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Appearance alteration of fruits and vegetables to increase their appeal to and consumption by school-age children: A pilot study

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Abstract

Picky eating with regard to fruit and vegetables is common among children. This study investigated the effectiveness of enhancing the visual appeal of fruit and vegetables to increase children's liking and consumption of fruit and vegetables. A pre–post experimental design was used, and the control and experimental groups were repeatedly exposed to the original food and transformed food, respectively, over 6 weeks. Significant differences in the consumption of pumpkin, sweet potato, spinach, carrot and aubergine were observed between the groups, demonstrating that the appearance appeal of fruit and vegetables improves the willingness of children to try disliked fruit and vegetables and increases their vegetable consumption.

Keywords

appearance alteration, fruit and vegetable consumption, fruit and vegetable liking, repeated exposure, school-age children

Introduction

For the growth and health of school-age children, a daily minimum intake of two pieces of fruit and three vegetables is recommended (World Health Organization, 2015). However, this is challenging to implement. Low rates of fruit and vegetable (FV) consumption among children are a severe dietary problem worldwide. A study revealed that only 26 per cent of children aged 6–11 years and approximately 10 per cent of children aged 4–8 years consumed the recommended amount of FVs (Guenther et al., 2006). In Hong Kong, a study reported that less than half of the surveyed children consumed the recommended amount of fruit and fewer than 20 per cent of them consumed sufficient portions of vegetables (Department of Health, 2011; Lo et al., 2015). This echoed the finding of another study which reported that 22 per cent of children were rarely provided with vegetables during lunch, which could probably be attributed to the frequency of dining out among local families (Hui and Nelson, 2006). Other than at lunch, few FVs were consumed by children at home because many children disliked FVs and parents reported it difficult to successfully serve FVs in meals. Despite the same study reporting that 93.3 per cent of the parents who responded ensured the daily availability of fruit, total daily FV consumption was only 201, 182 and 159 g among children aged 6–7 years in the overweight, middle-weight and low-weight groups, respectively. The findings indicated that children in Hong Kong did not meet the recommended daily FV consumption of 400 g and that increased promotion is required because children with lower FV intake are prone to higher intake of foods with greater energy densities (Spill et al., 2011), which may lead to an increased risk of obesity. Moreover, sufficient consumption of FVs in early

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childhood was reported to improve health throughout this period and into adulthood (Craigie et al., 2011). Consequently, effective strategies are required to increase the appeal and consumption of FVs among children. Some studies have identified numerous reasons for low FV intake among children, for example, children typically prefer sweet and salty foods and tend to reject unfamiliar or bitter foods (Cooke, 2007; Drewnowski et al., 2012) because they have an evolutionary inclination to select sweet-tasting foods because such foods are energy dense and thus provide essential nutrients for growth. Their inclination for energy-dense foods has a correlation with their affinity for FVs, with greater sweetness resulting in a higher acceptability among children (Gibson and Wardle, 2003). However, only some fruits and vegetables are sweet tasting, which may explain the low intake of FVs among children. To exacerbate the situation, children have an inherent inclination to reject foods of unknown or bitter taste because they fear possible toxins or bacteria (Wardle and Cooke, 2008). This negative attitude towards new foods develops during early childhood and can extend into adulthood if available food variety does not increase (Dazeley et al., 2012).

To address the problem of low FV intake among children, a study investigated how the visual appeal of food can promote its consumption (Jansen et al., 2010). This is because food first stimulates humans visually, and its appearance may induce expectations regarding its other sensory features, consequently enhancing its acceptance and consumption (Dazeley et al., 2012). In support of this argument, Hurling and Shepherd (2003) reported an association between the appearance and expectation of liking a food, which influences a consumer's final evaluation of the food. Overall, these studies have provided a basis for further investigating the visual appeal of FVs to child consumers.

