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INFLUENCE OF CHEMOSENSORY IMPAIRMENT ON INTAKE AND LIKING OF A FUNCTIONAL DRINK IN UNDERNOURISHED INSTITUTIONALIZED ELDERLY PEOPLE

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Abstract: *Background:* Age-related chemosensory impairments (i.e., reduction of taste and smell acuity) affect a large proportion of the population older than 65 years. These conditions can affect overall health, quality of life and influence food appreciation and intake. The knowledge about the relation between chemosensory perception and hedonic food liking in older people might facilitate the development of effective strategies aiming to improve their nutritional wellbeing. *Objectives:* The key objective of this study is to test the influence of a sensory compensatory strategy on liking and intake of a functional red fruit drink in undernourished nursing home elderly people. *Design:* The research consisted of three main phases. In the first step the enrolled subjects were classified on the basis of their taste and olfaction sensitivity; in the second step the sensory compensatory strategy, aiming to counteract age-associated sensory losses and increase product pleasantness, was identified; the last step consisted of 14 days of exposure to each drink variant (standard and enhanced) to observe the effects of sensory modifications on liking and intake. *Setting:* "Villa delle Querce" Clinical Rehabilitation Institute of Nemi (Rome- Italy). *Participants:* 76 elderly people (64-97 years). *Results:* Overall the prevalence of measured chemosensory impairments in this sample of institutionalized older adults was very high (81%). The sensory modification strategy did influence significantly neither the intake nor liking in the elderly people. Consistent with the findings of previous studies (3, 6, 24, 25) no significant correlation was found between sensory capabilities and hedonic responses. *Conclusion:* These findings highlight that, in accordance to other studies (2, 3, 6-8), the role of sensory compensatory strategies in increasing products appreciation and intake of institutionalized elderly people have been overestimated.

Key words: Chemosensory impairment, sensory compensatory strategy, undernutrition, institutionalized elderly people.

Introduction

In institutionalized elderly people poor energy intake is an important factor related to malnutrition which is often associated with frailty and increased morbidity and mortality (1). One of the potential causes of inadequate food intake is considered the age related reduction of taste and smell acuity (2). Several studies have found a progressive decline in taste and smell functioning, which tends to begin around 65 years of age (3, 4). The prevalence of sensory impairment is reported to be high and to increase with age (5-8).The causes can be physiological aging as well as certain disease states, pharmacologic and surgical interventions, radiation and environmental exposure (4). Chemosensory impairments are supposed to affect food perception and liking and consequently to modify food choice, although data in support of this "sequence of assumptions" are currently lacking (9, 10).

Chemosensory deficit experienced by elderly people generally cannot be reversed. However, sensory interventions including intensification of food taste and odor might compensate for reduced acuity. Food flavor enhancement strategies for undernourished patients have been used over the last 25 years to increase intake of nutrient dense food (11) with contradictory results (3, 6-8). According to some studies (11-13) addition of flavor could be an efficient strategy to cope with nutritional problems such as "anorexia of aging". However, as pointed out by Kremer et al (8) in these earlier studies poor sensory acuity of elderly people has been assumed but not measured. Previous studies (12, 14) suggested that higher liking for stronger flavor and taste is an age-related feature, which might be attributed to a compensation effect. Some authors suggested that elderly people may prefer a higher sweetness intensity (14). There are, however, other researches (3, 15) that are

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in contradiction with these findings. Also, in most hedonic studies, liking is based on first impressions of an evaluated product, and does not reflect preferences that result after a longer exposure to the product.

In the light of the above considerations, the aim of the present study is to observe the effect of a sensory compensatory strategy on the intake and hedonic response to a functional drink in undernourished elderly patients living in nursing home, classified on the basis of their taste and smell sensitivity compared to a group of healthy free living adults with normal chemosensory acuity.

