

Age related sensory changes & ONS

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

3

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

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

11 **Design:** prospective, observational.

12 **Subjects:** Thirty six young adults (18-33 years) and 48 healthy older adults (63-85
13 years).

14 **Setting:** Dept. of Food & Nutritional Sciences and the Clinical Health Sciences at the
15 University of Reading.

16 **Methods:**

17 Detection and recognition threshold levels, basic taste identification and 'just about
18 right' level of sweetness were examined. Three ONS (chocolate, vanilla, strawberry)
19 and sucrose solutions were evaluated for hedonic sweetness, overall hedonic liking,
20 sweetness intensity and rank preference.

21 **Results**

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

30 **Conclusions:** Sweetness appears to be one of many factors contributing to the dislike
31 of ONS. Manufacturers are encouraged to reconsider the formulations of these
32 products so that beneficial effects of ONS can be delivered in a more palatable and
33 acceptable form and wastage reduced.

34

35 **Keywords:** oral nutritional supplement, taste, acceptability, preference

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37

38

39 **Introduction**

40

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

56 Many authors, including early work by McWhirter and Pennington [7], have
57 suggested that the earlier nutritional intervention is started, the greater the clinical
58 benefit to patients. This will in turn lower the total cost of treating malnutrition to the

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59 UK National Health Service (NHS), estimated at £7.4 billion [8] and to the UK; £13
60 million per annum [9]. Nutritional intervention therapies such as dietary supplements
61 are commonly used to treat malnutrition, and can be given enterally or parenterally
62 [10]. Oral supplements such as ONS ready to drink supplements available in cartons,
63 cans, bottles and cups, can be provided on prescription to patients and used in addition
64 to normal food consumption to increase nutrient intake. The typical nutritional content
65 of an ONS is 1.5 Kcal per ml and consists of 14-20% protein, 25-35% fat, 50%-60%
66 carbohydrates; the vitamin and mineral content generally supplies a proportion of the
67 Recommended Nutrient Intake (RNI) in a 200ml pack [11]. Much previous research
68 and reviews have examined the prevention/treatment of malnutrition using products
69 such as these. [10, 13, 14].

70 However, it is reported that the use of ONS is associated with high wastage,
71 therefore, the benefit of ONS cannot be delivered if they are not consumed. Gosney
72 [13] investigated the palatability and consumption of ONS and the reasons for
73 wastage. Wastage in four wards (96 patients) within a 24 hour period was as much as
74 63% and this wastage was further extrapolated to a net loss of £18,924 on ONS per
75 year our elderly care wards in the 1990's. Sweetness was given as one of the reasons
76 leading to dislike of these products.

77

78 **Aim of this study**

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

86

87 **Methods and materials.**

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

90

91 *Recruitment of young and older adult participants*

92 The young adults were recruited by advertising through email and posters from
93 students and staff at the University of Reading. Older adults were recruited via postal
94 communication with those on the older adults' database held by Clinical Health
95 Sciences at the University of Reading. All self selected respondents who met the
96 inclusion criteria were invited to participate in the study; therefore a convenience
97 sampling strategy was employed. Thirty-six young adults age 18-33 (mean age 23)

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98 and forty-eight healthy older adults age 63-85 (mean age 74.4) participated in this
99 study.

100

101 *Sensory tests*

102 *Stimuli for sweetness threshold tests*

103 The series of sucrose solutions for testing were prepared according to British Standard
104 ISO 3972:1991[15]. Commercially available spring water (Harrogate Spa) was used
105 throughout the study. All solutions were prepared within 24-hours prior to each test in
106 order to retain freshness and to prevent separation.

107

108 *Stimuli for preference tests*

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

114

115 *Procedures*

116 All the sensory sessions for the young adults took part in a dedicated sensory
117 laboratory, and the sensory tests for the older adults took place at the Clinical Health

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118 Sciences, both located at the University of Reading. Participants in both groups
119 completed two sets of tests on each of three separate occasions; a series of threshold
120 tests and a series of sensory attribute intensity, hedonic liking and rank preference
121 tests. Each sample in each test was coded with a randomised 3 digit code and samples
122 in the second set of tests were presented in randomised order. Water and crackers
123 (Carr's brand) were provided as palate cleansing tools to minimise carry over effects.

