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Sensory acceptability of a reformulated reduced salt frozen ready meal

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Abstract

This study investigated the effect of reducing salt levels and the addition of salt substitutes on the sensory acceptability of a frozen lasagne ready meal. Commercially produced lasagne with standard salt levels (1.05% NaCl) and lasagne with reduced salt levels (0.55% NaCl) was supplied by an industrial partner. Salt was added to the reduced salt meal via the meat sauce layers at levels to produce meals with salt concentrations of 0.55%, 0.65%, 0.75% and 0.85%. Paired comparison and triangle tests indicated that 0.3% of salt could be removed without a sensory difference being observed ($P > 0.05$). Salt substitutes were incorporated into the lowest salt lasagne ready meal at a concentration of 0.5%. Triangle, paired comparison and preference tests were carried out on these meals to determine acceptability. A consumer acceptability trail conducted with 175 consumers found that the low-salt KCl meal was preferred over the control ($P > 0.1$).

Introduction

Changes in lifestyle have resulted in an increased demand for convenience foods such as ready meals. Today convenience remains one of the major drivers of change in consumer markets. However, this increased demand for convenience foods should not mean an increased risk to health. It is now estimated that approximately 75% of the salt we consume comes from processed convenience foods (Dyer *et al.* 1997; Irish Heart Foundation 2004) such as ready meals. An earlier study (Mitchell, unpublished data) found that of 67 commercial ready meals surveyed, eight contained greater than 100% of an Irish adult's recommended dietary allowance (RDA) of 4 g salt per day (FSAI Scientific Committee 2005) in one single portion and a further 51 ready meals were found to contain greater than 50% of an Irish adult's RDA of salt. This increased intake of dietary salt from processed convenience foods, such as ready meals, can lead to a rise in blood pressure with age and the development of hypertension in industrialised countries (Antonios & MacGregor 1996; MacGregor & Server 1996; Law 1997; Appel *et al.* 2001; MacGregor 2004; FSAI 2006). Increased salt intake has also been linked to instances of oedema (MacGregor & de Wardener 1997), stomach cancer (Forman *et al.* 1991; Joossens *et al.* 1996; Wong *et al.* 2004), asthma (Burney 1987; Carey *et al.* 1993) and raised urinary calcium excretions (Matkovic *et al.* 1995; Lin *et al.* 2003).

The effect of dietary salt on health prompted the World Health Organization (WHO) to recommend the consumption of less than 5 g salt (or <2 g sodium) per day as a worldwide population nutrient intake goal (WHO 2003). Since these

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recommendations back in 2003, the UK has set the benchmark worldwide in terms of salt reduction strategies, and to date, salt reductions between 20–30% have been achieved in a broad spectrum of processed foods (He & MacGregor 2008). Following the launch of World Salt Awareness Week 2009 – 'salt and eating out', salt-reduction strategies are now being focused on the foodservice industry. Recent research published by Consensus Action on Salt and Health (CASH) identified that many popular three-course meals eaten in UK high-street restaurants frequently contain over twice the daily maximum limit of salt (6 g salt per day; UK Department of Health 1994) for an adult (CASH 2009). With more people skipping breakfast at home and instead opting for a café/restaurant on the way to work or eating on-the-go, a separate CASH study revealed that a full English breakfast can contain as much as 6 g of salt (CASH 2008). Popular on-the-go breakfast snacks such as croissants, pastries and muffins were found to contain more salt than a rasher of bacon, while a 'healthy' at-home breakfast of coffee, orange juice, 30 g cornflakes and two slices of toast with butter contained almost 50% of an adult's daily maximum limit of salt (CASH 2009).

The challenge currently faced by the foodservice industry to combine convenience with health is further complicated by the sensory impact salt reductions may have on a product or meal. The sensory aspects of a product are one of the major influences on an individual's acceptance of a food or beverage. Numerous consumers consider low-salt or low-sodium foods to be unpalatable and unpleasant, while many other consumers perceive salt-restricted/sodium-restricted diets to be bland and tasteless (Walsh 2007). Therefore, maintaining the flavour and taste of the original salted product is one of the key challenges facing the industry as they strive to formulate reduced salt foods (Bertino *et al.* 1981).

