Investigating age-related changes in taste and affects on sensory perceptions of oral nutritional supplements

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Abstract

Background: sip feeds are oral nutritional supplements (ONSs) that are commonly prescribed to malnourished patients to improve their nutritional and clinical status. However, ONSs are poorly consumed and frequently wasted, with sweetness being identified as one of the factors leading to patients’ dislike of ONSs.

Objectives: to investigate if age affects sweetness thresholds and if this impacts upon perceived sweetness intensity, hedonic (sweetness and overall) and ranked preference of ONS products.

Design: prospective, observational.

Subjects: thirty-six young adults (18–33 years) and 48 healthy older adults (63–85 years).

Setting: Department of Food and Nutritional Sciences and the Clinical Health Sciences at the University of Reading.

Methods: detection and recognition threshold levels, basic taste identification and ‘just about right’ level of sweetness were examined. Three ONSs (chocolate, vanilla, strawberry) and sucrose solutions were evaluated for hedonic sweetness, overall hedonic liking, sweetness intensity and rank preference.

Results: significant differences were found in both sweetness detection and recognition thresholds \( (P = 0.0001) \) between young and older adults, with older adults more likely to incorrectly identify the taste \( (P = 0.0001) \). Despite the deterioration in sweetness sensitivity among the older adults, there were no significant differences found in sweetness intensity perceived for the ONS products presented \( (P > 0.05) \) when compared with the young adults. However, across both groups sweetness intensity was found to be correlated with overall product dislike across all flavour variants tested \( (R = 0.398, P = 0.0001) \).

Conclusions: sweetness appears to be one of many factors contributing to the dislike of ONSs. Manufacturers are encouraged to reconsider the formulations of these products so that beneficial effects of ONSs can be delivered in a more palatable and acceptable form and wastage reduced.

Keywords: oral nutritional supplement, taste, acceptability, preference, elderly
Introduction

In the UK, the population is ageing with 16% of the population aged 65 and over [1]. Healthy ageing is essential to maintain a high quality of life and is defined by World Health Organisation (WHO) as the state of complete physical, mental and social well-being [2]. However, malnutrition among older adults diminishes quality of life by contributing to serious illness, decreased functional capability and altered self-perception of health and chronic disability [3]. The prevalence of malnutrition in older adults is widespread across the UK and varies geographically, with higher prevalence in the north (19.4%) than the south (11.2%) of England [4]. Recent statistics from National Institute for Health and Clinical Excellence [5] suggested that more than 10% of over 65 in the general population are at medium or high risk of malnutrition and that this figure rises to 60% in the hospital setting. The 2008 British Association for Parenteral and Enteral Nutrition (BAPEN) Nutrition screening survey found that one in three adults admitted to hospitals was malnourished and that those aged 65 plus had 40% greater risk of malnutrition than those <65 years [6].

Many authors, including early work by McWhirter and Pennington [7], have suggested that the earlier nutritional intervention is started, the greater the clinical benefit to patients. This will in turn lower the total cost of treating malnutrition to the UK National Health Service (NHS), estimated at £7.4 billion [8], and to the UK, £13 million per annum [9]. Nutritional intervention therapies such as dietary supplements are commonly used to treat malnutrition and can be given enterally or parenterally [10]. Oral supplements such as oral nutritional supplement (ONS) ready to drink supplements available in cartons, cans, bottles and cups can be provided on prescription to patients and used in addition to normal food consumption to increase nutrient intake. The typical nutritional content of an ONS is 1.5 kcal/ml and consists of 14–20% protein, 25–35% fat and 50–60% carbohydrates; the vitamin and mineral content generally supplies a proportion of the recommended nutrient intake in a 200 ml pack [11]. Much previous research and reviews have examined the prevention/treatment of malnutrition using products such as these [10, 12, 13].

However, it is reported that the use of ONSs is associated with high wastage, and therefore, the benefit of ONSs cannot be delivered if they are not consumed. Gosney [12] investigated the palatability and consumption of ONSs and the reasons for wastage. Wastage in four wards (96 patients) within a 24 h period was as much as 63%, and this wastage was further extrapolated to a net loss of £18,924 on ONSs per year in our elderly care wards in the 1990s. Sweetness was given as one of the reasons leading to dislike of these products.

Aim of this study

This aim of the study was to investigate whether a difference in sweetness perception as indicated by threshold and detection levels exist between young and older adults and to examine whether this was related to differences, if any, in the perception of sensory attributes, acceptability and hedonic liking of ONSs. Our null hypothesis is that differences in sweetness thresholds between young and older adults are so small that they will not relate to the perception of sensory attributes, acceptability and hedonic liking of ONSs.