To enhance the effectiveness of our experiment, the children must have sufficient exposure to the food because unfamiliarity often hinders the introduction of new foods to children. Some studies have reported that increasing the number of exposure incidents was effective in persuading school-age children to like a food (Wardle et al., 2003a, 2003b). Such exposure can be visual or gustatory. Visual exposure is effective for influencing the willingness of children to try unfamiliar fruits, but gustatory exposure is more effective for helping to persuade them to try unfamiliar vegetables (Houston-Price et al., 2009). Liking, as a measured outcome in some studies, is the expectation of a food generated by its appearance that affects a consumer's final evaluation of the food (Hurling and Shepherd, 2003). Liking a food may not necessarily elicit the willingness to try or consume the food. Sudre et al. (2012) used three methods to explore the different patterns of dynamic liking during food consumption, with the result that the beginning of the consumption event determined the overall liking of a food. This implies that actual consumption is highly correlated with the liking of a food at the beginning of the consumption event; however, the antecedent of liking and consumption remains unknown. According to Houston-Price et al. (2009), 'willing to try' is described as a subject undergoing the act of placing a food in their mouth. In addition, the effectiveness of repeated exposure varies depending on the food type. Repeated exposure is more effective for changing a child's liking of fruits than for changing their liking of vegetables. Horne et al. (2004) indicated that as few as three tastes sufficed to establish a liking of fruits. Similarly, Hausner et al. (2012) indicated that mere exposure to a novel vegetable changed some children's intake by the fifth exposure, even though 30 to 40 per cent of the children were resistant to change. Although less effective of repeated exposure to vegetables on children's intake, Lakkakula et al. (2010) reported that eight to nine tastes of a vegetable influenced the greatest number of children in changing their 'poorly liking' status to one of 'liking'. However, O'Connell et al. (2012) reported that repeated exposure did not increase vegetable consumption. In summary, these findings suggest that future research should set the minimum exposure to three presentations for fruits and eight presentations for vegetables to change a child's preference from 'dislike' to 'like'. Through associative conditioning, a significant increase in the liking of vegetables was observed by the sixth exposure; however, this affinity did not increase afterwards (Frasca et al., 2012). Overall, our hypothesis follows these guidelines to facilitate proper food preference transformation through six exposures to vegetables.

Children's liking of vegetables was identified as an elementary predictor of their vegetable consumption (Brug et al., 2008), and this liking can be learnt (Caton et al., 2014), whereas their liking of fruits can be increased by enhancing their visual appeal. The effect of FV transformation on children's liking and acceptance is worth investigating. Because studies have primarily investigated the presentation of fruit to increase visual appeal, children can recognise the types of fruit that they dislike, which often lowers the effectiveness of such trials. To overcome this psychological barrier, we considered FV transformation in which the appearance was changed completely, but the original ingredients were retained. For example, a banana would be cut, frozen and moulded into various shapes and then transformed into ice cream without adding additional ingredients. Such transformed FVs, if repeatedly exposed to children, are hypothesised to be able to increase children's liking and consumption of these foods. Therefore, the primary purpose of this study was to investigate the effectiveness of repeated exposures to transformed FVs to increase children's liking and consumption of certain foods. The secondary purpose of this study was to compare the effectiveness of repeated exposure to the visual appeal of transformed FVs for enhancing children's liking and consumption.

Care was taken in this study to prevent the interference of factors that might influence the test results. In particular,

nonsensory factors were revealed to contribute significantly to the liking and acceptance of foods (Wadhera et al., 2014). These include food names (Cardello et al., 2012), proximity and visibility (Deng and Srinivasan, 2013; Kennedy-Hagan et al., 2011; Privitera and Creary, 2012; Wansink et al., 2006), varieties (Levitsky et al., 2012), portion sizes (Burger et al., 2011), colours (Koza et al., 2005) and shapes and surface areas (Van Ittersum and Wansink, 2011; Wada et al., 2007).

Methods

Design and settings

This pilot study adopted a pre–post experimental design. Approval for the study was granted by the Ethics Review Committee of the Research Department at the University. The sample, comprising students at a primary school in Hong Kong that had been chosen through convenience sampling within the school network of the research team, participated in screening for FV liking and consumption. The primary school was a direct subsidised school located in Tin Shui Wai, a location with a mix of public and private residential estates, in the New Territories West in Hong Kong. Thus, most students were of an average socioeconomical background.

Participants

The target participants were school children aged 7–10 years and of Chinese ethnicity. The age inclusion criterion was included to ensure that the children could cognitively express their liking of FVs and understand the instructions given for the experiment (Chen et al., 1996). The inclusion criterion for Chinese ethnicity was to control for the interference of cultural differences on the outcome measures of the experiment. The exclusion criteria for the sample were students with known food allergies, on restricted diets, or with chewing or swallowing problems because these factors might limit their food choices, which may in turn affect the outcome measures of their food liking and consumption.

