Influence of hotness and acidity of food on sweet taste perception

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Abstract

The sweet taste plays an important role in overall liking and enjoyment of food. The present study aimed to investigate the impact of spice addition on consumers‘ colour perception, smell and sweetness. The gradually sweetened rice (1 %, 3 % and 5 % of sugar added), as the main ingredient was supplemented with hot pepper, chilli pepper and wasabi paste. The experimentally formed samples were sensory analysed by the panellists. The colour was the most affected sensory property, with more expressive differences in samples containing both pepper spices than the wasabi. The highest colour intensity change was recorded in a sample group containing 1 % added sugar and spiced with hot pepper (control sample: 0.18; spice concentration of 0.8 %: 6.84). Addition of vinegar had a noticeable effect on smell and sweetness of samples in which it was added. In the samples with no vinegar added, wasabi contained samples had notably the highest impact on smell and sweetness of the samples. Consumers' perceptions of smell changed from 1.86 for control to 6.87 for 2.5 % wasabi paste concentration; the sweetness increased from 3.56 for control to 6.04 for the same wasabi concentration. When taking into consideration the impact in all sample groups, wasabi induced the smallest change in comparison to the controls. The observation was confirmed by the Principal Component Analysis. It can be concluded that added spices could enhance specified sensory properties and thus possibly reduce the need for using the sweeteners as a means of making the product more desirable among the consumers.

hot pepper, chilli pepper, wasabi, rice, vinegar

Introduction

Food preference, food intake and eating habits are heavily influenced by its taste, and by human perception, taste plays a significant role contributing to its overall pleasure and enjoyment (Leturque et al., 2012, Liauchonak et al., 2019). In recent years, initial studies underlying sweet taste perception and the brain processes, have been established (Fernstrom et al., 2012). Thus, much of the work regarding the intake of carbohydrates was focused on simple sugars and sweet taste which is marked as the initiator of the food intake and can be activated by sweet taste substances including sugars and non-nutritive sweeteners (Ma et al., 2017). The science behind the carbohydrate cravings is not yet fully understood. However, it is known that carbohydrates are an essential part of a healthy diet and provide many important nutrients found in foods and beverages. Carbohydrates represent a fast and efficient source of energy that is used for the proper functioning of the brain and central nervous system (Adair, 2007). However, high carbohydrate intake causes an excess of energy that is stored as fat in the body causing obesity. Naturally, fruits, vegetables, milk, nuts, grains, legumes and seeds contain carbohydrates. Beside those naturally occurring carbs, food manufacturers also add carbohydrates to processed foods in the form of starch, sugar or non-nutritive sweeteners. (Drewnowski et al., 2012). Trends are going toward the addition of sugars to every kind of food to raise acceptance among the consumers and without taking care of essential nutrients. In parallel with these trends, obesity rates among children, adolescents and adults are increasing (Drewnowski, 2007). At this point, non-caloric sweeteners such as aspartame, acesulfame potassium, sucralose, thaumatin or saccharin seemed to be one of the solutions for decreasing calorie

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consumption. Non-caloric sweeteners offer an option for controlling obesity, caries and overall consumption of sugar (Wintjens, 2011). The problems which may occur are allergies or intolerance, even when very small amounts of those artificial sweeteners are consumed (Shankar et al., 2013).

Some of the positive effects of spices in the food are appetite stimulation suppression, increase of energy spending, antioxidant and antimicrobial activity and many others (Ludy et al. 2012). Due to its unique hot taste, pungent smell and bright green colour, wasabi has found widespread appeal in western cuisine (Sultana et al., 2002). The antibacterial property along with its natural green colour, specific flavour and advantage of safeguarding food at the ingestion point makes wasabi a promising natural edible antibacterial plant (Lu et al., 2016). Hot and chilli pepper are spices rich in bioactive compounds with the capsaicin as the most known representative. Their strong antioxidant activity was reported, same as high polyphenolic content (Hervert-Hernández et al., 2010, Caporaso et al., 2013).

It was proved that the addition of spices to the reduced sugar food increases the liking and the food's overall flavour profile may have been enhanced by spices. When combined with the effectiveness of culinary herbs and spices to minimize fat and salt, even a small impact of spices on sugar intake could help promote healthy eating (Peters et al., 2018).

This study aimed to analyze the effect of spices and vinegar addition into cooked rice and to observe the perception of colour change, smell and sweetness among the panellists.

