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Preference and consumption of a taste enhanced meat meal by older hospital patients: A pilot study

Maria Dermiki[a], Joanne Willway[a], Laura Sargent[a], James Kidman[a], Claire Anderson[a], Orla B. Kennedy[a], Margot A. Gosney[b] and Lisa Methven[a,*]

[a]*Department of Food and Nutritional Sciences, University of Reading, Whiteknights, Reading, UK*
[b]*Clinical Health Sciences, University of Reading, London Road, Reading, UK*

Abstract.
BACKGROUND: Older hospital patients are considered to be at risk of malnutrition due to insufficient dietary intake.
OBJECTIVE: To determine whether taste enhancement, using ingredients naturally high in umami compounds, increases preference and consumption of a meal by older hospital patients.
METHODS: 31 patients (65–92 years) on elderly care wards in a UK NHS Trust hospital took part in a single-blinded preference and consumption study. They tasted two meats (control and enhanced, presented in balanced order) and stated their preference. At lunch, control and enhanced cottage pie and gravy were served concurrently; patients were asked to consume *ad libitum* and intake was measured.
RESULTS: Taste enhanced meat was significantly preferred ($P = 0.001$). Although mean consumption was higher for the enhanced compared to control meal (137 g versus 119 g), with higher levels of energy (103 kcal versus 82 kcal) and protein (4.6 g versus 3.4 g) consumed; differences were not significant.
CONCLUSIONS: Natural ingredients rich in umami taste compounds can successfully be used to increase preference of meat based meals by older hospital patients. Larger trials are needed to determine whether such increases in preference can significantly increase consumption.

Keywords: Malnutrition, taste enhancement, umami, older patients

1. Introduction

In the 2011 nutrition screening week, where patients admitted to care across the UK were screened for malnutrition using the Malnutrition Universal Screening Tool (MUST), it was found that 34% of patients admitted to elderly care wards were malnourished [1]. Many physiological, social and psychological factors predispose older people to undernutrition. Among physiological factors, sensory impairment is important. Studies conclude that taste thresholds deteriorate with age [2], and with medication [3]. This can reduce satisfaction from food and impact on food intake [4].

Umami is savoury taste perception, stimulated by glutamic and aspartic acid and 5′-nucleotides [5]. The effect of taste enhanced food on liking and consumption by older people remains unclear. Monosodium glutamate (MSG) and flavourings added to nursing home residents' food ($n = 50$, mean age = 82) increased satisfaction ratings [6]. Moreover, in another study its addition resulted in increased dietary intake and

*Corresponding author: Lisa Methven, Department of Food and Nutritional Sciences, University of Reading, Whiteknights, Reading, RG6 6AP, UK. Tel.: +44 118 3788714. E-mail: l.methven@reading.ac.uk.

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body weight of nursing home residents who received enhanced meals ($n = 36$) compared to a control ($n = 31$) [7]. One hospital study found that 40 of 43 patients increased calorie intake by minimum 10% when consuming MSG enhanced meals [6]. Two studies contradict these findings; there was no increase in intake by nursing home residents when food enhanced with flavour and/or MSG ($n = 97$, age >65) [8], or MSG alone ($n = 53$, age >65) was consumed [9]. The same group of researchers found no effect from flavour and/or MSG on liking and intake of soup consumed by free living older people ($n = 120$, age = 72 ± 6) [10]. Potential reasons for differing study results include use of different MSG concentrations, different exposure times and different methods of addition.

There are few hospital studies, yet the high prevalence of undernutrition in older hospital patients suggests research is needed in this setting. Direct MSG addition is unacceptable to many consumers and less effective to achieve strong savoury taste than using natural ingredients where synergy between glutamate and 5'-nucleotides is utilised [11]. The two aims of this study were to establish whether an increase in umami taste within meat, achieved through use of natural ingredients, could lead to (a) an increased preference for the meat and (b) increased consumption of a meal, by older hospital patients.

