RESEARCH NOTE

THREE SCALING METHODS FOR CONSUMER RATING OF SALT INTENSITY

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ABSTRACT

This study aimed to identify a scaling technique, which would offer the greatest degree of discrimination and accuracy in an evaluation of soup samples, varying in salt concentration (0.3, 0.8 and 1.3% salt). A Seven Point Category Scale, a 100 mm Line scale and non-modulus Magnitude Estimation were used to evaluate samples by consumers (n = 36).

A Friedman Two-Way ANOVA and a Wilcoxon Signed Ranks test were applied to the data to compare discriminatory ability and accuracy of the scaling techniques. Results revealed that each of the techniques could be used to discriminate between samples ($P < 0.001$). However, none of the three techniques were significantly more accurate than one another. In view of the results and consumer preference/comments for using the Seven Point Category Scale, this technique is proposed as an effective method for consumer rating of salt intensity.

INTRODUCTION

The Food Industry has been instrumental in developing an increasingly wide range of value added products for consumers. However, many of the processed food products currently available to consumers are heavily loaded with large amounts of salt (Gibson *et al.* 2000). It has been reported that an estimated 75%

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of dietary salt intake is attributed to processed foods (IFST 1999) and the excessive quantities of salt added to these foods, has led to calls from health professionals, food researchers and nutritional advisory groups to reduce the existing levels of salt in processed foods (de la Hunty 1995; Whitworth 2001). In order for the food industry to develop products with low salt status, it is paramount that the appropriate sensory evaluation techniques are implemented (Galvez and Resurreccion 1990). This means appropriateness not only in relation to validity and reliability, but also in relation to ease of use with the assessor.

It is widely accepted that descriptive analysis techniques, such as Quantitative Descriptive Analysis, can be used to evaluate the sensory attributes of a product (Piggott *et al.* 1998), while traditionally consumer acceptance ratings have been measured using the 9 Point Hedonic Scale (Peryam and Pilgrim 1957). However, consumer perception of the intensity of specific product attributes, is equally important, particularly when relating consumer perception and acceptance ratings. To date, understanding consumer perception of sensory attributes such as saltiness has received limited discussion and is less definitive with regard to the application of specific sensory techniques. This is important as continued success within the food industry will be directly related to its ability to develop more precise knowledge about consumer attitudes and perceptions towards food products and how these are best measured and implemented (Sidel and Stone 1993).

Given the current development of reduced salt food products, there is a renewed need for further research into the scaling techniques available for rating attribute intensities, such as saltiness.

Specific attribute intensities may be evaluated using a variety of scaling techniques which involve the use of either numbers or words to express the intensity of a perceived attribute and/or the acceptability of the products (Lawless and Malone 1986b; Meilgaard *et al.* 1991).

There are at present three types of scales in common use for the sensory evaluation of products. These include category scales, linear scales and magnitude estimation or ratio scales (Meilgaard *et al.* 1991). However, the relative merits of applying these different scaling techniques in sensory evaluation have received little systematic study (Lawless and Malone 1986a), and as a consequence, no one scaling technique has been identified for rating salt intensity. Moskowitz and Sidel (1971) and Giovanni and Pangborn (1983) have commented that direct comparisons of the techniques within a single experimental setting have been rare, and differences between scales from a practical point of view are unclear.

Clearly, sensory evaluation must develop and improve its methods and more clearly delineate its role and responsibilities in the food industry (Sidel and Stone 1993). In addition, it is important to select evaluative techniques which are user friendly as well as being valid and reliable.

The purpose of this study therefore was to identify a scaling technique (Seven Point Category Scale, Line or nonmodulus Magnitude Estimation) which offered the greatest degree of discrimination and accuracy in the evaluation of soup samples, varying in salt concentration. In addition, consumer panelists were required to identify which rating scale they preferred using and why.

MATERIALS AND METHODS

Determining Salt Concentrations - Pilot Study

Preliminary testing was carried out with a trained sensory panel to ascertain a range of salt concentrations which provided detectable differences in soup as well as to determine if soup was a suitable product category in which to rate salt intensity.

The sample sets consisted of three samples each (set one: 0.3, 0.8 and 1.3%; set two: 0.5, 0.8 and 1.1% salt concentration), based around the current salt concentration (0.8%) of ready prepared chilled soups. The trained sensory panel (n = 7) ranked each set of samples in order of salt intensity (1 = low, 2 = moderate, 3 = high level of salt). Results revealed that sample set one, offered detectable differences between samples and group discussions further confirmed soup as an appropriate product category for perception of salt intensity.