Material and methods

Rice with added different concentrations of sugar, vinegar and spices was used for sensory evaluation by the panellists. Long-grain rice (Tesco) was used as the main ingredient for making the trial samples. The rice was prepared in the rice cooker, (model Sencor SRM 0600 WH) with the addition of water to obtain rice/water ratio 1:2. The sugar was added in concentrations of 1, 3 and 5 % according to cooked rice, and vinegar (produced by ST. Nicolaus - trade CZ) was added (40 mL to 500g of cooked rice) to the samples containing 1 and 5 % of sugar. Samples were divided into batches of 50g and added spices and labelled according to Table 1. The spices which were used were chilli pepper powder (Albert basic), hot pepper powder (Albert basic) and wasabi paste (SHIN). Sample which contained no spices was used as the control.

Table 1. Sample labels and spices addition to the cooked rice samples

Sample label	Chilli pepper powder	Sample label	Hot pepper powder	Sample label	Wasabi
C102	0.2 % = 0.1g	P102	0.2 % = 0.1 g	W105	0.5 % = 0.25 g
C205	0.5 % = 0.25 g	P205	0.5 % = 0.25 g	W215	1.5 % = 0.75 g
C308	0.8 % = 0.4 g	P308	0.8 % = 0.4	W325	2.5 % = 1.25 g

The panellists evaluated the intensity of colour, smell and sweetness. The intensity of parameters was recorded according to the scale (10 cm; 0 - 10), where 0 meant no intensity and 10 meant high intensity in comparison to the control sample.

Statistics

The obtained results were compared using One-Way ANOVA test in the IBM SPSS Statistics computer program, to check if there was a statistically significant difference between the values ($p < 0.05$). Principal component analysis (PCA) was used to check overall differences among the samples and differences by each sensory parameter.

Results and Discussion

The results of sensory evaluation of samples with addition of hot pepper, chilli pepper and wasabi in different concentrations are presented in Tables 2., 3. and 4.

Table 2. Sensory evaluation of sample colour containing different concentration of sugar

Samples	Color of samples with added 1 % of sugar	Color of samples with added 3 % of sugar	Color of samples with added 5 % of sugar
P102	3.18 ± 1.78^{b}	4.50 ± 1.62^{b}	5.49 ± 1.91^{b}
P205	5.20 ± 2.27^{bc}	6.36 ± 1.80^{c}	6.13 ± 1.54^{b}
P308	6.84 ± 2.79^{c}	8.91 ± 1.08^{d}	6.86 ± 1.62^{b}
W105	1.09 ± 1.37	0.69 ± 1.37^{b}	1.03 ± 0.84
W215	1.63 ± 2.11	1.00 ± 1.58^{bc}	1.67 ± 1.36
W325	2.31 ± 2.65	2.04 ± 2.10^{c}	2.79 ± 2.08
C102	2.73 ± 1.49^{b}	2.50 ± 1.92^{b}	4.78 ± 1.43^{b}
C205	4.71 ± 2.28^{bc}	4.36 ± 2.11^{bc}	5.65 ± 1.63^{b}
C308	6.43 ± 2.91^{c}	5.77 ± 2.55^{c}	6.42 ± 1.63^{b}
Control	0.18 ± 0.22	2.23 ± 1.27	2.13 ± 1.86

*different letters (a. b. c) show statistically significant difference ($p < 0.05$)

According to the colour evaluation results, hot pepper and chilli pepper influenced the colour change in all samples (Table 2). The carotenoids, which are abundant in those spices, are most probably responsible for this effect (Arimboor et al., 2015). The greater amount of added spices resulted in higher colour intensity. Though, the addition of wasabi affected the colour statistically significantly ($p < 0.05$) in the sample group with no added vinegar. Vinegar in mixture with spices can affect the colour by partially eliminating the spice dye and thus lowering its intensity (Montoya-Ballesteros et al., 2014).