Methods and materials

The study was approved by the Research and Ethics Committee at the University of Reading, UK, prior to recruiting the study participants.

Recruitment of young and older adult participants

The young adults were recruited by advertising through email and posters from students and staff at the University of Reading. Older adults were recruited via postal communication with those on the older adults’ database held by Clinical Health Sciences at the University of Reading. All self-selected respondents who met the inclusion criteria were invited to participate in the study; therefore, a convenience sampling strategy was employed. Thirty-six young adults aged 18–33 (mean age 23) and 48 healthy older adults aged 63–85 (mean age 74.4) participated in this study.

Sensory tests

Stimuli for sweetness threshold tests

The series of sucrose solutions for testing were prepared according to British Standard ISO 3972:1991[14]. Commercially available spring water (Harrogate Spa) was used throughout the study. All solutions were prepared within 24 h prior to each test in order to retain freshness and to prevent separation.

Stimuli for preference tests

Ensure Plus, a commercially available nutritional sip feed, was chosen for this study as it was identified to be the most often prescribed brand within the elderly care wards at the local NHS Trust. Three ONS flavours, vanilla, strawberry and chocolate, were chosen as these were the most commonly prescribed product variants. All had identical nutritional values and sweetness levels.

Procedures

All the sensory sessions for the young adults took part in a dedicated sensory laboratory, and the sensory tests for the older adults took place at the Clinical Health Sciences, both located at the University of Reading. Participants in both groups completed two sets of tests on each of three separate occasions: a series of threshold tests and a series of sensory attribute intensity, hedonic liking and rank
Threshold tests
Participants compared each of nine solutions with the reference sample (water) and identified the point where they could detect a difference (detection threshold) and the point where they could identify the taste (recognition threshold) which they had perceived. Detection threshold is a sensory term used to describe the concentration (or level) at which an individual (or group of individuals) can detect the existence of a signal from the background noise. To calculate a threshold, the participant is given a series of increasing stimuli (in this case, concentrations of sucrose in water), the detection threshold is calculated as the geometric mean between two samples, the highest concentration at which the participant could not detect the signal and the lowest concentration at which they could. Both thresholds enable the study to identify the sensitivity of sweetness in each participant. Participants were also required to choose the just about right (JAR) concentration of the presented solutions.

Sensory attribute and preference tests
Volunteers were presented with three flavours of the sip feeds and a sucrose solution containing the equivalent sugar content (28.8 g in 500 ml/5.76 g in 100 ml), presented using a randomised balanced order design. The sucrose solution acted as a control, enabling the investigation ofavour type impacts sweetness perception. Sweetness liking/hedonic and the overall product liking of the samples using a 7-point hedonic scale [like extremely (1) to dislike extremely (7)]. Following this, participants were asked to rank products in the order of overall preference (1 most preferred to 3 least preferred). Sweetness intensity was measured on a 100 mm line scale with descriptors ‘not at all sweet’ (0 mm) to ‘extremely sweet’ (100 mm). Participants were required to rate how much (quantitatively) they liked the sweetness intensity.

Statistical analysis
Data analysis was performed using Statistical Package for the Social Sciences (SPSS) (Chicago, IL, USA, Version 15.0). As no differences were found in intra-individual results between test days (P > 0.05), means of the triplicate test results were calculated for each participant and were used throughout for analysis (to compare between age groups and genders). A two-way analysis of variance was used throughout for analysis (to compare between age groups and genders).

Product hedonic liking tests
In overall hedonic liking (both young and older adults), chocolate was the most liked and the control sucrose solution was the least liked sample tested. These data are also mirrored by the rank preference data where the chocolate variant was ranked more preferred for both young and older adults (Table 2).

Results
No differences were found in intra-individual results between test days (P > 0.05); therefore, means of the triplicate test results were calculated for each participant and were used throughout for analysis (to compare between age groups and genders).

Threshold tests: sweetness sensitivity differences in young and older adults
A significant difference in detection threshold (P = 0.0001), recognition threshold (P = 0.0001) and JAR sweetness level (P = 0.03) was found between the young and older adults. The older adults were significantly less sensitive to sweetness than the young adults. A significant difference in the older adults compared with the younger group’s ability to identify the taste was found (P = 0.0001 data not shown). Gender did not affect any of the parameters measured (Table 1).

Product hedonic liking tests
In overall hedonic liking (both young and older adults), chocolate was the most liked and the control sucrose solution was the least liked sample tested. These data are also mirrored by the rank preference data where the chocolate variant was ranked more preferred for both young and older adults (Table 2).

