

## SALT ENHANCEMENT BY AROMA COMPOUNDS

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### Abstract

It is shown that multi-sensory interaction between aroma and taste can be employed to compensate the lower salt levels of healthy food products. The demonstrated saltiness enhancement by complex flavourings was unraveled by experiments with 'salt-congruent' single compounds, using trained and naïve panels. Several savoury compounds, but especially sotolon (4,5-dimethyl-3-hydroxy-2(5H)-furanone), have a significant impact on perceived saltiness. As expected, a naïve panel is more suitable to demonstrate multi-sensory interaction than a trained panel. The results were confirmed by consumer tests. A combination of KCl-based salt replacer and extra aroma was found to compensate approximately 30% sodium reduction without significant change of the flavour profile.

### Introduction

High dietary sodium has been shown to cause hypertension and hence increase the risk of developing cardiovascular diseases. In fact there is even epidemiologic evidence of a direct correlation between stroke incidence and salt consumption (1). As 75% of sodium intake in industrialized countries is from processed and restaurant foods, the food industry is urged by national and international authorities to reduce sodium levels in their products. However, reduction of salt without affecting taste is a major challenge. Reducing the salt content in food products obviously leads to a loss of saltiness, but also to a decrease of overall flavour intensity. It is known that people can adapt to lower salt levels for instance in bread (2), but this approach will only work if it is done industry-wide in a concerted way, which is difficult to organise. Most approaches therefore are based on some kind of compensation, using salt replacers or salt boosters. These usually contain potassium chloride, which is definitely salty, but also bitter and metallic. Other minerals and specific amino acids may also be used in replacer mixes, but the salt reduction that can be compensated in savoury products like soups and sauces remains limited to approximately 15-20%.

Besides the salt-contrast concept discussed in one of the oral presentations (3), a further compensation of the effects of low salt content might be derived from the exploitation of multi-sensory integration. As stated before salt functions as (savory) flavour enhancer. It can be envisioned that this interaction is mutual, and that extra added aroma will not only restore the aroma attributes, but also the perceived saltiness. For sweet flavour the enhancing effect of taste on aroma, and vice versa, has clearly been shown (4-6). The interaction takes place at the cognitive level (7). Relatively few publications deal with salt-aroma interactions. Only one study reports an enhancement of saltiness by a 'congruent' aroma, namely that of soy sauce (8). The aroma here, however, is administered orthonasally, and findings can not easily be exploited in real-life food products.

The present work was aimed to show that the principle can be used in a very practical way: flavourings were selected that, when added to a salt-reduced bouillon or soup, could compensate the effects of the low salt level, without significantly changing the flavour profile of the product. In first instance the savoury flavourings used in the recipe were simply increased in level. The second part is a systematic study of the impact of various types of potentially congruent, savoury aroma compounds on perceived saltiness in the context of an industrial bouillon. The selection of the single compounds is based on the known key aroma composition of meat flavour, encompassing 'brothy', 'meaty', and 'roasted' notes. The aim of the study was to identify which of the mentioned flavour directions and compounds is most effective in saltiness boosting.

Earlier studies indicated that the magnitude of multisensory interaction between taste and aroma varies between individuals, and especially trained panelists appeared insensitive and capable of separating aroma from basic taste (9). This indicates that cross-modal interactions to a large extent are not "hard-wired", but rather based on learned associations, and hence can be unlearned by training. In line with this, instructions to panelists strongly influence the results obtained (10). For that reason products were evaluated with an untrained and a trained panel, as well as with naïve consumers.

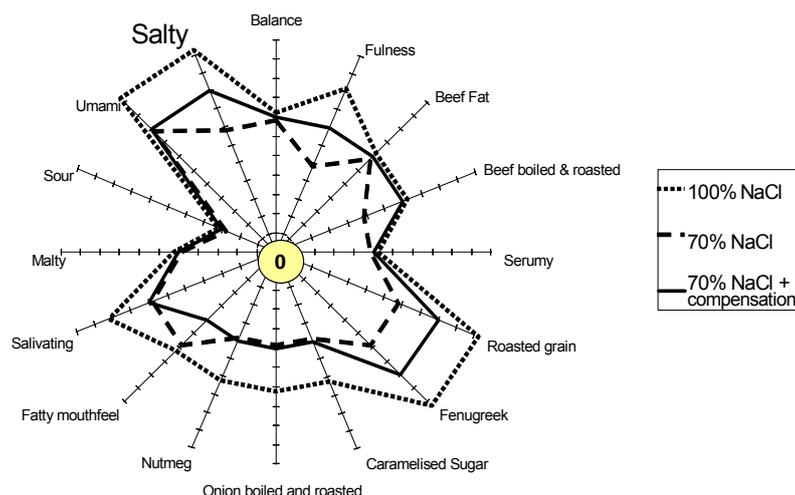
## Experimental

All aroma chemicals were from Aldrich, food-grade KCl and NH<sub>4</sub>Cl were from Merck and Riedel-de Haan respectively. Regular dry bouillon ingredients were from Unilever-Germany. Bouillons were prepared in advance and served at ~60°C in a 50ml medicinal cup.

The naïve panel (or 'untrained panel') was composed of ~12 untrained subjects. All panelists were tested on taste sensitivity, mainly focused on salt. Taste sessions took place in a sensory room with individual booths. The sessions were held once every two weeks in order to limit exposure and avoid training. Samples were served at 60 °C, and attributes were scored on a 12-points scale using bouillons of two different salt levels as references. To reduce the dumping effect (a salt enhancement effect only due to the response bias), it was decided to score on two attributes: the "salt intensity" and the "overall flavour intensity". Only salt intensity data are shown.

