MODEL NO.
				Whole	Decimal	

Anthropometric Measurements

age: ______

weight (kg): ______

height (cm): ______

ideal wt. for ht.: ______

arm circum. (cm): ______

triceps SF (mm): 1 ______

2 ______

3 ______

av. ______

elbow breadth (cm): ______

Appendix 11. Part I. Sample of a Food Record Form

1-day record

INSTRUCTIONS

WHEN RECORDING FOOD INTAKE:

1. Please write down everything you eat or drink for the specified day on the following sheets.

2. In the first column, list the time of day the food or beverage was consumed.

3. In the second column, list the amount consumed as a volume, weight, number of pieces, etc. Whenever possible, copy the portion size or the appropriate portion eaten from cans, bottles and packages.

4. In the last column, please give us as many details as possible:
   a) describe the kind of food eaten: for example, if you eat bread, write whether it is white, whole wheat, 60% whole wheat, etc.
   b) describe the method of preparation: for example, raw, baked, boiled, pan-fried, deep-fried, etc.

5. When you are eating away from home, please continue to record what you eat.

6. Please remember to record all snacks, gum, candy, alcoholic or other beverages, cough drops and especially vitamin or mineral supplements, and the amount you consume.

7. Please record the food actually eaten and not the amounts served.

An example of the correct method of filling out your food record is shown on the following page.

Should you have any difficulties or questions, please do not hesitate to contact one of us:

Christina Ko	432-5239
Susanna Ko	432-5239

Thank you for participating in this study.

continue ...

Appendix 11. Part I continued

24-HOUR FOOD RECORD

NAME ______________________

DATE ______________________

TIME OF DAY	AMOUNT	DESCRIPTION

Appendix 11. Part II. Sample of a Completed Food Record

CORRECT METHOD OF COMPLETING A 24-HOUR FOOD RECORD

TIME OF DAY	AMOUNT	DESCRIPTION
7:00 a.m.	2 slices	toasted white bread
	3 Tbs	Kraft® strawberry jam
	6 oz	perked coffee
	1 tsp	sugar
	2 Tbs	homo milk
12:15 p.m.	1/2 10 oz can	Campbell's® chicken noodle soup
	1 slice	rye bread
	3"x3"x1/4" slice	baked ham
	1 Tbs	mayonnaise
	3 - 2" diameter	Oreo cookies
6:30 p.m.	1	hamburger bun
	3" wide x 1" thick	broiled beef patty
	1 - 8 oz cup	frozen peas, boiled
	1 - 6"	banana
	4 oz	2% milk
10:30 p.m.	6 oz	tea
	2 - 3" square	unsalted soda crackers
	2"x1"x1/2" slice	cheddar cheese

Appendix 12. Consent Form From the Participants

Title of Research Project

A comparison of taste perception and dietary intake of elderly and young Albertans.

Explanation of Project

Elderly people often have nutritional problems. The purpose of this study is to find out what older Edmontonians eat and how well nourished they are. We are also trying to find out more about how the sense of taste changes with age.

You will be asked to participate in some interviews and tests which will be done in your home. A Foods and Nutrition researcher will visit you at home five times to ask you about your food intake. You will be asked to keep a record of what you eat and drink for 4 days.

You will be asked to taste some food samples and to answer some questions about how the samples taste. All samples are foods with commonly used ingredients. This information will be usedful in developing, preparing and providing food for elderly people.

__________________________(Name of Foods and Nutrition researcher) has explained to me that I will be interviewed at home. I will keep a dietary record for 4 days; I will undergo some body measurements: I will taste the food samples and answer questions about how the samples taste. I will be involved in the study for approximately one month.

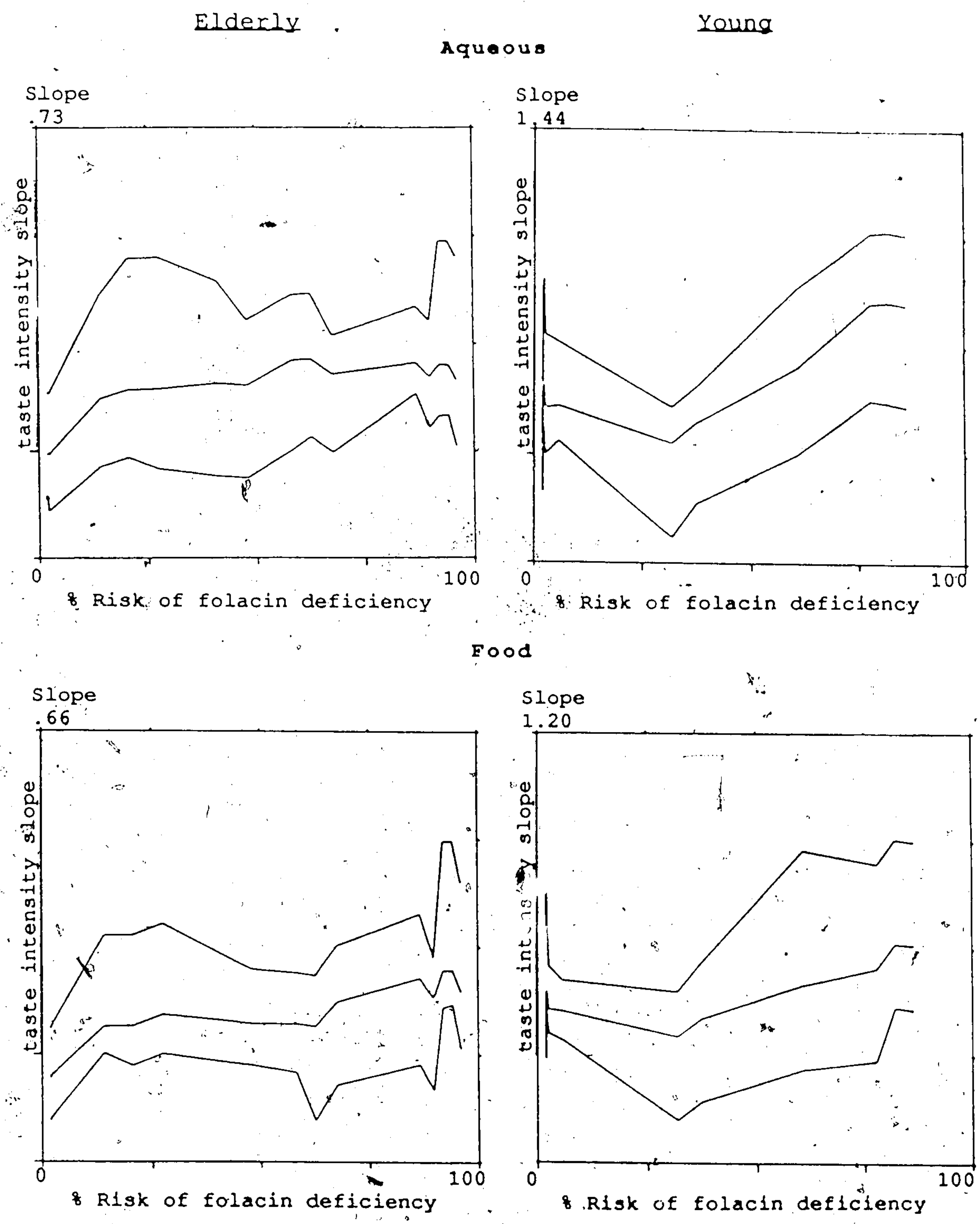
I certify that the procedures have been described to me, and any quesitons that I have asked have been answered to my satisfaction. I understand that I have no obligation to consent to enter the study.

I understand that I am free to withdraw from the study should circumstances require me to do so. I have been assured that records relating to me will be kept confidential and that no information will be released or printed that would expose my personal identity without my permission.

I have read and understand the above information and hereby give consent to participate in the study.