The participants' parents received a screening questionnaire to complete. Questions were asked regarding the general FV eating patterns of participants with reference to 10 types of FVs. Out of these 10 types, 5 were fruits (namely, apple, orange, mango, blueberry and banana) and 5 were vegetables (namely, sweet potato, pumpkin, spinach, carrot and aubergine). These 10 common FVs were selected because of their ready availability and high accessibility all year in Hong Kong markets. Our intention was to exclude the factor of neophobia or unfamiliarity with rare foods, which would undermine the acceptance of the food. Each question was provided with categorical choices of *often, sometimes, rarely* and *never* for each FV consumption. This screening questionnaire was validated with 5 parents with their children tasting 10 sampled FVs. The validity index of the questionnaire was 0.84, and its internal consistency was 0.9. The children were asked to rate their liking of FVs during baseline measurements. The categorical choices for liking were *super good, really good, good, not sure, bad, really bad* and *super bad* for each of the 10 sampled FVs. If the parents selected *rare* and *never* for general FV consumption questions, or the children selected one or more of *not sure, bad, really bad* and *super bad* for the liking questions of the 10 sampled FVs, then the children were screened and recruited to participate in the experimental study.

Material preparation

The transformed FVs are listed in Table 1. We designed and developed the transformed FVs based on snacks that were appealing to school-age children. Most of the snacks were prepared using raw ingredients with no other ingredients or condiments added (e.g. an apple popsicle, orange popsicle and pumpkin pancake). Some of them required additional ingredients to set them in their new shapes (e.g. blueberry jelly required agar-agar, and the sweet potato, spinach and carrot cake needed flour). Several required decorations and supporting ingredients (e.g. the banana ice cream required cones and the mango sushi required rice cubes for support). Although the transformed aubergine cube required a small amount of oil for cooking, the food was no different from its original form. Overall, the principle for transformation was, as much as possible, to retain the natural flavour of the ingredients and ensure that the cooking process was healthy, with little oil and no condiments.

Intervention

In the first 4 weeks, the children in each intervention group (the control group and the experimental group) were served a pairing of one fruit and one vegetable every afternoon. The pairings were the same for the two intervention groups. Five distinct pairings of FVs were served in 1 week, and this FV pattern was repeated in the first 4 weeks for both groups, with the children tasting the same FVs but in different physical forms each time for the experimental group. To control food intake, every child in both groups received approximately 50 g each of the fruit and the vegetable daily, and the actual weight of each food sample in the experiment was measured before and after it was served. In week 5, the same pattern and food forms were served to the children in both groups; however, those in the transformed food (TF) group were required to participate in a workshop session before each pairing was served. In the session, a researcher presented the original food (OF) and preparation of the TF to be served that day. The rationale for these workshops was to provide the children in the TF group with information on the original TF ingredients and prepare them to try the OF in week 6. Therefore, in week 6, only the

Table 1. Summary on food preparation.