The trained (descriptive) panel was composed of 10-12 external people and was selected and trained to characterise savoury products in terms of perceived attributes and intensities. The used Spectrum training procedure is an extension of the QDA descriptive analysis technique (standardised lexicon of terms, all scales standardised on the same basis and anchored with multiple reference points). Assessors scored the products in booths in a comparative way, per attribute instead of per product to increase sensitivity.

In the consumer study (with up to 60 subjects) individuals were subjected to either a 2-AFC test, simply answering the question 'which of the two samples is most salty', or a 'multi-attribute-scale' test. The latter paired-comparison test avoids dumping effect by using a 2-step approach and open questions rather than forced choice. First it was asked if any difference is tasted, and if the answer was yes, individuals were asked in step 2 whether a difference was tasted on 6 attributes (bitter, sweet, salt, sour, aroma, and thickness) and if so, which sample was most intense on the attribute in question.



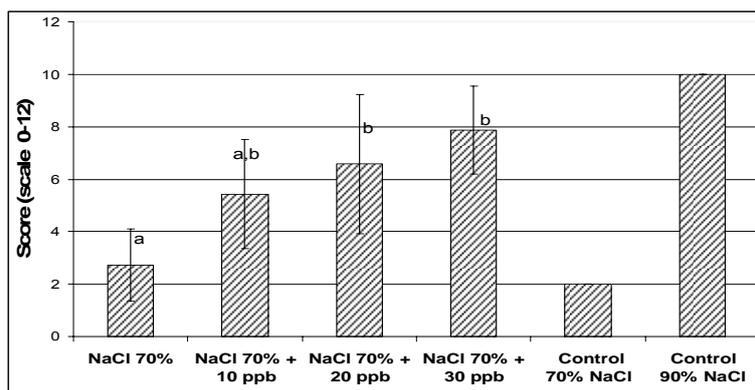
**Figure 1.** Sensory effect of salt reduction in beef bouillon, and subsequent compensation by extra aroma.

## Results

Figure 1 clearly shows the flavour enhancing effect of sodium chloride in beef bouillon in a descriptive panel. Upon reduction of the sodium level with 30% not only the perceived saltiness is reduced, but in fact the rating on most other attributes is lowered as well, also on those primarily related to aroma, like ‘beef’, ‘fenugreek’, etc. Reduction of salt apparently leads to a bland, tasteless product. It is shown that the flavour profile could indeed be partially restored by addition of extra flavouring. For most of the attributes, about half of the flavour loss is compensated. Most remarkably this also holds for attribute ‘salty’. This effect was solely due to the aroma, since we made sure that the salt added via the flavouring was compensated.

Higher levels of aroma did not add to the compensation, and instead led to unbalance in the flavour profile. Combining the extra flavour with a mixture of potassium- and ammonium chloride, however, a close match of the original flavour profile could be obtained. Compensation on the basis of solely these minerals at higher levels led to improved saltiness, but also to a bitter off-note not perceived in the combination with flavour. Similar results were obtained with chicken bouillon and various types of dry soups (data not shown). Generalizing it can be stated that about 15% sodium reduction can be compensated by extra aroma without significant change of the flavour profile, and 30% in combination with KCl-based salt replacers (not shown).

For further unraveling of the effect of these cross-modal interactions in terms of key enhancing compounds, we have made use of three categories of subjects: untrained panellists, trained panellists and naïve consumers. A commercial chicken bouillon was used for these studies. Using the naïve panellists we found that several ‘congruent’ single compounds significantly enhanced salt perception. ‘Seasoning’ or ‘brothy’ compounds, esp. sotolon (4,5-dimethyl-3-hydroxy-2(5H)-furanone), had the largest impact (Figure 2). Significant salt enhancement was also found for several sulphur-containing ‘meaty’ and ‘roasted’ components. The trained panel did not demonstrate a statistically significant effect on saltiness, in line with its analytical way of tasting and due to its training, which leads to unlearning of the associations on which multi-sensory interactions are based (10).



**Figure 2.** Saltiness enhancement in 30% salt-reduced bouillon by increasing doses (10, 20, and 30 ppb) of sotolon, assessed by the untrained panel. The letters refer to significance of differences ( $p < 0.05$ ).

When tested with naive consumers (data not shown) the effect of single aroma compounds could only be noticed when subjects were focused on saltiness perception by means of a 2-AFC forced comparison test. This approach bears the risk that any difference, e.g. in flavour intensity, is dumped on the single attribute 'saltiness', and cannot be used as conclusive evidence for saltiness enhancement. For a complex flavouring, in contrast, saltiness enhancement could be demonstrated in a convincing way using open questions, hence not biased by a 'dumping' effect. The difference in perceived saltiness here was clearly significant.

The data provided show that indeed aroma-taste multi-sensory interaction can be employed to compensate salt reductions. Further analysis showed that several classes of potentially congruent aroma compounds, giving 'brothy', 'meaty' and 'roasted notes', contribute to the salt enhancement effect. In line with earlier studies of multi-sensory interactions the set-up of the sensory experiments (trained vs. naïve panel, forced choice vs. open questions) determines to a large extent the results. Trained descriptive panels, due to their analytical way of tasting, are not very suitable instruments to assess multimodal interaction, but can be used to check for undesired changes in the flavour pattern.

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