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Identification on Sensory Attributes and Children's Ratings of Fruits and Vegetables with and without Appearance Modification: A Pilot Study

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Abstract

Most previous studies have addressed that children dislike fruits and vegetables because of their sensory characteristics. Intervention focusing on sensory modification may promote children's liking of fruits and vegetables. This study modified the appearance of 10 fruits and vegetables to resemble snacks. As the food was prepared, other sensory characteristics changed as well. A sensory evaluation was conducted on 10 original and 10 modified foods, involving 12 children. The results revealed that modified eggplant and pumpkin gained favorable ratings among the children. Appetizing and repulsive sensory attributes were identified through a corresponding analysis to facilitate future studies on food modification.

Keywords: Sensory attributes; Perceptions; Appearance

Introduction

Low intake of fruits and vegetables is a health concern among children that correlates highly with childhood obesity [1,2]. Daily consumption among school-aged children has been found to be lower than that recommended by United States Department of Agriculture (USDA) guidelines [3-5]. Various studies have also addressed the prominently lower daily intake of vegetables compared with that of fruits [6,7]. One reason for such insufficient consumption of fruits and vegetables is their low preference among children [8,9]. Previous studies have shown that taste [10], texture [11-13] and appearance [14,15] are sensory characteristics accounting for children's low preferences for fruits and vegetables. Taste and texture are particularly crucial factors in children's negative impressions of vegetables because most types of vegetables are unsweet, plain, sour, or bitter in taste [16]. Children naturally exhibit low preferences for plain vegetables [17]. Another factor in this regard is the dietary fiber in certain vegetables, which is typically difficult for children to manipulate with their premature teeth and jaw muscles [13]. Notably, a change in texture may further alter other sensory characteristics, such as the appearance and taste of food. Given this connection, children's liking of fruits and vegetables could involve a complex sensory interaction. Children's preferences have been evidenced in various studies by enhancing fruit's appeal and presentation [14] and by changing the texture of vegetables through cooking [18]. However, limited understanding on how the change of attributes in these sensory characteristics affect children's preference on fruit and vegetables.

Early studies on vegetable preparation found that the method of preparation highly correlates with children's acceptance of vegetables [11,18]. Zeinstra et al. [19] explained that various cooking methods may change the appearance, taste, and texture of foods and revealed that foods with a uniform appearance, consistent texture, and favorable taste were more acceptable to children. According to Cardello's model [20] of food-related behaviors, sensory attributes were found to be significant in the overall perception and acceptance of a food product. In this model, taste, smell, texture, and appearance were deemed crucial attributes characterizing food. Among the sensory attributes, texture and taste exhibited a profound effect on individual preference; however, the initial food appearance was noted as the most critical factor in accepting or rejecting a food because it is the initial basis of judgement and affects other sensory perceptions [21].

Walker et al. [22] further reported that children's dislike on tasting a particular food was based on prejudice. There is also less research showing how olfactory modalities affect children's preferences on fruits and vegetables. Coulthard and Blissett [23] experimented that olfactory characteristic is critical information for children to integrate with sight and feel before they decided to taste the unfamiliar vegetables. It is unknown which sensory characteristics most optimally promote children's consumption of fruits and vegetables and there is a limited sensory description on fruits and vegetables that promoting or demoting children's preferences. Therefore, it is crucial to identify these characteristics to facilitate further research on sensory alterations that applies cooking or preparation techniques. This could present further implications for fruit and vegetable intervention programs targeting children's selective eating. It is important to identify the sensory attributes that fruits and vegetables could be kept or changed for children's preferences. One objective of this study was to determine whether the modified forms of fruits and vegetables would change the sensory characteristics of fruits and vegetables. Another aim of this study was to identify the sensory attributes which were differently perceived by the children when fruits and vegetables were presented in different forms. The sensory attributes and the sensory ratings were also compared to determine whether the variation in sensory attributes changed with sensory ratings.

