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Combinations of vegetables can be more accepted than individual vegetables

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ABSTRACT

Enhancing sweetness of vegetables by addition of sucrose or sweeteners can increase acceptance but is not necessarily desirable. An alternative strategy could be to combine vegetables with other vegetables. By offering combinations of vegetables it might be possible to suppress bitterness, enhance sweetness and provide texture variety leading to increased acceptance. The aim of this study was to determine the influence of combining vegetables with other vegetables on sensory properties and acceptance. Carrot (sweet), cucumber (neutral), green bell pepper (bitter) and red bell pepper (sour) were assessed individually and in combination with the other three vegetables in two mixing ratios (1:2 and 2:1). Additionally, four combinations of three vegetables (mixing ratio 1:1:1) were assessed. A trained panel (n = 24) evaluated taste, flavour and texture and a consumer panel (n = 83) evaluated acceptance of all vegetables and combinations. Combining green bell pepper with carrot (1:2 and 2:1) increased sweetness and decreased bitterness. Combining cucumber, carrot or red bell pepper with green bell pepper (1:2) increased bitterness. Mainly sweetness and bitterness were associated with acceptance whereas texture (crunchiness, firmness and juiciness) did not strongly influence acceptance. Cucumber was the most accepted vegetable followed by carrot, red bell pepper and green bell pepper. Acceptance of vegetable combinations can differ from acceptance of individual vegetables depending on vegetable type and mixing ratio. Only 3 of 16 vegetable combinations had higher acceptance compared to the least accepted vegetable in the combination and similar acceptance as the more accepted vegetable in the combination. For 13 of 16 vegetable combinations acceptance did not increase compared to acceptance of individual vegetables. These findings suggest that strategies aimed at increasing vegetable consumption can be devised using specific combinations of vegetables.

1. Introduction

Taste, especially bitterness, can contribute to low acceptance and low consumption of vegetables. Vegetables contain phytochemicals which can be beneficial for health, however some can be bitter (Drewnowski & Gomez-Carneros, 2000). As humans generally do not like bitter taste (Beauchamp & Mennella, 2011; Birch, 1999), the food industry started to decrease bitterness of some vegetables by cultivation (Drewnowski & Gomez-Carneros, 2000; van Doorn, 1999), which might be accompanied by a decrease of phytochemical content. It has been suggested that there should be more focus on increasing phytochemical content of vegetables as this could be beneficial for health (Drewnowski & Gomez-Carneros, 2000; Sun-Waterhouse & Wadhwa, 2013). However, a higher phytochemical content can lead to higher bitterness (Breslin, 2013) and this might decrease consumer acceptance of vegetables (Dinehart, Hayes, Bartoshuk, Lanier, & Duffy, 2006; Donadini, Fumi, & Porretta, 2012; Duffy, Hayes, & Feeney, 2017).

While it is a challenge to develop healthy and highly palatable vegetables, considerable efforts have been made in recent years. There have been numerous studies evaluating the effect of taste modifications on acceptance of vegetables in adults and children. Enhancing taste of foods such as water, lemonade and gelatine gels by addition of sucrose or citric acid can increase acceptance (De Graaf & Zandstra, 1999; Liem & Mennella, 2003; Liem, Westerbeek, Wolterink, Kok, & de Graaf, 2004). Sucrose addition can reduce initial dislike of bitter grapefruit juice (Capaldi & Privitera, 2008). In vegetables, taste modifications can also increase acceptance. Bouhlal, Chabanet, Issanchou, and Nicklaus (2013) showed that adding sodium chloride to green beans can increase children's green beans intake. Van Stokkom et al. (2018a) and (2018b) showed that addition of sucrose to vegetables increased sweetness and

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consequently increased acceptance of a neutral tasting vegetable (cucumber) and a slightly bitter tasting vegetable (green bell pepper) in adults and children. Additionally, a recent study by Bakke et al. (2018) showed that adding sucrose (1 and 2%) increased acceptance of broccoli and kale purees, and addition of only 2% sucrose increased acceptance of spinach. However, even though sucrose addition can increase acceptance of vegetables, adding sucrose to vegetables is not desirable as the intake of sugars should be reduced (World Health Organization, 2015). Sharafi, Hayes, and Duffy (2013) showed that addition of sweeteners to vegetables can also suppress bitterness and increase acceptance. However, taste modifications by addition of sweeteners might also be not desirable as sweetness might be dissociated from energy and therefore alters taste response and possibly appetite (Drewnowski, Mennella, Johnson, & Bellisle, 2012).

An alternative strategy to modify taste properties of vegetables to enhance acceptance could be to combine different vegetables with each other. By offering combinations of vegetables it might be possible to suppress bitterness and enhance sweetness leading to higher acceptance of the vegetable combination compared to the individual vegetables. In addition to taste, texture influences acceptance of foods and vegetables (Nederkoorn, Theibetaen, Tummers, & Roefs, 2018). Zeinstra, Koelen, Kok, and de Graaf (2010) showed that children prefer crunchiness in vegetables, so combining a crunchy vegetable with a not crunchy vegetable might increase acceptance. De Moura (2007) suggested that even disliked vegetable might become acceptable when they are part of a tasty mixture. It is generally known that by combining foods that are not liked with foods that are liked, liking of the combination can be higher than liking of the less liked food in the combination and can be lower than liking of the more liked food in the combination. However, acceptance of food combinations cannot be predicted in detail *a priori* since acceptance is not simply additive, i.e. acceptance of food combinations is not necessarily the mean of the acceptances of its individual components (Bergamaschi et al., 2016). The challenge for combining vegetables to optimize acceptance is to obtain vegetable combinations that are equally accepted than the most liked vegetable in the combination although the combination contains substantial amounts (i.e. 33 or 50%) of less liked vegetable. In case the vegetable combination has lower acceptance than the individual more liked vegetable and higher acceptance than the individual less liked vegetable, from an acceptance perspective there is no added value in combining those vegetables. To the best of our knowledge, the influence of combining vegetables with other vegetables on sensory properties and acceptance has not been studied yet. The aim of this study was to determine the influence of combining vegetables with other vegetables on sensory properties and acceptance. We hypothesize that by adding sweet vegetables to bitter vegetables in vegetable combinations acceptance of the vegetable combination can be higher compared to acceptance of the individual bitter vegetable and similar to acceptance of the individual sweet vegetable.

2. Methods

2.1. Vegetables

Carrot (*Daucus carrotota)*, cucumber (*Cucumberumis sativus*), green bell pepper and red bell pepper (*Capsicum annuum)* were used. Vegetable selection was based on the following criteria: vegetables should be able to be consumed raw, vegetables should be commonly consumed in The Netherlands (Van Rossum, Fransen, Verkaik-Kloosterman, Buurma-Rethans, & Ocke, 2011) and vegetables should have different taste profiles. Van Stokkom et al. (2016) and Poelman, Delahunty, and de Graaf (2017) determined taste profiles of vegetables using the modified Spectrum Method. They demonstrated that carrot had a sweet taste profile (high sweetness and low intensities for other taste modalities), cucumber a fairly neutral taste profile (low intensities for all taste modalities), green bell pepper a bitter taste profile (high bitterness and low intensities for other taste modalities), and red bell pepper a slightly sour and sweet taste profile (moderate sweetness and sourness and low intensities for other taste modalities). Carrot (variety Evora, Spain) was obtained from a local retailer for the sensory evaluation, and from Bakker Barendrecht, Ridderkerk, The Netherlands for the hedonic evaluation. For cucumber, different varieties were used for the sensory and hedonic evaluation due to seasonal variation in availability. In consultation with the cultivator, another similar variety from the same cross-breeding program was selected. Cucumber (variety Proloog, The Netherlands for sensory evaluation, Variety Lausanna for hedonic evaluation), green bell pepper and red bell pepper (variety Keessie, The Netherlands) were obtained from Personal Vision, Bleiswijk, The Netherlands.

2.2. Vegetable preparation

Vegetables were stored for max. 48 h at 15 °C before preparation. Carrots were pealed, all other vegetables were not pealed. After rinsing the vegetables with water, they were cut into cubes of 5 × 5 × 5 mm (brunoise) and used within 4 h. After vegetables were cut, they were stored at 7 °C. One hour prior to consumption vegetable cubes were removed from the refrigerator and kept at room temperature.