Table 3. Sensory evaluation of sample smell containing different concentration of sugar

Samples	Smell of samples with added 1 % of sugar	Smell of samples with added 3 % of sugar	Smell of samples with added 5 % of sugar
P102	2.71 ± 1.53	2.31 ± 1.84a	3.36 ± 1.79
P205	3.56 ± 2.08	3.73 ± 2.16b	3.74 ± 1.58
P308	4.26 ± 2.58	5.35 ± 2.72b	4.19 ± 1.82
W105	3.81 ± 1.73	3.56 ± 2.42a	3.89 ± 1.71
W215	4.83 ± 1.88b	5.24 ± 2.37b	5.05 ± 1.70
W325	5.59 ± 2.23c	6.87 ± 2.86b	5.51 ± 2.04
C102	3.33 ± 2.48	2.02 ± 1.98a	4.02 ± 1.60
C205	3.85 ± 1.99	3.17 ± 2.15	4.20 ± 1.64
C308	4.54 ± 2.24	4.21 ± 2.21b	4.25 ± 1.67
Control	2.23 ± 1.27	1.86 ± 1.07a	4.44 ± 2.66

*different letters (a. b. c) show statistically significant difference ($p < 0.05$)

The evaluation of rice smell in samples with added 1 % of sugar, showed that smell was statistically significantly ($p < 0.05$) influenced by the addition of wasabi in concentrations of 1.5 and 2.5 % (Table 3.). The possible reason can be the strong and penetrating aroma of horseradish contained in wasabi paste (Jelen and Gracka, 2016). The higher concentration of Wasabi added had a bigger effect on the rice sample smell. There was a slight effect of hot and chilli peppers on smell in highest concentrations, but no statistically significant ($p < 0.05$) difference was obtained. The smell of samples contained no vinegar was much more affected than the other two groups that can be attributed to the vinegar masking smell effect. No significant ($p < 0.05$) difference for the smell was obtained among the samples in the group with the highest sugar concentration.

Table 4. Sensory evaluation of sample sweetness containing different concentration of sugar

Samples	Sweetness of samples with added 1 % of sugar	Sweetness of samples with added 3 % of sugar	Sweetness of samples with added 5 % of sugar
P102	2.84 ± 1.84	2.61 ± 2.21a	3.44 ± 1.66
P205	2.41 ± 1.93	3.57 ± 2.55	3.40 ± 2.09
P308	2.81 ± 2.27	5.06 ± 2.67	3.05 ± 2.07
W105	2.19 ± 1.16	4.38 ± 2.24b	4.05 ± 2.34
W215	2.39 ± 1.12	5.54 ± 2.08	4.22 ± 2.72
W325	2.78 ± 1.41	6.04 ± 2.81b	4.32 ± 2.74
C102	2.21 ± 1.48	2.51 ± 2.29	3.78 ± 2.03
C205	2.06 ± 1.32	3.28 ± 1.74	3.15 ± 1.79
C308	1.94 ± 1.39	3.56 ± 1.84	2.90 ± 1.88
Control	2.13 ± 1.86	3.56 ± 2.11a	2.54 ± 2.17

*different letters (a. b. c) show statistically significant difference ($p < 0.05$)

The perception of sweet taste (Table 4.) was statistically significantly ($p < 0.05$) influenced by wasabi paste in samples with no vinegar added. The wasabi that was added in the form of a paste, contained sweetener sorbitol that could influence the evaluation. Unlike paprika (chilli and hot pepper) that on average contains approximately 5 g of sugar in 100 g (USDA, 2019), wasabi paste used in the experiment had 10.5 g of sugar in 100 g (wasabi paste product specification; wasabi paste from producer SHIN), which is more than twice than pepper itself, and wasabi was added in higher concentrations. This can be the explanation of why wasabi paste addition influenced the perception of rice sweetness in this sample group. In samples containing vinegar, lack of statistically significant differences might not only be related to the addition of spices, but also to the fact that bitterness (from vinegar) and sweetness (from added sugar) suppress each other in mixtures (Lesschaeve & Noble, 2005).

Principal component analysis (PCA)

The obtained results for all three parameters colour, smell and sweetness together (Fig. 1.) and the results of each separate parameter (Fig. 2., 3. and 4.) were compared using the principal component analysis (PCA). Overall PCA shows the formation of two groups (100 % of variance): i) the control and wasabi spiced samples; ii) the samples with different percentages of chilli and hot pepper. The results are indicating that the wasabi samples do not differ much from the control samples concerning the sensory perception among the panellists. Chilli and hot pepper are similar spices and thus they influenced the panellists analogue to that.

The PCA for colour shows the smallest difference between control and wasabi sample in the 1 % sugar addition group (Fig. 2.). Another cluster is created from the same sample group with the addition of chilli and hot pepper. On the other hand, the biggest difference occurred between the control samples and all other samples in the group with 3 % of added sugar. This means that the addition of vinegar has an important role in masking the coloured substances.