The research consisted of three main phases. In the first step the enrolled subjects were classified on the basis of their taste and olfaction sensitivity; in the second step the sensory compensatory strategy, aiming to counteract age-associated sensory losses and increase product pleasantness, was developed; while, the last step consisted of 14 days of exposure to each drink variant (standard and enhanced) to observe the effects of sensory modifications on liking and intake.

Materials and Methods

Subjects

Residents from "Villa delle Querce" Clinical Rehabilitation Institute of Nemi (Rome, Italy) participated in this study. The local ethics committee approved the study.

A clinical screening was performed and the followings were evaluated for each individual: clinical status, number of pathologies, number of medications taken, cognitive functions (by Short Portable Mental Status Questionnaire, SPMSQ), nutritional status (with Mini Nutritional Assessment, MNA).

Inclusion criteria were: age >65 years; being at risk of malnutrition (MNA ≤23. 5); energy deficiency (intake of 20 kcal/kg/day or lower); no severe cognitive impairment (SPMSQ <4); no smoking.

Participants were selected for their physiological and cognitive ability to carry out the evaluation. After the screening 76 subjects were included in the study and provided their written informed consent. The mean age of the sample was 81.4 ±8.3 years (age range 64-97 years). Seventy percent participants were women. Prevalence of chemosensory impairments was measured on 76 individuals. Eleven participants dropped out because of taste dislike to the drink, health and personal reasons.

A group of adult (n=38; 30-50 years) with normal sensory acuity, recruited from the staff of CRA-NUT served as control.

Sensory classification

Chemosensory acuity was assessed by means of three validated sensitivity tests produced by Burghart (GmbH Wedel Germany). The original methodology of test administration (16, 17) was simplified in order to make it more suitable for elderly people (18, 19).

Testing for odor identification. This method is based on pen-like odor dispensing devices. Individuals were presented with 9 pens containing common odorants at an interval of 30 seconds. They were asked to smell each pen and to choose the odor name from four alternatives. For instance, whether it was presented orange odor, subjects had to choose between orange, strawberry, blackberry, pineapple.

Threshold odor test. Odor thresholds for phenylethanol were assessed using a single-staircase, three alternative forced choice (3- AFC) procedure. Three pens were presented in a randomized order, with two containing the solvent and the third the odorant. Subjects had to identify the odor-containing pen. Twelve triplets were presented at intervals of approximately 20 s.

Gustatory test . The used technique is based on strips made from filter paper which were impregnated with different taste solutions (sweet, sour, salty and bitter). Three concentrations were used for each taste quality resulting in a maximum total score of 12. The taste strips were presented in increasing concentrations in a randomized order and placed on the tongue. Then subjects were asked to close the mouth and choose one of five possible answers on a form (sweet, sour, salty, bitter, no taste).

Subjects were then classified in four groups on the basis of the performance in the screening test: 1) Normal chemosensory acuity/function; 2) Taste impaired (gustatory test <9 correct answers); 3) Smell impaired (Threshold test < 5 and Smell Identification <3); 4) Taste and smell impaired (gustatory test <9; Threshold test < 5 and Smell Identification <3).

Subjects affected by anosmia and ageusia were excluded from successive evaluations.

Sensory compensatory strategy

The product employed is a functional red fruit (grapes, raspberries and red berry) drink containing antioxidant ingredients (Vitamin C, vitamin E and green tea extract), supplied by Barilla Food Company. The sensory compensatory strategy aiming to make the drink more palatable for elderly people, was developed with the aid of our expert sensory panel (n=8). Following the results of the sensory analysis, the manufacturer provided two versions of the functional drink: the standard version (red fruit drink commercially available) and the enhanced version with a significantly ($p<0.001$) higher sweet taste, a

lower sour taste ($p<0.001$) and unvaried red fruit flavor.

Intervention study

Each subject was randomly assigned to consume 1 glass (125 ml) of one drink variant (enhanced or standard) along with breakfast for 14 consecutive days and, after 1 day washout period, switched to the other variant for 14 days. The subjects of the control group were asked to consume the functional drinks along with breakfast at their own home.