Carrot, cucumber, green bell pepper and red bell pepper were assessed individually and in combinations with each other. Each vegetable was combined with any of the other three vegetables in two mixing ratios (1:2 and 2:1). All samples provided to subjects were composed of six vegetable cubes. The mixing ratio was based on number of cubes used. For example, the sample carrot-cucumber (2:1) contained four carrot cubes and two cucumber cubes. Additionally, all vegetables were offered in combinations of three vegetables in a mixing ratio of 1:1:1 corresponding to two cubes per vegetable. This resulted in 20 vegetables samples (Table 1).

Table 1

Overview of individual vegetables and vegetable combinations. All samples provided to subjects were composed of six vegetable cubes (5 × 5 × 5 mm each cube). The mixing ratio corresponds to number of cubes per vegetable.

No.	Ratio	Composition		
			Variety	
	Individual vegetables			
1	NA	Carrot	Evora (Spain)	
2	NA	Cucumber	Proloog/Lausanna (The Netherlands)	
3	NA	Green bell pepper	Keessie (The Netherlands)	
4	NA	Red bell pepper	Keessie (The Netherlands)	
	Combinations of two vegetables			
5	2:1	Carrot	Cucumber	
6	1:2	Carrot	Cucumber	
7	2:1	Carrot	Green bell pepper	
8	1:2	Carrot	Green bell pepper	
9	2:1	Carrot	Red bell pepper	
10	1:2	Carrot	Red bell pepper	
11	2:1	Cucumber	Green bell pepper	
12	1:2	Cucumber	Green bell pepper	
13	2:1	Cucumber	Red bell pepper	
14	1:2	Cucumber	Red bell pepper	
15	2:1	Green bell pepper	Red bell pepper	
16	1:2	Green bell pepper	Red bell pepper	
	Combinations of three vegetables			
17	1:1:1	Carrot	Cucumber	Green bell pepper
18	1:1:1	Carrot	Cucumber	Red bell pepper
19	1:1:1	Carrot	Green bell pepper	Red bell pepper
20	1:1:1	Cucumber	Green bell pepper	Red bell pepper

2.3. Sensory evaluation

Sensory test rooms of Wageningen University & Research, Business Unit Greenhouse Horticulture, Bleiswijk, The Netherlands, were used for sensory evaluation. Quantitative Descriptive Analysis (QDA) was carried out by a trained panel of 24 subjects (58.5 ± 10.2 yrs, 19 female, 6 male) experienced in the sensory evaluation of fruits and vegetables such as melon, tomatoes, bell pepper and beans. On average, panel members take part in 1–2 sessions per week of descriptive sensory profiling of fruits and vegetables. In addition to the descriptive analysis sessions, panel members follow about 15 sessions per year for product and attribute training. For the sensory evaluation of this study, panel members came to the test location twice. On each test day, ten samples (randomly divided over the two test days) were evaluated during one session of 45 min. Each panel member received the samples in a random order. Samples were offered in plastic cups of 25 ml. Each sample contained six vegetable cubes (5 × 5 × 5 mm each cube). Panel members were instructed to always put all six vegetable cubes on a spoon and assess sensory properties. A second sample was available for tasting, if needed. Twelve sensory attributes describing taste, flavour and texture of vegetables were assessed: firmness, crunchiness, juiciness, chewiness, sweetness, sourness, bitterness, umami, saltiness, flavour, astringent and filming. A 100-mm line scale anchored at the ends of the line with 'weak' and 'strong' was used. Attributes were selected based on experience of the panel leaders. Panel members were familiar with all attributes that were included from previous trainings and descriptive evaluations. Between each sample was a break of 20 s during which panel members neutralized their taste with water. After five samples, a break of 5 min followed. The following day, the panel members returned for the second session. Sessions took place between 10.00 am and 06.00 pm.

2.4. Hedonic evaluation

For the hedonic evaluation, naïve consumers were recruited at the University of Applied Sciences, Delft, The Netherlands. Participants were included when they were at least 18 years, not pregnant or breastfeeding and in good general health (self-reported). Participants were excluded when they had any allergies for vegetables. Participants had to come to the test location twice on separate days. Sessions took place between 12.00 am and 5.00 pm. Participants were asked not to eat or drink (except water) at least 30 min prior to the test. For each participant all 20 samples were randomly divided over two sessions of 20 min. Within both sessions, the order of samples was randomized. All samples were coded with three-digit randomized numbers. Participants were seated in individual booths. During the first session participants received general instructions and completed a questionnaire to obtain general participant information (e.g. age, gender, educational level) and to assess vegetable consumption frequency. In total, $n = 83$ subjects (26.5 ± 11.8 yrs, 45 female, 38 male) participated in the study. None of the subjects participating in the hedonic evaluation participated in the sensory evaluation. Most participants (72%) had at least an intermediate education level (high school). All target vegetables were consumed at least monthly by most participants (80%). Vegetable samples consisted of six cubes (5 × 5 × 5 mm each cube) and were offered simultaneously on a tray in non-transparent plastic containers covered with a lid. Participants were instructed to remove the lid of the sample they had to assess, and to taste all six cubes simultaneously using the spoon provided with each sample. Participants rated acceptance of the vegetables using a 9-point hedonic scale ranging from 'extremely like' to 'extremely dislike'. After each sample, a 20 s break followed during which participants were instructed to neutralize their palate with water.

2.5. Statistical data analyses

Statistical data analyses were performed using IBM statistics SPSS 24.0. A significance level of $p < 0.05$ was used. Sensory and hedonic data were analysed individually and together. For the sensory data, means and standard deviations for each attribute for each sample were calculated. To determine significant differences between samples, MANOVA was used. Four separate analyses of variance were conducted, for samples containing carrot, samples containing cucumber, samples containing green bell pepper and samples containing red bell pepper. This means that 10 samples were included per analysis, one individual vegetable and nine combinations containing that vegetable. Panel members were included in the model as random effect and sample as fixed effect. Tukey post-hoc test was used to further investigate significant differences between samples. Principle component analysis (PCA) was performed on the covariance matrix of the mean attribute scores using varimax rotation. Products were grouped based on cluster analysis.

For the hedonic data, four analyses of variance were conducted, one per individual vegetable and combinations containing that vegetables. This resulted in 10 samples per analysis of variance. Participants were included in the model as random effect and sample as fixed effect. Tukey post-hoc test was used to investigate significant differences in acceptance.

To link the sensory to the hedonic evaluation data, external preference mapping was used. Individual acceptance scores were related to sensory evaluation data by external preference mapping. The external preference map was created using a quadratic model with EyeOpenR® 4.9.6.

3. Results

3.1. Sensory evaluation

The mean intensity scores of all sensory attributes of all individual vegetable and the combinations containing that vegetable are presented in Appendices 1–4. In total, 20 vegetable samples were assessed by the panel (see Table 1). The tables in Appendices 1–4 compare mean intensity scores of all sensory attributes of each individual vegetables with all combinations containing the vegetables to allow for direct and convenient comparison of samples. This implies that sensory data of some samples is presented repetitively in different tables of Appendices 1–4.

Compared to carrot as individual vegetable (Appendix 1), sweetness was significantly lower in the combinations carrot-cucumber (1:2), carrot-green bell pepper (1:2), carrot-cucumber-green bell pepper (1:1:1) and carrot-green bell pepper-red bell pepper (1:1:1). Sourness was significantly higher in the combinations carrot-green bell pepper (1:2), carrot-red bell pepper (1:2) and carrot-green bell pepper-red bell pepper (1:1:1). Bitterness was significantly higher in the combinations carrot-green bell pepper (1:2) and carrot-red bell pepper (1:2). Juiciness was significantly higher in the combinations carrot-cucumber-red bell pepper (1:1:1) and carrot-green bell pepper-red bell pepper (1:1:1).