____________________	____________________
Participant's Signature	Researcher's Signature
____________________	____________________
Witness	Date

Appendix 13: Part I - Graphical presentations[1] of slope of taste intensity vs. percent risk of folacin deficiency: Sourness

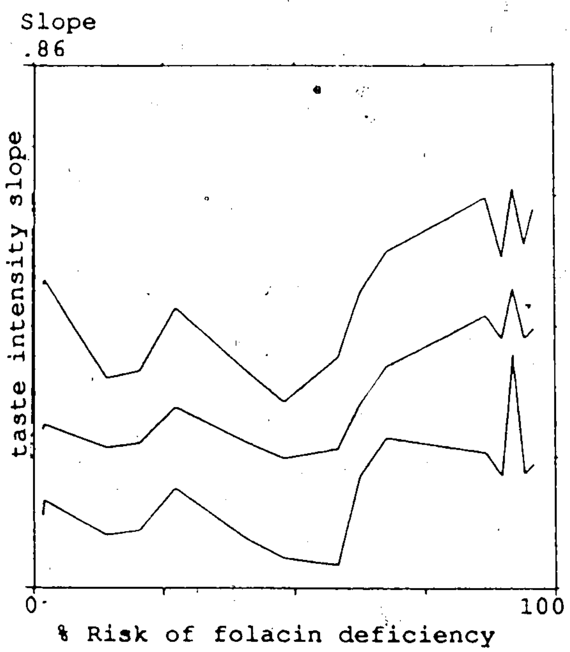


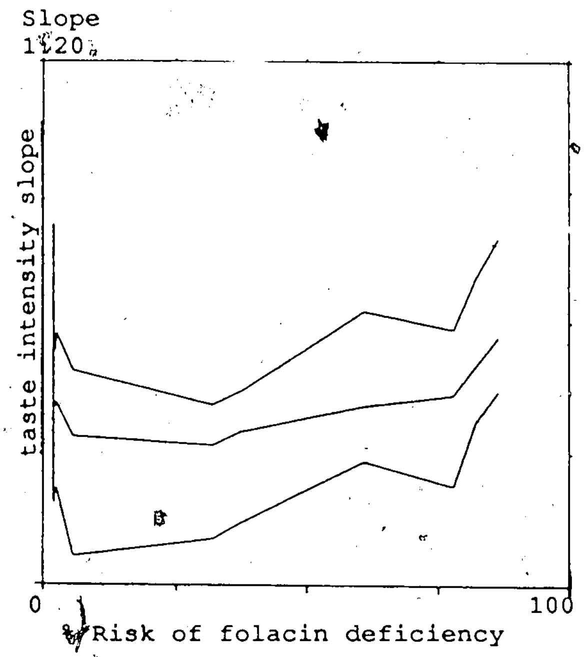
[1]showing upper semi-midmean, midmean, and lower semi-midmean

Appendix 13: Part II - Graphical presentations[1] of slope of taste intensity vs. percent risk of folacin deficiency: Saltiness

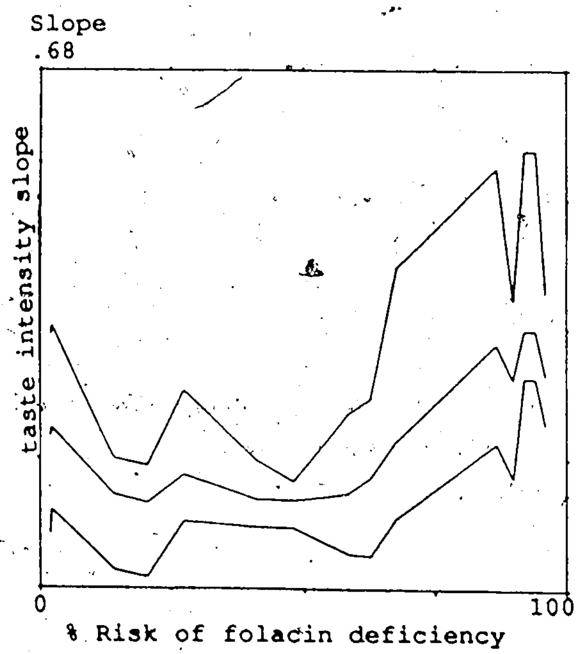
Elderly | Young

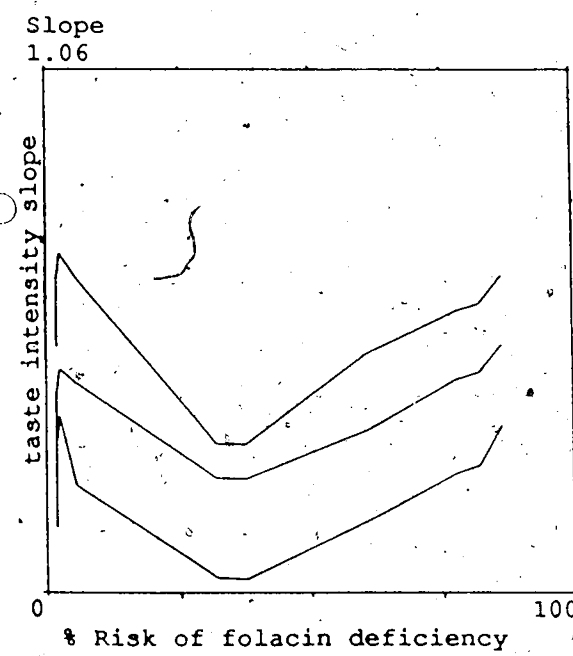
Aqueous





Food



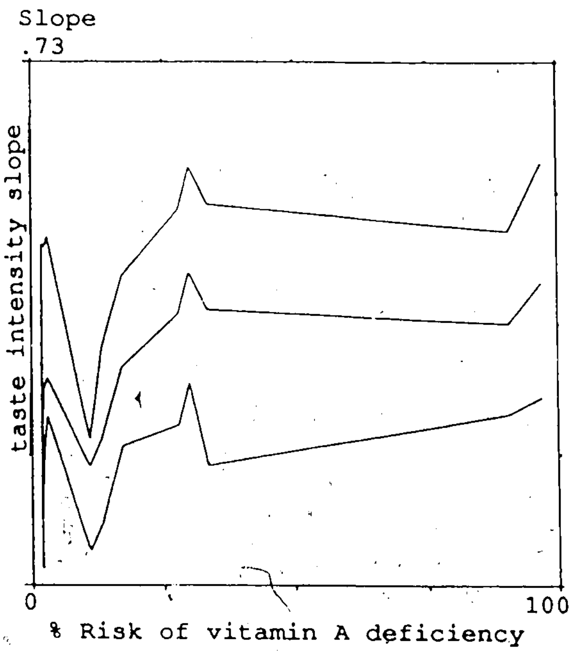


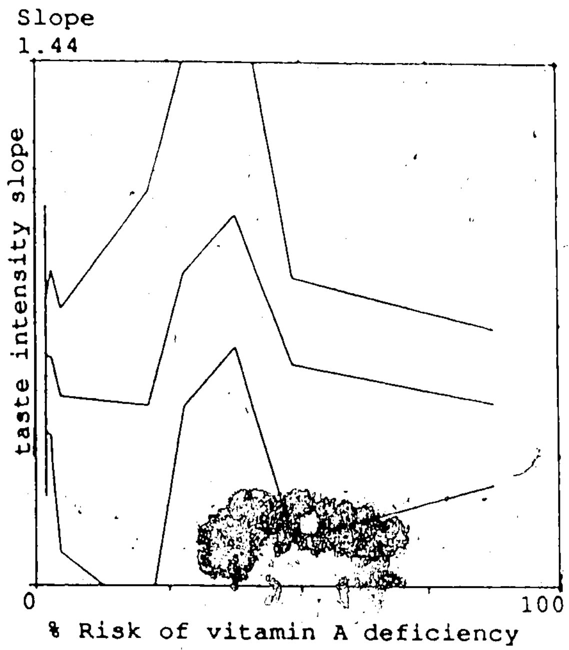
[1] showing upper semi-midmean, midmean, and lower semi-midmean

Appendix 3: Part III - Graphical presentations[1] of slope of taste intensity vs. percent risk of vitamin A deficiency: Sourness

