Sensitivity of Assessors to Ferrous Salts

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Abstract: Taste is the chemical sensation whose function is not very well known. Recently it was shown that the range of taste is more extensive than the five basic taste sweet, salty, bitter, sour and umami. A metallic taste has been suggested as another basic taste, but its mode of perception is not well understood and has not been really accepted in the taste literature. Ferrous sulphate solutions were presented to the assessors so their sensitivity and best estimate thresholds (BET) were measured. The best estimated threshold range was 0.00049–0.00669 g/l for demineralised water, 0.00079–0.00669 g/l for distilled water and 0.00108–0.00669 g/l for tap water.

Keywords*:* sensory analysis; ferrous sulphate solutions; sensitivity; detection thresholds

INTRODUCTION

Food fortification has become an important tool to treat or prevent specific nutritional deficiencies. The Regulation (EU) No. 1925/2006 which harmonises national laws and regulates the fortification of food within the EC came into effect on July 1, 2007. The directive permits the use of those vitamins and minerals which occur naturally in food and are consumed as nutrients for food fortification purposes: it also refers, among others things, to the purity criteria of food additives, their maximum concentrations and the limitations of their use. The directive covers more than 80 different chemical compounds and 9 compounds which contain Fe ions such as ferric ammonium, ferric pyrophosphate citrate, ferric saccharate, ferric sodium pyrophosphate, ferrous citrate, ferrous fumarate, ferrous gluconate, ferrous lactate, and ferrous sulphate. Iron salts are used for fortification because iron is needed for many reactions which occur in the body and it is part of the haemoglobin molecule. Lack of iron in the diet eventually results in the iron deficiency anaemia. Iron is the most difficult mineral to add to foods and to ensure adequate absorption. The main problem is that the water-soluble iron compounds, which are the most bio available, often lead to the development of unacceptable colour and flavour changes in the food (Hurrell 2002). Because consumer acceptance of a food is strongly determined by its sensory characteristics, such as flavour (taste and aroma) it is necessary to study the sensitivity of people to substances that are used for fortification. For every substance the detection threshold which is the minimum amount of stimulus energy necessary to elicit a sensory response is measured. The threshold is not a constant for a given substance but rather a constantly changing point on the sensory continuum from non perceptible to easily perceptible. Thresholds change with moods, the time of the biorhythm and with hunger and satiety. Classically, in sensory research, the best estimate threshold (BET) is used for studying perception value. The detection thresholds of individual subjects are very different in various studies. The nature of metallic sensations from iron compounds was widely studied by scientists from Cornell University (Lawless *et al.* 2004; Yang & Lawless 2006). Some people can be very sensitive in discriminating ferrous sulphate solutions and other ferrous salts in very low concentrations. The differences among people can range from three orders depending on the salts. The International Standard ISO 3972:1991 describes the concentrations for testing metallic taste. Iron (II) sulphate heptahydrate is recommended as a standard for metallic tastes in the range of 0.0007–0.008 g/l concentrations. The Laboratory of Sensory Analysis uses this standard for testing people from different companies. Assessors usually have difficulties in correctly identifying metallic taste. The aim of the study was to pay more attention to the assessors' sensitivity to metallic taste in order to choose the concentrations that are the most suitable for further studies.

MATERIALS AND METHODS

Materials. Eight solutions of ferrous sulphate $FeSO_4 \cdot 7H_2O$ (concentration 0.0007, 0.0009, 0.0013, 0.0019, 0.0027, 0.0039, 0.0059, 0.008 g/l) and one solution of ferrous chloride $FeCl_2$ – 0.04 g/l were prepared in tap, distilled and demineralised water before each experiment. Concentrations were chosen on the basis of ISO standard (ISO 3972 1991) and our previous experiments.

Sensory analyses. The sensory properties of the metal samples were determined by two panels. A ten-member permanent trained panel (ISO 8586-1:1993) and an untrained student panel age 20–22. All testing was carried out at the Institute of Chemical Technology in Prague in the standard sensory laboratory provided with 10 testing booth (ISO 8589:2007). Test solutions were presented in a random sequence or as a triangle test to the assessors with 30 ml samples in 50 ml plastic cups at room temperature 20°C. They were coded with four-digit random codes. The panellists were given water and white rolls to cleanse their palates between each sample.

Procedure. Free describing method, ranking test and triangle test. Ascending forced-choice procedures were used to measure the detection threshold.