Compared to cucumber as individual vegetable (Appendix 2), firmness and crunchiness were significantly higher in the combination cucumber-carrot (1:2). Bitterness was significantly higher in the combinations cucumber-green bell pepper (1:2). Flavour was significantly higher in the combinations cucumber-green bell pepper (1:2), cucumber-red bell pepper (1:2) and cucumber-carrot-red bell pepper (1:1:1).

Compared to green bell pepper as individual vegetable (Appendix 3), firmness was significantly lower in the combination green bell pepper-cucumber (1:2). Crunchiness was significantly lower in the combinations green bell pepper-red bell pepper (1:2) and green bell

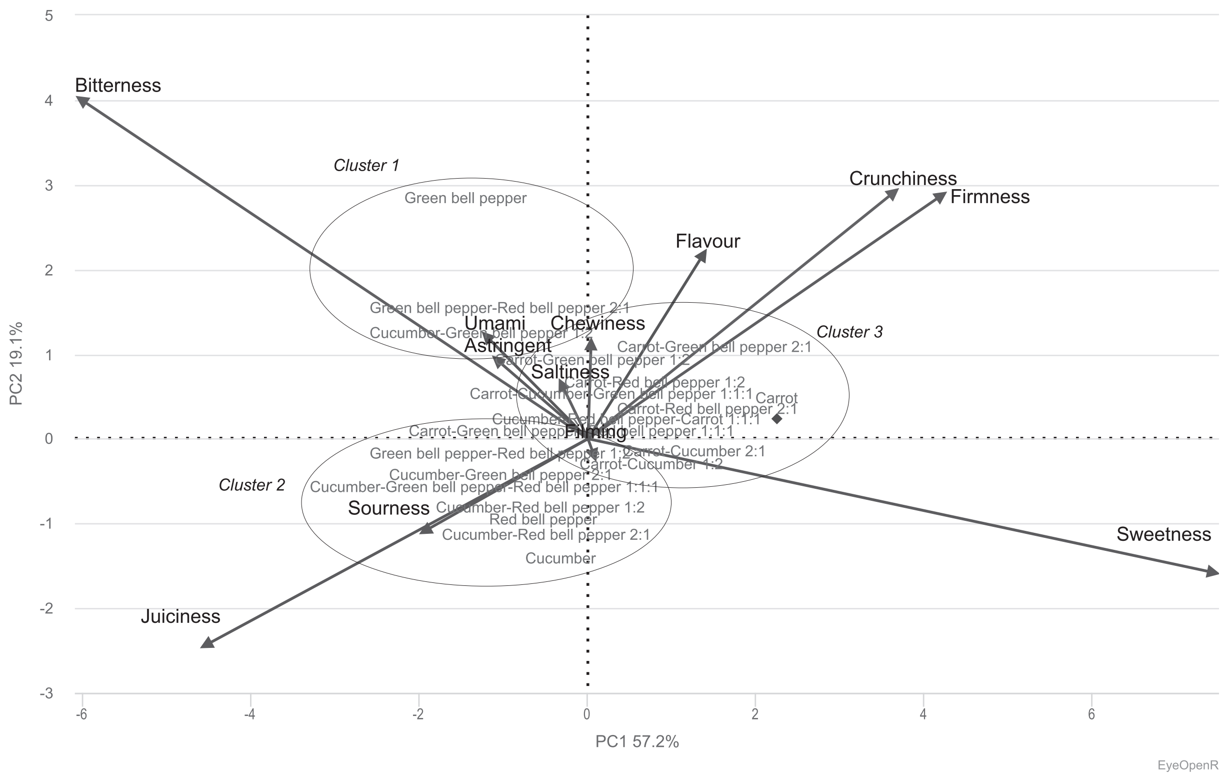

Fig. 1. Biplot representation of the PCA covariance matrix of sensory attributes obtained by Quantitative Descriptive Analysis (n = 24 trained subjects) of individual vegetables and all vegetable combinations together with visualization of three main clusters.

pepper-cucumber-red bell pepper (1:1:1). Juiciness was significantly lower in the combination green bell pepper-carrot (2:1) and sweetness was significantly higher in the combinations green bell pepper-carrot (1:2 and 2:1), green bell pepper-red bell pepper (1:2), green bell pepper-carrot-cucumber (1:1:1) and green-bell pepper-carrot-red bell pepper (1:1:1). Bitterness was significantly lower in the combinations green bell pepper-carrot (2:1 and 1:2), green bell pepper-cucumber (1:2), green bell pepper-carrot-cucumber (1:1:1) and green bell pepper-carrot-red bell pepper (1:1:1).

Compared to red bell pepper as individual vegetable (Appendix 4), crunchiness was significantly higher in the combination red bell pepper-carrot (1:2). Juiciness was significantly lower in the combinations red bell pepper-carrot (2:1 and 1:2), red bell pepper-green bell pepper (1:2) and red bell pepper-carrot-green bell pepper (1:1:1). Bitterness was significantly higher in the combination red bell pepper-green bell pepper (1:2).

3.2. Principle component analysis of QDA data

The biplot representation of the PCA and visualization of three vegetable clusters are shown in Fig. 1. The first component accounted for 57.2% of the variance and the second component for 19.1%, in total explaining 76.3% of the variance between samples. Vegetables were grouped into three clusters. Cluster 1 can be described as bitter and not sweet containing green bell pepper, cucumber-green bell pepper (1:2) and green bell pepper-red bell pepper (2:1) (15% of all samples). Cluster 2 can be described as sour, juicy, not firm and not crispy containing most samples with cucumber and red bell pepper (40% of all samples). Cluster 3 can be described as sweet, not bitter, not sour, firm, crunchy and not juicy and contained all samples with carrot (45% of all samples) except for carrot-green bell pepper-red bell pepper (1:1:1) which was the only sample with carrot belonging to cluster 2.

3.3. Hedonic evaluation

Appendices 1–4 summarize the mean acceptance of all vegetable samples. Cucumber and carrot were the most accepted individual vegetables, acceptance for red bell pepper was lower and acceptance for green pepper was the lowest of individual vegetables. The mean differences in acceptance between individual vegetables and all combinations containing the vegetable are presented in Fig. 2. When carrot was combined with green bell pepper (1:2 and 2:1), acceptance of the vegetable combination was significantly lower compared to carrot and not significantly different compared to green bell pepper. Acceptance of the combination carrot-green bell pepper-red bell pepper (1:1:1) was significantly lower compared to carrot, but not significantly different compared to green bell pepper and red bell pepper. Acceptance of the combination cucumber-green bell pepper (1:2) was significantly lower than acceptance of cucumber and not significantly different from acceptance of green bell pepper. Acceptance of the combination cucumber-green bell pepper-red bell pepper (1:1:1) was significantly lower compared to cucumber, significantly higher compared to green bell pepper and not significantly different to red bell pepper.

For 4 of 9 combinations containing green bell pepper, acceptance of the combinations was higher than acceptance of green bell pepper as individual vegetable. For only 3 of 16 vegetable combinations, acceptance of the combination was higher than acceptance of the individual, least accepted vegetable in the combination and not significantly different from acceptance of the individual, more accepted vegetables in the combination. For example, for the combination cucumber-green bell pepper (2:1), acceptance of the combination was not significantly different from acceptance of cucumber and significantly higher