Method

Design and settings

This study was a quasi-experimental design, conducted in a quiet laboratory setting in a Hong Kong primary school. Recruited school-aged children were asked to evaluate the sensory attributes and render corresponding ratings for five selected fruits and five selected vegetables in both their original and modified forms.

Samples and sampling

Six boys and six girls aged 8-10 were recruited through quota sampling. Because previous study with children aged 8-10 showed the good repeatability between 0.68-0.72, children at these ages would be able to express their preferences and likings through hedonic scales [24]. Therefore, children in third and fifth grade at the aforementioned school were invited to participate in this sensory experiment. The inclusion criteria comprised knowledge of Chinese ethics and the capability to read Chinese and understand Chinese instructions. The exclusion criteria comprised food allergies, vegetarianism, and selectivity in eating fruits and vegetables; children with these qualities may have acquired a bias because of prior experiences with certain food choices. Children who were willing to participate in this sensory study were randomly selected by drawing a class and class number from a random table. When the quota of either boys or girls was reached, participant recruitment was stopped.

Material preparation

In this study, common fruits and vegetables were selected to be used because we would like to exclude the factor of food familiarity because novel foods were well documented as barriers for children's intake. Since the focus of this study was to identify the appealing and repulsive sensory attributes that could be modified by food preparation, the selection of familiar fruits and vegetables ensured children's preference was not related to unfamiliarity with the sampled food. The final products of the modified foods were based on snacks that typically appeal to school-aged children. The research team first evaluated the difficulty of adapting characteristics of various popular children's snacks and considered which fruits or vegetables could be used in the modification. After a few cooking trials, apples, oranges, mangoes, blueberries, and bananas were chosen to be modified as apple popsicles, orange popsicles, sushi, jelly, and ice cream, respectively (Figure 1); sweet potatoes, pumpkin, spinach, carrots, and eggplant were chosen to be modified as cookies, pancakes, noodles, cake, and cubes, respectively (Figure 1). Most of the modified fruits and vegetables were prepared from raw ingredients, involving no other ingredients or condiments (e.g., orange ice, apple ice, and pumpkin pancake). A few modified fruits and vegetables required thickening agents for obtaining the new shape (e.g., sweet potatoes, spinach, and carrot cake needed flour; blueberry jelly required agar). Several of the modified fruits and vegetables required supporting ingredients to facilitate the appearance of snacks (e.g., banana ice cream was served in cones; mango sushi was placed on rice cubes). The modified eggplant cube required a small amount of oil for cooking but was deemed identical process to cook its original form. Thus the nutrition values of original eggplant and modified eggplant was the same. Overall, the food modification process restricted contents same to the original ingredients as much as possible. Healthy cooking methods were applied, with little oil and no condiments being added.

Figure 1: Photos of modified fruits and vegetables.

Instruments

Sensory vocabulary

Because the children were too young to develop their own sensory attributes, a sensory vocabulary developed by the British Nutrition Foundation and Ministry of Agriculture Fisheries and Food was used by the primary schoolchildren for sensory evaluation [25]. This tool involves a wide range of sensory vocabulary words to describe various sensory characteristics, such as the odor, taste, appearance, and texture of food products.

The sensory vocabularies of odor included aromatic, floral, rotten, perfumed, acrid, musty, fragrant, scented and pungent. The sensory vocabularies of taste included sweet, cool, bitter, zesty, warm, hot, tangy, sour, sharp, rich and salty. The sensory vocabularies of appearance included stringy, heavy, flat, fizzy, crystalline, wet, cuboid, fragile and dull. The sensory vocabularies of texture included brittle, rubbery, short, gritty, clammy, close, stodgy, bubbly, sandy, tacky, tender, waxy, open and soft. The sensory vocabulary words were translated into Chinese for Hong Kong children. The sensory vocabulary words were also backward translated, to ensure that their meanings corresponded with those of the original English. During the tasting of each food sample, the children rated the appearance, odor, taste, and texture using a 7-point hedonic facial scale with a descriptor for each point of scale [26]. A hedonic facial scale was employed in this study because it used smiley faces and sad faces to incrementally reflect the favorability, facilitating children's easy understanding of the representations of the sensory characteristics.