2. Methods

2.1. Subjects

Subjects recruited from elderly care wards at an NHS Foundation Trust (Royal Berkshire NHS Trust, Reading, UK). Inclusion criteria: age >65 years, ability to consent, abbreviated mini-mental state examination (MMSE) score above 18 (out of 30), ability to eat without assistance, non vegetarians, no relevant food allergy or intolerance. Subjects were recruited the day before they took part in the study, following advertisement of the study on the wards for more than 24 hours. Copies of the participant information sheet were left with patients while they considered if they wanted to take part. Potential subjects were able to discuss the study with hospital clinical staff and then the researchers met with interested patients. Ninety five suitable patients were identified, of whom 31 agreed to take part in the study. Consent forms were completed and signed by the subjects and witnessed by the researcher.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were given favourable opinion to proceed by the Isle of Wight, Portsmouth and South East Hampshire research ethics committee (study number 10/H0501/58).

2.2. Test foods

Control recipes for gravy, minced meat (the minced beef plus stock and vegetables used as the base of the cottage pie) and cottage pie (the minced meat base plus mashed potato) were from the NHS Trust (Table 1). Natural umami ingredients incorporated into meat base during cooking were reduced salt soy sauce (Kikkoman, Netherlands) and concentrated tomato extract (Lycored, USA). Enhanced gravy contained reduced salt soy sauce. The combination and quantities used were selected following sensory and liking (older consumers) tests of various umami ingredients [11]. Cottage pies comprised of cooked minced meat base (90 g) plus mashed potato (90 g). Equivalent total sodium was assured in enhanced and control products by addition of sodium chloride to the control meat base only (Table 1). The level of salt added to the control (0.30 % w/w, as normally used in this hospital recipe) equated to the sodium present in the umami-rich ingredients (declared on specifications) used in the enhanced recipe (soy sauce and concentrated tomato extract). Foods were cooked in the Trust kitchen and frozen (-18°C). On study days, pies were heated for 40 minutes at 180°C (convection steam oven) and gravies reconstituted by heating and by adding corn flour. Nutritional profiles determined using Dietplan 6 (Forestfield, UK) (Table 1).

2.3. Hospital procedure

Volunteers were included based on inclusion criteria and written consent as explained above. They completed a hospital anxiety and depression score test (HADS, scale 0 to 42) and it was recorded whether or not they used dentures. Mid-morning, patients tasted samples of control and enhanced cooked minced meat base (25 g) in a balanced order and stated their preferred sample of the two.

Table 1
Test food specifications and characteristics

Ingredient (g)	Control meat (g/100g)	Enhanced meat (g/100g)	Control gravy (g/100g)	Enhanced gravy (g/100g)
Minced Beef	38.7	38.7	0	0
Onions	12.9	12.9	2.2	2.2
Oil	0.52	0.52	0.83	0.83
Tomato Puree	1.3	1.3	1.8	1.8
Beef Stock	0.46	0.46	2.2	2.2
Thyme	0.11	0.11	0	0
Carrots	12.9	12.9	0	0
Peas	5.2	5.2	0	0
Cornflour	2.6	2.6	4.5	4.5
Soy Sauce	0.0	1.7	0	2.5
Tomato extract	0.0	1.8	0	0
Salt	0.15	0	0.22	0
Browning	0	0	0.90	0.90
Water	25.3	21.8	87.3	85.0
Nutritional Composition[A]:	Control Meal[B] per portion (per 100 g)		Enhanced Meal[B] per portion (per 100 g)	
Energy (kcal)	221 (77)		229 (80)	
Protein	11.1 (3.9)		11.7 (4.1)	
Fat	8.3 (2.9)		8.3 (2.9)	
Concentration of umami compounds (g/100g)[C]	Minced meat		Cottage pies with gravy[D]	
	Control	Enhanced	Control	Enhanced
5′-Adenosine monophosphate (AMP)	0.006[b]	0.010[a]	0.006[b]	0.007[b]
5′-Guanosine monophosphate (GMP)	0.000[b]	0.001[ab]	0.001[a]	0.001[a]
5′-Inosine monophosphate (IMP)	0.004[a]	0.003[a]	0.003[a]	0.002[a]
Glutamic acid	0.036[b]	0.070[a]	0.039[b]	0.069[a]
Aspartic Acid	0.012[d]	0.037[a]	0.014[c]	0.028[b]
EUC	0.29[c]	0.77[a]	0.38[bc]	0.62[ab]