The effects of exposure to the two variants of the drink on intake and hedonic response were assessed during the experimental period. Participants were asked to rate the "Liking "of the drink on the 1st , 6h and 14th day of each treatment with a 7 point Likert Scale. The left anchor of the scale was explained as "I don't like it at all" and the right anchor corresponded with "I like it very much". The intake was measured daily, only on the elderly subjects, on the basis of leftover.

Data Analysis

All statistical analyses were performed using XLSTAT v. 2012.1.01 (Addinsoft).

The distribution of the prevalence of chemosensory impairment by gender was tested using Chi-square analysis and Fisher's exact test.

Data on hedonic ratings were submitted to the analysis of variance (ANOVA) to test the effect of drink samples (standard, sensory enhanced), subject clusters (C= control group; N= elderly with no sensory deficit; S= elderly with smell impairment; T= elderly with taste impairment; TS= elderly with taste and smell impairment), sequence of drink sample administration and time (1, 6, 14 days of treatment). The two-way interactions were also analyzed.

One-way ANOVA and Fisher's least significant difference were performed for mean separation.

Results

Prevalence of chemosensory impairment

Overall the prevalence of measured chemosensory impairment in this sample of institutionalized elderly people was very high (81%).

Table 1 shows in details the prevalence of taste and smell impairment for the whole sample and by gender. The distribution of chemosensory impairment did not significantly differ for gender (P=0.656). Measured taste impairment is the same among men and women, while smell impairment tended to be higher in men. The observed very high prevalence of taste impairment is probably related to the intake of large number of medications, as polypharmacy is considered a common cause of impaired chemosensory perception (20).

Table 1
Prevalence of chemosensory impairment and gender distribution

	No impairment	Taste impairment	Smell impairment	Taste + smell imparments
Total sample (n=76; age 64-97) mean=81)	19 %	40%	12%	29%
Women (70 %)	22 %	39%	9%	30%
Men (30%)	13 %	40%	17%	30%

Intake

The daily intake was measured registering the amount of leftover in the glass. The scale was from 0 to 4, where 0 means no leftover; 1= 1 /4 of the glass; 2= half glass; 3= ¾ glass, and 4= full glass. A high variability of leftover was observed. No effect of sample (standard or sensory enhanced) on intake (P=0.980) was observed. No significant difference among the groups of subjects (P= 0.974) was detected. Average intake was 70% of sample both for standard and enhanced variant. Intake was stable over time.

Hedonic ratings

Liking was measured on 67 elderly (11 drop-out) grouped by their taste and olfactory sensitivity and on 38 adults with normal sensory acuity (control group).

According to the ANOVA results, the compensatory strategy did not lead to an increase of the product liking among the elderly. From the analysis of variance it emerged that overall the elderly people rated both drink variants more positively then the control group (P <0.0001). Hedonic rating was in general not significantly influenced by the sample variant(P= 0.158), sequence of administration (P= 0.602) and time of exposure (P=0.447). No significant interactions were found.

In table 2 the hedonic ratings of the different groups of subjects for the standard sample at day 1, 6 and 14 of treatment are reported. Liking is significantly lower in the control group and in elderly people with normal sensory acuity at the beginning (day 1) of the treatment (P= 0.052).

A lightly downward trend in liking over time was observed for the standard sample in the control group (P = 0.073) while a significant increase among the group of elderly with normal sensory acuity (P =0.042). In the groups of elderly with sensory deficit the liking doesn't change over time.