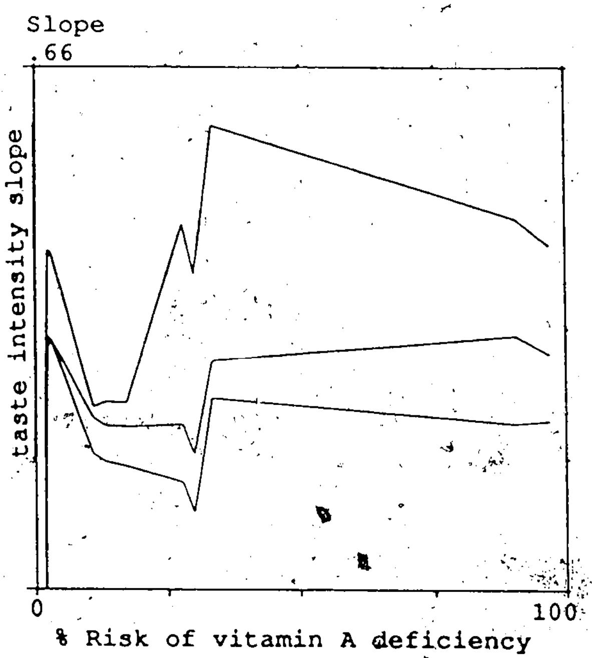
Elderly | Young

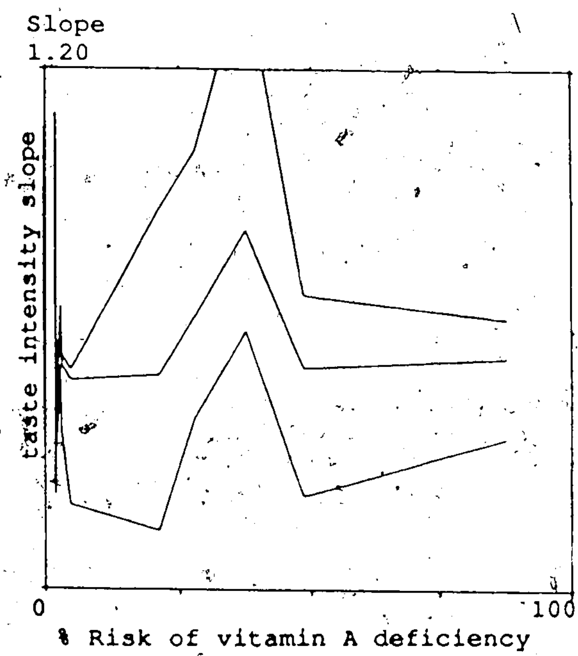
Aqueous





Food



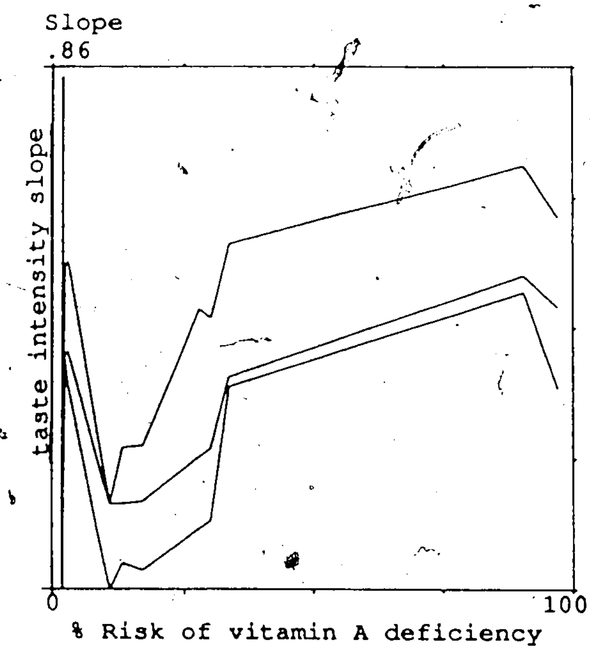


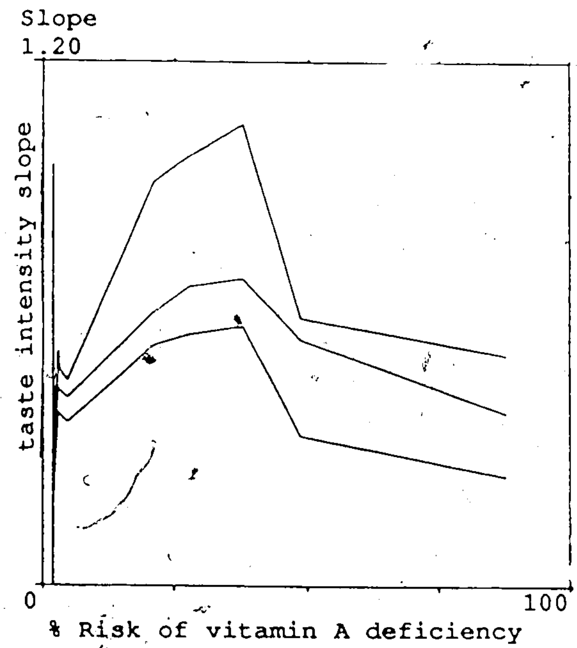
[1]showing upper semi-midmean, midmean, and lower semi-midmean

Appendix 13: Part IV - Graphical presentations[1] of slope of taste intensity vs. percent risk of vitamin A deficiency: Saltiness