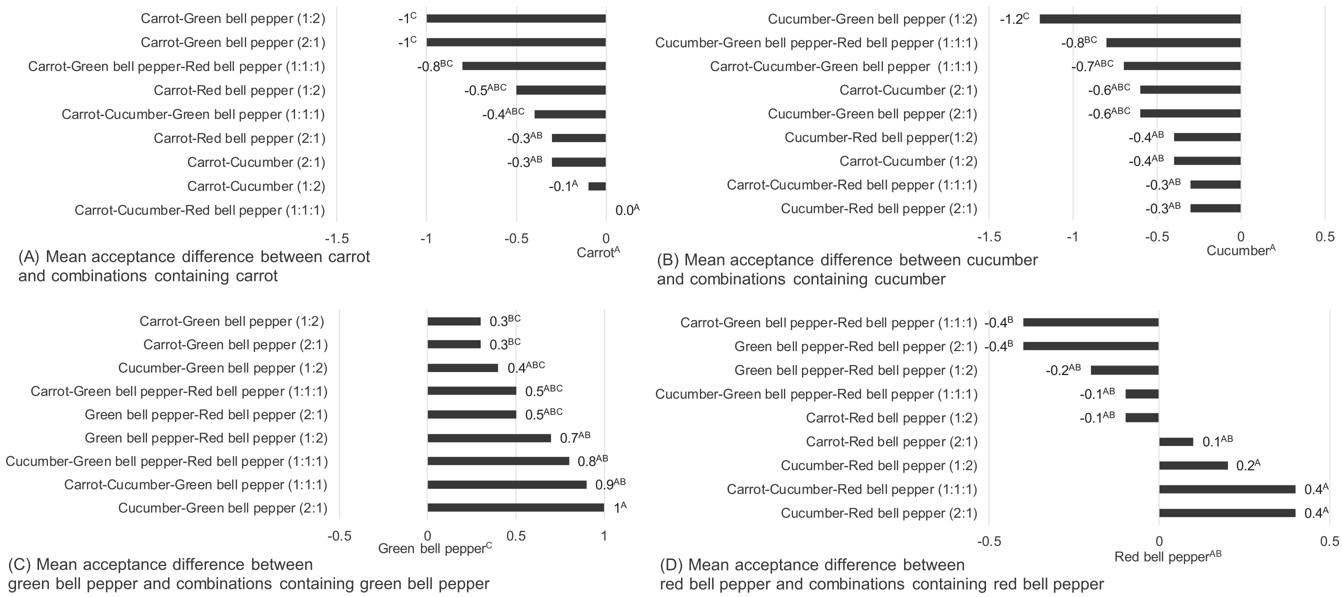

Fig. 2. Mean difference in acceptance between carrot (A), cucumber (B), green bell pepper (C), red bell pepper (D) and combinations (mixing ratio) containing those vegetables (9 combinations per vegetable, n = 83 naïve consumers). Letters A-C indicate significant differences in acceptance between samples (p < 0.05).

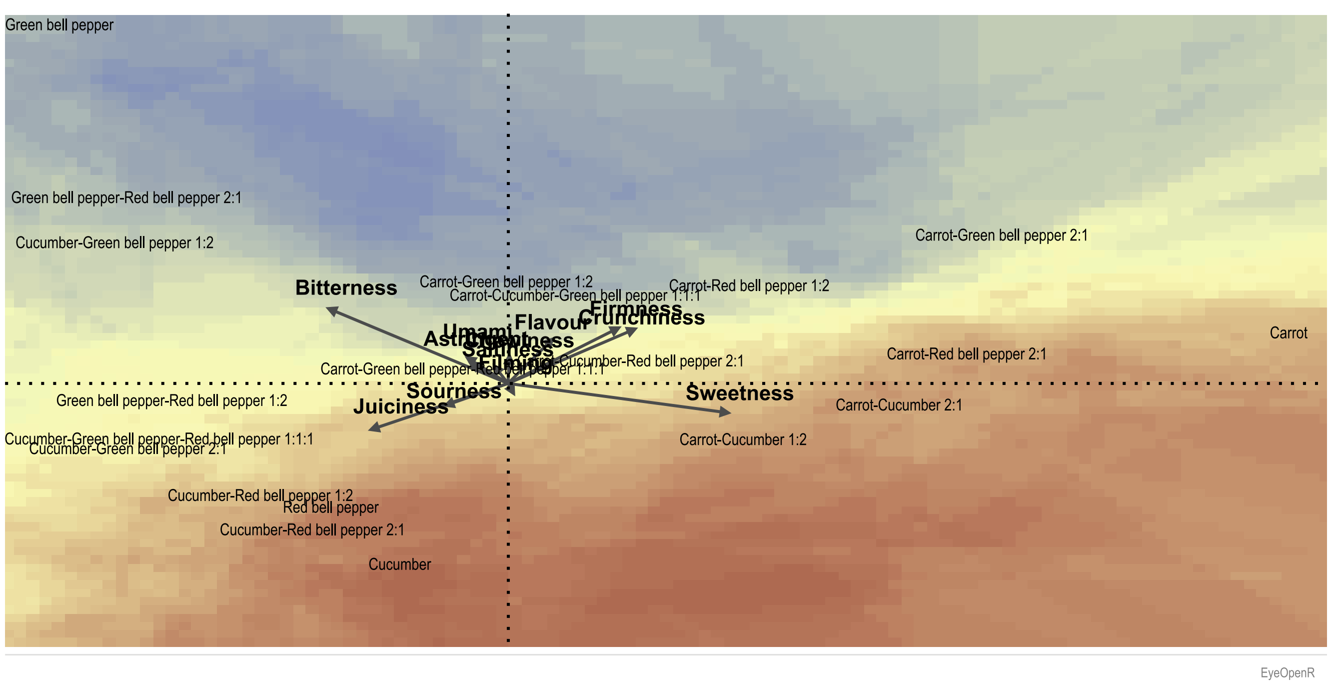

Fig. 3. External preference map linking acceptance (n = 83 naïve consumers) to sensory properties (n = 24 trained subjects, Quantitative Descriptive Analysis) of individual vegetables and vegetable combinations. Red colour indicates high acceptance, yellow indicates neutral acceptance and blue indicates low acceptance. Combinations of vegetables can be more accepted than individual vegetables. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

compared to green bell pepper. For the combination green bell pepper-red bell pepper (1:2), acceptance of the combination was significantly higher compared to acceptance of green bell pepper and did not significantly differ compared to acceptance of red bell pepper. For the combination green bell pepper-carrot-cucumber (1:1:1), acceptance of the combination was significantly higher compared to acceptance of green bell pepper and did not significantly differ from acceptance of carrot and cucumber. For the majority of vegetable combinations (13 of 16 vegetable combinations) acceptance did not increase compared to acceptance of individual vegetables.

3.4. External preference map of vegetables and combinations thereof

External preference mapping was used to link consumer acceptance with sensory properties of all vegetables and their combinations assessed by a trained panel (Fig. 3). Red colour indicates high acceptance, yellow indicates neutral acceptance and blue indicates low acceptance. The sweetness-bitterness axis is the main driver for acceptance. The other sensory axis ranges from juiciness/sourness towards crunchiness/firmness. This sensory axis does not play a major role in acceptance of vegetable, and tends to run parallel to the contour lines of acceptance in the external preference map. Samples containing carrot and cucumber are mostly in the red area indicating high acceptance. Green bell pepper is in the blue area indicating low acceptance, while carrot-green bell pepper (1:2 and 2:1) are in the area of neutral acceptance.

3.5. Discussion

3.5.1. Sweetness and bitterness as main drivers of vegetable acceptance

For 3 of 16 vegetable combinations (cucumber-green bell pepper, 2:1; green bell pepper-red bell pepper, 1:2 and carrot-cucumber-green bell pepper, 1:1:1), acceptance of the vegetable combination was significantly higher than acceptance of the individual least accepted vegetable (green bell pepper) while acceptance did not change compared to the individual, more accepted vegetable(s) in the combination (carrot, cucumber and red bell pepper). Compared to green bell pepper, the combination green bell pepper-red bell pepper (1:2) was higher in sweetness and crunchiness and the combination green bell pepper-carrot-cucumber (1:1:1) was higher in sweetness and lower in bitterness. The combination cucumber-green bell pepper (2:1) was not significantly different in sweetness compared to both individual vegetables, but bitterness was significantly lower in the combination cucumber-green bell pepper (2:1). This demonstrates that by combining vegetables sensory properties can be altered in the direction of enhanced sweetness and reduced bitterness. By those means combinations of vegetables can be obtained of which acceptance of the combination is higher than the acceptance of the least accepted individual vegetable and similar to acceptance of the other vegetables used in the combination. However, for the majority of vegetable combinations (13 of 16 vegetable combinations) acceptance of the combinations did not increase compared to acceptance of individual vegetables. Thus, combinations of vegetables are not always better accepted than individual vegetables. Moreover, acceptance of combinations was only higher compared to green bell pepper but not compared to carrot, cucumber or red bell pepper.