Several different approaches have been adopted by food manufacturers as they endeavour to reduce salt contents in their products, approaches that could be applied successfully within the foodservice industry. The first involves incremental reductions in the amount of salt added to food formulations over an extended period until the desired low salt level is achieved. Evidence suggests that as the salt reductions are gradual, the sensory attributes of the food appear unchanged to the consumer as their salt appetite adjusts to the decreased salt level over time (Bertino *et al.* 1982). The second approach involves an immediate removal of the salt present in the product with the resultant loss in salt taste compensated for through the use of substitutes that deliver the required flavour by other means. The use of salts that replace the cation Na^+ with potassium, calcium, lithium, magnesium or ammonium and by anions such as phosphates or glutamates (Kilcast & den Ridder 2007) is commonplace; however, each is not without negative side effects. For example, the most popular of these, potassium chloride (KCl), has been shown to impart bitter and/or metallic notes to foods when used at high levels (Fitzgerald & Buckley 1985; Desmond 2006). Other products often used include salt or flavour enhancers that enhance or modify the original taste and/or aroma of a food and can create an intense flavour within a product that is not necessarily a typical salty flavour (Gillette 1985). Bitter inhibitors have also been used to mask or block the bitter taste associated with the use of KCl. More recently, flake- or dendritic-type salts, which are sodium chloride salts where the crystals are branched or star-like instead of the normal cubic structure, have been used as they are said to impart stronger saltiness at a lower level (Kilcast & den Ridder 2007).

Despite the downwards pressure on salt levels, there is very little published information on the impact of salt reductions and the addition of salt substitutes on the sensory acceptability of foods and food products in the foodservice industry. Given the popularity of the ready meal format and their aforementioned high salt levels, the principle objective of the present study is to investigate the effect of salt reduction on the sensory acceptability of a popular ready meal. This information will then be used to determine the minimal salt level possible at which there is no discernible sensory difference between a reduced salt meal and a meal with normal salt levels. In addition, the effectiveness of the inclusion of a range of salt substitutes on the sensory acceptability of a ready meal in which panellists could detect a difference in saltiness will be examined.

Materials and methods

Sample preparation

Two 45-kg batches of a frozen lasagne ready meal were prepared by Dawn Fresh Foods Ltd., Fethard, Ireland, according to their standard industrial protocol. One batch was formulated to contain the normal commercial levels of salt (1.05% w/w; control meal), whereas the second batch contained only residual salt levels (0.55% w/w); samples were packaged in 375-g portions, blast frozen and stored at −18°C upon receipt. The day before sensory evaluation, a number of control and reduced salt ready meals were removed from the freezer and thawed over night at 4°C. Aqueous salt solutions were added to the bolognese-type meat sauce layers of the lasagne to give a range of low-salt meals with salt concentrations of 0.55%, 0.65%, 0.75% and 0.85% salt. This was achieved by separating out the individual layers of each low-salt lasagne ready meal and placing the meat sauce layers from each meal into separate trays [110 × 150 × 60 mm (Dynopak Ltd, Dublin, Ireland)]. The contents of each tray were thoroughly mixed to ensure a homogeneous distribution of salt. Each meal was then reassembled into their original tray and held at 4°C for 1–2 h prior to testing to ensure the salt had equilibrated fully through the meal. The lasagne ready meals were cut into eight equal portions within the tray and then cooked for 12 min on full power in a microwave oven (850 watt) as per manufacturer's instruction. Equal portions of the meals were subsequently distributed into individual circular foil cases (50-mm diameter). All samples were presented to the panellists in a random order on white paper plates labelled with three-digit random codes derived from the Compusense® five software (Compusense Inc., Guelph, Canada). The panellists were presented with the samples in individual testing booths adjacent to the sample preparation area equipped with serving windows, controlled lighting and computers for ballot presentation and data collection using Compusense® five software. Plastic cutlery, napkins and water to cleanse the palate were also provided. For the salt substitutes study, a selection of commercial salt substitutes and flavour enhancers were sourced from AllinAll Ingredients (Dublin, Ireland) and AlsoSalt (Maple Valley, WA) (Table 1). Each salt substitute/flavour enhancer was made up as a 30% solution in water. The day before testing, the number of ready meals were removed from frozen storage and thawed overnight at 4°C. Salt substitutes were added to the low-salt meal [0.55% salt (w/w)] at a level of 0.50% using the procedure outlined earlier. Sample presentation and preparation was as described for real salt samples.