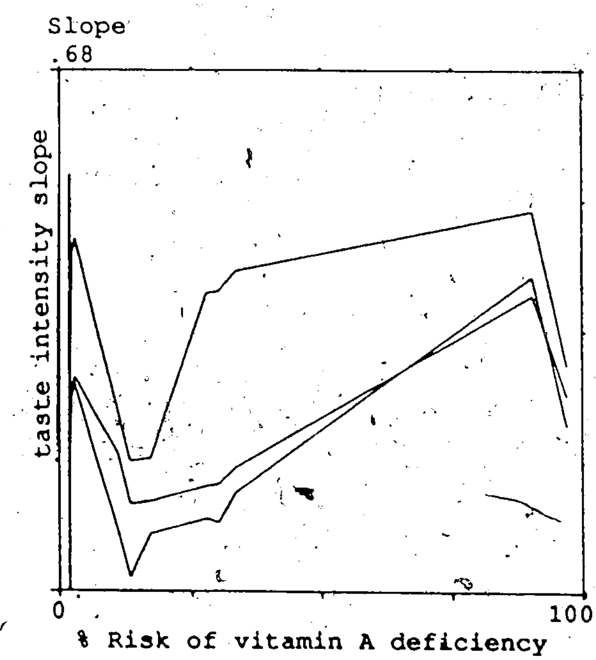
Elderly | Young

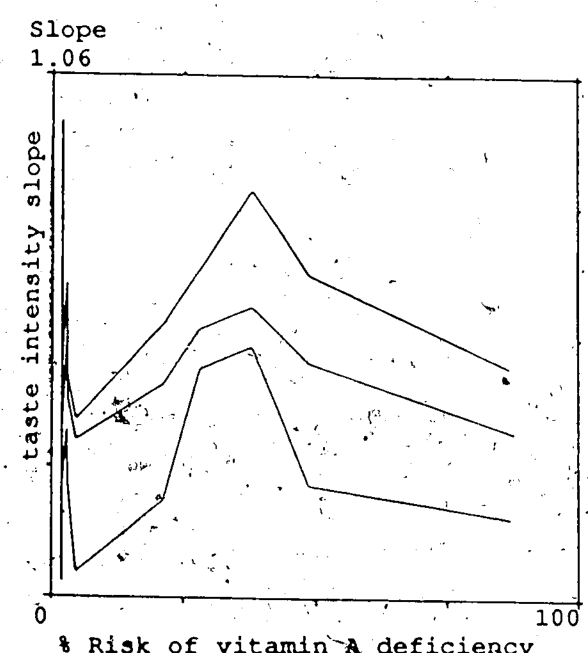
Aqueous





Food



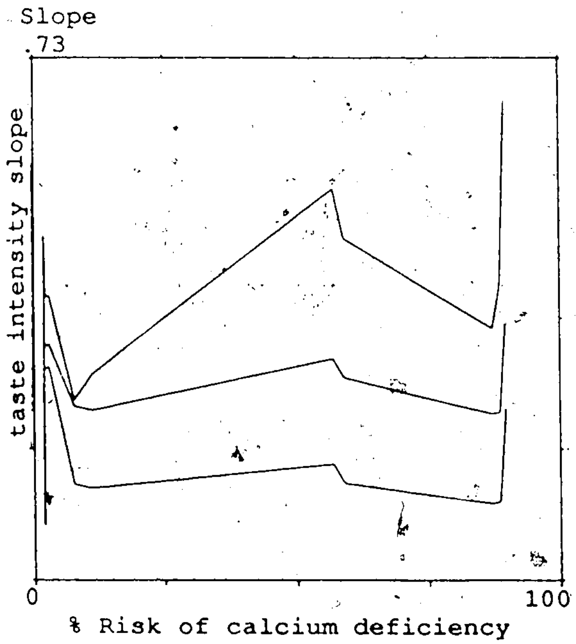


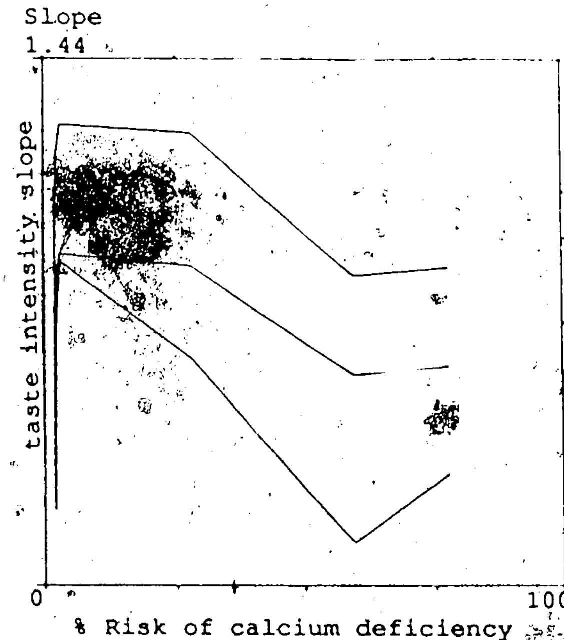
[1]showing upper semi-midmean, midmean, and lower semi-midmean

Appendix 13: Part V - Graphical presentations[1] of slope of taste intensity vs. percent risk of calcium deficiency: Sourness

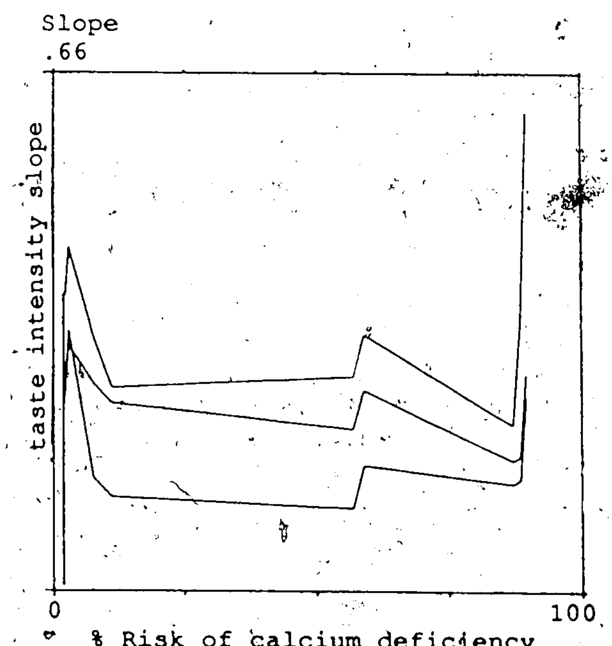
Elderly | Young

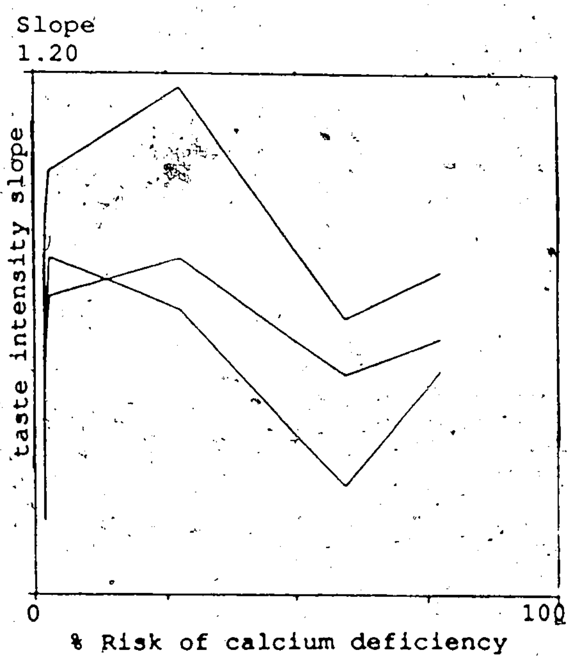
Aqueous





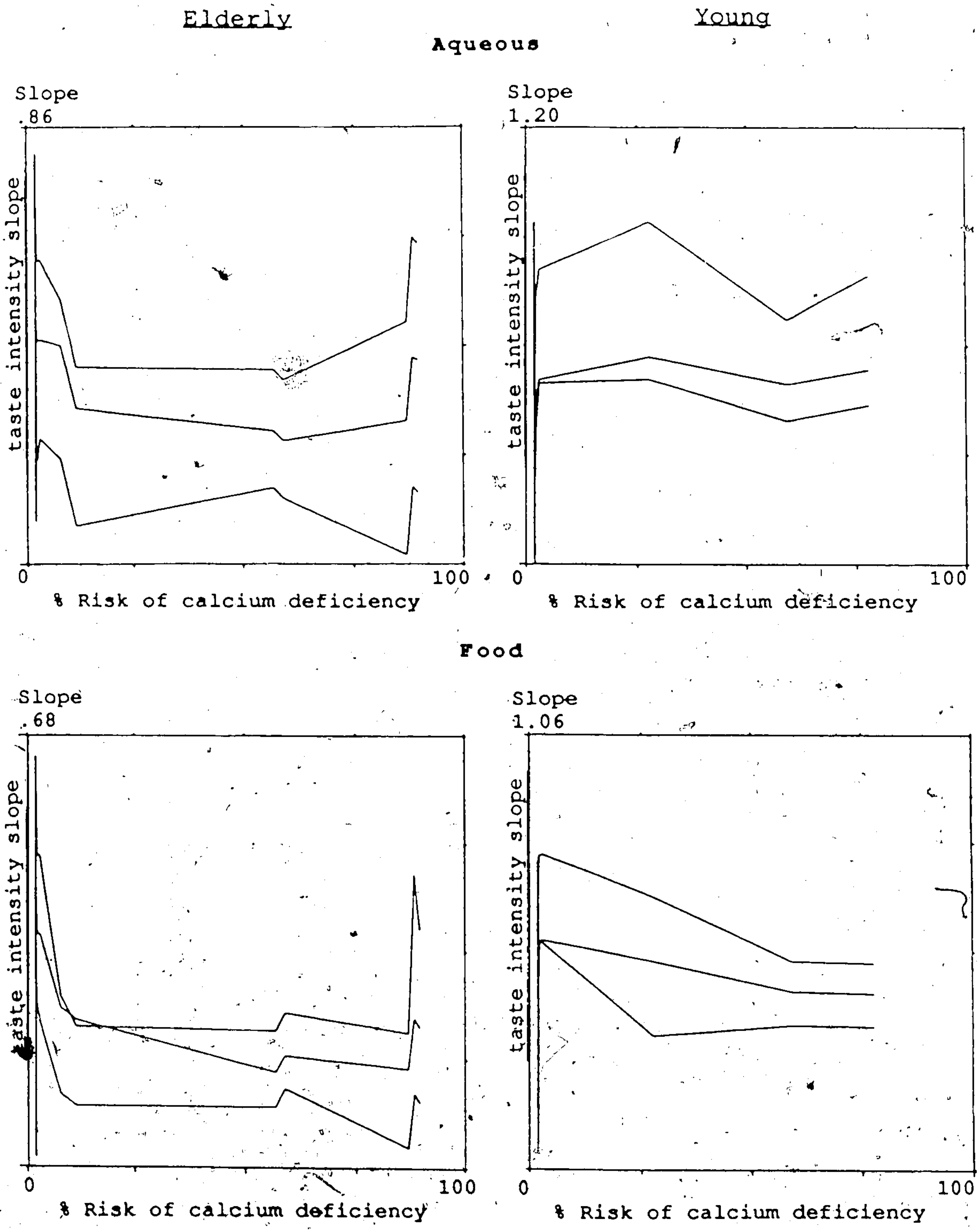
Food





[1]showing upper semi-midmean, midmean, and lower semi-midmean

Appendix 13 : Part VI - Graphical presentations[1] of slope of taste intensity vs. percent risk of calcium deficiency: Saltiness