[A]Compositions allowed for measured 30% cooking weight loss. [B]Meals comprised cottage pie (90 g meat, 90 g potato), gravy (51 g) and vegetables (50 g). [C]Concentration of umami 5′-nucleotides (5′-AMP, 5′-GMP and 5′-IMP) and aspartic acid and glutamic acid in final cooked samples; where EUC = equivalent umami concentration expressed as the concentration of monosodium glutamate MSG equivalent and calculated according to Equation 1. [D]Cottage pie (90 g minced meat, 90 g potato puree) and 17 g of corresponding gravy. Superscript [a,b,c,d]: mean values of the same letter within the same row are not significantly different at $p < 0.05$.

The consumption measurements were conducted on the same day during lunchtime (12:30). Lunch comprised of two plates, each containing a cottage pie (180 g), mixed vegetables (50 g) and gravy (51 g), along with any starter and dessert the patient had ordered. The two plates were presented concurrently, balanced left/right position on bedside table; the left/right position additionally balanced according to whether the patients were left/right handed. The participant was asked to try both pies and consume as much as they liked from both plates. Pre and post lunch weights of main course plated meals were recorded and the total meal and pie consumption was calculated. The methodology of testing control and enhanced food within one meal aimed to overcome issues of patient conditions changing daily, a recognised challenge for nutrition studies in an acute care setting.

2.4. Sensory discrimination test for umami taste

Healthy subjects ($n = 35$ (18 women), age: 20–40 years old) were recruited for this study through email and asked to visit the sensory evaluation booths at the University of Reading, They were first asked to taste a small sample of MSG solution (0.5% w/w) in order to become familiar with umami taste. They were then asked to carry out two directional alternative forced choice (2-AFC) discrimination tests. Given the two samples of minced meat base, in balanced order, they were asked to state which tasted the most ‘umami’.

Table 2
Subject characteristics

Characteristics	N, Mean or Median	%, SD or IQR[a]	*n*
Gender (Male/Female)	11/20	35/65	31
Age (y)	84.3 (mean)	6.3 (SD)	31
Smoker (Y/N)	3/28	10/90	31
Dentures (Y/N)	14/15	48/52	29
MMSE score (scale 0–30)	27 (median)	8 (IQR)	31
HADS total score (scale 0–42)	8.5 (median)	5.3 (IQR)	28
HADS depression (scale 0–21)	3 (median)	5 (IQR)	28

[a] SD = standard deviation, IQR = interquartile range.

This was then repeated for the two samples of cottage pie with gravy. Minced meat samples were reheated in a microwave (temperature >75°C). Cottage pies were cooked in a gas oven (core temperature >80°C). Samples were held in a heating trolley (60–65°C) for a maximum of 30 min before serving.

2.5. Chemical analysis

Minced meat and the cottage pie mixed with gravy were analysed for their amino acid and 5′-nucleotides content, since these compounds contribute to the umami taste. Extraction, analysis of 5′-nucleotides content using Capillary Electrophoresis and analysis of amino acids content using GC-MS were conducted as described by Dermiki et al. [11]. The equivalent umami concentration (EUC) of the samples was then calculated using the following formula:

$$Y = \sum a_i b_i + 1218 \left(\sum a_i b_i \right) \left(\sum a_j b_j \right) \quad (1)$$

Where Y = the EUC, a_i = the concentration of each umami amino acid, a_j = the concentration of each umami 5′-nucleotide, b_i = the relative umami concentration (RUC) for each umami amino acid to MSG, b_j = the RUC for each umami 5′-nucleotide and 1218 = a synergistic constant. All values were in g/100g [12]. The EUC equation is the concentration of monosodium glutamate MSG equivalent (defined as g/100g) to the umami intensity given by the mixture of glutamic acid (Glu), aspartic acid (Asp) and the 5′-ribonucleotides.