Determination of the sodium content by atomic absorption spectrometry

Following the addition of salt solutions or salt substitutes to the various meals, all meals were held at 4°C to allow the salt/salt substitute to equilibrate fully throughout the meal. The entire contents of each ready meal were blended in a Moulinex Iseo 1.4 L 450-watt food processor (Caen, France) at low speed for 2 min. Three samples (approximately 0.5 g) from each meal containing each of the various salt levels were removed from the food processor and placed into acid-washed, oven-dried 100-mL conical flasks. Ten millilitres of 10% nitric acid and 5 mL of 70% perchloric acid were added to each conical flask and placed on a hotplate, initially on a low heat, until the sample dissolved, and left simmering until the contents of the flask went clear (approx. 10 mL). The flasks were allowed to cool and then made up to 100 mL using distilled water

Table 1 Salt substitutes/flavour enhancers sourced for lasagne ready meal

Salt substitutes/flavour enhancers	Active ingredients	Supplier
Potassium Chloride (KCl)	KCl	AllinAll Ingredients, Dublin
AlsoSalt®	KCl and L-lysine	AlsoSalt®, Maple Valley, Washington
Provesta® 512	Autolysed yeast extract	AllinAll Ingredients, Dublin

and 1 mL of 3 M KCl. One millilitre of this sample digest was transferred into a 100-mL volumetric flask with 1-mL 3 M KCl and diluted to volume (100 mL) with distilled water. The standards used for instrument calibration were prepared by diluting 0.1 mL and 0.02 mL of 1000 mg/L Na^+ calibrated stock solution (JVA Analytical Ltd., Dublin, Ireland) with 2 mL of 3 M KCl in 200-mL distilled water, giving 0.5-mg/L and 0.1-mg/L Na^+ standards, respectively. Sample concentrations were read using Perkin Elmer Atomic Absorbance Spectrometer 3110 (Perkin-Elmer, Norwalk, CT) fitted with a hollow cathode ray lamp with an emission wavelength of 590 nm. Sodium and salt levels were calculated as mg/100 g ready meal using equations (1) and (2) in the next section:

$$[Na, mg/100g] = \frac{[AA, ppm] \times 100 \times 100}{Sample\ weight\ (g) \times 10} \quad (1)$$

$$[Salt, g/100g] = \frac{[Na, mg/100g] \times 2.5}{1000} \quad (2)$$

Training of panellists

Thirty-five staff members of the Ashtown Food Research Centre (AFRC), Dublin, composed of 20 females and 15 males aged between 22 years and 65 years, participated in the sensory panels. All of the panellists were untrained when recruited but had partaken in previous taste panels within the AFRC. Prior to participation, the panellists were presented with a series of coded salt solutions with concentrations of 0.4%, 0.6%, 0.8%, 1.0% and 1.5% (w/v) and asked to rank the solutions in order from saltiest to least salty. The panellists were accepted for further testing based on those who ranked the samples in the correct order or those who inverted an adjacent pair only. A total of 30 panellists, 18 females and 12 males, were selected for the remainder of the trial.

Sensory analysis methods used

All sensory analysis tests were conducted on separate days (1–7 days apart) at the same time each day (before lunch) and varied in length, from 5–15 min. All salt reduction sensory analyses were completed and conducted prior to the salt substitute sensory analysis. Sensory tests were carried out in the numerical order as outlined in the next section. Within each test, samples were presented in a balanced random order. Thirty panellists (18 females, 12 males aged between 22 and 65 years) took part in all the paired comparison and preference tests, 20 panellists (12 females, 8 males aged between 24 and 57 years) took part in all the triangle tests and 15 panellists (8 females, 7 males aged between 24 and 57 years) took part in all the ranking tests. A total of 175 untrained consumers (99 females, 76 males aged between 19 and 70 years) took part in the consumer acceptability trial.