[1]showing upper semi-midmean, midmean, and lower semi-midmean

Appendix 14. Part Ia. Pearson Correlation Coefficients: Slope of Taste Intensity Vs Percent Risk of Nutrient Deficiency (Diet Only)

	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
NUTRIENT	Elderly[1]	Young[1]	Elderly	Young	Elderly	Young	Elderly	Young
Index of Overall Nutritional Risk[2]	0.44 (0.01)[3]	0.29 (0.12)	0.54 (0.00)**	0.32 (0.08)	0.28 (0.14)	0.25 (0.18)	0.25 (0.19)	0.15 (0.44)
Protein	0.22 (0.24)	-0.22 (0.23)	0.45 (0.01)*	-0.08 (0.66)	0.30 (0.11)	0.05 (0.81)	0.41 (0.02)*	-0.01 (0.98)
Thiamin	--	--	--	--	--	--	--	--
Riboflavin	0.51 (0.00)**	-0.06 (0.77)	0.53 (0.00)**	-0.03 (0.88)	0.10 (0.60)	0.11 (0.56)	0.09 (0.63)	0.13 (0.48)
Folacin	0.33 (0.07)	0.33 (0.08)	0.38 (0.04)*	0.22 (0.25)	0.32 (0.08)	0.17 (0.37)	0.36 (0.05)	0.13 (0.49)
Vit B_{12}	0.41 (0.03)*	0.48 (0.01)**	0.40 (0.03)*	0.46 (0.01)*	-0.02 (0.93)	0.50 (0.01)**	-0.05 (0.81)	0.15 (0.42)
Vit B_6	-0.07 (0.72)	0.14 (0.46)	0.01 (0.95)	0.10 (0.60)	-0.15 (0.44)	-0.06 (0.75)	-0.24 (0.21)	0.17 (0.38)
Vit C	0.02 (0.90)	-0.22 (0.23)	-0.09 (0.62)	-0.08 (0.66)	-0.00 (0.99)	0.05 (0.81)	-0.15 (0.44)	-0.01 (0.98)
Vit A(RE)	0.31 (0.10)	0.11 (0.57)	0.33 (0.08)	0.18 (0.36)	0.38 (0.04)*	0.08 (0.66)	0.24 (0.21)	0.10 (0.59)
Vit D	0.20 (0.28)	0.48 (0.01)**	0.28 (0.14)	0.40 (0.03)*	0.00 (1.00)	0.32 (0.09)	-0.01 (0.94)	0.11 (0.57)
Calcium	0.29 (0.12)	-0.05 (0.81)	0.32 (0.08)	0.17 (0.36)	-0.02 (0.91)	0.20 (0.30)	-0.03 (0.89)	0.05 (0.78)
Iron	--	--	--	--	--	--	--	--
Zinc	0.22 (0.24)	-0.14 (0.46)	0.33 (0.08)	0.01 (0.94)	0.12 (0.53)	0.08 (0.67)	0.12 (0.51)	0.08 (0.66)

1 n=30
2 Calculated from sum of risk of deficiency : 12 nutrients (protein, thiamin, riboflavin, folacin, vit B_{12}, vit B_6, vit C, vit A, vit D, calcium, iron and zinc) divided by [illegible]
3 probability level of significance
*,** Significant at $p < 0.05$, 0.01, respectively

Appendix 14: Part Ib - Pearson Correlation Coeffecients: Slope of Taste Intensity Vs Percent Risk of Nutrient Deficiency (Diet Plus Vitamin/Mineral Supplements)

	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
NUTRIENT	**Elderly**[1]	Young[1]	Elderly	Young	Elderly	Young	Elderly	Young
Index of Overall Nutritional Risk[2]	0.46 (0.01)[3]*	0.21 (0.27)	0.51 (0.00)**	0.23 (0.21)	0.30 (0.11)	0.23 (0.23)	0.26 (0.17)	0.07 (0.70)
Protein	0.22 (0.24)	-0.22 (0.23)	0.45 (0.01)*	-0.08 (0.66)	0.30 (0.11)	0.05 (0.81)	0.41 (0.02)*	-0.01 (0.98)
Thiamin	- -	- -	- -	- -	- -	- -	- -	- -
Riboflavin	0.51 (0.00)**	-0.06 (0.77)	0.53 (0.00)**	-0.03 (0.88)	0.10 (0.60)	0.11 (0.56)	0.09 (0.63)	0.13 (0.48)
Folacin	0.32 (0.08)	0.24 (0.20)	0.32 (0.09)	0.14 (0.47)	0.35 (0.06)	0.15 (0.42)	0.35 (0.06)	0.07 (0.72)
Vit B_{12}	0.44 (0.02)*	0.48 (0.01)**	0.41 (0.03)*	0.46 (0.01)*	0.01 (0.94)	0.50 (0.01)**	-0.02 (0.93)	0.15 (0.42)
Vit B_6	-0.07 (0.72)	-0.26 (0.16)	0.01 (0.95)	-0.07 (0.70)	-0.15 (0.44)	-0.11 (0.56)	-0.24 (0.21)	-0.06 (0.74)
Vit C	-0.11 (0.55)	-0.22 (0.23)	-0.00 (0.99)	-0.08 (0.66)	-0.04 (0.84)	0.05 (0.81)	-0.16 (0.41)	-0.01 (0.98)
Vit A(RE)	0.31 (0.10)	0.01 (0.95)	0.32 (0.08)	0.06 (0.75)	0.38 (0.04)*	0.03 (0.88)	0.23 (0.21)	-0.00 (1.00)
Vit D	0.40 (0.03)*	0.46 (0.01)*	0.39 (0.04)*	0.38 (0.04)*	0.14 (0.46)	0.31 (0.10)	0.11 (0.55)	0.09 (0.62)
Calcium	0.30 (0.11)	-0.05 (0.80)	0.32 (0.09)	0.17 (0.38)	-0.01 (0.95)	0.20 (0.30)	-0.02 (0.92)	0.06 (0.77)
Iron	- -	- -	- -	- -	- -	- -	- -	- -
Zinc	0.22 (0.23)	-0.15 (0.42)	0.33 (0.08)	-0.00 (1.00)	0.12 (0.53)	0.08 (0.68)	0.12 (0.51)	0.09 (0.62)

1 n=30
2 Calculated from sum of risk of deficiency for 12 nutrients (protein, thiamin, riboflavin, folacin, vit B_{12}, vit B_6, vit C, vit A, vit D, calcium, iron and zinc) divided by 12
3 Probability level of significance
*,** Significant at $p < 0.05$, 0.01, respectively

Appendix 14. Part IIa. Pearson coefficients: slope of taste intensity vs average nutrient intake (diet only)