The two main clusters have been created in PCA of obtained results for samples smell (Fig. 3). The one is created by samples containing sugar in the concentration of 5 % and the other one from the rest of the samples.

The PCA of sweetness parameter revealed that samples containing 1 % and 3 % of sugar cannot be grouped in two clusters since they are not defined ubiquitously. The samples belonging to the group prepared with 5 % sugar created a noticeable cluster (Fig. 4).

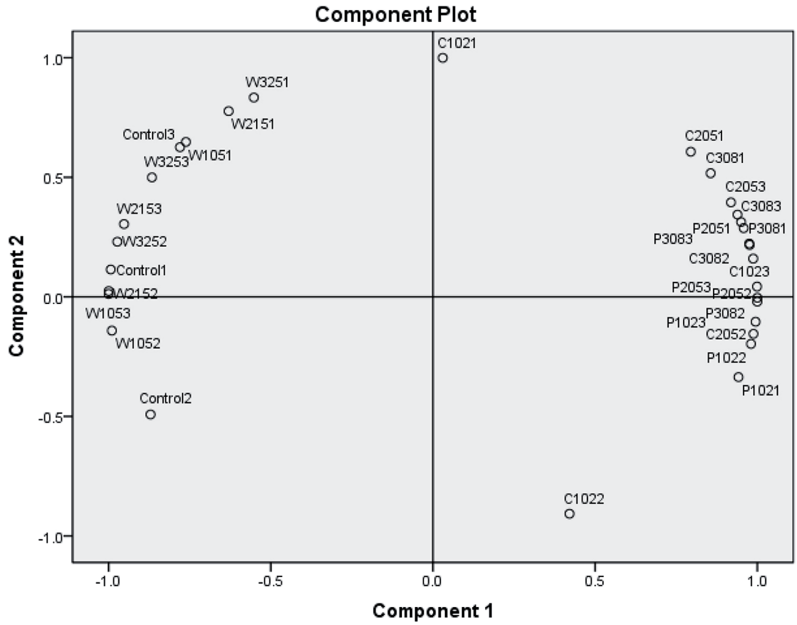

Fig. 1. Principal Component Analysis (PCA) of all evaluated sensory properties in the samples (labels ending with 1: samples with 1% of sugar added, labels ending with 2: samples with 3% of sugar added, labels ending with 3: samples with 5% of sugar added)

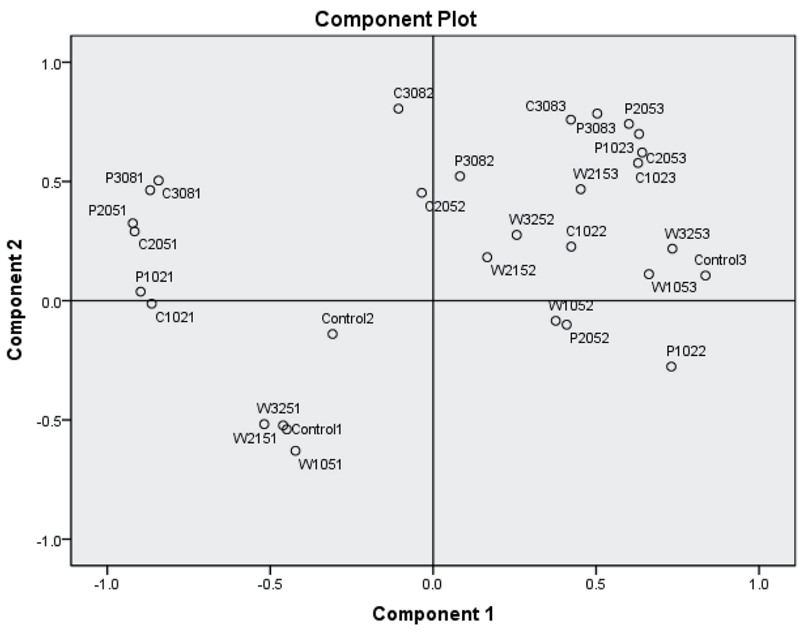

Fig. 2. Principal Component Analysis (PCA) of color sensory property in the samples (labels ending with 1: samples with 1% of sugar added, labels ending with 2: samples with 3% of sugar added, labels ending with 3: samples with 5% of sugar added)