Paired comparison test

A paired comparison test, also referred to as a directional difference test, was conducted to determine if the ready meals differed in relation to one specific-named attribute, i.e. salt or saltiness. As this sensory test is attribute-specific, a result of no difference between samples does not imply that no overall difference exists (Meilgaard *et al.* 1991) between the samples. It is therefore important that an overall difference test is carried out in conjunction with this paired comparison test to identify if the changes made to the original formulation with regard to salt has impacted on the overall sensory properties of the product and not just salty taste.

Each of the low-salt meals [0.55%, 0.65%, 0.75% and 0.85% (w/w) salt] were individually compared to the control commercial ready meal [control; 1.05% (w/w) salt], using the procedure described by Meilgaard *et al.* (1991). Thirty panellists received two coded samples, one control sample (A) and one of the low-salt samples (B). Equal numbers of the combinations AB and BA were prepared and presented at random among the panellists. The panellists were asked to taste each sample and determine which sample they perceived to be saltier. A section was included for the panellists to leave comments on any aspect of the test. Thirty panellists were also asked to individually compare each of the three salt substitutes (see Table 1 for a list of salt substitutes used) incorporated into the lowest salt ready meal (0.55% salt) with the control ready meal (1.05%

salt), and the panellists were again asked to identify the saltier sample.

Triangle test

Triangle tests were carried out to determine if an overall sensory difference existed between two samples, i.e. between the control commercial ready meal (1.05% salt) and one of the low-salt meals [0.55%, 0.65%, 0.75% and 0.85% (w/w) salt]. Three coded samples were presented to 20 panellists, two control samples and one low-salt sample or one control sample and two low-salt samples. Equal numbers of the combinations ABB, BAA, AAB, BBA, ABA and BAB, where A was the control sample and B was the low-salt sample, were prepared and presented at random among the panellists. The panellists were informed that two of the samples were the same and one was different. The panellists were asked to taste the three samples and to identify the odd or different sample. A section in the questionnaire was included for the panellists to leave comments on any aspect of the test. This sensory test was also used to compare each of the three salt substitutes (see Table 1 for a list of salt substitutes used) incorporated into the lowest salt meal with the control ready meal.

Preference test

A basic preference test was carried out. Thirty panellists were presented with two coded samples, one control sample (1.05% salt) (A) and one of the low-salt samples [one sample from 0.55%, 0.65%, 0.75% and 0.85% (w/w) salt] (B), or one control sample (A) and one of the salt substitute samples (see Table 1 for a list of salt substitutes used) (B). Equal numbers of the combinations AB and BA were prepared and presented at random among the panellists. The panellists were asked to taste the two samples and to indicate which sample they preferred. A section was included for the panellists to comment on any aspect of the test.

Ranking preference test

Fifteen panellists were presented with a total of four coded samples, one control sample and one sample of each of the three salt substitute ready meals (see Table 1 for a list of salt substitutes used). The panellists were asked to taste the four samples and rank them in their order of preference from the sample they liked most, which received a rank of 1, followed by the sample they liked second, which received a rank of 2, down to the sample they least liked, which received a rank of 4. Therefore, the sample receiving the lowest overall rank total will be the sample most preferred by the panellists, while the sample with the highest overall rank total will equal the sample panellists least preferred. A section was included for the panellists to comment on any aspect of the test.