Table 1. Mean detection and recognition thresholds, JAR sweetness levels by age and gender

<table>
<thead>
<tr>
<th></th>
<th>Young males</th>
<th>Young females</th>
<th>Older males</th>
<th>Older females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection (g/l)</td>
<td>3.75a</td>
<td>3.52b</td>
<td>3.45a</td>
<td>3.87a</td>
</tr>
<tr>
<td>Recognition (g/l)</td>
<td>5.94a</td>
<td>5.89b</td>
<td>5.77a</td>
<td>6.00a</td>
</tr>
<tr>
<td>JAR (g/l)</td>
<td>6.34a</td>
<td>6.87b</td>
<td>5.92a</td>
<td>6.51b</td>
</tr>
</tbody>
</table>

Mean values within the same row with different superscripts are significantly different as determined by Fisher's LSD (P < 0.05).

Table 2. Mean product overall hedonic liking and sweetness intensity for all products across all groups

<table>
<thead>
<tr>
<th></th>
<th>Vanilla</th>
<th>Strawberry</th>
<th>Chocolate</th>
<th>Sucrose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall hedonics</td>
<td>3.77a</td>
<td>3.91a</td>
<td>3.69a</td>
<td>4.44b</td>
</tr>
<tr>
<td>Sweetness intensity</td>
<td>64.5a</td>
<td>68.5b</td>
<td>54.2c</td>
<td>75.4d</td>
</tr>
</tbody>
</table>

Mean values within the same row with different superscripts are significantly different as determined by Fisher’s LSD (P < 0.05).

<sup>a</sup>7-point hedonic scale.
<sup>b</sup>100 mm line scale.
Product sweetness intensity

The sweetness intensity of the sucrose solution perceived by the older adults was significantly lower than ratings from the young group \((P = 0.03)\), and young males perceived the solutions as significantly sweeter than all other groups \((P < 0.05)\). No differences were found between other flavour variants in terms of sweetness intensity ratings by either age or gender.

Despite the identical sweetness level across all samples, the sweetness intensity perceived by both groups (young and older adults) were significantly different for each product variant, with the chocolate flavour sweetness intensity perceived as significantly lower than all other variants and the sucrose solution as the highest sweetness intensity \((P < 0.05)\). This suggests that there is a strong taste and/or aroma interaction in perceptions of sweetness intensity. It is possible that coca would increase bitterness which may have suppressed the sweetness.

Relationship between sweetness intensity and hedonic measures

An inverse relationship was found for overall and individual product variants sweetness intensity and both hedonic liking of the product sweetness \((R = 0.399, P = 0.001)\) and overall product characteristics \((R = 0.398, P = 0.001)\). It may therefore be inferred that as the products perceived sweetness intensity increased, so too did product dislike.

Discussion and conclusion

Significant differences were found in both detection and recognition thresholds and the correct identification of the basic taste of sweetness between young and older adults, which reflect the findings of other researchers \([15–17]\) who have reported that taste sensitivity decreases with age. It has been suggested that differences in taste recognition, such as those found in this study may be due to a time lag in the turnover of taste receptor cells \([18]\), as work has shown that there is no decrease in the number of taste buds with age which earlier research had postulated \([19, 20]\).

Although previous work has demonstrated age-related changes in taste acuity, few studies have explored the interaction of this with real food systems such as ONSs used in the current study. Work carried out in the Netherlands found older adults perceived sweet ingredients in chocolate drinks and vanilla waffles as less intense than the young \([21, 22]\). However, no differences in perceived sweetness of dairy products \([23]\) or custards \([24]\) have been found.

In the current study, dislike of ONSs was found, the degree of which varied across flavours, genders and age groups. The chocolate flavour ONS was found to be the most liked and was perceived as less sweet than other product variants presented in this study. In general, all older adults who had significantly higher sweetness thresholds rated the ONSs more negatively for liking (both sweetness and overall liking of the samples), although they perceived the sweetness intensity of the products to be less intense than the young adults. This infers that other product sensory attributes in addition to sweetness are contributing to the dislike of these products. Indeed, it has been suggested by others that the incongruence found between sensory and hedonic modalities is due to different processing pathways for these in the brain \([25, 26]\).

It had been assumed in the past that age-related sensory losses may lead to modifications of food pleasantness and food choice \([27]\); however, others suggest that a habituation process to the decreased perception exists which may offer a compensatory mechanism to prevent decreases in food liking \([28]\). This may in part explain why significant differences in taste acuity found in the current study did not translate into significant differences in liking across the age groups.

In Gosney’s study \([12]\), 38% of participants disliked the sweetness of ONSs (not flavour-specific) which reflects the results of the current study where 27% of the older adults disliked the sweetness, whereas in young adults this was more accepted as only 6% disliked the sweetness. However, in this study, 25% disliked that taste, 19% the texture and a further 19% commented that they felt sick or bloated post-consumption. Compliance was extremely low at only 37%. Although we did not find that sweetness acuity directly related to liking of these products, we did find that sweetness intensity is one of the factors leading to dislike of these products.