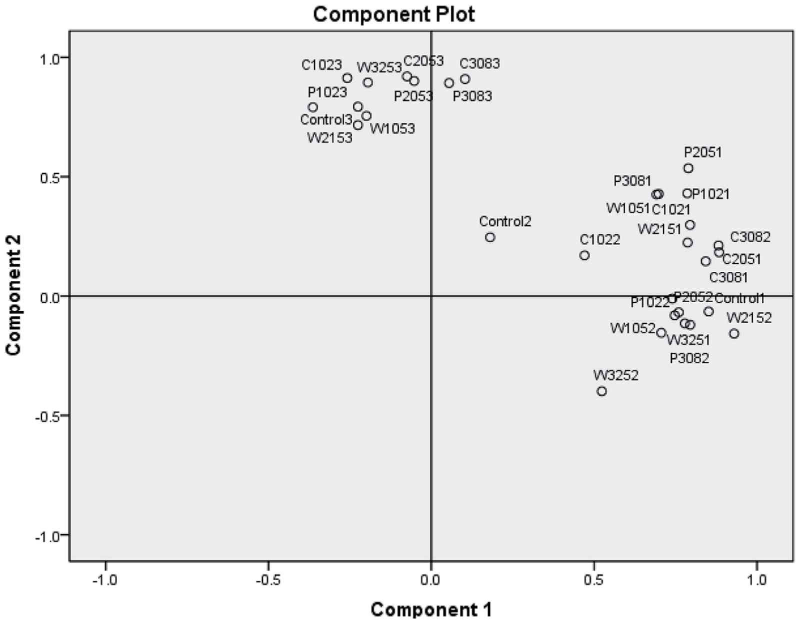

Fig. 3. Principal Component Analysis (PCA) of smell sensory property in the samples (labels ending with 1: samples with 1% of sugar added, labels ending with 2: samples with 3% of sugar added, labels ending with 3: samples with 5% of sugar added)

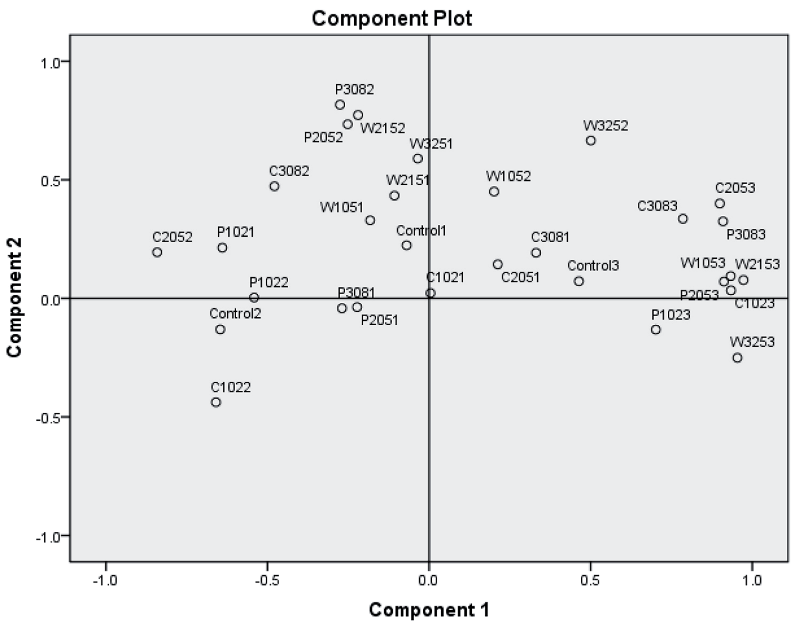

Fig. 4. Principal Component Analysis (PCA) of sweetness sensory property in the samples (labels ending with 1: samples with 1% of sugar added, labels ending with 2: samples with 3% of sugar added, labels ending with 3: samples with 5% of sugar added)

Conclusion

The results revealed information regarding the sensory properties of sweetened rice (with and without added vinegar) spiced with hot pepper, chilli pepper and wasabi paste. All spices affected colour in comparison to the control samples. Though, colour changes were less noticeable when spices were added to the samples with vinegar. The highest effect on samples sweetness had wasabi paste which originally contained artificial sweeteners and more sugar than the other two used spices. Overall PCA analysis indicated the lowest changes in samples containing wasabi paste in comparison to the control samples. The study emphasized the possibilities of spices addition for the purpose to decrease sugar and sweeteners addition. The conducted study can be recognized as the source of valuable information for further studies investigating sweet taste perception in the presence of different spices.