Procedure

This study was approved by the ethics review committee of the Research Development Office of The Education University of Hong Kong. Over 10 school days, each recruited child was invited to taste the sampled foods. Fruits and vegetables in one form were served the first 5 days, and fruits and vegetables in another form were served the second 5 days. The children tasted one type of fruit and one type of vegetable each school day. Three boys and three girls were requested to taste fruits and vegetables in their original form during the first week and in the modified form during the second week. The other three boys and three girls were served fruits and vegetables in the modified form during the first week and in the original form during the second week. This aimed at countering any variation because of tasting the food samples in different sequences.

Before the study, the children were given a brief introduction on the tasting procedure. The tasting was conducted in a quiet laboratory with one research assistant. To avoid pressure or external influence, no teachers or peers accompanied the participants. Each child sat in a chair at a desk. A glass of distilled water at room temperature was placed on the desk. Each child was given a type of fruit in the order of mango, apple, orange, banana, and blueberry, as well as a type of vegetable in the order of carrot, pumpkin, spinach, sweet potato, and eggplant. Adhering to this sequence, each child was given mango and carrot samples on Monday, apple and pumpkin samples on Tuesday, orange and spinach samples on Wednesday, banana and sweet potato samples on Thursday, and blueberry and eggplant samples on Friday. Each prepared food sample weighed approximately 50 grams. The children were instructed to rinse their mouths with the provided distilled water. Subsequently, three boys and three girls in the first group were provided sampled foods in original forms in the first week and sampled foods in modified forms in the second week; another three boys and three girls in the second group were provided sampled foods in modified forms in the first week and sampled foods in original forms in the second week.

The children were provided a fruit sample. Each food sample was served on a white plate, and the participants were provided spoons. Each child was given 10 minutes to complete the tasting. Subsequently, each child was administered a questionnaire, on which they circled the most accurate attribute from the vocabulary to describe the sample's sensory characteristic. The children were also asked to rate their liking of the samples by using the hedonic smiley scale for each sensory characteristic. The children were instructed to rinse their mouths again with the provided distilled water. The same tasting procedure, also lasting 10 minutes, was subsequently employed for a vegetable sample. The children participated in tasting other fruits and vegetables on subsequent days until 10 food samples were completed.

Data Analysis

The sensory characteristics with significant differences detected by the Wilcoxon signed-rank test were further subjected to correspondence analysis (CA). Correspondence analysis is a useful statistical tool for expressing the information in a contingency table. The goal of CA was to visually present the likelihood of occurrence between the sensory attributes and sensory ratings for each sensory characteristic in each food sample.

A cumulative inertia higher than 70% was regarded as sufficient for the two first dimensions to convey most of the information of the contingency table [27]. Higgs' [27] criterion on >70% retention of the first two dimensions was adopted in this study. Obtaining a two-dimensional CA map of the sensory attributes and corresponding ratings clearly showed the relative contributions of each point in the first and second dimensional spaces.

Results

Comparisons of the sensory ratings of odor, taste, appearance, and texture between the original and modified forms were analyzed using the Wilcoxon signed-rank test (Table 1). Regarding the fruits, significant variations in sensory ratings were found for the appearance and texture of the mango samples, the texture of the apple samples, and the odor, taste, and texture of the orange samples. Of the significant differences found in appearance and texture of mango, respectively, 43.5% (n=10) and 52.2% (n=12) children liked them in both original form and modified form.

For those children showing preference on mango form, significantly more children preferred the appearance ($p<0.01$) and texture ($p<0.05$) in original form than the modified form. Of the significant differences found in the texture of apple, 63.6% (n=14) children liked them in both original form and modified form. For those children showing preference on apple form, significantly more children preferred the texture ($p<0.05$) in original form than the modified form. Of the significant differences found in the odour, taste and texture of orange, 76.2% (n=16), 81.0% (n=17) and 81.0% (n=17) of children correspondingly liked them in both original form and modified form. For those children showing preference on apple form, significantly more children preferred the odour ($p<0.05$), taste ($p<0.05$) and texture (($p<0.05$) in original form than the modified form.