The study shows that sweetness is mainly associated with high acceptance and bitterness with low acceptance. Because combining green bell pepper with carrot significantly increased sweetness and decreased bitterness (both mixing ratios), it is surprising that these combinations were not significantly more liked than green bell pepper. Dinehart et al. (2006) concluded that in addition to bitterness, sweetness influences the acceptance of vegetables. However, in this study bitterness in the combination cucumber-green bell pepper (2:1) was lower, while sweetness was not significantly higher compared to green bell pepper. This was more accepted than higher sweetness of the combination carrot-green bell pepper (1:2, 2:1). Beauchamp (2016) suggested that it is not only the sweet taste that is responsible for food selection or rejection, but the ratio between sweetness and bitterness. While the combination green bell pepper-carrot (1:2) was not better accepted, it might be that the balance between sweet and bitter was more appreciated in the combination with cucumber. Another potential explanation is that the combination carrot-green bell pepper was significantly lower in juiciness compared to green bell pepper as individual vegetable (only 2:1 ratio), however in the external preference map juiciness was not clearly associated with acceptance.

While the combination cucumber-green bell pepper (2:1) was better accepted than green bell pepper and equally accepted as cucumber, the ratio containing a majority of green bell pepper, (cucumber-green bell pepper 1:2) was less accepted than cucumber as individual vegetable. Additionally, combinations with carrot or cucumber and a majority of green bell pepper (1:2 ratio) were the least accepted combinations. In general, more green bell pepper in a combination, leads to higher bitterness. As green bell pepper is a more bitter vegetable, this was not surprising, but the findings indicate the importance of offering the vegetables in a balanced mixing ratio. Compared to red bell pepper as individual vegetable, acceptance of none of the combinations was significantly different. While some combinations of vegetables are better accepted than the least accepted vegetable while maintaining acceptance of the other vegetables used in the combination, it should be kept in mind when selecting vegetable combinations or developing vegetable products that adding too much of a bitter vegetable to the combination, acceptance of the combination might be lower than acceptance of otherwise well liked vegetables.

3.6. Influence of other taste and texture attributes on acceptance of vegetable combinations

Sourness was significantly higher for the combination carrot-red bell pepper (1:2) compared to carrot. Carrot was the least sour and red bell pepper the most sour vegetable, so this was not surprising. Whether sourness is a desired taste in vegetables or not remains unclear. In our study, sourness was not associated with acceptance. Previous studies showed that increasing sourness of vegetables does not increase but can decrease acceptance (Van Stokkom et al., 2018a, b). In our study, combinations containing a vegetable with a slightly sour vegetable (red bell pepper), did not have high sourness intensities (range sourness 6.3–19.5) (range sourness 6.3–19.5) and did therefore not influence acceptance. This also applies for umami and saltiness: since intensities were low, they did not influence acceptance (range umami 9.8–20.3, range saltiness 5.1–10.3). Low intensities for umami and saltiness were not surprising as van Stokkom et al. (2016) showed that in general, vegetables have low taste intensities compared to other foods. Moreover, vegetables more known for having an umami taste, such as tomatoes (Van Stokkom et al., 2016), were not included in this study.

Werthmann et al. (2015) showed that texture and not taste was important for children's liking or disliking of yoghurt. In a study by Nederkoorn et al. (2018) sensing the texture of a food increased children's acceptance of foods with a similar texture. Texture also seems to play a role in vegetable acceptance as Zeinstra et al. (2010) showed that vegetable liking was moderately associated with crunchiness. Therefore, several texture and mouthfeel attributes were included in the QDA profiling: firmness, crunchiness, juiciness, chewiness, astringent and filming. Carrot is a crunchy vegetable, more so than pepper and cucumber (Fillion & Kilcast, 2002). Combinations with carrot were often higher in firmness, crunchiness or both. Duffy et al. (2017) found that raw carrots are most preferred, also indicating that for some vegetables crunchiness is a desired attribute as raw vegetables in general are more crunchy than boiled vegetables (Miglio, Chiavaro, Visconti, Fogliano, & Pellegrini, 2008). However, Poelman and Delahunty (2011) showed that differences in texture as a result of different preparation methods were not associated with vegetable acceptance. In our study, none of the texture or mouthfeel attributes were strongly associated with acceptance, taste clearly had a stronger influence on acceptance. The only indication that texture might play a role was that juiciness of green bell pepper-carrot was significantly lower compared to green bell pepper as individual vegetable.

As we only used raw vegetables in our study, differences in texture, such as crunchiness between carrot, cucumber, red- and green bell pepper were probably smaller than in other studies (Duffy et al., 2017; Zeinstra et al., 2010) as in those studies different preparation methods were included which influence texture stronger.

3.7. Future implications and limitations

Drewnowski & Gomez-Carneros (2000) and Sun-Waterhouse & Wadhwa (2013) suggested that vegetable consumption should be increased without decreasing the phytochemical content as phytochemicals have important health benefits. However, this is difficult as phytochemical content is associated with bitterness (Breslin, 2013) and bitterness is associated with decreased acceptance of vegetables (Dinehart, Hayes, Bartoshuk, Lanier, & Duffy, 2006; Donadini, Fumi, & Porretta, 2012; Duffy, Hayes, & Feeney, 2017). This study shows that sensory properties of vegetables, including sweetness and bitterness, can be different for vegetable combinations without negatively influencing the phytonutrient content of individual vegetables. However, it should be considered that combinations of vegetables do not necessarily contain the same amount and same composition of phytochemicals as individual vegetables. Taste enhancement, by addition of tastants can increase acceptance but might not be desirable from a health perspective. This study shows that sensory properties of vegetable combinations, including sweetness and bitterness, can be altered to obtain vegetable combinations that are equally accepted as the most liked individual (sweet) vegetable in the combination and more accepted than the least liked individual (bitter) vegetable in the combination. Thus, vegetables can become more palatable by combining them with each other without adding sucrose, sweeteners or dips. Additionally, combining raw vegetables is easy to implement by both consumers and food industry. Results of this study can be used to develop combinations of raw vegetables with good consumer acceptance. To some extent, combinations of raw vegetables are already commercially available in supermarkets. For example, in The Netherlands raw bell peppers, cherry tomatoes and cucumber are commercially sold in combination. This indicates that offering combinations of raw vegetables in supermarkets is feasible which might contribute to increasing vegetable intake in the future.

It might be that the increase in acceptance of vegetable combinations is caused by offering a variety of vegetables differing in colour, flavour and texture compared to offering a single vegetable only. Mennella et al. (2008) and Parizel et al. (2017) showed that offering a variety of vegetables (green beans, zucchinis and spinach) in a meal can increase vegetable acceptance compared to offering only one vegetable. Additionally, Meengs et al. (2012) and Bucher et al. (2014) showed that offering a variety of vegetables can increase choice and intake, although this effect of variety on choice and intake was not found by Parizel et al. (2017). Bergamaschi et al. (2016) investigated how levels of variety of vegetables, fruits and nut snacks influence children's acceptance. While liking of foods by children changed with variety level, adding more variety did not increase consumption. Bergamaschi et al. (2016) suggested that familiarity and acceptance of foods used in variety exposure is more important than variety itself to achieve an increase in intake and acceptance. In our study the hedonic evaluation shows that in general the combinations with three vegetables differing in colour, flavour and texture were not more accepted than the combination with two vegetables or even the individual vegetables. In our study participants always evaluated the vegetable combinations within a bite. Timing of perception was not taken into account, it is possible that during the tasting of the combinations, some participants perceived vegetable A first and vegetable B second, while for others this order might have been different. However, this order was likely random and consumers were asked to rate the overall impression. It is therefore unlikely that this influenced the results. Consumers might pick out the vegetable they prefer out of the combinations. To avoid this, it is essential that the combination is equally accepted than the most liked vegetable in the combinations. Also, cubes could be made very small making it difficult to remove specific vegetable cubes.