3. Statistical analysis

Binomial expansion used for paired comparison test on preference data and 2-AFC data, and paired *t*-test on consumption data. For other comparisons Mann-Whitney tests were used. Variables categorised for analysis were: dentures (yes or no), age (<or ≥87, the median age), depression score (<or ≥3, the median HAD depression score) and gender (male or female). Software used was XLSTAT (Addinsoft, version 2009) and DiffTest (Statbasics, version 2.00).

4. Results

31 hospital patients (20 women, 11 men; age 65–92, mean 84.3) were recruited to the study. An overall summary of subject characteristics can be seen in Table 2. All subjects had relatively high MMSE scores (median 27 out of 30) suggesting good cognition, and low HADS scores (median HADS were 8.5 out of 21), suggesting low levels of anxiety and depression in these patients. Of those recruited, 30 completed the preference test and 29 completed the consumption test.

The taste enhanced meat base was significantly preferred (24 out of 30 subjects, $P = 0.001$) (Table 3). Average consumption of enhanced cottage pie meal was higher than control meal (137 g versus 119 g), but was not significant ($t(28) = 1.1$, $P = 0.30$; difference between means 18.2, 95 % CI −17.3 to 53.8). Twenty percent higher calories were consumed from the enhanced meal (103 kcal versus 82 kcal) although not significant ($t(28) = 1.4$, $P = 0.17$; difference between means 21.2, 95 % CI −9.6 to 52.0). The higher average protein content consumed (4.6 g versus 3.4 g) was also not significant ($t(28) = 1.8$, $P = 0.09$; difference between means 1.2, 95 % CI −0.19, 2.7).

There were no significant effects on consumption from other factors measured including dentures, age or gender. Depression had a notable but not significant effect on consumption ($P = 0.38$). The median HAD depression score was 3; patients with higher than aver-

Table 3
Preference and consumption of test meals

Variable	Control		Taste Enhanced		
	Median, Mean or *n*	SD or %	Median, Mean or *n*	SD or %	*P*-value
Preference of meat (number patients preferring this sample)	6	20%	24	80%	0.001
Weight of meal[a] consumed (mean, g)	119	76	137	74	0.30
Energy consumed from meal[a] (mean, kcal)	82	60	103	65	0.17
Protein consumed from meal[a] (mean, g)	3.4	2.1	4.6	3.1	0.09

[a]meal = pie with vegetables and gravy.

age depression score (42% with >3) had a lower, but not significant, mean food intake(225 g versus 280 g).

Results from the sensory study confirmed that the enhanced meat base tasted more 'umami' ($P = 0.045$; identified by 23 out of the 35 subjects), and 21 subjects identified the enhanced cottage pie with gravy as having a more umami taste which was not significant ($P = 0.16$).

5. Discussion

Using natural ingredients to enhance taste significantly increased preference for the meat. Mean consumption of enhanced meal was higher than for control meal, however, within the limitations of this acute study design, this was not significant. The average total consumption from both plates presented at lunch time was 185 kcal, 8.0 g protein. The higher average proportion consumed of the enhanced meal compared to the control meal equated to 21 kcal and 1.2 g protein which represented an increase, although non-significant, of 26% and 37% respectively of actual calories and protein consumed. Where intake is compromised this could have a large impact on the nutritional status of at risk individuals. However, for energy and protein the daily recommended values (DRV) for older people in residential care (FSA 2006 guidelines) are 1955 kcal and 50 g respectively [13]. Therefore, the mean intake of the taste enhanced meal contributed to 5% of the daily recommended energy intake and 9% of the protein intake. However, actual daily intake of older hospital patients is often lower than recommendations, one study recording mean daily intake at 1379 kcal and 44.6 g protein over a 27 day period with 22 patients per day in one UK hospital [14]. Our results suggest that further support to increase nutrient intake from a single meal is needed. It is recommended that further studies on taste enhancement of meals for older patients are combined with macronutrient fortification.