Regarding the vegetables, significant differences in the sensory ratings were found in eggplant, spinach and sweet potato. Of the significant differences found in the odour, taste and texture of eggplant, 36.4% (n=8) of children liked them in both original form and modified form. For those children showing preference on eggplant form, significantly more children preferred the odour ($p<0.05$), taste ($p<0.05$) and texture ($p<0.05$) in modified form than the original form. Of the significant differences found in the odour of spinach, 42.9% (n=9) children liked them in both original form and modified form. For those children showing preference on spinach form, significantly more children preferred the odour ($p<0.05$) in original form than the modified form. Of the significant differences found in the odour of sweet potato, 59.1% (n=13) children liked them in both original form and modified form. For those children showing preference on sweet potato, significantly more children preferred the odour ($p<0.05$) in original form than the modified form.

	Sensory test	TF>OFb	OF>TFc	OF=TFd	Wilcoxon signed-rank test	Effect Size
Fruit		n (%)	n (%)	n (%)		
Mango (N=23)						
	Odor	4 (17.4)	5 (21.7)	14 (60.9)	Z=-1.217, p=0.223	r = -0.25
	Taste	3 (13.0)	7 (30.4)	13 (56.5)	Z=-1.887, p=0.059	r = -0.39
	Appearance	3 (13.0)	10 (43.5)	10 (43.5)	Z=-2.580, p=0.010	r = -0.53
	texture	4 (17.4)	7 (30.4)	12 (52.2)	Z=-1.990, p=0.047	r = - 0.41
Apple (N=22)						
	Odor	3 (13.6)	4 (18.2)	15 (68.2)	Z=-0.862, p=0.389	r = -0.18
	Taste	2 (9.1)	5 (22.7)	15 (68.2)	Z=-1.292, p=0.196	r = -0.27
	Appearance	4 (18.2)	4 (18.2)	14 (63.6)	Z=-0.845, p=0.398	r = -0.18
	texture	1 (4.5)	7 (31.8)	14 (63.6)	Z=-2.326, p=0.020	r = -0.49
orange (N=21)						
	Odor	0 (0)	5 23.8)	16 (76.2)	Z=-2.414, p=0.016	r = -0.50
	Taste	0 (0)	4 (19.0)	17 (81.0)	Z=-2.232, p=0.026	r = -0.47
	Appearance	1 (4.8)	2 (9.5)	18 (85.7)	Z=-1.633, p=0.102	r = - 0.34
	texture	0 (0)	4 (19.0)	17 (81.0)	Z=-2.232, p=0.026	r = - 0.47
Banana (N=22)						
	Odor	3 (13.6)	5 (22.7)	14 (63.6)	Z=-0.811, p=0.417	r = -0.17
	Taste	2 (9.1)	3 (13.6)	17 (77.3)	Z=-0.319, p=0.750	r = -0.07
	Appearance	2 (9.1)	6 (27.3)	14 (63.6)	Z=-1.310, p=0.190	r = -0.27
	texture	3 (13.6)	4 (18.2)	15 (68.2)	Z=-0.586, p=0.558	r = -0.12
Blueberry (N=22)						
	Odor	3 (13.6)	8 (36.4)	11 (50.0)	Z=-1.126, p=0.260	r = -0.23
	Taste	2 (9.1)	7 (31.8)	13 (59.1)	Z=-0.759, p=0.448	r = -0.15
	Appearance	3 (13.6)	6 (27.3)	13 (59.1)	Z=-0.670, p=0.503	r = -0.14
	texture	3 (13.6)	7 (31.8)	12 (54.5)	Z=-0.947, p=0.344	r = -0.19
Vegetables						
Eggplant (N=22)						
	Odor	13 (59.1)	1 (4.5)	8 (36.4)	Z=-2.154, p=0.031	r = -0.44
	Taste	12 (54.5)	2 (9.1)	8 (36.4)	Z=-1.997, p=0.046	r = -0.41
	Appearance	11 (50.0)	2 (9.1)	9 (40.9)	Z=-1.594, p=0.111	r = -0.33
	texture	12 (54.5)	2 (9.1)	8 (36.4)	Z=-1.972, p=0.049	r = -0.40
Carrot (N=22)						
	[a]Odor	4 (18.2)	7 (31.8)	11 (50.0)	Z=-1.514, p=0.130	r = -0.32
	[a]Taste	4 (18.2)	7 (31.8)	11 (50.0)	Z=-0.953, p=0.341	r = -0.20