As this study shows that sensory properties of vegetable combinations depend on the vegetables used in the combinations, we recommend similar studies including other bitter and sweet vegetables. The vegetables included in this study are all consumable raw. It would be interesting to investigate how acceptance is influenced in cooked, warm vegetables, so for example using Brussel sprouts or broccoli in combination with carrot or another sweet vegetable. Also, vegetables used in this study are commonly consumed. Future studies could explore how offering vegetable combinations can be used to increase acceptance of less commonly consumed vegetables. It would also be interesting to investigate the effect of adding herbs and spices to vegetable combinations on acceptance. Carney et al. (2018) investigated the effect of three different herbs and spice blends on consumption of carrots and found that there is potential for improving vegetable intake in children who are sensitive to bitter taste.

From this study, it is not known how offering raw vegetable combinations influences food choice and intake. However, previous studies showed that offering a variety of vegetables can increase choice and intake (Bucher et al., 2014; Meengs et al., 2012).

4. Conclusion

Combinations of vegetables can be more accepted than individual, not well accepted vegetables that are part of the combination, depending on type of vegetable and mixing ratio. Mainly sweetness and bitterness were associated with vegetable acceptance and texture attributes such as crunchiness, firmness and juiciness did not strongly influence acceptance. Combining vegetables can increase or decrease acceptance compared to the individual vegetables depending on the type of vegetable and the mixing ratio. Only 3 of 16 vegetable combinations demonstrated increased acceptance compared to the least accepted vegetable while acceptance of these combinations remained unchanged compared to the other, more accepted vegetables. For the majority of vegetable combinations (13 of 16 vegetable combinations) acceptance of the combinations did not increase compared to acceptance of individual vegetables. We conclude that combining vegetables with other vegetables influences sensory properties and that specific combinations can be more accepted than individual vegetables. This suggests that this approach can be followed for the development of fresh vegetable products and to devise strategies to increase vegetable consumption.

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Appendix A

See Appendices 1–4.

Appendix 1

Mean intensity scores with standard deviation for all attributes (n = 24 trained subjects, Quantitative Descriptive Analysis) and acceptance (n = 83 naïve consumers, hedonic evaluation) of samples containing carrot (n = 10). Letters A-D indicate significant differences ($p < 0.05$) between vegetables for each attribute. Same letters indicate no significant difference between vegetables.

Attribute	F-value	Carrot	Carrot – Cucumber	Carrot – Cucumber	Carrot – Green bell pepper	Carrot – Green bell pepper	Carrot – Red bell pepper	Carrot – Red bell pepper	Carrot-Cucumber – Green bell pepper	Carrot – Cucumber – Red bell pepper	Carrot – Green bell pepper – Red bell pepper
		NA	2:1	1:2	2:1	1:2	2:1	1:2	1:1:1	1:1:1	1:1:1
Firmness	$F(9,207) = 10450.73$, $p < 0.01$	73 ± 18^{A}	70 ± 15^{A}	66 ± 13^{A}	74 ± 15^{A}	69 ± 16^{A}	71 ± 16^{A}	69 ± 17^{A}	67 ± 15^{A}	66 ± 14^{A}	64 ± 18^{A}
Crunchiness	$F(9,207) = 11962.76$, $p = 0.09$	76 ± 18^{A}	73 ± 17^{A}	69 ± 16^{A}	73 ± 16^{A}	70 ± 18^{A}	70 ± 19^{A}	68 ± 16^{A}	67 ± 16^{A}	67 ± 16^{A}	69 ± 17^{A}
Juiciness	$F(9,207) = 2904.64$, $p < 0.01$	36 ± 18^{C}	$45\ 19^{ABC}$	44 ± 17^{ABC}	37 ± 16^{BC}	46 ± 19^{ABC}	40 ± 20^{ABC}	42 ± 18^{ABC}	41 ± 21^{ABC}	49 ± 17^{A}	48 ± 21^{AB}
Chewiness	$F(9,207) = 512.89$, $p < 0.05$	21 ± 20^{AB}	20 ± 17^{AB}	10 ± 12^{B}	20 ± 18^{AB}	22 ± 15^{A}	20 ± 19^{AB}	18 ± 16^{AB}	18 ± 19^{AB}	16 ± 16^{AB}	16 ± 15^{AB}
Sweetness	$F(9,207) = 3684.22$, $p < 0.01$	55 ± 18^{A}	46 ± 19^{ABCD}	43 ± 17^{BCD}	48 ± 18^{ABC}	37 ± 22^{D}	51 ± 20^{AB}	48 ± 18^{ABC}	39 ± 18^{CD}	47 ± 21^{ABCD}	37 ± 21^{D}
Sourness	$F(9,207) = 421.47$, $p < 0.01$	6 ± 13^{C}	9 ± 14^{ABC}	8 ± 9^{BAC}	7 ± 10^{BC}	14 ± 16^{AB}	13 ± 15^{ABC}	15 ± 17^{A}	9 ± 13^{ABC}	9 ± 14^{ABC}	14 ± 16^{AB}
Bitterness	*$F(9,207) = 428.03$, $p < 0.01$*	9 ± 11^{B}	12 ± 13^{AB}	15 ± 17^{AB}	17 ± 16^{AB}	22 ± 18^{A}	16 ± 16^{AB}	22 ± 25^{A}	21 ± 20^{AB}	21 ± 20^{AB}	21 ± 17^{AB}
Umami	$F(9,207) = 280.96$, $p = 0.11$	10 ± 14^{A}	10 ± 15^{A}	11 ± 16^{A}	16 ± 19^{A}	14 ± 16^{A}	10 ± 14^{A}	15 ± 17^{A}	16 ± 14^{A}	19 ± 21^{A}	13 ± 16^{A}
Saltiness	$F(9,207) = 326.19$, $p = 0.77$	6 ± 10^{A}	8 ± 11^{A}	8 ± 13^{A}	8 ± 12^{A}	8 ± 11^{A}	7 ± 12^{A}	6 ± 9^{A}	9 ± 13^{A}	8 ± 10^{A}	7 ± 8^{A}
Flavour	$F(9,207) = 5251.37$, $p = 0.05$	59 ± 15^{A}	51 ± 16^{A}	50 ± 17^{A}	57 ± 17^{A}	53 ± 17^{A}	56 ± 17^{A}	60 ± 17^{A}	53 ± 12^{A}	58 ± 13^{A}	54 ± 19^{A}
Astringent	$F(9,207) = 516.94$, $p = 0.50$	12 ± 19^{A}	15 ± 19^{A}	16 ± 22^{A}	14 ± 21^{A}	18 ± 18^{A}	14 ± 16^{A}	16 ± 20^{A}	17 ± 22^{A}	13 ± 19^{A}	13 ± 17^{A}
Filming	$F(9,207) = 361.68$, $p = 0.34$	14 ± 17^{A}	11 ± 14^{A}	9 ± 12^{A}	10 ± 14^{A}	10 ± 13^{A}	10 ± 16^{A}	11 ± 15^{A}	11 ± 16^{A}	14 ± 18^{A}	9 ± 14^{A}
Acceptance	$F(9,738) = 6.813$, $p < 0.01$	6.4 ± 2.0^{A}	6.1 ± 1.8^{AB}	6.3 ± 1.4^{A}	5.4 ± 1.9^{C}	5.4 ± 1.7^{C}	6.1 ± 1.8^{AB}	5.9 ± 1.9^{ABC}	6.0 ± 1.4^{ABC}	6.4 ± 1.4^{A}	5.6 ± 1.7^{BC}

Appendix 2

Mean intensity scores with standard deviation for all attributes (n = 24 trained subjects, Quantitative Descriptive Analysis) and acceptance (n = 83 naïve consumers, hedonic evaluation) of samples containing cucumber (n = 10). Letters A-C indicate significant differences (p < 0.05) between vegetables for each attribute. Same letters indicate no significant difference between vegetables.