Even though the difference in results shown in Table 3 may appear small and some may question their clinical relevance, however, in terms of consumer acceptability, products with a value of <5 are unlikely to be available on the open market, and these low scores indicate poor liking of the products, but show that the degree of this was moderated by flavour. In addition, the difference between liking scores of over 1 point (on a 7-point scale) for some of the flavour variants between older males and females is of interest and concern. Liking scores of <3, as a mean for older males, would certainly be expected to lead to product rejection. It is also interesting to note that in general males across both age groups scored the products less favourably than females, again increasing the likelihood of their rejection.

Table 3. Overall hedonic liking of products rating by age group and gender

<table>
<thead>
<tr>
<th>Hedonic liking</th>
<th>Young adults</th>
<th>Older adults</th>
<th>Young males</th>
<th>Older females</th>
<th>Young females</th>
<th>Males</th>
<th>Older females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanilla</td>
<td>3.71a</td>
<td>3.81a</td>
<td>3.05a</td>
<td>3.97a</td>
<td>2.81a</td>
<td>4.4b</td>
<td></td>
</tr>
<tr>
<td>Strawberry</td>
<td>3.88a</td>
<td>3.92a</td>
<td>3.35a</td>
<td>4.08a</td>
<td>2.98a</td>
<td>4.49b</td>
<td></td>
</tr>
<tr>
<td>Chocolate</td>
<td>3.41a</td>
<td>3.74a</td>
<td>3.22a</td>
<td>3.49a</td>
<td>3.45a</td>
<td>3.91a</td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>4.07a</td>
<td>4.71a</td>
<td>4.85a</td>
<td>3.76b</td>
<td>4.31a</td>
<td>4.97a</td>
<td></td>
</tr>
</tbody>
</table>

Mean values within the same row with different superscripts are significantly different as determined by Fisher’s LSD \((P < 0.05)\).

*7-point hedonic scale.*
We acknowledge that we used a convenience sample of young and older adults, and therefore our results may not be generalisable; however, we feel that they are important in pointing out some directions in which research could be focused in terms of effective treatment of malnutrition. Although it has long been known that ONSs are wasted with the common reason being given that consumers/patients dislike the taste, our research has sought to address what aspects of taste are disliked and examine whether this is related to sweetness thresholds and sweetness and flavour of the products. The research which we have presented in this paper has used a multidisciplinary approach involving sensory scientists, flavour chemists, dietitians, nutritionists and clinicians to try and understand some of the ‘taste’ issues surrounding poor consumption and we are currently using these findings to develop solutions to improve ONS acceptability.

We would suggest that more research is needed in this area as results of this study indicate that ONSs may need to be reformulated depending on target group (age and gender) to increase acceptance and increase consumption. Reformulation will be especially beneficial among malnourished older adults but also within all groups where these products are used, so that required nutrients could be delivered in a more palatable form, maximising the nutritional effects of ONSs and in turn reducing wastage.

Key points
• Young and older adults possess significantly different sweetness threshold levels.
• As perceived products sweetness increased, liking of the products decreased.
• Chocolate flavour ONS was the most preferred product tested.

Acknowledgements
Abbott Nutrition is thanked for the supply of ONSs used in this study.

Conflict of interest
None declared.

Supplementary data
Supplementary data mentioned in the text is available to subscribers in Age and Aging online.

References
Population attributable risk for functional disability associated with chronic conditions in Canadian older adults

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Abstract

Objectives: to investigate the population impact on functional disability of chronic conditions individually and in combination.

Methods: data from 9,008 community-dwelling individuals aged 65 and older from the Canadian Study of Health and Aging (CSHA) were used to estimate the population attributable risk (PAR) for chronic conditions after adjusting for confounding variables. Functional disability was measured using activity of daily living (ADL) and instrumental activity of daily living (IADL).

Results: five chronic conditions (foot problems, arthritis, cognitive impairment, heart problems and vision) made the largest contribution to ADL- and IADL-related functional disabilities. There was variation in magnitude and ranking of population attributable risk (PAR) by age, sex and definition of disability. All chronic conditions taken simultaneously accounted for about 66% of the ADL-related disability and almost 50% of the IADL-related disability.

Conclusions: in community-dwelling older adults, foot problems, arthritis, cognitive impairment, heart problems and vision were the major determinants of disability. Attempts to reduce disability burden in older Canadians should target these chronic conditions; however, preventive interventions will be most efficient if they recognize the differences in the drivers of PAR by sex, age group and type of functional disability being targeted.

Keywords: chronic disease, functional disability, activities of daily living, risk factors, ageing, elderly