	Appearance	5 (22.7)	7 (31.8)	10 (45.5)	Z=-0.603, p=0.546	r = -0.12
	texture	4 (18.2)	6 (27.3)	12 (54.5)	Z=-0.832, p=0.405	r = -0.17
Spinach (N=21)						
	Odor	4 (19.0)	8 (38.1)	9 (42.9)	Z=-2.100, p=0.036	r = -0.44
	Taste	5 (23.8)	8 (38.1)	8 (38.1)	Z=-1.577, p=0.115	r = -0.33
	Appearance	4 (19.0)	8 (38.1)	9 (42.9)	Z=-1.803, p=0.071	r = -0.38
	texture	4 (19.0)	7 (33.3)	10 (47.6)	Z=-1.878, p=0.060	r = -0.39
Sweet potato (N=22)						
	Odor	1 (4.5)	8 (36.4)	13 (59.1)	Z=-2.511, p=0.012	r = -0.52
	Taste	4 (18.2)	7 (31.8)	11 (50.0)	Z=-1.151, p=0.250	r = -0.24
	Appearance	3 (13.6)	7 (31.8)	12 (54.5)	Z=-1.584, p=0.113	r = -0.33
	texture	4 (18.2)	7 (31.8)	11 (50.0)	Z=-1.409, p=0.159	r = -0.29
Pumpkin (N=23)						
	Odor	8 (34.8)	5 (21.7)	10 (43.5)	Z=-0.253, p=0.800	r = -0.05
	Taste	6 (26.1)	7 (30.4)	10 (43.5)	Z=-0.0063, p=0.949	r = -0.001
	Appearance	6 (26.1)	8 (34.8)	9 (39.1)	Z=-0.315, p=0.753	r = - 0.06
	texture	7 (30.4)	5 (21.7)	11 (47.8)	Z=-0.140, p=0.888	r = -0.03

OF= fruits and vegetables without appearance modification; TF= fruits and vegetables with appearance modification.

[a] One participant did not respond to odor or taste for the carrot samples.

[b] Mean rating of the modified food was superior that of the original food for the specified sensory characteristic.

[c] Mean rating of the original food was superior to that of the modified food for the specified sensory characteristic.

[d] Mean rating of the modified food was equal to that of the original food for the specified sensory characteristic.

Table 1: Summary of Wilcoxon signed-rank test

Effect of sensory attributes of fruits on children's ratings

Those sensory ratings and sensory characteristics showed significant variations in the Wilcoxon signed-rank test were then performed with correspondence analysis to identify the sensory attributes which appealing or repulsive children's preferences on fruits and vegetables. The ratings of extremely bad and extremely good comprised the extreme points of dimension 1; the direction of dimension 1 was defined by sensory ratings in the CA maps (Figures 2 and 3). The results from correspondence analysis revealed the possible differences in sensory attributes that were modified through food preparation and appearance alteration for each sampled food. Regarding the mango, the first two dimensional axes of appearance in the CA map accounted for cumulative proportions of inertia equal to 30.6% and 50.4% ($p<0.05$), totaling 81.0%. The attribute "lumpy" was clearly associated with extremely bad, whereas the attributes "dull" and "vivid" were clearly associated with extremely good (Figure 2a). The first two dimensional axes of texture had cumulative proportions of inertia equal to 26.1% and 47.2% ($p<0.05$), totaling 73.3%. Regarding the texture of the mango samples, the attribute "crispy" was associated closely with extremely bad, and the attributes "smooth" and "stringy" were associated with extremely good (Figure 2b). Regarding the apple, the first two dimensional axes of texture had cumulative proportions of inertia equal to 39.3% and 60.7% ($p<0.05$), totaling 100.0%. The attribute "filled with air" was associated with good, and the attributes "firm," "stringy," and "smooth" were associated with extremely good (Figure 2c).