Consumer acceptability trial

The consumer acceptability of two frozen lasagne ready meal samples {one commercially available control salt sample and one low-salt KCl sample [low-salt meal (0.55% salt) with 0.5% KCl added] were evaluated by 175 untrained consumers, all of whom were regular consumers of ready meals. The consumers were recruited from staff and students of the AFRC, which previously had not partaken in any low-salt ready meal sensory analysis, and visiting personnel who ranged in age from 19 to 70 years of age (99 females, 76 males). Four sessions (n = 25–50) were conducted over 1 month, with analysis being conducted at the same time and on the same day each week. The consumers were individually asked to do a blind taste test on both coded samples and rate their acceptability using the following nine-point hedonic acceptability scale: 9 = liked extremely, 8 = liked very much, 7 = liked moderately, 6 = liked slightly, 5 = neither liked nor disliked, 4 = disliked slightly, 3 = disliked moderately, 2 = disliked very much and 1 = disliked extremely. The consumers were also asked if they perceived the samples to be the 'same/identical' or 'different'.

Data collection and statistical data analysis

Compusense® five software, a computer software package for sensory analysis data collection, was used during the course of this study. The software was used to create questionnaires, present questionnaires to the panellists according to an experimental design plan and collect and analyse all data. All statistical analyses were preformed using the Compusense® five software. All preference and paired comparison sensory analysis tests carried out were recognised as ranking data by the software, as is often the case when the panellists are asked to pick one sample from two, the chosen sample is ranked first and the remaining sample is inevitably ranked second (Meilgaard *et al.* 1991), and therefore, cross-tabulation (samples by ranking order) and percentage cross-tabulation, Friedman analysis of rank, chi-square and Tukey's Honestly Significant Difference for rank were carried out on these data. The triangle test data were analysed as frequency counts with binomial probabilities (number of correct responses required for significance, and *P*-value) and cross-tabulation of responses. The acceptability test data were analysed using cross-tabulation and percentage cross-tabulation, summary statistics (counts, medians, means and standard deviations) and two-way analysis of variance.

Table 2 Significant difference levels to control samples (1.05% NaCl) for sensory analysis of lasagne ready meals with salt levels of 0.55–0.85% (w/v)

Salt Concentration (%)	Significant difference to control* Paired comparison test	Triangle test	Preference test
0.55	0.003	0.004	0.273
0.65	0.000	0.000	0.003
0.75	0.273	0.092	0.715
0.85	0.465	0.001	0.273

*Results of Compusense® five statistical analyses for comparison of control lasagne ready meals with low-salt lasagne ready meals with salt added at levels from 0–0.3%.

Results and discussion

Determination of the maximum level of salt reduction

The results of the atomic absorption spectroscopy confirmed that the levels of salt in all meals were in line with expected values. The determination of the maximum amount of salt to be removed from a frozen lasagne ready meal without the sensory panellists noticing a difference in taste was achieved using paired comparison and triangle tests. The *P*-value results for these sensory tests are presented in Table 2. In paired comparison tests, the panellists detected a significant difference in salt taste between the control salt meal and the low-salt meals with final concentrations of 0.55% and 0.65% salt ($P < 0.005$; Table 2). At salt concentrations of 0.75% and 0.85%, the panellists reported no significant difference ($P > 0.05$) between the control lasagne ready meal and either of these two low-salt meals, indicating that there was no difference between these meals in terms of salty taste. Similarly, the triangle tests indicated a significant difference ($P < 0.005$) between the control ready meal and low-salt meals with 0.55% and 0.65% salt. Unexpectedly, the panellists were also able to detect a significant difference between the 0.85% low-salt meal and the control ready meal ($P < 0.005$). This result highlights the importance of combining the attribute-specific paired comparison test with the triangle test, as although the panellists could not differentiate between the control meal and the 0.85% low-salt meal with regard to salty taste during the paired comparison test, they were, however, able to detect a significant difference in terms of overall taste during the triangle test. Therefore, despite salty taste being unaffected in the reduced salt meal, the reduction in salt content in the meal may have affected the other sensory properties of the meal such as flavour intensity or texture, for example. No significant difference ($P > 0.05$) was reported between the 0.75% low-salt meal and the control ready meal during the triangle test, indicating that the panellists were unable to distinguish an overall difference between these two meals. Discounting the apparent anomaly at 0.85% NaCl, this result, combined with results from the paired comparison test, would appear to indicate that the maximum amount of salt to be removed from a frozen lasagne ready meal without the panellists noticing a difference in taste is 0.3% salt. Hence, a gradual salt reduction programme may successfully be applied to ready meals without consumers detecting any sensory differences in the product and could potentially be applied to similar prepared foods within the foodservice industry. Gradual salt reduction programmes whereby incremental reductions are made to the amount of salt added to foods over an extended time period until the desired low salt level is achieved is becoming the salt-reduction strategy of choice by many countries. The world action group 'World Action on Salt and Health' (WASH) encourages this approach, and it is currently being implemented by food manufacturers worldwide in countries such as Australia, UK and Ireland (He & MacGregor 2008).