Product Formulation and Production Methods

Samples of Leek and Potato soup were prepared with salt concentrations of 0.3%, 0.8% and 1.3%, using the formulation in Table 1.

Production of white stock involved roughly chopping all vegetables and placing into a saucepan. The water was added and brought to a boil. The stock was skimmed to remove all visible fat and strained when fully cooked (approximately 45 min).

Production of the soup involved leeks being cut into ½ cm paysanne (round thin pieces) and cooked slowly in butter with a lid until soft, but without coloring. Stock was added and bouquet garni. Potatoes were cut into ½ cm paysanne, 2 mm thick. The soup was simmered until leeks were soft and potatoes were cooked (for approximately 15 min) and the salt was added. When fully cooked the soup was blended until uniform in consistency.

Panelists and Samples

Thirty-six untrained consumer panelists (Meilgaard *et al.* 1991) participated in rating the salt intensity of soup samples, using three different scaling

techniques. Product ratings were carried out in a 6 booth sensory laboratory (BS 7138, 1989) and all responses were recorded using a computerized sensory system (PSA 3, Version 2.05 OP&P Product Research).

TABLE 1.
FORMULATION FOR LEEK AND POTATO SOUP AT 0, 0.3, 0.8, 1.3% SALT

Raw Materials	% Raw Materials			
Leeks, trimmed and washed	32.8	32.7	32.5	32.4
Unsalted Butter	1.6	1.6	1.6	1.6
White Stock (78.8% water; 5.3% onion; 5.3% carrot; 5.3% leek)	52.5	52.3	52.1	51.8
Potatoes	13.1	13.1	13.0	12.9
Bouquet Garni				
Salt	**0**	**0.3**	**0.8**	**1.3**

(Ceserani *et al.* 2000)

Nine soup samples (3 samples × 3 scales) were presented to consumers in a single test session lasting 20 min. Sample presentation was randomized, as determined by the computerized sensory system. The order of tests was also randomized for each set of six consumers to ensure reliability and elimination of any possible bias in order effects.

Scaling Techniques

Three rating scales (Seven Point Category Scale, 100 mm Line Scale and Magnitude Estimation) were selected for sensory testing and subsequent evaluation.

Seven Point Category Scale. The Seven Point Category Scale (Shepherd *et al.* 1984a, b; Drewnowski *et al.* 1996) required consumers to place a cross against the response which represented their rating of salt. Response options were placed in ascending order from *No Salt Taste, Very Weak, Weak, Moderate, Strong, Very Strong* to *Extremely Strong*.

Line Scale. The 100 mm Line Scale (Little and Brinner 1984) required consumers to place an '**X**' at any position on the line, which best represented their rating of salt intensity (Lawless and Heymann 1998). The line scale was anchored 10 mm from each end, with the end points, *Not at all salty* and *Extremely Salty*.

Magnitude Estimation. The Magnitude Estimation Scaling technique (Moskowitz 1974; Stevens 1975) required consumers to assign numbers to represent perception ratios. In this procedure, each respondent is allowed to use any positive number to reflect the ratios of the magnitudes perceived (Lawless and Heymann 1998). In this study, untrained consumers rated the salt intensity of soup samples using limited instructions, considering recent discussion (Gray *et al.* 2000) on the effectiveness of Magnitude Estimation with untrained consumers.

On completion of the three scaling techniques, consumers were asked to state their preferred technique for rating salt intensity and comment on reasons for their choice.

Statistical Analysis

The data were analyzed using the Statistical Package for Social Sciences (SPSS) for Windows Version 9.0. Mean scores and standard deviations for the three scaling techniques were reported. The data were then converted to percentage scores and the means and standard deviations calculated.

Mean percentage scores for the Seven Point Category Scale were calculated by assuming the value of 1 on the scale to represent 0% and the value of 7 to represent 100%. The mean score for the 0.3% salt sample was 1.9 and so the percentage score for this value was calculated as follows: $(1.9\text{-}1^{1}) \times 100/(7\text{-}1)^{2} = 14.4$. The 100 mm Line Scale required no additional conversion of mean scores to percentages since the original values were based on a scale of 0 to 100. The mean percentage scores for Magnitude Estimation were determined by transforming the values of each product for each consumer, to a geometric mean of 10. The values were then normalized using the technique modulus equalization (Lane *et al.* 1961). The minimum (0.58) and maximum (69.32) values for each product were then identified and assumed to be 0% and 100%. For example, the mean percentage for the 0.3% salt sample was calculated by applying the following equation: $(5.1\text{-}0.58) \times 100/(69.32\text{-}0.58) = 6.5$ (Tables 2 and 3).

