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EVALUATION OF A SENSORY-BASED FOOD EDUCATION PROGRAM ON FRUIT AND VEGETABLE CONSUMPTION AMONG KINDERGARTEN CHILDREN

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ABSTRACT

Objectives: To pilot whether a sensory-based food education program, "Rainbow Food Heroes," increases children's intended and actual fruit and vegetable consumption.

Methods: The behavioral intervention, Rainbow Food Heroes, a sensory-based food education program, consisted of two 90-minute workshops delivered in one week, followed by a "Rainbow Plate" themed school assembly one week later. Baseline and post-intervention data were collected 11 days before the beginning of the intervention period and two days after the completion of the school assembly at the end of the intervention, respectively. The participants were 72 kindergarten children in a Canadian urban elementary school. The outcomes measured were intention to eat fruit and vegetables, number of colors of fruit and vegetables children selected, and actual consumption of these foods. Comprehension of the Rainbow Plate message was assessed by measuring the number of colors of pictures of fruit and vegetables added to a paper "theoretical Rainbow Plate" during the second workshop.

Results: Post-intervention, children selected an average of 261.13 grams of fruit and vegetables compared to 185.96 grams at baseline assessment (75.17 grams more). They also selected more varied colors (0.3) on their plates compared to baseline. Children consumed an average of 159.35 grams post-intervention compared to 106.74 grams at baseline, which was an increase of 52.6 grams. Children added, on average, four different colored fruits and vegetables to their theoretical rainbow plates, which suggested good comprehension of the Rainbow Plate concept during the workshop.

Applications to Child Nutrition Professionals: The Rainbow Food Heroes sensory-based food education program may influence children to increase fruit and vegetable consumption. The Rainbow Food Heroes program may be adopted as a fun sensory-based element of a nutrition curriculum.

Key Words: kindergarten children; fruit and vegetable consumption; behavioral intervention; sensory-based; food education.

INTRODUCTION

Similar to recommendations for adults, children should consume at least five servings (about 400g) of fruit and vegetables per day (WHO, 2015). A Canada-wide survey in 2004 suggested that 59% of children aged 2-17 eat fewer than five servings of fruit and vegetables per day (Shields, 2005) and several other recent studies have supported this finding (Glen, Thomas, Loebach, Gilliland, & Gobert, 2013; Government of Canada, 2015; Moffat & Galloway, 2008). The situation is similar in the United States: according to data from 2007-2010, 93% of children did not meet the recommended vegetable intake and 60% did not meet the recommendation for fruit (Centers for Disease Control and Prevention [CDC], 2014). Because consuming fruit and vegetables has been associated with health benefits (Boeing et al., 2012; Slavin & Lloyd, 2012), including lower rates of obesity (Shields, 2005) and delayed onset of non-communicable diseases (WHO, 2017), increasing consumption during childhood is desirable for improving population health outcomes.

Eating behaviors formed during early childhood tend to persist through childhood and even into adulthood for some individuals (Birch, Savage, & Ventura, 2007; Mikkilä, Räsänen, Raitakari, Pietinen, & Viikari, 2005). Thus, successful interventions targeting young children may be an effective way of supporting healthy eating behaviors throughout life. This age group, however, presents multiple challenges, including strong innate taste preferences for sweetness and aversions to sour and bitter flavors linked to genetic predispositions (Fildes et al., 2016). This makes children's acceptance of bitter or sour fruit and vegetables particularly challenging. Furthermore, young children frequently exhibit "food neophobia," which is the reluctance to try unfamiliar foods. This typically begins around age two (Battjes-Fries, Haveman-Nies, Renes, Meester, & van't Veer, 2015; Dazeley, Houston-Price, & Hill, 2012). Food neophobia and innate preferences often limit children's appetite for healthy foods, variety in the diet (Dazeley et al., 2012), and particularly the consumption of vegetables (Knaapila et al., 2015).

Successful strategies for increasing children's food neophilia (willingness to try new foods), and acceptance of a variety of fruit and vegetables include: early and repeated exposures, food tasting associated with positive food experiences, and good role models (Holley, Farrow, & Haycraft, 2017; Nekitsing, Hetherington, & Blundell-Birtill, 2018). The greatest increases in vegetable acceptance and intake occurred with repeated taste exposure (Nekitsing et al., 2018), but modest increases also occur with exposure using the other senses—touch, sight, hearing, and smell (Coulthard & Sealy, 2017; Heath, Houston-Price, & Kennedy, 2014; Holley et al., 2017). Based on such findings, sensory-based food education has been developed to expose children to healthy foods by allowing them to interact with and explore foods through various activities which use their five senses (Coulthard, Williamson, Palfreyman, & Lyttle, 2018; Hoppu, Prinz, Ojansivu, Laaksonen, & Sandell, 2015; Witt & Dunn, 2012). Songs, games, stories and other creative activities have been used to make the sensory-based food education fun and engaging (Dazeley et al., 2012; Witt & Dunn, 2012). Sensory-based interventions have been found to be most effective with children under six years old (Lynch, 2012); outcomes have included reduction in food neophobia, short-term increases in food neophilia (Battjes-Fries et al., 2015; Coulthard & Thakker, 2015; Hoppu et al., 2015; Mustonen & Tuorila, 2010; Park & Cho, 2016), and greater knowledge of and positive attitudes towards unfamiliar foods, vegetables, and healthy eating (Battjes-Fries et al., 2015).