Original food	Preparation of food in OF group	Serving temperature	Transformed appearance	Preparation of food in TF group	Serving temperature
Fruits					
Apple	Raw apples were peeled and cut into four slices radiated from the core.	20°C–23°C	Popsicle	Raw apple slices were peeled to remove skin. They were cut and blended into thick smoothie texture. They were filled into popsicle moulds and covered with sticks. They were stored in refrigerator at −20°C until the smoothie was frozen.	−20°C–0°C
Orange	Raw oranges were peeled and cut into four slices radiated from the core.	20°C–23°C	Popsicle	Raw orange were peeled to remove skin. Slices were blended and then filtered to extract the orange flesh and juice. They were filled into popsicle moulds and covered with sticks. They were stored in refrigerator at −20°C until the smoothie was frozen.	−20°C–0°C
Mango	Raw mango were peeled and cut into irregular flesh.	20°C–23°C	Sushi	Raw mango was cut into thin pieces in size of 6 cm × 2 cm and in 0.5-cm thickness. Rice was cooked and cooled to room temperature. Each piece of mango was put on top of a rice cuboid of 30 g.	20°C–23°C
Blueberry	Blueberry were washed and served as their original sizes.	20°C–23°C	Jelly	Raw blueberries were blended into thick smoothie texture. With 200 mL blueberry smoothie, 5 g agar-agar were added and mixed. The smoothie was then filled in the jelly moulds. They were stored in refrigerator at 4°C until the smoothie was in solid state.	Around 4°C
Banana	Banana was peeled and cut into shorter pieces of 4 cm length each.	20°C–23°C	Ice cream	Raw banana was peeled to remove skin. The banana was cut into smaller units which were put in the refrigerator at −20°C. They were frozen for 12 hours. Before administration to the students, the frozen banana was put into a pressor, and the banana was pressed slim and flew continuously out of the machine. They were swirled into a cracker cone.	−20°C–0°C
Vegetables					
Sweet potato	Sweet potatoes were cut into smaller size and steamed at 100°C for 20 minutes. Sweet potatoes were cooled down at room temperature.	20°C–23°C	Cookies	Sweet potatoes were steamed at 100°C for 20 minutes. They were meshed and pressed into 0.5 cm thick and cut with a star shape cutter. They were then baked in an oven at 175°C for 20 minutes. The cookies were cooled down at room temperature.	20°C–23°C
Pumpkin	Pumpkins were cut into smaller sizes and were steamed at 100°C for 20 minutes. Pumpkins were cooled down at room temperature.	20°C–23°C	Pancake	Pumpkins were steamed at 100°C for 20 minutes. They were meshed and pressed into 0.5 cm thick and cut into circles and each of 10 cm in diameter. They were then pan-fried in a flat bottom pan in medium fire for 3 minutes. No oil was added. The pancakes were cooled down at room temperature.	20°C–23°C
Spinach	Spinach was washed. A bowl of water was boiled at 100°C and spinach was put into the boiling water. After 5 minutes, water was drained and spinach was cooled down at room temperature.	20°C–23°C	Noodles	Fresh spinach was smashed in a blender. Flour and water was added to the spinach in a ratio of 1:1:2. The mixture was put in a mixer and mixed until the ingredients formed a dough. The dough was cut into long and round noodles. A bowl of water was then boiled to 100°C. The noodles were put into the boiled water for 12 minutes. Water was drained and noodles were cooled down at room temperature.	20°C–23°C
Carrot	Raw carrot was cut into 0.5 cm thick and 8 cm long.	20°C–23°C	Cakes	Carrots were grated into small pieces. Vegetable oil and flour were added to the grated carrot in the ratio of 1:6:6. Three eggs and two teaspoons of baking soda were added. The mixture was mixed in a mixer at low speed and was filled into the batter. The mixture was scooped to paper muffin cups with each ¾ full. The muffin cups were baked in an oven at 177°C for 35 minutes. The cupcakes were then cooled down at room temperature.	20°C–23°C
Eggplant	Eggplants were cut into 0.5 cm thick and 8 cm long. A tablespoon of vegetable oil was added to a flat bottom pan. The cuboids of eggplants were pan-fried in medium fire for 5 minutes. The slices were cooled down at room temperature.	20°C–23°C	Cube	Eggplants were cut into small cuboids. A tablespoon of vegetable oil was added to a flat bottom pan. The cuboids of eggplants were pan-fried in medium fire for 5 minutes. The eggplant cuboids were cooled down at room temperature.	20°C–23°C

OF: original food; TF: transformed food.

OFs were served to the children in both groups, and the pairing pattern remained the same as before.

Instruments

Hedonic Facial Scale. A 7-point Hedonic Facial Scale (HFS) was used to assess the children's FV liking (Pagliarini et al., 2003). It comprised smiley faces and sad faces that represented the degree of like or dislike for children's ease of comprehension. In the experiment, children were required to colour in a smiley or sad face to reflect their liking of a given food.

Outcome measurements

FV liking evaluations. FV liking was evaluated in classrooms in the presence of a researcher at the baseline and in weeks 4 to 6 of the experiment. The ordinal data recorded in the HFS represented liking coded as 1 to 7, with 1 indicating the most liked and 7 indicating the least liked. In the evaluations, the children in both the TF and OF groups were required to indicate their level of liking in the HFS of the served FVs 5 minutes after they had eaten the foods. The purpose of the 5-minute wait was to ensure that the children had stopped trying the food samples. For simplicity, liking of a fruit or vegetable at the baseline was recorded under LF0. Similarly, FV liking was recorded as LF4 and LV4 in week 4, LF5 and LV5 in week 5 and LF6 and LV6 in week 6.