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[1] 1 is the lowest possible score of the Seven Point Category Scale

[2] In the equation multiplying by 100 and dividing by 6 (the range of the scale) establishes the percentage.

Nonparametric statistical tests were applied to the data, given that the respondents were untrained consumers and the data was not normally distributed. To determine the ability of the various scaling techniques to discriminate between the samples, a Friedman Two-Way ANOVA was applied (Lawless and Malone 1986a). To determine if significant differences existed between the 0.3 and 0.8% and 0.8 and 1.3% salt concentrations in soup, a Wilcoxon Signed Ranks test was also applied. Accuracy of the scaling techniques was determined by calculating the relative error of each scale (difference between the observed and expected ratings) and further analyzed using the Friedman Two-Way ANOVA.

RESULTS AND DISCUSSION

Mean Scores

Consumers were able to distinguish between the samples, as reflected by the increase in mean scores with increasing salt intensity (Table 2). This would suggest that the product category (leek and potato soup) and the salt concentrations selected, were appropriate for rating salt intensity. However, when using both the 7 Point Category Scale and Line Scale consumers tended to avoid using the upper end of the scale. Using only the middle section of scales is a common problem and partly due to assessors reserving scale extremes for hypothetical samples, which may never come (Meilgaard *et al.* 1991). Despite this potential limitation, it was evident that each of the scaling techniques could be used to rate the salt intensity of soup samples.

TABLE 2.
MEAN SCORES (STANDARD DEVIATIONS) FOR ORIGINAL DATA

Soup Samples (% salt)	Mean Scores (Standard Deviations)		
	7 Point Category	Line Scale	Magnitude Estimation
0.3	1.9 (1.0)	13.5 (11.2)	5.1 (4.6)
0.8	3.8 (1.0)	46.2 (22.8)	12.9 (4.3)
1.3	5.3 (1.3)	69.4 (20.4)	23.8 (13.9)

In order for the results to be more meaningful and for the authors to make valid comparisons between the scaling techniques, the mean scores for each technique were converted to percentages (Table 3). When the percentage scores

for each of the soup samples were compared, it was revealed that the scores for the 7 Point Category Scale and the Line Scale were very similar. The mean percentage scores for the Magnitude Estimation technique were lower, even though consumers were unrestricted in the values which they could apply, but were proportional with the other scaling techniques. The difference between the scores for the 0.3% and 0.8% samples, respectively, was greater than the difference between the 0.8% and 1.3% samples, using the 7 Point Category Scale and the Line Scale. A different trend was observed for the Magnitude Estimation, where the difference between the scores for the 0.8% and 1.3% samples was greater than the difference between the 0.3% and 0.8% samples, however, this difference was only marginal.

The results suggest that when using the 7 Point Category Scale and the Line Scale, consumers' perception of the variation in soup samples was greater with lower salt concentrations. Consumers appeared not to recognize the same variation in soup samples at higher salt concentrations. Magnitude Estimation scores revealed consumer perception of the variation in salt intensity between samples to be similar.

TABLE 3.
MEAN PERCENTAGE SCORES (STANDARD DEVIATIONS)

Soup Samples (% salt)	Mean (%) Scores (Standard Deviations)		
	7 Point Category	Line Scale	Magnitude Estimation
0.3	14.4 (16.0)	13.5 (11.2)	6.5 (6.8)
0.8	46.8 (17.3)	46.2 (22.8)	17.9 (6.3)
1.3	71.8 (21.0)	69.4 (20.4)	33.8 (20.3)

Discrimination

The discriminatory ability of the scaling techniques was determined by comparing the mean ranks of the three scaling techniques for each of the soup samples. The Friedman Two-Way ANOVA (Table 4) revealed that each scaling technique could discriminate between the soup samples at a highly significant level ($P<0.001$). Food product developers could therefore confidently apply any one of these scaling techniques in the development and sensory evaluation of new and existing products, of reduced salt status. In fact, where a detailed sensory profile of a product already exists, it may be sufficient for developers to determine consumer perception of saltiness in reformulated reduced salt

foods, using one of the outlined techniques. In addition, however, product developers would be advised to implement effective sensory tests to establish consumer acceptability of their products.