In table 3 the hedonic ratings for the enhanced sample of the different groups of subjects are reported. Overall the hedonic response to the enhanced variant does not

Table 2

Hedonic ratings with standard deviations for the standard sample of the different groups of subjects. C=control group; N= elderly with no sensory deficit; S= elderly with smell impairment; T= elderly with taste impairment; TS= elderly with taste and smell impairment

	Day 1		Day 6		Day 14		
Subjects	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**p**
C	[1]3.2[a]	0.76	[2]2.8[ab]	0.78	[3]2.8[b]	0.76	0.073
N	[1]3.2[b]	1.17	3.8[ab]	1.03	4.4[a]	0.50	0.042
S	4.0	0.54	4.3	0.83	4.0	0.87	0.788
T	3.7	1.08	3.9	0.76	3.8	0.81	0.581
TS	3.8	0.81	3.9	0.64	3.7	1.10	0.773
p	0.052		<0.001		<0.001		

In the rows means with different letter are statistically different; 1. Lower than S, T, TS at p<0.05; 2. Lower than N, S, T, TS at p<0.05; 3. Lower than N, S, T, TS at p<0.05; % (95%CI)**

Table 3

Hedonic ratings for the enhanced sample of the different groups of subjects. C=control group; N=elderly with no sensory deficit; S= elderly with smell impairment; T=elderly with taste impairment; TS=elderly with taste and smell impairment

	Day 1		Day 6		Day 14		
Subjects	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**p**
C	[1]3.1	0.79	[2]3.1	0.86	[3]2.9	0.76	0.810
N	3.7	1.14	3.8	1.11	3.9	0.83	0.937
S	3.9	0.99	3.9	0.35	3.9	0.35	0.999
T	4.1	0.95	4.3	0.80	4.1	0.92	0.712
TS	3.8	0.98	4.1	0.99	3.9	1.06	0.698
p	<0.001		<0.0001		<0.0001		

1. Lower than N, S, T, TS at p<0.05, 2. Lower than N, S, T, TS at p<0.05, 3. Lower than N, S, T, TS at p<0.05

significantly change in any group after 14 days repeated exposure. The four subgroups of elderly rated the enhanced drink more positively then the control group (P<0.0001). No significant difference is observed between the elderly with normal sensory acuity and those having taste or smell impairment, even though those with taste impairment gave the highest hedonic ratings to the sensory enhanced drink (P=0,05).

Discussion

Prevalence of chemosensory impairment

The prevalence of measured chemosensory impairments in this study was quite high. Specifically, the frequency of smell impairment in this population of frail elderly people was comparable to data obtained in previous studies (2, 5), while the frequency of taste impairment was higher than expected on the basis of previous investigations, pointing out that aging seems to affect smell stronger then taste (6-8). This could be related to the health condition and large use of medications (20) in the sample considered in the present study. Moreover, overall men seem to have higher prevalence of chemosensory impairment as reported in other studies (5, 21).

Intake and hedonic responses

The intake of both drinks was consistent over time in all groups of subjects and was not influenced by the sensory modification. So the compensatory strategy was not proven to be effective in increasing the intake of the drink. The general consistency of hedonic ratings over time indicates that both drink variants were equally accepted among the elderly subjects.

Overall, as shown in other researches (3, 22) the elderly subjects rated the samples more positively than the adult group. This result can be due to the perceived health benefits of the drink or to the novelty respect to a monotonous diet at the nursing home, although should also be considered as a relevant factor the willingness of the elderly people to please the interviewer.

Consistently with the findings of previous studies (3, 6, 23, 24) no significant correlation was found between sensory capabilities and hedonic responses in elderly people. Here subjects with taste impairments rated more positively the enhanced sample, but as the relation is not

significant and the size of the subgroups in this study is small, and further investigation is needed to explore the association.

Conclusion

This research does not support the assumption that age associated decline in chemosensory acuity inevitably reduces food liking and intake. In accordance with other studies (2, 3, 6-8) it can be concluded that the role of sensory compensatory strategies in increasing products appreciation and intake in frail elderly people has been overestimated. Therefore, in the light of the results of this study it can be suggested that more effective strategies to increase product pleasantness and intake for institutionalized elderly people should definitely take into consideration other age-related factor such as psychological conditions, loneliness, reduced social interaction and limited food choice.

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