	Sourness				Saltiness			
	Aqueous		Food		Aque		Food	
NUTRIENT	Elderly[1]	Young[1]	Elderly	Young	Elderly	Young	Elderly	Young
Calories	-0.24 (0.21)	-0.34 (0.06)[2]	-0.39 (0.03)*	-0.37 (0.04)*	-0.14 (0.47)	-0.41 (0.02)*	-0.21 (0.27)	-0.42 (0.02)*
Protein	-0.25 (0.18)	-0.25 (0.18)	-0.48 (0.01)**	-0.39 (0.03)*	-0.04 (0.84)	-0.44 (0.02)*	-0.18 (0.35)	-0.43 (0.02)*
Thiamin	-0.28 (0.14)	-0.32 (0.08)	-0.47 (0.01)**	-0.32 (0.08)	-0.00 (1.00)	-0.26 (0.17)	-0.25 (0.18)	-0.31 (0.10)
Riboflavin	-0.17 (0.38)	-0.26 (0.16)	-0.48 (0.01)**	-0.37 (0.04)*	-0.01 (0.95)	-0.39 (0.04)*	-0.05 (0.78)	-0.31 (0.10)
Folacin	-0.43 (0.02)*	-0.28 (0.14)	-0.47 (0.01)**	-0.19 (0.33)	-0.25 (0.19)	-0.26 (0.16)	-0.25 (0.18)	-0.28 (0.13)
Vit B_{12}	-0.18 (0.33)	-0.18 (0.34)	-0.30 (0.11)	-0.36 (0.05)	-0.21 (0.26)	-0.37 (0.04)*	0.03 (0.89)	-0.17 (0.36)
Vit B_6	-0.29 (0.12)	-0.23 (0.22)	-0.46 (0.01)**	-0.42 (0.02)*	-0.25 (0.19)	-0.32 (0.08)	-0.35 (0.06)	-0.46 (0.01)**
Vit C	-0.10 (0.59)	00.03 (0.86)	0.06 (0.76)	0.06 (0.74)	-0.16 (0.40)	-0.15 (0.44)	-0.12 (0.53)	-0.06 (0.77)
Vit A(RE)	-0.28 (0.13)	-0.14 (0.46)	-0.38 (0.04)*	-0.16 (0.39)	-0.27 (0.14)	0.05 (0.81)	-0.05 (0.79)	-0.21 (0.26)
Vit D	-0.16 (0.39)	-0.37 (0.05)*	-0.29 (0.12)	-0.32 (0.08)	0.08 (0.68)	-0.20 (0.29)	0.06 (0.76)	-0.14 (0.47)
Calcium	-0.28 (0.14)	-0.20 (0.28)	-0.41 (0.02)*	-0.33 (0.08)	-0.05 (0.80)	-0.39 (0.03)*	-0.13 (0.51)	-0.25 (0.18)
Iron	-0.34 (0.07)	-0.30 (0.11)	-0.56 (0.00)**	-0.23 (0.21)	-0.12 (0.54)	-0.19 (0.33)	-0.24 (0.19)	-0.26 (0.17)
Zinc	-0.24 (0.21)	-0.18 (0.33)	-0.36 (0.05)	-0.32 (0.08)	0.09 (0.64)	-0.36 (0.05)	0.02 (0.93)	-0.35 (0.06)
Dietary Fiber	-0.41 (0.02)*	-0.25 (0.17)	-0.51 (0.00)**	-0.16 (0.41)	-0.18 (0.33)	-0.04 (0.82)	-0.23 (0.22)	-0.10 (0.59)

1 n=30
2 Probability level of significance
*,**,*** Significance at p < 0.05, 0.01, 0.001 respectivly

Appendix 14. Part IIb. Pearson coefficients: slope of taste intensity vs average nutrient intake (diet plus vitamin/mineral supplements)

NUTRIENT	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
	Elderly	Young[1]	Elderly	Young	Elderly	Young	Elderly	Young
Calories	-0.24 (0.21)	-0.34 (0.06)[2]	-0.39 (0.03)*	-0.37 (0.04)*	-0.14 (0.47	-0.41 (0.02)*	-0.21 (0.27)	-0.42 (0.02)*
Protein	-0.25 (0.18)	-0.25 (0.18)	-0.48 (0.01)**	-0.39 (0.03)*	-0.04 (0.84)	-0.44 (0.02)*	-0.18 (0.35)	-0.43 (0.02)*
Thiamin	-0.18 (0.35)	0.05 (0.81)	-0.14 (0.47)	0.03 (0.87)	-0.18 (0.35)	-0.14 (0.48)	-0.15 (0.43)	-0.23 (0.22)
Riboflavin	-0.15 (0.43)	0.13 (0.51)	-0.14 (0.46)	0.02 (0.90)	-0.14 (0.45)	-0.24 (0.21)	-0.13 (0.51)	-0.20 (0.29)
Folacin	-0.31 (0.10)	-0.19 (0.31)	-0.25 (0.18)	-0.12 (0.54)	-0.30 (0.11)	-0.27 (0.16)	-0.20 (0.29)	-0.28 (0.14)
Vit B_{12}	-0.26 (0.17)	0.02 (0.93)	-0.32 (0.09)	-0.13 (0.50)	0.03 (0.87)	-0.33 (0.08)	-0.02 (0.93)	-0.21 (0.26)
Vit B_6	-0.15 (0.43)	0.07 (0.72)	-0.13 (0.48)	0.00 (1.00)	-0.13 (0.48)	-0.16 (0.39)	-0.12 (0.52)	-0.30 (0.11)
Vit C	-0.20 (0.29)	0.09 (0.65)	-0.09 (0.65)	0.14 (0.46)	0.15 (0.44)	-0.[illegible] (0.56)	0.01 (0.95)	-0.07 (0.70)
Vit A(RE)	-0.29 (0.12)	0.02 (0.94)	-0.23 (0.23)	-0.09 (0.65)	-0.22 (0.25)	-0.01 (0.96)	-0.13 (0.48)	-0.15 (0.44)
Vit D	-0.29 (0.12)	-0.22 (0.25)	-0.34 (0.06)	-0.25 (0.18)	0.03 (0.88)	-0.21 (0.27)	0.00 (1.00)	-0.12 (0.53)
Calcium	-0.25 (0.19)	-0.20 (0.29)	-0.42 (0.02)*	-0.32 (0.08)	0.12 (0.53)	-0.39 (0.03)*	-0.02 (0.90)	-0.25 (0.18)
Iron	-0.32 (0.09)	-0.23 (0.21)	-0.37 (0.05)*	-0.18 (0.33)	-0.10 ([illegible])	-0.22 (0.23)	-0.21 (0.27)	-0.28 (0.14)
Zinc	-0.25 (0.18)	-0.10 (0.61)	-0.21 (0.26)	-0.19 (0.31)	-0.04 (0.84)	-0.33 (0.08)	-0.10 (0.58)	-0.39 (0.03)*
Dietary Fiber	-0.41 (0.02)*	-0.25 (0.17)	-0.51 (0.00)**	-0.61 (0.41)	-0.18 (0.33)	-0.04 (0.82)	-0.23 (0.22)	-0.10 (0.59)

[1] n=30
[2] Probability level of significance
*,** Significant at $p < 0.05$, 0.01, respectively

Appendix 14: Part IIIa - Partial Correlation: Slope of Taste Intensity Vs. Percent Risk of Nutrient Deficiency (Diet Only) Controlling for Previous Smoking Habits and Medication

NUTRIENT	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
	Elderly[1]	Young[1]	Elderly	Young	Elderly	Young	Elderly	Young
Index of Overall Nutritional Risk[2]	0.53 (0.00)[3]**	0.32 (0.10)	0.56 (0.00)**	0.31 (0.10)	0.43 (0.02)*	0.24 (0.22)	0.38 (0.05)*	0.14 (0.49)
Protein	0.25 (0.20)	-0.23 (0.23)	0.46 (0.01)*	0.11 (0.56)	0.32 (0.10)	0.05 (0.82)	0.43 (0.02)*	-0.02 (0.91)
Thiamin	- -	- -	- -	- -	- -	- -	- -	- -
Riboflavin	0.56 (0.00)**	-0.06 (0.76)	0.54 (0.00)**	-0.06 (0.78)	0.22 (0.26)	0.11 (0.57)	0.20 (0.30)	0.12 (0.54)
Folacin	0.43 (0.02)*	0.31 (0.10)	0.41 (0.03)*	0.31 (0.11)	0.45 (0.02)*	0.21 (0.29)	0.47 (0.01)*	0.18 (0.35)
Vit B_{12}	0.47 (0.01)*	0.49 (0.01)**	0.40 (0.03)*	0.47 (0.01)*	0.08 (0.68)	0.51 (0.01)**	0.04 (0.84)	0.14 (0.48)
Vit B_6	-0.09 (0.64)	0.11 (0.58)	0.02 (0.91)	0.18 (0.37)	-0.23 (0.23)	-0.02 (0.92)	-0.32 (0.09)	0.22 (0.27)
Vit C	0.02 (0.92)	-0.23 (0.23)	-0.10 (0.62)	-0.11 (0.56)	0.01 (0.98)	0.05 (0.82)	-0.15 (0.45)	-0.02 (0.91)
Vit A	0.28 (0.15)	0.16 (0.42)	0.33 (0.09)	0.12 (0.56)	0.48 (0.01)**	0.04 (0.84)	0.31 (0.11)	0.06 (0.75)
Vit D	0.25 (0.20)	0.49 (0.01)**	0.28 (0.16)	0.38 (0.05)*	0.12 (0.53)	0.32 (0.10)	[illegible] (0.63)	0.08 (0.68)
Calcium	0.37 (0.05)	0.02 (0.94)	0.33 (0.08)	0.11 (0.56)	0.08 (0.70)	0.15 (0.46)	0.06 (0.76)	0.02 (0.94)
Iron	- -	- -	- -	- -	- -	- -	- -	
Zinc	0.30 (0.12)	-0.15 (0.44)	0.35 (0.07)	-0.01 (0.95)	0.18 (0.35)	0.09 (0.66)	0.18 (0.36)	0.07 (0.73)