TABLE 4.
DISCRIMINATORY ABILITY OF EACH SCALING TECHNIQUE, USING THE FRIEDMAN TWO-WAY ANOVA

Scaling Technique	Mean Ranks of Soup Samples (% salt)			Level of Significant Difference
	0.3	0.8	1.3	
7 Point Category	1.08	2.01	2.9	$\chi^2_2 = 64.5$, $P<0.001$
Line Scale	1.01	2.01	2.97	$\chi^2_2 = 69.5$, $P<0.001$
Magnitude Estimation	1.06	2.06	2.89	$\chi^2_2 = 60.7$, $P<0.001$

Having determined the discriminatory ability of the scaling techniques, a Wilcoxon Signed Ranks test was performed to establish the degree of discrimination between the 0.3 and 0.8% samples and the 0.8 and 1.3% samples. Table 5 illustrates that each of the scaling techniques could discriminate at a highly significant level ($P<0.001$) between the 0.3 and 0.8% samples and the 0.8 and 1.3% samples.

Accuracy

In determining the accuracy of the scaling techniques, a Friedman Two-Way ANOVA was then performed on the mean ranks of the relative error. The mean ranks of the scaling techniques were as follows: 7 Point Category Scale = 1.89; Line Scale = 2.19; Magnitude Estimation = 1.92. The analysis of variance test revealed no significant difference ($\chi^2_2 = 2.1$, $P>0.05$) between the mean ranks of the relative error, suggesting that none of the rating scales were significantly more accurate than the others, when used to rate salt intensity.

TABLE 5.
ABILITY OF EACH SCALING TECHNIQUE TO DISCRIMINATE BETWEEN THE 0.3 AND 0.8% SAMPLES AND 0.8 AND 1.3% SAMPLES

Scaling Technique	Comparison of 0.3% & 0.8% and 0.8% & 1.3% Salt[1] (Z Scores and Level of Significant Difference)	
	0.3 & 0.8%	0.8 & 1.3%
7 Point Category Scale	$Z = 4.8$, $P<0.001$	$Z = 4.8$, $P<0.001$
Line Scale	$Z = 5.2$, $P<0.001$	$Z = 5.2$, $P<0.001$
Magnitude Estimation	$Z = 4.7$, $P<0.001$	$Z = 4.7$, $P<0.001$

[1] Using the Wilcoxon Signed Ranks test

Although no one scaling technique was significantly more accurate than the others, consumer preference for using a specific rating scale does become important when selecting a scaling technique for future research and product development, particularly if consumer motivation is to be sustained.

Consumer Preference for the Rating Scales

It was evident from consumer preference scores that the 7 Point Category Scale was most preferred (42%), followed by Magnitude Estimation (36%) and the Line Scale (22%). Consumer preference for the various scaling techniques was supported by qualitative consumer comments (Table 6). Consumers who were in favor of each of the scaling techniques have sufficiently justified the reasons for their preference.

With the majority of consumers clearly in favor of the 7 Point Category Scale, and the ability of this technique to discriminate between soup samples, it would appear that this technique should be recommended and selected for rating salt intensity in this study.

CONCLUSIONS

The findings of this study are of relevance to both sensory researchers and food product developers alike. The study revealed that each of the scaling techniques when applied to soup could discriminate between samples of different salt concentrations. However, no one technique was significantly more accurate than the others in rating salt intensity. When consumer opinion was considered, the majority of consumers preferred the 7 Point Category Scale, which will be utilized in subsequent work in this area.

TABLE 6.
TYPICAL CONSUMER COMMENTS — REASON FOR PREFERRED SALT INTENSITY RATING SCALE

Salt Intensity Rating Scales	Consumer Comments
7 Point Category Scale	*"Clearer method; categories helped decision making process".* *"Definite descriptions for taste; not vague; no temptation to compare samples (decisions independent of each other)".* *"Quantitative description helped to quantify/categorize level of salt; more accurate".* *"Specific categories to choose from enabled more accurate and fast judgements".*
Magnitude Estimation	*"The idea of giving relative scores is more accurate; this technique gives the consumer a good opportunity to compare, retaste samples and give more accurate responses".* *"Able to compare samples more than once; this appears to be more accurate".* *"Feel more confident about consistency of this test; much easier to score; easier when testing all three samples together".*
Line Scale	*"Easier to document difference visually". "Easier to assess level of saltiness with line scale". "Appears to reflect personal opinion accurately - not constrained by categories". "Easiest test to use; allowed estimate of saltiness without the need to quantify/pick a category". "Simple technique allowed for variance".*

The recommendations of this study, in addition to the sensory techniques, already provide product developers with a scaling technique appropriate for determining consumer perception of saltiness. Used in collaboration with well established descriptive and effective techniques, product developers can implement a full evaluation of the sensory properties of reduced salt processed foods. The protocol could also have wider application to other product categories and/or developmental activities.

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