Attribute	F-value	Cucumber NA	Carrot – Cucumber 1:2	Carrot – Cucumber 2:1	Cucumber – Green bell pepper 2:1	Cucumber – Green bell pepper 1:2	Cucumber – Red bell pepper 2:1	Cucumber – Red bell pepper 1:2	Carrot –Cucumber – Green bell pepper 1:1:1	Carrot –Cucumber – Red bell pepper 1:1:1	Cucumber – Green bell pepper – Red bell pepper 1:1:1
Firmness	$F(9,207) = 8906.94$, $p < 0.01$	59 ± 18^{B}	66 ± 3^{AB}	70 ± 15^{A}	57 ± 13^{B}	63 ± 16^{AB}	58 ± 17^{B}	58 ± 16^{B}	67 ± 15^{AB}	66 ± 14^{AB}	59 ± 17^{B}
Crunchiness	$F(9,207) = 7307.86$, $p < 0.01$	61 ± 17^{B}	69 ± 6^{AB}	73 ± 17^{A}	61 ± 16^{B}	64 ± 17^{AB}	60 ± 20^{B}	60 ± 19^{B}	67 ± 16^{AB}	67 ± 16^{AB}	59 ± 22^{B}
Juiciness	$F(9,207) = 3485.10$, $p < 0.01$	48 ± 20^{ABC}	44 ± 7^{BC}	45 ± 19^{ABC}	50 ± 18^{ABC}	46 ± 20^{ABC}	50 ± 16^{ABC}	53 ± 18^{AB}	41 ± 21^{C}	49 ± 17^{ABC}	56 ± 19^{A}
Chewiness	$F(9,207) = 524.99$, $p = 0.10$	21 ± 21^{A}	10 ± 12^{B}	20 ± 17^{AB}	17 ± 15^{AB}	17 ± 14^{AB}	19 ± 20^{AB}	18 ± 17^{AB}	18 ± 19^{AB}	16 ± 16^{AB}	15 ± 15^{AB}
Sweetness	$F(9,207) = 2485.08$, $p < 0.01$	37 ± 20^{ABC}	43 ± 17^{A}	46 ± 19^{A}	28 ± 17^{C}	28 ± 21^{C}	37 ± 17^{ABC}	38 ± 19^{ABC}	39 ± 18^{AB}	47 ± 21^{A}	33 ± 18^{BC}
Sourness	$F(9,207) = 414.04$, $p < 0.01$	12 ± 14^{AB}	8 ± 9^{B}	9 ± 14^{B}	11 ± 12^{B}	11 ± 13^{AB}	15 ± 14^{AB}	20 ± 18^{A}	9 ± 13^{B}	9 ± 14^{B}	13 ± 13^{AB}
Bitterness	$F(9,207) = 612.40$, $p < 0.01$	16 ± 17^{BC}	15 ± 7^{C}	12 ± 13^{C}	23 ± 18^{ABC}	31 ± 23^{A}	19 ± 17^{BC}	21 ± 19^{ABC}	21 ± 20^{ABC}	21 ± 20^{ABC}	27 ± 17^{AB}
Umami	$F(9,207) = 304.61$, $p = 0.14$	12 ± 8^{A}	11 ± 16^{A}	10 ± 15^{A}	11 ± 14^{A}	15 ± 20^{A}	17 ± 22^{A}	17 ± 19^{A}	16 ± 14^{A}	19 ± 21^{A}	15 ± 17^{A}
Saltiness	$F(9,207) = 319.62$, $p = 0.67$	8 ± 9^{A}	8 ± 13^{A}	8 ± 11^{A}	6 ± 8^{A}	8 ± 11^{A}	10 ± 12^{A}	7 ± 9^{A}	9 ± 13^{A}	8 ± 10^{A}	7 ± 10^{A}
Flavour	$F(9,207) = 4774.84$, $p < 0.01$	42 ± 21^{B}	50 ± 17^{AB}	51 ± 16^{AB}	50 ± 18^{AB}	54 ± 17^{A}	49 ± 18^{AB}	54 ± 16^{A}	53 ± 12^{AB}	58 ± 13^{A}	52 ± 15^{AB}
Astringent	$F(9,207) = 453.66$, $p = 0.44$	17 ± 23^{A}	16 ± 22^{A}	15 ± 19^{A}	12 ± 19^{A}	17 ± 16^{A}	11 ± 16^{A}	16 ± 20^{A}	17 ± 22^{A}	13 ± 19^{A}	17.4 ± 16.1^{A}
Filming	$F(9,207) = 380.44$, $p = 0.35$	11 ± 15^{A}	9 ± 12^{A}	11 ± 14^{A}	10 ± 13^{A}	12 ± 14^{A}	15 ± 16^{A}	10 ± 14^{A}	11 ± 16^{A}	14 ± 18^{A}	10.1 ± 14.8^{A}
Acceptance	$F(9,738) = 4.824$, $p < 0.01$	6.7 ± 1.6^{A}	6.3 ± 1.4^{AB}	6.1 ± 1.8^{ABC}	6.1 ± 1.3^{ABC}	5.5 ± 1.5^{C}	6.4 ± 1.4^{AB}	6.3 ± 1.7^{AB}	6.0 ± 1.4^{ABC}	6.4 ± 1.4^{AB}	5.9 ± 1.7^{BC}

Appendix 3

Mean intensity scores with standard deviation for all attributes (n = 24 trained subjects, Quantitative Descriptive Analysis) and acceptance (n = 83 naïve consumers, hedonic evaluation) of samples containing green bell pepper (n = 10). Letters A-D indicate significant differences ($p < 0.05$) between vegetables for each attribute. Same letters indicate no significant difference between vegetables.

Attribute	F-value	Green bell pepper NA	Carrot – Green bell pepper 1:2	Carrot – Green bell pepper 2:1	Cucumber – Green bell pepper 1:2	Cucumber – Green bell pepper 2:1	Green bell pepper – Red bell pepper 2:1	Green bell pepper – Red bell pepper 1:2	Carrot – Cucumber – Green bell pepper 1:1:1	Carrot – Green bell pepper – Red bell pepper 1:1:1	Cucumber-Green bell pepper – Red bell pepper 1:1:1
Firmness	$F(9,207) = 7959.38$, $p < 0.01$	68 ± 15^{ABC}	69 ± 16^{AB}	74 ± 15^{A}	63 ± 16^{BCD}	57 ± 13^{D}	61 ± 16^{BCD}	58 ± 21^{CD}	67 ± 15^{ABCD}	64 ± 18^{ABCD}	59 ± 17^{BCD}
Crunchiness	$F(9,207) = 8443.05$, $p < 0.01$	71 ± 16^{AB}	70 ± 18^{ABC}	73 ± 16^{A}	64 ± 17^{ABCD}	61 ± 16^{BCD}	66 ± 15^{ABCD}	60 ± 23^{CD}	67 ± 16^{ABCD}	69 ± 17^{ABCD}	59 ± 22^{D}
Juiciness	$F(9,207) = 3433.83$, $p < 0.01$	49 ± 19^{AB}	46 ± 19^{ABC}	37 ± 16^{C}	46 ± 20^{ABC}	50 ± 18^{AB}	47 ± 16^{ABC}	52 ± 17^{AB}	41 ± 21^{BC}	48 ± 21^{ABC}	56 ± 19^{A}
Chewiness	$F(9,207) = 514.63$, $p = 0.25$	22 ± 23^{A}	22 ± 15^{A}	20 ± 18^{A}	17 ± 14^{A}	17 ± 15^{A}	24 ± 20^{A}	18 ± 16^{A}	18 ± 19^{A}	16 ± 15^{A}	15 ± 15^{A}
Sweetness	$F(9,207) = 2029.91$, $p < 0.01$	24 ± 18^{D}	37 ± 22^{BC}	48 ± 18^{A}	28 ± 21^{CD}	28 ± 17^{CD}	32 ± 21^{BCD}	39 ± 19^{AB}	39 ± 18^{AB}	37 ± 21^{BC}	33 ± 18^{BCD}
Sourness	$F(9,207) = 565.89$, $p < 0.01$	12 ± 15^{AB}	14 ± 16^{AB}	7 ± 10^{B}	11 ± 13^{AB}	11 ± 12^{AB}	13 ± 14^{AB}	16 ± 17^{A}	9 ± 13^{AB}	14 ± 16^{AB}	13 ± 13^{AB}
Bitterness	$F(9,207) = 852.72$, $p < 0.01$	39 ± 24^{A}	22 ± 18^{CD}	17 ± 16^{D}	31 ± 23^{ABC}	23 ± 18^{BCD}	36 ± 23^{AB}	31 ± 21^{ABC}	21 ± 20^{CD}	21 ± 17^{CD}	27 ± 17^{ABCD}
Umami	$F(9,207) = 359.77$, $p = 0.26$	20 ± 23^{A}	14 ± 16^{A}	16 ± 19^{A}	15 ± 20^{A}	11 ± 14^{A}	14 ± 14^{A}	11 ± 13^{A}	16 ± 14^{A}	13 ± 16^{A}	15 ± 17^{A}
Saltiness	$F(9,207) = 394.95$, $p = 0.38$	10 ± 11^{A}	8 ± 11^{A}	8 ± 12^{A}	8 ± 11^{A}	6 ± 8^{A}	9 ± 11^{A}	7 ± 10^{A}	9 ± 13^{A}	7 ± 8^{A}	7 ± 10^{A}
Flavour	$F(9,207) = 4206.31$, $p = 0.78$	55 ± 19^{A}	53 ± 17^{A}	57 ± 17^{A}	54 ± 17^{A}	50 ± 18^{A}	55 ± 18^{A}	55 ± 19^{A}	53 ± 12^{A}	54 ± 19^{A}	52 ± 15^{A}
Astringent	$F(9,207) = 468.93$, $p = 0.24$	21 ± 24^{A}	18 ± 18^{A}	14 ± 21^{A}	17 ± 16^{A}	12 ± 19^{A}	14 ± 18^{A}	18 ± 16^{A}	17 ± 22^{A}	13 ± 17^{A}	17 ± 16^{A}
Filming	$F(9,207) = 394.64$, $p = 0.51$	10 ± 16^{A}	10 ± 13^{A}	10 ± 14^{A}	12 ± 14^{A}	10 ± 13^{A}	13 ± 16^{A}	14 ± 17^{A}	11 ± 16^{A}	8.5 ± 13.6^{A}	10 ± 15^{A}
Acceptance	$F(9,738) = 4.402$, $p < 0.01$	5.1 ± 1.9^{C}	5.4 ± 1.7^{BC}	5.4 ± 1.6^{BC}	5.5 ± 1.5^{ABC}	6.1 ± 1.3^{A}	5.6 ± 1.9^{ABC}	5.8 ± 2.0^{AB}	6.0 ± 1.4^{AB}	5.6 ± 1.7^{ABC}	5.9 ± 1.7^{AB}