124

125 *Threshold tests*

126 Participants compared each of nine solutions with the reference sample(water) and
127 identified the point where they could detect a difference (detection threshold) and the
128 point where they could identify the taste (recognition threshold) which they had
129 perceived. Detection threshold is a sensory term used to describe the concentration (or
130 level) at which an individual (or group of individuals) can detect the existence of a
131 signal from the background noise. To calculate a threshold the participant is given a
132 series of increasing stimuli (in this case concentrations of sucrose in water), the
133 detection threshold is calculated as the geometric mean between two samples, the
134 highest concentration at which the participant could not detect the signal and the
135 lowest concentration at which they could. Both thresholds enable the study to identify
136 the sensitivity of sweetness in each participant. Participants were also required to
137 choose the Just About Right (JAR) concentration of the presented solutions.

138 *Sensory attribute & preference tests*

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

Comment [OBK1]: Suggest that this goes into supplementary information as will take the words to below 2500

142 enabling the investigation of how flavour type impacts on sweetness perception.
143 Sweetness liking/hedonic and the overall product liking of the samples using a 7 point
144 hedonic scale (like extremely (1) to dislike extremely (7)). Following this, participants
145 were asked to rank products in order of overall preference (1 most preferred to 3 least
146 preferred). Sweetness intensity was measured on a 100mm line scale with descriptors
147 'not at all sweet' (0mm) to 'extremely sweet' (100mm). Participants were required to
148 rate how much (quantitatively) they liked the sweetness intensity.

149

150 **Statistical analysis:**

151 Data analysis was performed using Statistical Package for the Social Sciences (SPSS)
152 (Chicago, Illinois, Version 15.0). As no differences were found in intra-individual
153 results between test days ($P>0.05$), means of the triplicate test results were calculated
154 for each participant and were used throughout for analysis (to compare between age
155 groups and genders). A two way analysis of variance (ANOVA) was used to
156 examine the impact of age and gender on the variables measured with post hoc
157 analysis, the multiple pair-wise comparisons test used to compare samples was
158 Fishers least significant difference (LSD) ($P<0.05$).

159

160 **Results**

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

164

165 *Threshold tests-sweetness sensitivity differences in young and older adults.*

166 A significant difference in detection threshold ($P=0.0001$), recognition threshold
167 ($P=0.0001$) and Just About Right (JAR) sweetness level ($P=0.03$) was found between
168 the young and older adults. The older adults were significantly less sensitive to
169 sweetness than the young adults. A significant difference in the older adults compared
170 to the younger group ability to identify the taste was found ($P=0.0001$ data not shown).

171 Gender did not affect any of the parameters measured.

172

173

174 **Table 1.** Mean detection and recognition thresholds, Just About Right (JAR)

175 sweetness levels by age and gender.

176

	Young adults	Older adults	Young males	Young females	Older Males	Older females
Thresholds (g/L)	Mean	Mean	Mean	Mean	Mean	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

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

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

179

180 *Product hedonic liking tests*

181 In overall hedonic liking (both young and older adults), chocolate was the most liked

182 and the control sucrose solution was the least liked sample tested. This data is also

183 mirrored by the rank preference data where the chocolate variant was ranked more

184 preferred for both young and older adults.

185

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

188

	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

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

190 *by Fishers least significant difference (LSD) (P<0.05) \$ 7 point hedonic scale; *100mm line scale*

191

192

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

194

	Young adults	Older adults	Young males	Young females	Older Males	Older females
Hedonic liking*	Mean	Mean	Mean	Mean	Mean	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

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

196 *by Fishers least significant difference (LSD) (P<0.05)*

197

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

199 website

200 <http://www.ageing.oxfordjournals.org/>

201

202 *Product sweetness intensity*

203 The sweetness intensity of the sucrose solution perceived by the older adults was

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204 significantly lower than ratings from the young group ($P=0.03$), and young males
205 perceived the solutions as significantly sweeter than all other groups ($P<0.05$). No
206 differences were found between other flavour variants in terms of sweetness intensity
207 ratings by either age or gender.