FV consumption. A researcher was present when the foods were consumed. The net weight of the served foods before consumption was measured to the nearest 0.1 g using an electronic scale. In the experiment, the children had full autonomy regarding their food consumption. After consumption, the children left the room and the researcher measured the food remaining in the containers used to serve the FVs. The differences in the weights of the foods before and after consumption provided the weight consumed, and the percentage of consumption was calculated by dividing the weights of the foods consumed by their respective original weights.

Procedure

At the beginning of the study, an information sheet describing the study objective, task details, duration, and implications were sent with a consent form to the parent of each child who met the inclusion criteria. Consequently, 35 children with parental consent were recruited to participate in the study. They were then randomly assigned to two intervention groups: 17 to the OF group and 18 to the TF group.

The purpose of the OF (control) group was to examine the effect of only exposure on children's liking, whereas the TF (experimental) group was used to observe the effect of transformed FVs in combination with their repeated exposure on children's liking of them. As already stated, some studies have reported that five repeated exposures with associative conditioning persuaded 60 per cent of children to taste vegetables (Frasca et al., 2012), and the intervention in this study was designed to allow each child to try all 10 FVs in 5 pairings per week; this pattern was repeated for 6 consecutive weeks. The experiment was conducted in a quiet room on one child at a time to avoid peer influence. Children were asked to eat a pair of FVs at their own pace and, when finished eating, to rate their liking of the provided FVs by using the HFS. The child then left the room, and the net weights of the unfinished FVs were measured using an electronic scale.

Data analysis

SPSS (version 21) was used to statistically analyse the data collected in the study. A median test was performed and indicated that no significant differences existed between the baseline FV liking of the two groups (all $p > 0.05$). Hence, Mann–Whitney U tests were used to compare the groups at the baseline and identify any heterogeneity in the children's liking of the 10 sampled FVs; Wilcoxon signed-rank tests were conducted to compare the children's FVs liking before and after repeated mere exposure of the foods. A repeated-measures analysis of variance (ANOVA) was then performed to determine whether any significant effects could be observed over the 6-week FV consumption period. All tests were conducted at a significance level of $p = 0.05$. Because participants were selected randomly and were independent from one another, the collected ordinal data for FV liking in the HFS met the assumptions of the Mann–Whitney U test and Wilcoxon tests. For FV consumption, the ratio data, converted into percentages, also met the assumptions of the ANOVA.

Results

The participant characteristics presented in Table 2 indicate that the mean age of the TF group was significantly higher than that of the OF group ($p < 0.001$). This was primarily because of the randomisation of the group assignments on a class basis to prevent the cross-contamination of participants. A chi-square test was performed and yielded nonsignificant results regarding sex differences in the OF and TF groups, demonstrating that the proportion of male and female participants assigned to the two groups had a nonsignificant effect on the test results. As for the liking of the transformed fruits, the Mann–Whitney U test results revealed nonsignificant differences in children's liking of bananas ($U = 108.5, z = -1.503, p = 0.133$), apples ($U = 147.5$, $z = -0.189$, $p = 0.850$), blueberries ($U = 138.5$, $z = -0.487$, $p = 0.626$), mangos ($U = 135.00$, $z = -0.672$, $p = 0.501$) and oranges ($U = 100.00$, $z = -1.818$, $p = 0.069$) between the groups. These results indicated that the five sampled

Table 2. Participants' characteristics.

	OF ($n=17$)	TF ($n=18$)	p-value
Age, mean (SD)	8.85 (0.34)	9.39 (0.50)	<0.001
Sex			
Male	7 (41.2%)	8 (44.4%)	>0.05
Female	10 (58.8%)	10 (55.6%)	
Baseline liking rate of fruits, mean (SD)	2.18 (1.47)	3.53 (2.04)	>0.05
Baseline liking rate of vegetables, mean (SD)	2.28 (1.02)	3.17 (1.10)	>0.05

OF: original food; TF: transformed food; SD: standard deviation.