Appendix 4

Mean intensity scores with standard deviation for all attributes ($n = 24$ trained subjects, Quantitative Descriptive Analysis) and acceptance ($n = 83$ naïve consumers, hedonic evaluation) of samples containing red bell pepper ($n = 10$). Letters A-D indicate significant differences ($p < 0.05$) between vegetables for each attribute. Same letters indicate no significant difference between vegetables.

Attribute	F-value	Red bell pepper NA	Carrot – Red bell pepper 1:2	Carrot – Red bell pepper 2:1	Cucumber – Red bell pepper 1:2	Cucumber – Red bell pepper 2:1	Green bell pepper – Red bell pepper 1:2	Green bell pepper – Red bell pepper 2:1	Carrot – Cucumber – Red bell pepper 1:1:1	Carrot – Green bell pepper – Red bell pepper 1:1:1	Cucumber – Green bell pepper – Red bell pepper 1:1:1
Firmness	$F(9,207) = 6848.79$, $p < 0.01$	62 ± 17^{AB}	69 ± 17^{AB}	71 ± 16^{A}	58 ± 16^{B}	58 ± 17^{B}	58 ± 21^{B}	61 ± 16^{AB}	66 ± 14^{AB}	64 ± 18^{AB}	59 ± 17^{B}
Crunchiness	$F(9,207) = 7779.25$, $p < 0.01$	62 ± 23^{B}	68 ± 16^{AB}	70 ± 19^{A}	60 ± 19^{AB}	60 ± 20^{B}	60 ± 23^{AB}	66 ± 15^{AB}	67 ± 16^{AB}	69 ± 17^{AB}	59 ± 22^{B}
Juiciness	$F(9,207) = 5227.92$, $p < 0.01$	58 ± 17^{A}	42 ± 18^{C}	40 ± 20^{C}	53 ± 18^{AB}	50 ± 16^{ABC}	52 ± 17^{AB}	47 ± 16^{BC}	49 ± 17^{ABC}	48 ± 21^{BC}	56 ± 19^{AB}
Chewiness	$F(9,207) = 481.20$, $p = 0.42$	21 ± 21^{A}	18 ± 16^{A}	20 ± 19^{A}	18 ± 17^{A}	19 ± 20^{A}	18 ± 16^{A}	24 ± 20^{A}	16 ± 16^{A}	16 ± 15^{A}	15 ± 15^{A}
Sweetness	$F(9,207) = 2573.85$, $p < 0.01$	42 ± 2^{ABCD}	48 ± 18^{AB}	51 ± 20^{A}	38 ± 9^{BCD}	37 ± 17^{BCD}	39 ± 19^{BCD}	32 ± 21^{D}	47 ± 21^{ABC}	37 ± 21^{CD}	33 ± 18^{D}
Sourness	$F(9,207) = 519.63$, $p < 0.05$	18 ± 16^{AB}	15 ± 17^{AB}	13 ± 15^{AB}	20 ± 18^{A}	15 ± 14^{AB}	16 ± 17^{AB}	13 ± 14^{AB}	9 ± 14^{B}	14 ± 16^{AB}	13 ± 13^{AB}
Bitterness	$F(9,207) = 708.95$, $p < 0.01$	21 ± 18^{BC}	22 ± 25^{BC}	16 ± 16^{C}	21 ± 19^{BC}	19 ± 17^{BC}	31 ± 21^{AB}	36 ± 23^{A}	21 ± 20^{BC}	21 ± 17^{BC}	27 ± 17^{ABC}
Umami	$F(9,207) = 378.56$, $p = 0.15$	13 ± 17^{A}	15 ± 17^{A}	10 ± 14^{A}	17 ± 19^{A}	17 ± 22^{A}	11 ± 13^{A}	14 ± 14^{A}	19 ± 21^{A}	13 ± 16^{A}	15 ± 17^{A}
Saltiness	$F(9,207) = 403.40$, $p = 0.14$	5 ± 8^{A}	6 ± 9^{A}	7 ± 12^{A}	7 ± 9^{A}	10 ± 12^{A}	7 ± 10^{A}	9 ± 11^{A}	8 ± 10^{A}	7 ± 8^{A}	7 ± 10^{A}
Flavour	$F(9,207) = 5177.75$, $p = 0.15$	54 ± 17^{AB}	60 ± 17^{A}	56 ± 17^{AB}	54 ± 16^{AB}	49 ± 18^{B}	55 ± 19^{AB}	55 ± 18^{AB}	58 ± 13^{AB}	54 ± 19^{AB}	52 ± 15^{AB}
Astringent	$F(9,207) = 564.26$, $p = 0.35$	16 ± 18^{A}	16 ± 20^{A}	14 ± 16^{A}	16 ± 20^{A}	11 ± 16^{A}	18 ± 16^{A}	14 ± 18^{A}	13 ± 19^{A}	13 ± 17^{A}	17 ± 16^{A}
Filming	$F(9,207) = 450.00$, $p = 0.15$	12 ± 7^{A}	11 ± 5^{A}	10 ± 16^{A}	10 ± 14^{A}	15 ± 16^{A}	14 ± 17^{A}	13 ± 16^{A}	14 ± 18^{A}	9 ± 14^{A}	10 ± 15^{A}
Acceptance	$F(9,738) = 4.203$, $p < 0.01$	6.0 ± 2.3^{AB}	5.9 ± 1.9^{AB}	6.1 ± 1.8^{AB}	6.3 ± 1.7^{A}	6.4 ± 1.4^{A}	5.8 ± 2.0^{AB}	5.6 ± 1.9^{B}	6.4 ± 1.4^{A}	5.6 ± 1.7^{B}	5.9 ± 1.7^{AB}

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2018.10.009.

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