In a preference test comparing each of the low-salt meals with the control ready meal, the panellists expressed no significant preference ($P > 0.05$) between the control and low-salt meals with 0.55%, 0.75% and 0.85% salt concentrations. Ainsworth *et al.* (1993) observed similar results as they found no significant difference in the panellists' acceptability scores when varying levels of salt ranging from 0–0.68% salt was added to a chilli con carne meal. Blankenship & Hagen (1986) (as cited by Perlmutter *et al.* 1997) also found no difference in acceptability between entrees that had been modified for sodium, as well as for total fat, saturated fat and cholesterol when both modified and unmodified recipes were tasted by a group of firefighters. These results highlight that implementing a gradual salt reduction programme can be achieved without affecting consumers' preference and sensory acceptability for a product, possibly one of the most important factors in terms of repeat purchase of a food by a consumer. The panellists did, however, show a significant preference ($P < 0.005$) for the control lasagne meal over the 0.65% low-salt meal, with 23 out of the 30 panellists preferring the control over this particular low-salt meal. A reduction of this scale, i.e. approximately 40% salt removed from the original recipe at once, may have caused an off-balanced flavour within the meal that the panellists could detect. Smaller reductions of approximately 10% result in the sensory attributes of the food appearing unchanged to the consumer as their salt appetite adjusts to the decreased salt level over time (Bertino *et al.* 1982).

Salt substitute trials

The second salt reduction approach that could potentially be employed in the foodservice industry is the use of salt substitutes and flavour enhancers. This approach involves immediately removing the desired amount of salt from the original product and masking the effect on the sensory properties with salt substitutes or flavour enhancers, which can be anything from herbs and spices or more specific commercially sold products. Two commercially available salt substitutes (KCl and AlsoSalt®) and one flavour enhancer (Provesta® 512, AllinAll Ingredients, Dublin, Ireland) were incorporated into the lowest salt meal, i.e. 0.55% low-salt lasagne ready meal at a level of 0.5%, a replacement of 48% of the original salt content present in the control salt lasagne ready meal (1.05% salt). The salt substitutes used and their active ingredients are presented in Table 1, while sensory analysis results are presented in Tables 3 and 4 and Figs 1 and 2.

Table 3 Significant difference level to control samples (1.05% NaCl) for sensory analysis of lasagne ready meals with 0.5% added salt substitutes

	Significant difference to control*		
Salt substitutes	**Paired comparison test**	**Triangle test**	**Preference test**
KCl	0.715	0.092	0.144
AlsoSalt®	0.465	0.004	0.011
Provesta® 512	0.000	0.000	0.068

*Results of Compusense® five statistical analyses for comparison of control lasagne ready meals with low-salt lasagne ready meals with salt substitutes added at a level of 0.5%.

Salt substitute 1 – KCl

KCl is one of the most commonly used salt substitutes within the food industry today. However, the bitter taste often associated with the use of KCl in low-salt/low-sodium foods has limited its industrial use. For example, Sanceda *et al.* (2003) found that replacement of more than 25% of the salt with KCl in a fish sauce imparted an unacceptable bitter taste, while Phelps *et al.* (2006) stated that a 50 : 50 ratio of salt to KCl is a common practical limit within the food industry. This bitterness perception may, however, be product-specific, as results from this study indicated that the panellists did not notice or comment on a bitter taste or

Table 4 Summary statistics for the consumer acceptability trial ($n = 175$) results comparing control and low-salt KCl lasagne ready meals*

	Summary statistics		
Ready meals	Median	Mean	Standard deviation
Control	8.00	7.42	1.314
Low-salt KCl	8.00	7.57	1.182

*Nine-point hedonic acceptability scale used where, liked extremely = 9, liked very much = 8, liked moderately = 7, liked slightly = 6, neither liked nor disliked = 5, disliked slightly = 4, disliked moderately = 3, disliked very much = 2, disliked extremely = 1.