Table 3. Comparison of children's reported likings of fruit and vegetables by Hedonic Facial Scale.[a]

	Median			Median		
	OF			TF		
	Pre	Post	Wilcoxon test, Z	Pre	Post	Wilcoxon test, Z
Fruits						
Banana	2	1	−1.260	3	2	−2.796**
Apple	3	1	−2.026*	2	2	−0.226
Orange	2	1	−1.309	3	1	−3.001**
Mango	1	1	−0.669	1	1	−0.106
Blueberry	4	3	−1.912	3	3	−0.106
Vegetables						
Sweet potato	5	4	−0.889	4.5	4	−0.665
Pumpkin	6	5	−2.745**	5	4.5	−1.507
Spinach	4	3	−0.670	3.5	3	−0.924
Carrot	5	5	−1.075	5	5	−0.032
Eggplant	6	5	−1.131	5	5	−0.160

OF: original food; TF: transformed food.
[a]Hedonic Facial Scale: 1 indicating the most liking and 7 indicating the least liking.
*$p<0.05$; **$p<0.01$.

transformed fruits had limited effects on children's liking. As for transformed vegetables, the Mann–Whitney U test results revealed nonsignificant differences in the children's liking of sweet potato ($U=122.50$, $z=-1.031$, $p=0.302$), pumpkin ($U=113.50$, $z=-1.372$, $p=0.170$), spinach ($U=130.50$, $z=-0.753$, $p=0.452$), carrot ($U=147.00$, $z=-0.203$, $p=0.839$) and aubergine ($U=106.00$, $z=-1.599$, $p=0.110$) between the groups. These results indicated that the five sampled transformed vegetables also exhibited limited effects on children's liking.

Children's liking of fruits and vegetables

Table 3 lists the median scores of self-reported liking for the sampled FVs in both groups. Regarding the repeated exposure of only the OF for 6 weeks, significantly increased liking for all five sampled fruits was noted. A significant increase in liking ($z=-2.026$, $p<0.05$) was discerned only for apples in their original forms. A significant increase in liking was observed for pumpkin in only its original form after 6 weeks of repeated exposure ($z=-2.745$, $p<0.01$). A significant increase in liking was discerned for bananas ($z=-2.796$, $p<0.01$) and oranges ($z=-3.001$, $p<0.01$), which constituted the largest effects of repeated exposure in their transformed forms. However, a nonsignificant increasing liking ($p>0.05$) was revealed for vegetables with repeated exposure in transformed forms.

Children's consumption of fruits and vegetables

Table 4 lists the mean percentages of food consumption observed from week 1 to week 6. The results revealed that the mean consumption percentages at week 6 were lower than those at week 1 for the 10 FV samples in both groups. Between the groups, all mean percentages of FV consumption in the experimental group were higher than those of the control group, as observed at week 1. At week 6, the mean percentages of FV consumption in the TF group were discovered to be higher than those in the OF group, with the exception of blueberry and aubergine. Statistically, no significant difference was observed between the groups with regard to fruit consumption. The effect sizes of fruit

Table 4. ANOVA analysis of direct observations in food consumption over 6 weeks between groups.

Food item	OF Mean % First vs sixth week	TF Mean % First vs sixth week	*F*-value	Effect size (η^2)
Mango	82, 71	96, 89	$F(1, 26) = 3.548$	0.120
Apple	87, 63	100, 67	$F(1, 25) = 3.101$	0.110
Orange	100, 68	100, 79	$F(1, 21) = 2.975$	0.124
Banana	82, 59	94, 81	$F(1, 33) = 3.971$	0.107
Blueberry	57, 40	73, 37	$F(1, 28) = 0.745$	0.026
Pumpkin	54, 29	89, 57	$F(1, 26) = 12.422^{**}$	0.323
Sweet potato	38, 28	83, 54	$F(1, 26) = 14.953^{**}$	0.365
Spinach	64, 45	96, 63	$F(1, 21) = 8.926^{**}$	0.298
Carrot	56, 41	86, 50	$F(1, 33) = 11.248^{**}$	0.254
Eggplant	33, 13	67, 10	$F(1, 28) = 6.007^{*}$	0.177

OF: group tested with repeated exposure in original food; TF: group tested with repeated exposure in transformed food; ANOVA: analysis of variance.
$^{*}p < 0.05$; $^{**}p < 0.01$.

consumption between the experimental and control groups were discovered to be intermediate for mango ($\eta^2 = 0.120$), apple ($\eta^2 = 0.110$), orange ($\eta^2 = 0.124$) and banana ($\eta^2 = 0.107$). The effect size of blueberry consumption, however, was found to be small ($\eta^2 = 0.026$).