1 n=30
2 Calculated from sum of risk of deficiency for 12 nutrients (protein, thiamin, riboflavin, folacin, vit B_{12}, vit B_6, vit C, vit A, vit D, calcium, iron and zinc) divided by 12
3 probability level of significance
*,** Significant at p<0.05, 0.01, respectively

Appendix 14: Part IIIb - Partial Correlation: Slope of Taste Intensity Vs. Percent Risk of Nutrient Deficiency (Diet Plus Vitamin/Mineral Supplements) Controlling for Previous Smoking Habits and Medication

NUTRIENT	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
	Elderly[1]	Young[1]	Elderly	Young	Elderly	Young	Elderly	Young
Index of Overall Nutritional Risk[2]	0.51 (0.01)[3]**	0.24 (0.23)	0.52 (0.01)**	0.22 (0.25)	0.42 (0.03)*	0.21 (0.29)	0.36 (0.06)	0.06 (0.75)
Protein	0.25 (0.20)	-0.23 (0.23)	0.46 (0.01)*	-0.11 (0.56)	0.32 (0.10)	0.05 (0.82)	0.43 (0.02)*	-0.02 (0.91)
Thiamin	- -	- -	- -	- -	- -	- -	- -	- -
Riboflavin	0.56 (0.00)**	-0.06 (0.76)	0.54 (0.00)**	-0.06 (0.78)	0.22 (0.26)	0.11 (0.57)	0.20 (0.30)	0.12 (0.54)
Folacin	0.38 (0.04)*	0.23 (0.24)	0.32 (0.09)	0.23 (0.23)	0.44 (0.02)*	0.20 (0.32)	0.43 (0.02)*	0.12 (0.53)
Vit B_{12}	0.49 (0.01)**	0.49 (0.01)**	0.41 (0.03)*	0.4[illegible] (0.0[illegible])*	0.10 (0.62)	0.51 (0.01)**	0.06 (0.77)	0.14 (0.48)
Vit B_6	-0.09 (0.64)	-0.28 (0.14)	0.02 (0.91)	-0.10 (0.60)	-0.23 (0.23)	-0.11 (0.59)	-0.32 (0.09)	-0.08 (0.67)
Vit C	0.11 (0.59)	-0.23 (0.24)	-0.01 (0.96)	-0.11 (0.56)	-0.02 (0.92)	0.05 (0.82)	-0.15 (0.45)	-0.02 (0.91)
Vit A	0.28 (0.15)	0.06 (0.78)	0.33 (0.09)	-0.06 (0.98)	0.48 (0.01)**	-0.02 (0.93)	0.31 (0.11)	-0.04 (0.84)
Vit D	0.43 (0.02)*	0.48 (0.01)**	0.38 (0.04)*	0.36 (0.06)	0.23 (0.23)	0.31 (0.11)	0.20 (0.32)	0.07 (0.74)
Calcium	0.37 (0.05)	0.01 (0.96)	0.33 (0.09)	0.11 (0.58)	0.08 (0.69)	0.15 (0.46)	0.06 (0.75)	0.02 (0.92)
Iron	- -	- -	- -	- -	- -	- -	- -	- -
Zinc	0.30 (0.12)	-0.16 (0.40)	0.35 (0.07)	-0.03 (0.90)	0.18 (0.35)	0.08 (0.67)	0.18 (0.36)	0.08 (0.69)

1 - n=30
2 Calculated from sum of risk of deficiency for 12 nutrients (protein, thiamin, riboflavin, folacin, vit B_{12}, vit B_6, vit C, vit A, vit D, calcium, iron and zinc) divided by 12
3 Probability level of sign..icance
*,** Significant at $p<0.05$, 0.01, respectively

Appendix 14: Part IVa - Partial Correlation: Slope of Taste Intensity Vs. Nutrient Intakes (Diet Only) Controlling for Previous Smoking habits and Medication

	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
NUTRIENT	Elderly[1]	Young[1]	Elderly	Young	[illegible]erly	Young	Elderly	Young
Calories	-0.28 (0.15)	-0.35 (0.07)	-0.39 (0.04)*	-0.34 (0.07)	-0.28 (0.14)	-0.43 (0.02)*	-0.35 (0.06)	-0.40 (0.04)*
Protein	-0.32 (0.10)	-0.28 (0.16)	-0.50 (0.01)**	-0.31 (0.10)	-0.15 (0.44)	-0.46 (0.02)*	-0.29 (0.14)	-0.39 (0.04)
Thiamin	-0.33 (0.08)	-0.35 (0.07)	[illegible]	-0.35 (0.07)	-0.12 (0.54)	-0.25 (0.20)	-0.39 (0.04)*	-0.32 (0.10)
Riboflavin	-0.28 (0.15)	-0.32 (0.10)	[illegible]	-0.37 [illegible]	-0.23 (0.24)	-0.36 (0.06)	-0.26 (0.18)	-0.31 (0.11)
Folacin	-0.55 (0.00)**	-0.26 (0.17)	[illegible]	[illegible]	-0.38 (0.04)*	-0.30 (0.12)	-0.38 (0.05)*	-0.33 (0.09)
Vit B_{12}	-0.23 (0.24)	-0.25 (0.19)	[illegible]	[illegible]	-0.29 (0.14)	-0.34 (0.08)	-0.02 (0.92)	-0.14 (0.47)
Vit B_6	-0.35 (0.07)	-0.24 (0.22)	[illegible]	[illegible]	-0.23 (0.25)	-0.32 (0.10)	-0.34 (0.07)	-0.44 (0.02)*
Vit C	-0.15 (0.44)	-0.01 (0.94)	[illegible]	[illegible] (0.94)	-0.23 (0.25)	-0.13 (0.52)	-0.17 (0.38)	-0.11 (0.58)
Vit A	-0.31 (0.11)	-0.15 (0.44)	-0.38 (0.05)	-0.18 (0.35)	-0.38 (0.04)*	0.05 (0.79)	-0.13 (0.50)	-0.22 (0.25)
Vit D	-0.20 (0.30)	-0.37 (0.05)*	-0.30 (0.13)	-0.33 (0.08)	0.09 (0.63)	-0.20 (0.30)	-0.10 (0.61)	-0.14 (0.48)
Calcium	-0.40 (0.03)*	-0.26 (0.18)	-0.46 (0.02)*	-0.35 (0.07)	-0.19 (0.34)	-0.37 (0.05)	-0.26 (0.18)	-0.27 (0.17)
Iron	-0.42 (0.03)*	-0.30 (0.12)	-0.59 (0.00)***	-0.22 (0.26)	-0.30 (0.12)	-0.19 (0.33)	-0.43 (0.02)*	-0.24 (0.21)
Zinc	-0.34 (0.08)	-0.21 (0.29)	-0.38 (0.04)*	-0.26 (0.17)	-0.05 (0.78)	-0.35 (0.07)	-0.13 (0.52)	-0.31 (0.11)
Dietary Fiber	-0.49 (0.01)**	-0.22 (0.26)	-0.53 (0.00)**	-0.23 (0.24)	-0.29 (0.13)	-0.09 (0.63)	-0.34 (0.08)	-0.14 (0.49)

1 n 30
2 Probability level of significance
*, **, *** Significant at p<0.05, 0.01, 0.001, respectively

Appendix 14: Part IVb - Partial Correlation: Slope of Taste Intensity Vs. Nutrient Intakes (Diet Plus Supplements) Controlling for Previous Smoking Habits and Medication