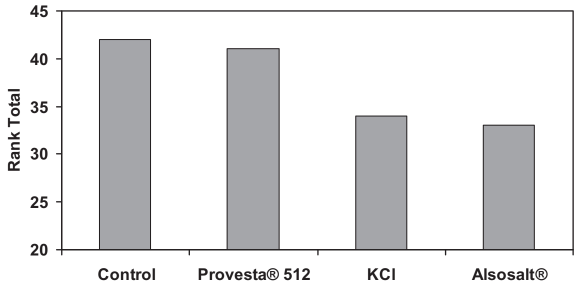

Figure 1 Rank totals (based on sum of rank) for ranking preference test of control lasagne (1.05%) and all salt substitutes incorporated at a concentration of 0.5% into low-salt (0.55%) lasagne ready meals ($n = 4$). $P > 0.05$. No significant difference between samples, calculated using Tukey's HSD.

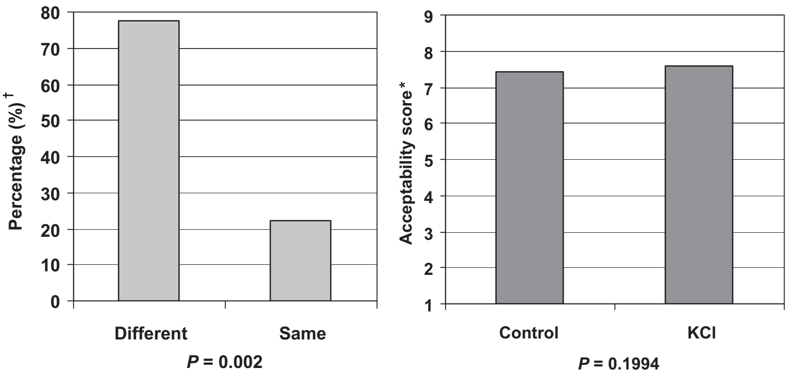

Figure 2 Results of the consumer acceptability trial ($n = 175$) comparing control and low-salt KCl lasagne ready meals. †Percentage of consumers who perceived sample to be the same or different. *Mean consumer acceptability score, where 9 = liked extremely, 8 = liked very much, 7 = liked moderately, 6 = liked slightly, 5 = neither liked nor disliked, 4 = disliked slightly, 3 = disliked moderately, 2 = disliked very much, 1 = disliked extremely.

aftertaste normally associated with the inclusion of KCl when almost 50% of the salt in a frozen lasagne ready meal was replaced with KCl. This may be due to the presence of flavour-potent herbs and spices in the lasagne ready meal that may have acted to mask the bitter taste normally associated with the inclusion of KCl. This could therefore be a potential salt substitute used by certain sectors of the foodservice industry, particularly those serving spiced foods.

The sensory tests indicated that the panellists were unable to detect a difference in the salty taste between the control meal and the low-salt meal containing KCl in the paired comparison and triangle tests ($P > 0.05$, Table 3). In the preference tests, 19 out of the 30 panellists preferred the low-salt KCl meal to the control ready meal; however, this was not be a significant preference ($P > 0.05$). In a ranking preference test where all salt substitute samples, along with the control salt sample were presented to the panellists, the low-salt meal containing KCl was ranked second favourite (Fig. 1); however, it must be noted that there was no significant difference/preference between any of the samples.