Regarding vegetable consumption, significant differences in the consumption of pumpkin, sweet potato, spinach, carrot and aubergine were observed between the two groups. The highest η^2 value was noted for sweet potato ($\eta^2 = 0.365$), followed by pumpkin ($\eta^2 = 0.323$), carrot ($\eta^2 = 0.254$), spinach ($\eta^2 = 0.298$) and aubergine ($\eta^2 = 0.177$), indicating high effect sizes in group variances. Hence, the appearance transformation produced a more favourable effect on children's FV consumption at the first and sixth attempts.

Discussion

Despite their excellent nutritional value, FVs are often rated the least popular foods among children (Cooke and Wardle, 2005). Our findings concurred with the global phenomenon that a low percentage of children meet the recommendations for healthy FV consumption. More critical is that the preference for unhealthy foods and eating habits in childhood leads to health problems in adulthood (Harris, 2008). To mediate the adverse effects, strategies for encouraging children to interact with FVs to increase consumption have been researched, and repeated exposure has been reported as among the successful strategies. Repeated exposure is often used to tackle the natural predispositions towards unfamiliar foods. To be more effective, some studies have suggested that children's liking of FVs is enhanced through multisensory experiences (Dazeley et al., 2012). The findings for the control group in this study supported this argument because FVs were repeatedly exposed to children's senses of taste, vision, touch and olfaction. The significant increase in consumption of most of the sampled FVs in this study demonstrated that mere exposure was sufficiently powerful to affect the willingness of children to try foods that they dislike. As for the duration of effective exposure, studies have suggested that 6–10 presentations, in general, entice children to accept their rejected foods (William et al., 2008), and this pilot study confirmed that exposing children six times to disliked apple and pumpkin was sufficient to increase their liking significantly. Moreover, children in the control group exhibited an increased liking of most sampled FVs, which indicated that mere exposure was effective in enhancing FVs acceptance, regardless of their appearance. Although some of our findings were nonsignificant (with the exception of apple and pumpkin), they complemented those of previous studies that have reported that increased exposure familiarises children with FVs, which may in turn alter children's FV perceptions and eating preferences. Hence, research has revealed that parents are justified in their continual endeavour to provide their children with FVs.

In real life, repeatedly reminding children to try foods that they dislike causes distress to parents. Parents can find it difficult to persist in exposing their children to disliked foods for the six times required to induce a positive change in their eating behaviours (Wardle et al., 2003a, 2003b). Research has revealed that 80 per cent of parents stop trying to control their children's diets once their children had rejected the offered food three to five times (Carruth et al., 2004). This indicated a practical obstacle for parental promotion of FV consumption at home. Food-exposure strategies are urgently required to support parents continue their attempts. In this respect, Dazeley's (2012) review contributed to addressing the nontaste properties of disliked foods, such as their appearance, smell and texture, which were often ignored but are worth exploring in future research. As demonstrated by this study, FVs prepared in appealing forms can be key to lowering the barriers for children to try these foods.

In our study, we were wary of the possible concerns of parents regarding daily FV servings, which were primarily served in conventional forms, that is, that they might doubt the practical value of TF in helping their children consume OFs in daily life. If a child's liking of FVs was not directly associated with consumption, it would be meaningful in our study to compare the results of FVs consumption in different forms. Furthermore, some individuals might wonder whether a higher consumption of TF is positively associated with their OF consumption. To test these arguments, the children in the TF group were informed of the FV ingredients in week 5 and were served the OF samples without any transformation in week 6. Their liking ratings at week 6 reflected their degree of liking for the original FVs, and the actual quantity consumed (g) reflected the willingness of the children to consume the original FVs. In this study design, the pre–post measures reflected the children's FV eating preferences and association between different forms of FVs.