References

Adair, W. L., 2007: Carbohydrates. XPharm: The Comprehensive Pharmacology Reference, 1–12

Arimboor, R., Natarajan, R. B., Menon, K. R., Chandrasekhar, L. P. and Moorkoth, V., 2015: Red pepper (Capsicum annuum) carotenoids as a source of natural food colors: analysis and stability-a review. Journal of food science and technology, **52**, 1258–1271

Caporaso, N., Paduano, A., Nicoletti, G. and Sacchi, R., 2013: Capsaicinoids, antioxidant activity, and volatile compounds in olive oil flavored with dried chili pepper (Capsicum annuum). European Journal of Lipid Science and Technology, **115**, 1434-1442

Drewnowski A., 2007: The real contribution of added sugars and fats to obesity. Epidemiol Rev. **29**, 160–71

Drewnowski, A., Mennella, J. A., Johnson, S. L. and Bellisle, F., 2012: Sweetness and food preference. The Journal of nutrition, **142**, 1142S–8S

Fernstrom, J. D., Munger, S. D., Sclafani, A., de Araujo, I. E., Roberts, A. and Molinary, S., 2012: Mechanisms for sweetness. The Journal of nutrition, **142**, 1134S-1141S

FoodData Central. USDA website. Available at https://fdc.nal.usda.gov/fdc-app.html#/food-details/170497/nutrients. Accessed June 6.2020

Hervert-Hernández, D., Sáyago-Ayerdi, S. G. and GONi, I. S. A. B. E. L., 2010: Bioactive compounds of four hot pepper varieties (Capsicum annuum L.), antioxidant capacity, and intestinal bioaccessibility. Journal of Agricultural and Food Chemistry, **58**, 3399-3406

Jelen, H. and Gracka, A., 2016: Characterization of aroma compounds: Structure, physico-chemical and sensory properties. Flavour: From food to perception, 126-153

Lesschaeve, I. and Noble, A. C., 2005: Polyphenols: factors influencing their sensory properties and their effects on food and beverage preferences. The American journal of clinical nutrition, **81**, 330S-335S

Leturque, A., Brot-Laroche, E. and Le Gall, M. 2012: Carbohydrate Intake. Progress in Molecular Biology and Translational Science, **108**, 113–127

Liauchonak, I., Qorri, B., Dawoud, F., Riat, Y. and Szewczuk, M. R., 2019: Non-Nutritive Sweeteners and Their Implications on the Development of Metabolic Syndrome. Nutrients, **11**, 644

Lu, Z., Dockery, C. R., Crosby, M., Chavarria, K., Patterson, B. and Giedd, M., 2016: Antibacterial Activities of Wasabi against Escherichia coli O157:H7 and Staphylococcus aureus. Frontiers in microbiology, **7**, 1403

Ludy, M. J. and Mattes, R. D. 2012: Comparison of sensory, physiological, personality, and cultural attributes in regular spicy food users and non-users. Appetite, **58**, 19-27

Ma, Y., Ratnasabapathy, R. and Gardiner, J. 2017: Carbohydrate craving: not everything is sweet. Current opinion in clinical nutrition and metabolic care, **20**, 261–265

Montoya-Ballesteros, L. C., González-León, A., García-Alvarado, M. A. and Rodríguez-Jimenes, G. C., 2014: Bioactive compounds during drying of chili peppers. Drying Technology, **32**, 1486-1499

Peters, J. C., Marker, R., Pan, Z., Breen, J. A. and Hill, J. O. 2018: The Influence of Adding Spices to Reduced Sugar Foods on Overall Liking. Journal of Food Science, **83**, 814–821

Shankar, P., Ahuja, S. and Sriram, K., 2013: Non-nutritive sweeteners: Review and update. Nutrition, **29**, 1293–1299

Sultana T., Savage G. P., McNeil D. L., Porter N. G., Martin R. J., and Deo B., 2002: Effects of fertilisation on the allyl isothiocyanate profile of the above ground tissues in New Zealand grown wasabi. J. Sci. Food Agric., **82**, 1477–1482

Wintjens, R., Viet, T. M. V. N., Mbosso, E. and Huet, J., 2011: Hypothesis/review: The structural basis of sweetness perception of sweet-tasting plant proteins can be deduced from sequence analysis. Plant science, **181**, 347-354