The increase in preference was in agreement with previous studies which found that adding MSG to foods increased acceptability, the difference in our study being that this was achieved through the use of natural ingredients. The lack of a significant difference in consumption is in line with results from other recent studies by Essed et al. [8–10]. Their studies all used direct addition of MSG, either as a repeated exposure 16 week parallel study where study size was relatively low (approximately $n = 20$ per group) [8], or as acute cross-over studies where there were higher numbers of participants ($n = 53$ institutionalised adults and $n = 120$ free lving older adults) [9, 10]. One of the main limitations of the current study was the small sample size of 31 participants. Considering the differences in the mean consumption between the control and taste-enhanced meals measured and the inter-subject variability (standard deviation), power calculations suggest that an adequate sample size to detect a difference significant at 5% with a power of 80% would be between 100 and 150 participants, depending on whether the output measure considered was protein or calorie intake.

The fact that the significant preference for the taste enhanced meat did not significantly increase consumption of the taste enhanced meal may imply the difference was insufficient. It is important to consider whether the increase in umami taste in the enhanced formulations was adequate. The content of umami compounds (glutamic acid, aspartic acid and 5′-adenosine monophosphate (5′-AMP), 5′-guanosine monophosphate (5′-GMP) and 5′-inosine monophosphate (5′-IMP)) and the calculated EUC were significantly higher in the enhanced minced meat base compared to the control meat (Table 1). This increase is due to presence of concentrated tomato extract and soy sauce in the enhanced samples [11].

The sensory discrimination tests confirmed that the enhanced minced meat base had significantly more umami taste than the control. However the difference between the pies with gravy was not significant, indicating that the mashed potato used on the cottage pie diluted the enhanced taste of the minced meat. This was further supported by the fact there was no significant difference between the EUC of the enhanced and control pies with gravy, although the content of umami amino acids were significantly higher in the enhanced pies (Table 1). Further increase of umami compounds with the ingredients used (soy sauce and concentrated tomato extract) was not possible, since it would have increased the sodium content in the final products. Moreover, the natural ingredients chosen for this study were based on previous research of this group where samples were tasted by old and young volunteers and also by trained sensory panellists [11], and a more suitable (well liked) combination of ingredients at a higher umami concentration (within a maintained sodium level) was not identified.

Each subject was presented with two identical plates which was overwhelming for some. Other studies which took place in retirement or nursing homes [6–10] gave subjects control and enhanced meals on separate days which avoided having to give them two servings in one day. However a crossover study is less feasible in a hospital setting where patient daily health status can vary substantially and people able to consent may be more likely to be discharged before the second study day.

Depression can affect food intake in older adults [15]. In this study there was a trend for those having a high depression score to have lower overall consumption, however this difference was not significant which may be attributed to the low number of participants in the study. Dentures did not have any significant effect on the consumption during this study ($P = 0.76$; mean consumption for patients without dentures 275 g versus 242 g for patients with dentures) although they can sometimes effect taste due to partial occlusion of the palate and through negative impact on oral hygiene [16].

The subjects received only a single exposure to enhanced umami taste. A recent paper studied repeated exposure to novel flavoured soup with and without MSG on subsequent liking and consumption. An increase in liking and intake was found where subjects were exposed repeatedly to the soup with MSG over 4 consecutive days [17]. A physiological feedback from ingestion of glutamate, which increases liking and signals for increased consumption, was hypothesised.

In conclusion, this study found that increasing the umami taste of cooked minced meat using natural ingredients significantly increased preference by older hospital patients. However, the greater mean consumption of the taste enhanced meal was not significant. Future work should investigate the effect of repeated exposure to umami enhanced meals on consumption with a larger patient group.

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