Between the two groups, higher consumption (all FVs, with the exception of orange) was observed in the TF rather than the OF group at week 6, indicating that children, in general, were more interested in consuming FVs in modified forms, which suggests that appearance compels children to try to eat more. This finding echoes Dazeley's (2012) explanation that the visual stimulation of foods has a potential influence on children's willingness to eat them. From the findings obtained over 6 weeks, consistently higher consumption of FVs was observed in the TF group than the OF group, indicating that the increased interest of children in consuming FVs can be sustained with lower levels of neophobia. This study added another dimension to current research because other studies have revealed that mere exposure did not increase the vegetable consumption of children and few studies have experimented with vegetable appearance to increase its consumption.

In this study, the children in the OF group liked bananas, oranges and mangos, whereas the children in the TF group liked apples and mangos. Conducting basic or transformed-appearance repeated FV exposure did not significantly enhance the children's liking. However, children who disliked the sampled vegetables at the baseline presented higher liking scores in both the OF and TF groups. Hence, the enhancement of liking was obvious after the intervention. Moreover, pumpkin and aubergine scored the least in liking among the five vegetables at the baseline measure. One possible explanation for this could be the children's innate acceptance of their sweet stimuli, which has been evidenced in early childhood development (Caton et al., 2014). The tasting experience changed their perception of the vegetables, and it was observed that the positive consumption experience of the TF may have benefitted OF consumption. The presentation of vegetables in appealing snack form thus warrants further detailed investigation.

Another observation is the enhancement of liking and consumption resulting from the change in serving temperature and texture. Regarding FV appearance transformation, the other nonsensory properties of FVs, such as colour, size, wholeness, shape, consistency and gloss, may change, which would affect the characterisation of their texture as crunchy, hard, soft or creamy. Moreover, cooking or food-preparation processes also affected the temperature of the served FVs. For example, apple in the form of an apple popsicle had a serving temperature that changed from warm to cold and a texture that changed from crunchy to hard. Although the children grew to like apple in this form more in this study, this could be mediated by the changed serving temperature and modified texture, and whether this transformation in appearance caused students to eat more apples was not determined. From another perspective, the results also revealed a lower consumption of FVs in the sixth attempt than in the first attempt. This lower consumption might be the result of boredom experienced by the children from consuming the same pattern of food samples over a period of 6 weeks, which had an adverse effect on their interest. In future studies, to increase effectiveness, the critical number of exposures should be less than that adopted in this study, and exposure to FVs should preferably be shorter and less intensive.

Nevertheless, the implications of the findings of this study are valuable because they provide preliminary evidence that children's acceptance of disliked FVs can be enhanced by simply altering their appearance. The findings are particularly useful in home settings because the food-preparation techniques involved are simple and can be readily applied. The findings add value to the current knowledge that appearance transformation is an essential factor for enhancing children's consumption of FVs. However, further in-depth investigation is required on how sensory attributes influence children's acceptance of FVs to obtain a more comprehensive understanding of the optimal sensory attributes.

Limitation and future research

In this pilot study, children from a primary school who seldom consumed FVs were screened for participation in this experiment. Some improvements to the study design can be introduced. First, in the target population, the children's FV preferences varied and they did not dislike all of the sampled FVs (such as mango). Second, those who disliked fruits may not have disliked vegetables, and vice versa. By testing children with regard to both FVs, the study was forced to restrict sampling to those children who disliked both fruits and vegetables. Third, the group assignment based on class was prone to cross-contamination among participants if they were from the same school because they had the opportunity to discuss intervention details during the study period.

This pilot study was the first of its type, and this article provides an innovative marketing strategy for enhancing FV consumption among school-age children. However, the study design could be improved by grouping children by

food type. Children who dislike fruit could be assigned to the fruit group and children who dislike vegetables could be assigned to the vegetable group of the experiment. This would allow for more accurate differentiation and delineation of the effect of appearance transformation with repeated exposure on children's acceptance and consumption of FVs. In our future study, the control and intervention group assignments will be randomised on a school basis to prevent cross-contamination among participants.

Practical applications

The insufficient FV intake of children is a challenge to parents as well as health authorities. With innovations in food technology, the appearances of foods can be transformed to be more appealing than the original forms. Our findings indicated that food appearance transformation is an effective marketing strategy for enticing children to consume more FVs. The results of this study can provide food manufacturers with valuable insights into strategies for encouraging children to taste and consume more FVs.

Conclusion

Repeated exposure and appearance transformation increased children's willingness to try FVs that they disliked and increased their vegetable consumption. This combined approach may facilitate behavioural changes leading to increased consumption of FVs.

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