NUTRIENT	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
	Elderly[1]	Young[1]	Elderly	Young	Elderly	Young	Elderly	Young
Calories	-0.28 (0.15)	-0.35 (0.07)	-0.39 (0.04)*	-0.34 (0.07)	-0.28 (0.14)	-0.43 (0.02)*	-0.35 (0.06)	-0.40 (0.04)*
Protein	-0.32 (0.10)	-0.28 (0.16)	-0.50 (0.01)**	-0.31 (0.10)	-0.15 (0.44)	-0.46 (0.02)*	-0.29 (0.14)	-0.39 (0.04)
Thiamin	-0.15 (0.46)	0.08 (0.67)	-0.14 (0.48)	0.05 (0.79)	-0.16 (0.42)	-0.17 (0.39)	-0.13 (0.50)	-0.22 (0.26)
Riboflavin	-0.13 (0.53)	-0.14 (0.49)	-0.14 (0.47)	0.05 (0.79)	-0.13 (0.51)	-0.25 (0.21)	-0.11 (0.57)	-0.19 (0.34)
Folacin	-0.32 (0.09)	-0.18 (0.36)	-0.25 (0.20)	-0.19 (0.34)	-0.34 (0.07)	-0.30 (0.12)	-0.23 (0.23)	-0.33 (0.09)
Vit B_{12}	-0.26 (0.18)	-0.01 (0.98)	-0.31 (0.10)	-0.08 (0.69)	0.02 (0.91)	-0.31 (0.11)	-0.03 (0.89)	-0.19 (0.33)
Vit B_6	-0.12 (0.53)	0.08 (0.68)	-0.14 (0.49)	-0.01 (0.94)	-0.11 (0.58)	-0.17 (0.38)	-0.10 (0.61)	-0.30 (0.12)
Vit C	-0.21 (0.27)	0.11 (0.56)	-0.08 (0.69)	0.14 (0.48)	0.10 (0.61)	-0.14 (0.49)	-0.04 (0.83)	-0.08 (0.69)
Vit A	-0.28 (0.15)	0.05 (0.81)	-0.23 (0.24)	-0.06 (0.76)	-0.20 (0.30)	-0.03 (0.88)	-0.12 (0.56)	-0.13 (0.52)
Vit D	-0.30 (0.12)	-0.18 (0.35)	-0.34 (0.08)	0.23 (0.23)	-0.04 (0.86)	-0.25 (0.19)	-0.06 (0.76)	-0.08 (0.67)
Calcium	-0.35 (0.07)	-0.26 (0.19)	-0.46 (0.02)*	-0.35 (0.07)	-0.01 (0.96)	-0.37 (0.05)	-0.14 (0.47)	-0.27 (0.16)
Iron	-0.32 (0.10)	-0.24 (0.22)	-0.37 (0.06)	-0.17 (0.38)	-0.13 (0.51)	-0.23 (0.24)	-0.24 (0.21)	-0.27 (0.16)
Zinc	-0.24 (0.22)	-0.11 (0.56)	-0.22 (0.27)	-0.14 (0.48)	-0.02 (0.93)	-0.32 (0.10)	-0.09 (0.65)	-0.37 (0.05)
Dietary Fiber	-0.49 (0.01)**	-0.22 (0.26)	-0.53 (0.00)**	-0.23 (0.24)	-0.29 (0.13)	-0.09 (0.63)	-0.34 (0.08)	-0.14 (0.49)

1 n=30
2 Probability level of significance
*, **, *** Significant at p<0.05, 0.01, 0.001, respectively

Appendix 14. Part V: Canonical correlation: slope of sourness and saltiness taste intensity vs. nutrient risk and nutrient intake (diet with vitamin/mineral supplements) for the elderly and the young

Nutrient Parameter	Sourness		Saltiness	
	Elderly	Young	Elderly	Young
I. Nutrient risk:				
Index of overall nutritional risk	0.54**	0.24	0.30	0.25
Protein	0.46*	0.24	0.41	0.07
Thiamin	--	--	--	--
Riboflavin	0.58**	0.06	0.10	0.14
Folacin	0.36	0.25	0.37	0.16
Vit B_{12}	0.47*	0.51*	0.04	0.57**
Vit B_6	0.10	0.30	0.24	0.11
Vit C	0.15	0.24	0.20	0.07
Vit A	0.35	0.07	0.39	0.04
Vit D	0.44	0.47*	0.14	0.35
Calcium	0.35	0.28	0.02	0.22
Iron	--	--	--	--
Zinc	0.33	0.21	0.13	0.10
II. Nutrient intake:				
Calories	0.39	0.39	0.21	0.45*
Protein	0.49*	0.40	0.23	0.48*
Fat	0.34	0.35	0.17	0.28
Carbohydrate				
Total	0.33	0.29	0.23	0.31
Dietary Fiber	0.52*	0.26	0.23	0.11
Thiamin	0.18	0.05	0.18	0.23
Riboflavin	0.16	0.15	0.15	0.24
Vit B_6	0.16	0.09	0.14	0.31
Vit B_{12}	0.33	0.19	0.07	0.33
Folacin	0.32	0.19	0.30	0.30
Vit C	0.20	0.14	0.21	0.11
Vit A	0.30	0.14	0.22	0.19
Vit D	0.36	0.26	0.04	0.21
Calcium	0.43	0.32	0.21	0.39
Iron	0.39	0.24	0.23	0.28
Zinc	0.26	0.20	0.12	0.40

-- indicates no canonical correlations made due to singularity of variable (no risks of deficiency for this nutrient for all subjects)

* significant at $p<0.05$

Appendix 14 Part VIa: Stepwise regression equations for sour and salty taste intensity slopes (Y), standard error of the estimate (S), and coefficient of multiple determination (R^2) for the elderly and the young (Percent risk of nutrient deficiency from diet plus supplements)

Parameter	Equation[1]	S	R^2
I. Sourness			
A. Elderly:			
Slope of Sourness in Aqueous System	Y=.364 +.071(Riboflavin Risk)*** -.036(Previous Smoking)*	.13	.34***
Slope of Sourness in Food System	Y=.165 +.057(Riboflavin Risk)*** +.003(Protein Risk)**	.12	.43****
B. Young:			
Slope of Sourness in Aqueous System	Y=-2.871 +.849(Vit B12 Risk)*** +.020(Height)***	.23	.42****
Slope of Sourness in Food System	Y=-2.549 +.765(Vit B12 Risk)*** +.017(Height)** -.122(Previous Smoking)**	.23	.44***
II. Saltiness			
A. Elderly			
Slope of Saltiness in Aqueous System	Y=.331 +.002(Vit A Risk)** -.042(Medication)** +.001(Folacin Risk)*	.17	.40***
Slope of Saltiness in Food System	Y=-1.383 +.003(Protein Risk)** +.009(Height)*	.13	.28**
B. Young			
Slope of Saltiness in Aqueous System	Y=.576 +.602(Vit B12 Risk)****	.18	.25***
Slope of Saltiness in Food System	Y=-1.465 +.011(Height)*	.21	.10*

[1] variables entered into equations at $p<0.10$

*, **, ***, **** significant at $p<0.10$, 0.05, 0.01 and 0.001, respectively

Appendix 14 Part VIb: Stepwise regression equations for sour and salty taste intensity slopes (Y), standard error of the estimate (S), and coefficient of multiple determination (R^2) for the elderly and the young (nutrient intake from diet plus vitamin/mineral supplements)

Parameter	Equation[1]		S	R^2
I. Sourness				
A. Elderly:				
Slope of Sourness in Aqueous System	Y=.558	-.008(Dietary Fiber Intake)*** -.038(Previous Smoking)*	.14	.26**
Slope of Sourness in Food System	Y=.374	-.008(Dietary Fiber Intake)****	.13	.26***
B. Young:				
Slope of Sourness in Aqueous System	Y=-2.097	+.019(Height)** -2.5x10-4(Caloric Intake)**	.25	.29**
Slope of Sourness in Food System	Y=-1.811	-.005(Protein Intake)** +.015(Height)*	.26	.27**
II. Saltiness				
A. Elderly				
Slope of Saltiness in Aqueous System	Y=.480	-.057(Dentures)**	.19	.14**
Slope of Saltiness in Food System	Y=-2.241	+.017(Height)*** -1.6x10-4(Caloric Intake)** -.049(Cardiovascular Drugs)**	.13	.39***
B. Young				
Slope of Saltiness in Aqueous System	Y=1.005	-.004(Protein Intake)**	.19	.19**
Slope of Saltiness in Food System	Y=-1.439	-.004(Protein Intake)** +.013(Height)** -.049(Vit B6)*	.18	.39***

[1] variables entered into equation at $p<0.10$

*,**,***,**** significant at $p<0.10$, 0.05, 0.01 and 0.001, respectively