208

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

216

217 *Relationship between sweetness intensity and hedonic measures*

218 An inverse relationship was found for overall and individual product variants
219 sweetness intensity and both hedonic liking of the product sweetness ($R=0.399$,
220 $P=0.001$) and overall product characteristics ($R=0.0.398$, $P=0.001$). It may therefore
221 be inferred that as the products perceived sweetness intensity increased, so too did
222 product dislike.

223

224 ***Discussion and conclusion.***

225 Significant differences were found in both detection and recognition thresholds and
226 the correct identification of the basic taste of sweetness between young and older
227 adults, which reflects the findings of other researchers [16, 17, 18] who have reported
228 that taste sensitivity decreases with age. It has been suggested that differences in taste
229 recognition, such as those found in this study may be due to a time lag in the turnover
230 of taste receptor cells [19] as work has shown that there is no decrease in the number
231 of taste buds with age which earlier research had postulated [20,21].

232 Although previous work has demonstrated aged related changes in taste acuity, few
233 studies have explored the interaction of this with real food systems such as ONS used
234 in the current study. Work carried out in the Netherlands found older adults perceived
235 sweet ingredients in chocolate drinks and vanilla waffles as less intense than the
236 young [22, 23]. However no differences in perceived sweetness of dairy products [24]
237 or custards [25] has been found.

238 In the current study, dislike of ONS was found, the degree of which varied across
239 flavours, genders and age groups. The chocolate flavour ONS was found to be the
240 most liked, and was perceived as less sweet than other product variants presented in
241 this study. In general, all older adults who had significantly higher sweetness
242 thresholds rated the ONS more negatively for liking (both sweetness and overall
243 liking of the samples) although they perceived the sweetness intensity of the products

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244 to be less intensive than the young adults. This infers that other product sensory
245 attributes in addition to sweetness are contributing to the dislike of these products.
246 Indeed, it has been suggested by others that the incongruence found between sensory
247 and hedonic modalities is due to different processing pathways for these in the brain
248 [26, 27).

249 It had been assumed in the past that age related sensory losses may lead to
250 modifications of food pleasantness and food choice [28], however others suggest a
251 habituation process to the decreased perception exists which may offer a
252 compensatory mechanism to prevent decreases in food liking [29]. This may in part
253 explain why significant differences in taste acuity found in the current study did not
254 translate into significant differences in liking across the age groups.

255 In Gosney's study [13], 38% of participants disliked the sweetness of ONS (not
256 flavour specific) which reflects the results of the current study where 27% of the older
257 adults disliking the sweetness, whereas in young adults this was more accepted as
258 only 6% disliked the sweetness. However in this study, 25% disliked that taste, 19%
259 the texture and a further 19% commented that they felt sick or bloated post
260 consumption. Compliance was extremely low at only 37%. Although we did not find
261 that sweetness acuity directly related to liking of these products, we did find that
262 sweetness intensity is one of the factors leading to dislike of these products.

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

273 We acknowledge that we used a convenience sample of young and older adults, and
274 therefore our results may not be generalisable, however we feel that they are
275 important in pointing out some directions in which research could be focused in terms
276 of effective treatment of malnutrition. It has long been known that ONS are wasted
277 with the common reason given that consumers/patients dislike the taste, our
278 research has sought to address what aspects taste are disliked, and examine if this is
279 related to sweetness thresholds and sweetness and flavour of the products. The
280 research which we have presented in this paper has used a multidisciplinary approach
281 involving sensory scientists, flavour chemists, dietitians, nutritionists and clinicians to

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282 try and understand some of the ‘taste’ issues surrounding poor consumption and we
283 are currently using these finding to develop solutions to improve ONS acceptability.

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

291

292 **Acknowledgements**

293 Abbott Nutrition are thanked for the supply of ONS used in this study.

294

295 **Key points**

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

300

301 **Conflict of Interest:**

302 None declared.

303

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372

373

374

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

377

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

	Young adults	Older	Young	Young	Older	Older
		adults	males	females	Males	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).*

381

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