Regarding the orange, the first two dimensional axes of odor had cumulative proportions of inertia equal to 23.8% and 76.2% ($p>0.05$), totaling 100.0%. The odor of the orange samples, the attribute "lightly scented" approached ratings of good and neutral, whereas the attributes "refreshingly fragrant" and "aromatic" were associated with extremely good (Figure 2d). The first two dimensional axes of taste had cumulative proportions of inertia equal to 19.1% and 80.9% ($p>0.05$) totaling 100.0%. The attribute of "weak-tasted" was closely associated with good, whereas "sweet," "sour," and "fresh" were associated with extremely good (Figure 2e). The first two dimensional axes of texture had cumulative proportions of inertia equal to 37.3% and 62.7% ($p<0.05$), totaling 100.0%. The sensory attribute of "rubbery" approached good, whereas "smooth" and "stringy" approached extremely good (Figure 2f).

Effect of sensory attributes of vegetables on children's ratings

Regarding the eggplant, the first two dimensional axes of odor had cumulative proportions of inertia equal to 35.0% and 42.1% ($p<0.05$), totaling 77.1%. The ratings of neutral comprised the extreme points, contrasting with ratings of good and bad. "Strongly perfumed" was associated with neutral, whereas "aromatic" approached various ratings, including good and bad. "Floral" approached extremely good. Ratings of neutral and extremely good were found the main contributors to dimension 1 (Figure 3a). The first two dimensional axes of taste of eggplant had cumulative proportions of inertia equal to 27.3% and 30.9% ($p<0.05$), totaling 58.2%. The ratings of good and extremely bad comprised the extreme points in dimension 1. The attribute of "tangy" was clearly associated with extremely bad, whereas" salty" approached good (Figure 3b). The first two dimensional axes of texture of eggplant had cumulative proportions of inertia equal to 25.3% and 36.6% ($p<0.05$), totaling 61.9%. According to Higgs' criterion, the attributes of taste and texture for eggplant were discarded. The sensory attributes of good and extremely bad again comprised the extreme points of dimension 1. The attributes "crispy" and "flaky" were associated with extremely bad, whereas the attribute "filled with air" was associated with good (Figure 3c).

