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

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

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: Dept. of Food & 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 ONS (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 to 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 ONS. Manufacturers are encouraged to reconsider the formulations of these products so that beneficial effects of ONS can be delivered in a more palatable and acceptable form and wastage reduced.

Keywords: oral nutritional supplement, taste, acceptability, preference

Introduction

In the United Kingdom 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 Organisations (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 U.K. 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's 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 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 per ml and consists of 14-20% protein, 25-35% fat, 50%-60% carbohydrates; the vitamin and mineral content generally supplies a proportion of the Recommended Nutrient Intake (RNI) in a 200ml pack [11]. Much previous research and reviews have examined the prevention/treatment of malnutrition using products such as these. [10, 13, 14].

However, it is reported that the use of ONS is associated with high wastage, therefore, the benefit of ONS cannot be delivered if they are not consumed. Gosney [13] investigated the palatability and consumption of ONS and the reasons for wastage. Wastage in four wards (96 patients) within a 24 hour period was as much as 63% and this wastage was further extrapolated to a net loss of £18,924 on ONS per year our elderly care wards in the 1990's. 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 if a difference in sweetness perception as indicated by threshold and detection levels exist between young and older adults and to examine if this was related to differences, if any, in the perception of sensory attributes, acceptability and hedonic liking of ONS. 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 ONS.

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 age 18-33 (mean age 23)

and forty-eight healthy older adults age 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[15]. Commercially available spring water (Harrogate Spa) was used throughout the study. All solutions were prepared within 24-hours 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 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 preference tests. Each sample in each test was coded with a randomised 3 digit code and samples in the second set of tests were presented in randomised order. Water and crackers (Carr's brand) were provided as palate cleansing tools to minimise carry over effects.

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 & preference tests

Volunteers were presented with three flavours of the sip feeds and a sucrose solution containing the equivalent sugar content (28.8g in 500ml/5.76g in 100ml), presented using a random balanced order design. The sucrose solution acted as a control,

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enabling the investigation of how flavour type impacts on 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 order of overall preference (1 most preferred to 3 least preferred). Sweetness intensity was measured on a 100mm line scale with descriptors '*not at all sweet'* (0mm) to '*extremely sweet'* (100mm). 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, Illinois, 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 (ANOVA) was used to examine the impact of age and gender on the variables measured with post hoc analysis, the multiple pair-wise comparisons test used to compare samples was Fishers least significant difference (LSD) ($P<0.05$).

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 Just About Right (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 to the younger group ability to identify the taste was found (P=0.0001 data not shown). Gender did not affect any of the parameters measured.

Table 1. Mean detection and recognition thresholds, Just About Right (JAR) sweetness levels by age and gender.

Thresholds (g/L)	Young adults Mean	Older adults Mean	Young males Mean	Young females Mean	Older Males Mean	Older females Mean
Detection	3.75 [a]	5.52[b]	3.45[a]	3.87[a]	5.10 [b]	5.78[b]
Recognition	5.94[a]	6.89[b]	5.77[a]	6.00[a]	6.79[b]	6.95 [b]
JAR	6.34[a]	6.87[b]	5.92[a]	6.51[*b*]	6.76 [b]	6.94 [b]

Mean values within the same row with different superscripts are significantly different as determined by Fishers least significant difference (LSD) (P<0.05).

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. This data is also mirrored by the rank preference data where the chocolate variant was ranked more preferred for both young and older adults.

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

	Vanilla	Strawberry	Chocolate	Sucrose
	Mean	Mean	Mean	Mean
Overall hedonics$	3.77[a]	3.91[a]	3.60[a]	4.44[b]
Sweetness intensity*	64.5[a]	68.5[b]	54.2[c]	75.4[d]

Mean values within the same row with different superscripts are significantly different as determined by Fishers least significant difference (LSD) (P<0.05) $ 7 point hedonic scale; * 100mm line scale

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

Hedonic liking*	Young adults Mean	Older adults Mean	Young males Mean	Young females Mean	Older Males Mean	Older females Mean
Vanilla	3.71 [a]	3.81 [a]	3.05 [a]	3.97 [a]	2.81 [a]	4.4 [b]
Strawberry	3.88 [a]	3.92 [a]	3.35 [a]	4.08 [a]	2.98 [a]	4.49 [b]
Chocolate	3.41 [a]	3.74 [a]	3.22 [a]	3.49 [a]	3.45 [a]	3.91 [a]
Sucrose	4.07 [a]	4.71 [a]	4.85 [a]	3.76 [b]	4.31 [a]	4.97 [a]

*7 point hedonic scale

Mean values within the same row with different superscripts are significantly different as determined by Fishers least significant difference (LSD) (P<0.05)

Please see the tables 4 & 5 Appendix 2 in the supplementary data on the journal website

http://www.ageing.oxfordjournals.org/

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 that 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/ 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=0.0.398, 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 reflects the findings of other researchers [16, 17, 18] 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 [19] as work has shown that there is no decrease in the number of taste buds with age which earlier research had postulated [20,21].

Although previous work has demonstrated aged related changes in taste acuity, few studies have explored the interaction of this with real food systems such as ONS 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 [22, 23]. However no differences in perceived sweetness of dairy products [24] or custards [25] has been found.

In the current study, dislike of ONS 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 ONS more negatively for liking (both sweetness and overall liking of the samples) although they perceived the sweetness intensity of the products

to be less intensive 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 [26, 27).

It had been assumed in the past that age related sensory losses may lead to modifications of food pleasantness and food choice [28], however others suggest a habituation process to the decreased perception exists which may offer a compensatory mechanism to prevent decreases in food liking [29]. 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 [13], 38% of participants disliked the sweetness of ONS (not flavour specific) which reflects the results of the current study where 27% of the older adults disliking 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, 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 that females, again increasing the likelihood of their rejection.

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. It has long been known that ONS are wasted with the common reason been given that consumers/patients dislike the taste, our research has sought to address what aspects taste are disliked, and examine if 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 finding 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 ONS may need to be reformulated depending on target group (age and gender) to increase acceptance and increase consumption. Reformulation will be especially beneficial amongst 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 ONS and in turn reducing wastage.

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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.

Conflict of Interest:

None declared.

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375 Supplementary data

376 **Table 4.** Flavour rank preference data according to age group.

	Most liked (came first in preference ranking)	Least liked
Young adults	Chocolate	Strawberry
Older adults	Chocolate	Vanilla

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378 **Table 5.** Mean product sweetness intensity perception rating by age group and gender.

	Young adults	Older adults	Young males	Young females	Older Males	Older females
Sweetness intensity*	Mean	Mean	Mean	Mean	Mean	Mean
Vanilla	6.45[a]	6.45 [a]	5.94 [a]	6.64 [a]	6.07 [a]	6.68 [a]
Strawberry	6.86 [a]	6.75 [a]	6.62 [a]	6.96 [a]	6.52 [a]	6.89 [a]
Chocolate	5.55 [a]	5.32 [a]	5.16 [a]	5.70 [a]	5.24 [a]	5.37 [a]
Sucrose	8.03 [a]	7.17 [b]	9.02 [a]	7.63 [b]	7.05 [b]	7.25 [b]

*7 point hedonic scale

379 ***Mean values within the same row with different superscripts are significantly different as***

380 ***determined by Fishers least significant difference (LSD) (P<0.05).***

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