RESULTS AND DISCUSSION

Description of taste

The taste sub-qualities of ferrous sulphate $FeSO_4$ solutions describing by panellists are given in Table 1. Oral sensations from iron salts were complex and changed with the concentration and with the time, this confirmed the findings of previous studies. In the beginning the assessors described the taste of $FeSO_4$ as sweet and bitter and later they noticed also metallic and astringency taste.

Men and women's descriptions of taste and pleasantness of $FeCl_2$ in concentration 0.04 g/l differed. The men used the words such as sweeter water, bitter, metallic taste and after one minute unpleasant bitter taste. The women used words like strong metallic taste, unpleasant bitter taste, rusty and slightly sweet.

Ranking test

A ranking test was used to determine whether panellists could rank different ferrous sulphur samples (concentrations 0.0007, 0.0009, 0.0013, 0.0019, 0.0027, 0.0039, 0.0059, 0.008 g/l demineralised water) in the correct order. None of seven trained panellists could rank the samples in the correct order, therefore for untrained panellists the range was divided into two parts and two groups of panellists ranked three different samples. The first group, with 47 panellists ranked the sample with 0.0000, 0.0019 (middle of concentration range) and 0.0080 g/l (the end of concentration range). The second group with 40 panellists ranked the concentrations 0.0000, 0.0009, 0.0039 g/l (concentration from the first half of range).

Table 1. Taste descriptions for ferrous sulphate

Concentration (g/l)	Taste descriptions for ferrous sulphate $FeSO_4 \cdot 7H_2O$
0.0000	distilled water, bitter, slightly metallic
0.0080	slightly sweet, metallic, slightly burnt, slightly metallic
0.0142	bitter, burnt, sweet, average metallic
0.0356	very sweet, mixture of sweet and bitter, unpleasant metallic taste
0.0890	strong metallic, sweet but more as a sweeteners than taste of sucrose, strong metallic
0.2224	sweet, astringency, metallic

Table 2. Best estimated thresholds of ferrous salts in different water

Water	Range of BET (g/l)	Average (g/l)	Geometric average (g/l)
Demineralised	0.00049–0.00669	0.00266	0.00210
Tap	0.00108–0.00669	0.00496	0.00428
Distilled	0.00079–0.00669	0.00345	0.00254

From the first group 3 men (33%) and 24 women (64%) ranked the samples in the correct order. From the second group 3 men (43%) and 20 women (61%) ranked the samples in the correct order. The results obtained from Friedman test showed that assessors could distinguish differences between concentrations (0.0000, 0.0019, 0.0080 g/l), but the lowest concentration rank were not significantly distinguished by men.

Determination of best estimate threshold (BET)

The best estimate threshold (BET) concentrations for the individual panellists were calculated as the geometric means of the highest undetected concentration and the lowest detectable concentration. The group best estimated threshold was calculated as the geometric mean of the individual thresholds of 10 trained panellists. Table 2 shows the results for concentrations in demineralised, tap and distilled water.

Triangle test

The triangle test is a procedure for determining whether a perceptible sensory difference exists between samples. Assessors received a set of three samples (a triad) and two of the samples were alike. The test was done for all concentrations in tap water 0.0007, 0.0009, 0.0013, 0.0019, 0.0027, 0.0039, 0.0059, 0.008 g/l and assessor compared every concentration with water. The assessors were not able to identify odd samples for lower concentrations. Only eleven out of 21 panellists correctly identified odd samples for the concentration 0.0056 g/l and ten out of 20 panellists for the concentration 0.0080 g/l. The critical value at level of $P < 0.05$ is 12 out of 21 respective 11 out of 20 panellists correctly identifying the odd sample.

CONCLUSIONS

The quality of metallic taste was described very differently by each assessor. The assessors usually used the words sweet, bitter, no defined unpleasant or metallic. The description of taste for two different ferrous salts (the difference being in the size of anion, chloride small and sulphate of intermediate size) was also different. Generally the assessors are not very familiar with metallic taste and its perception and its description is not as easy as perception of others basic tastes. There was a wide range of sensitivity among panellists. Some authors published, that sensitivities for $FeSO_4$ in water ranged from 2.26–9.56 mg/l, with a group mean threshold that was 7.90 mg/l. Others found all individual and group detection thresholds to exceed 8.00 mg/l (Lim & Lawless 2006). We can confirm that the suggested ISO range of 1.3–8.0 mg/l is very low and only very sensitive assessors could recognised them. Great role played also used water, panellists were more sensitive to solutions in demineralised water then in distilled and less sensitive to solutions in tap water. The information should be useful for further testing using ferrous salts in the fortification of food. However more work is needed to determine the differences between the sensitivity of people to ferrous substances and the role of using water for experiments.

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