Salt substitute 2 – AlsoSalt®

AlsoSalt® is a mixture of KCl and the amino acid L-lysine monohydrochloride. This salt substitute is typical of the many salt substitutes used today, as it combines KCl with a 'bitter blocker', i.e. a substance that masks the bitter taste associated with KCl. According to the manufacturers of

AlsoSalt®, L-lysine has a unique salty flavour that when combined with KCl, masks the associated bitter taste. Similar to the use of KCl alone in a lasagne ready meal, the panellists did not observe any bitter taste or aftertaste in the low-salt AlsoSalt®-containing meal in this study. As this product contains a bitter blocker, it has the potential to be used in many unspiced foods within the foodservice industry, as any taste effects of KCl on the product would be masked by the bitter blocking amino acid L-lysine monohydrochloride. The paired comparison tests indicated that there was no significant difference (Table 3, $P > 0.05$) between the control ready meal and this low-salt ready meal in terms of saltiness; however, in triangle tests, a significant difference ($P < 0.005$) between these meals was observed, with the panellists easily able to select the odd or different sample. While the panellists could differentiate between the control lasagne ready meal and the low-salt meal containing AlsoSalt®, they could not distinguish between these two meals on the basis of saltiness or salt taste. Therefore, while the loss in salty taste could be replaced through the inclusion of AlsoSalt® salt, the ability to enhance and intensify other flavours present in a food resulting from salt inclusion could not. The preference tests indicated that the panellists significantly preferred ($P < 0.05$) the low-salt AlsoSalt® meal over the control ready meal. In fact, this meal was rated as the most preferred meal (Fig. 1) during the ranking preference test; however, this preference was not statistically significant ($P > 0.05$).

Flavour enhancer – Provesta® 512

Provesta® 512 is a yeast-based flavour enhancer. Yeast extracts are commonly used in food as salt substitutes and/or flavour enhancers as they impart bouillon-like, clean tastes, thus, giving them the ability to enhance existing food ingredients such as meat and spices (Brandsma 2006; Desmond 2006). According to its manufacturers, Provesta® 512 is a low-sodium autolysed yeast extract containing a high level of the naturally occurring 5′-nucleotides IMP and GMP (disodium inosinate and disodium guanylate), which they claim amplifies flavours and contributes an umami effect (ABF Ingredients 2006). From Table 3, it can be seen that in paired comparison tests, the panellists detected a significant difference ($P < 0.005$) in terms of salty taste between the control lasagne ready meal and the low-salt meal containing Provesta® 512. The panellists also detected a significant difference ($P < 0.005$) between these two meals during the triangle test, indicating that the panellists were easily able to identify the odd or different sample. Despite the panelists' ability to differentiate between these two meals in terms of saltiness and as whole meals, they showed no significant preference ($P > 0.05$) for either of the meals during the basic preference test and ranked it as third favourite (Fig. 1) above the control ready meal during the ranking preference test.

Consumer acceptability trial

Based on the results from the previous salt substitutes trials (Table 3), it was decided to incorporate KCl at a level of 0.5% into the lowest salt lasagne ready meal (0.55% salt) for further acceptability testing as it proved the most promising of the three salt substitutes tested. The results from the consumer acceptability trial are shown in Fig. 2 and Table 4. The results in Fig. 2 show that 78% of the consumers thought the two meals were different ready meals, while 22% perceived them to be the same ready meal ($P < 0.005$). Both lasagne samples were considered to be acceptable, with sensory scores placing both samples between 'liked very much' = 8 and 'liked moderately' = 7, with the low-salt meal containing KCl being slightly favoured above the control commercial meal; however, this was not a significant difference. The standard deviation results in Table 4 show that acceptability scores for both samples were spread from a score of approximately 9, which equalled 'liked extremely', to a score of approximately 6, which equalled 'liked slightly'.

Conclusion

The sensory evaluations indicated that salt levels in a commercial frozen lasagne ready meal could be reduced to 0.75% (a 29% reduction in salt) without a difference in overall taste and saltiness being detected. The incorporation of a number of commercially available salt substitutes, particularly KCl, resulted in salt levels being reduced by a further 0.2% to a final concentration of 0.55% salt without compromising consumer acceptability, salty taste and sensory preference for the meal. Concerns over the use of KCl-based salt substitutes imparting bitter notes at the levels used in this study were not justified.

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