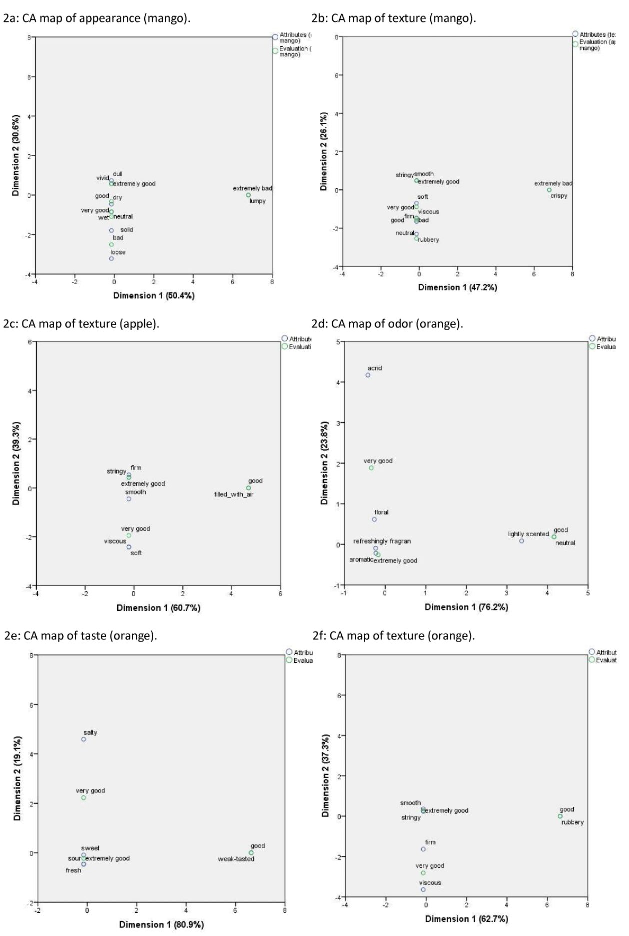

Figure 2: Correspondence analysis (CA) maps of attributes and their evaluations for fruits with significant differences before and after modification.

Regarding the spinach, the first two dimensional axes of odor had cumulative proportions of inertia equal to 36.7% and 36.7% ($p<0.05$), totaling 73.5%. The sensory attributes of extremely bad and bad were positioned distantly from the other attributes and were respectively the primary and secondary contributors to dimension 1. A rating of extremely bad was associated with the attribute "rotten," and a rating of bad was associated with the attribute "acrid." Other attributes regarding the odor of the spinach samples approached good, very good, and extremely good (Figure 3d).

Regarding the sweet potato, the first two dimensional axes of odor had cumulative proportions of inertia equal to 19.1% and 76.9% ($p>0.05$), totaling 96.0%. The ratings of good and very good were the two extreme positions in dimension 1. Although good was the primary contributor and very good was the secondary contributor, an association with good was not clearly observed for any attribute, whereas very good was somewhat close to the attribute "lightly scented" (Figure 3e).

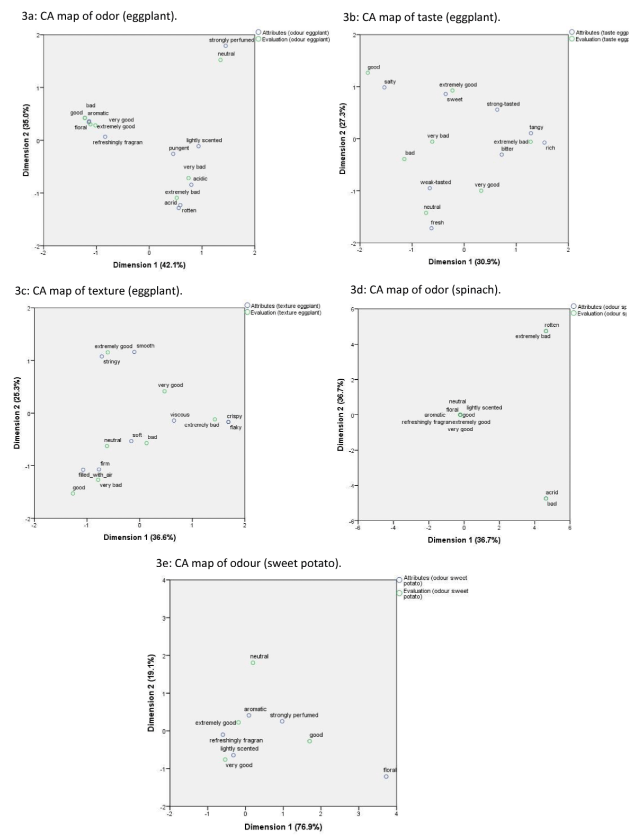

Figure 3: Correspondence analysis (CA) maps of attributes and their evaluations for vegetables with significant differences before and after modification.

With CA analysis, it was much clear to find which attributes of each sensory characteristics were favorable or unfavorable to the children. Besides, we could also identify common attributes that were appraising good or extremely good for the three fruits (mango, apple and orange). For example, stringy, smooth and filled with air were three texture attributes that commonly found favorable among the primary children. Unfavorable appearance such as lumpy and texture like crispy were found unfavorable to the primary children. It was found that common attributes in odour were appraising good or extremely good for the three vegetables (eggplant, spinach, sweet potato). The odor attributes were flora, refreshingly fragrant, aromatic and lightly scented. It was found that the texture of filled with air was found appealing to the primary children for apple and eggplant. With the above observation, we may suggest that texture of fruits whereas the odour of vegetables could be the prominent sensory characteristics to appeal children.

Discussion

Picky eating is highly associated with children's reduced consumption on fruits and vegetables [28]. There is individual difference among children in their preference of foods because they are found perceiving and responding to sensory characteristics across a range of sensory modalities such as visual, tactile, smell and taste [29]. Therefore, the sensory processing of fruits and vegetables is well supported as one possibly theory for some children to reject fruits and vegetables [23]. In recent research, intervention on fruits and vegetables focus on the visual appeal indicated this critical domain in children's appraisal of foods [30]. Other studies are found to evaluate other domains such as tactile and olfactory changes in explaining children's food preference, food neophobia or picky eating problems [31,32]. The findings of this study build on the foundations in previous studies by identifying the change in sensory attributes without change the fruits or vegetables. The study design tried to control variations caused by individual differences. Same food sample evaluated by same groups of children helped investigate if modification of fruits and vegetables could change the children's preference on fruits and vegetables. Appearance modification in this study had no effect on fruits and children even liked the original forms of fruits better than the modified forms. However, appearance modification showed better effect on vegetables, although its effect was only significant on eggplants. This reassured the findings of previous studies that children naturally has lower preferences for vegetables because of unsweet, plain, sour and sometimes bitter in taste [16,17]. On the contrary, fruits usually come with sweet taste and colourful appearance, children preferred fruits in original forms and they ate more if they were presented in appealing ways [14]. Therefore, the potential reasons that no significant difference was found between the two forms would be the children's individual preferences on fruits, independent of their forms.

This study showed that texture of fruits and the odor of vegetables were the primary sensory characteristics to appeal children. Through appearance modification, it could be possible to change the texture, odor and taste of fruits and vegetables and thus be appetizing to the children. Especially for vegetables, research found them less easy to attract children's consumption as compared with fruits, sensory modification may be worth trying in this connection. Among the five vegetables tested in this study, only eggplant showed significant preferences in modified form than the original form, not for other four testing vegetables. The potential reasons could be the appearance modification that changing another three sensory characteristics as there were significant preference in odor, taste and texture after appearance modification. For spinach and sweet potato, only odor was found with significant preference after appearance modification.

Another implication of this pilot study was the likely occurrence of various attributes and the ratings of ten familiar fruits and vegetables. The CA map results showed points of dimensions that were closely clustered together. The attributes closely associated with children's good or extremely good ratings may represent valuable data for our understanding in preparing new foods with fruits and vegetables that could appeal to children, thus prompting them to consume more. On the other hand, the attributes closely correlated with children's bad or extremely bad ratings could be avoided in contemporary food processing. An understanding of the sensory attributes of fruits and vegetables could assist the food industry in modifying food products, particularly rich in fruit and vegetable content. Food manufacturers could promote higher consumption of fruits and vegetables by modifying foods to exhibit attributes that are appetizing to children and by including fewer attributes that children perceive to be repulsive. With recent developments in molecular gastronomy, the sensory characteristics and thus the sensory attributes of fruits and vegetables could be modified with innovative cooking techniques. The findings of this study encourage further research in applying food technology to enhancing public health nutrition.

Limitation

This study is a preliminary study with 12 primary school students and the sampled fruits and vegetables were only ten. The identifications of sensory attributes with the small sample size could not be generalized to a whole populations and all fruits and vegetables. However, the significant improvement in eggplant would be worth for further studies in a robust design.

Conclusion

Modification in eggplants changing the sensory characteristics of odor, taste and texture was found to be appealing and gained more children's favor compared with their original forms. The appetizing and repulsive attributes of the sampled five fruits and five vegetables may provide supporting data for food modification in molecular gastronomy.

Disclosure

This manuscript has not been published elsewhere and has not been submitted for publication elsewhere.

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