Information on how food education programs impact actual fruit and vegetable consumption is limited (Coulthard & Thakker, 2015; Sirikulchayanonta, Iedsee, Shuaytong, & Srisorrachatr, 2010; Witt & Dunn, 2012), with some program evaluations based on parent self-reports rather than data collection (Coulthard & Thakker, 2015). Our pilot study aimed to add to the literature with data measuring fruit and vegetable consumption among kindergarten children who participated in a sensory-based food education program. Rainbow Food Heroes is a sensory-based food education program developed by the social enterprise, Rainbow Plate (http://www.rainbowplate.com/). This program incorporates a fun and engaging overarching "rainbow" theme that is also connected to the nutrition message to eat a variety of fruit and

vegetables from all the colors of the rainbow. This pilot assessed the immediate impact of the Rainbow Food Heroes on children's: (a) intention to consume and (b) consumption of a variety of different colored fruit and vegetables during a school lunch period.

METHODOLOGY

Study Design

A pre-post study design was used to assess the short-term impact of Rainbow Food Heroes sensory-based food education. This research received ethics approval from the School Board and the collaborating university prior to the study. The study period was a total of four weeks. Baseline data were collected 11 days before the intervention began. The intervention included two workshops and a school assembly. The second workshop was delivered approximately two days after the first workshop, and understanding of the Rainbow Plate (RP) concept was assessed at the end of the second workshop. The school assembly was held one week after the last workshop. The post-intervention data was collected two days after the school assembly.

Sample

Five classes of kindergarten students, a total of 118 children, were invited to participate in the study. Children were 4 to 6 years old, enrolled in junior or senior kindergarten. The junior kindergarten year is for children who are 4 years old by the end of the calendar year in which they enrolled; at the time of the study these children were 4 or 5 years old. The senior kindergarten is a second year of kindergarten, and these children were 5 or 6 years old when they participated in the study. Of the 118 children invited to participate, 94 parental consents were received (79%). Only participants who attended both workshops and had complete data sets from the pre- and post-intervention assessments, a total of 72 children, were included in the analyses. The classes of children were balanced in terms of the demographic characteristics of number, gender, and age, as shown in Table 1.

Table 1. ***Demographic Characteristics of Participants (n=72)***

Variable	N (%)
Gender	
Female	36 (50)
Male	36 (50)
Classroom	
A	17 (24)
B	15 (21)
C	14 (20)
D	8 (11)
E	18 (25)
Grade	
Junior (age 4-5)	33 (46)
Senior (age 5-6)	39 (54)

Intervention

The intervention consisted of two 90-minute workshops delivered to the children in their classroom (approximately 20 students in each class), and a school assembly. During the first workshop, children were told a story about eating a rainbow of foods. A rainbow of fresh fruit and vegetables was revealed and explored to generate excitement about the variety, colors, and sensory qualities of different fruit and vegetables. The children were taught how to create RPs by including fruit and vegetables of various colors on their plate at every meal and snack. They were also taught the RP rhyme, “Rainbow plate, rainbow plate; tell me the colors that you ate,” which they chanted while creating RPs. Children then explored (i.e. visually examined, smelled, touched, licked, bit, tasted and/or swallowed) a total of 15 different fruits and vegetables, three at five different color stations: red, orange, yellow, green and blue/purple. (See Table 2). Children spent approximately 7 minutes at each color station, rotating in groups of four or five. At each color station, the children were encouraged to chant the RP rhyme. Children also received a matching color sticker and bingo stamper to mark their keepsake RP on their paper plate such that after visiting each color-station, the children had collected all the colors of the rainbow on their paper plate. This keepsake "Rainbow Plate" also had a sticker with the RP rhyme on it.

During the second workshop, a brief presentation reviewed concepts from the first workshop. Children then completed the same color-station activity; some foods were the same, but each station had one or two new foods. At the end of the activity, children created their “theoretical RPs”: they were given a paper plate with a photo of a non-produce food item and a variety of fruit and vegetable images they could glue onto their plate. There were 20 images of rainbow produce items and 29 non-produce food images that included meats, grain products, eggs, dairy, and legumes. The children created the theoretical RPs individually while seated at clustered desks (four students). This activity assessed whether children could create a RP with produce and non-produce food items. Photographs of each child’s theoretical RP were taken at the end of the workshop. All RPs created by the children had magnets attached to them, and children took them home after the workshop where they could display them (e.g., on the

refrigerator), as cues to action as outlined by the Health Belief Model (Glanz, Rimer, & Viswanath, 2015).

The following week, kindergarten children helped lead a school assembly designed to share the RP concept with older primary students in grades one to three. Students were selected to transform a non-produce meal on a plate (e.g., chicken, noodles, yogurt) into a RP by adding fruits and vegetables from a display. The kindergarten students championed their peers by chanting the RP rhyme, and were acknowledged as Rainbow Food Heroes during the assembly. The school assembly was included as a component of the intervention because community and peer engagement is important in establishing school norms, peer and community recognition, fostering social support, and creating a sense of leadership for the children. In particular, social support has been identified as important for obtaining assistance from peers, feeling respected, and feeling a sense of belonging to the social network (Bandura, 2004).

Table 2. ***Fruit and Vegetables Used in Sensory Education at the Workshop Stations***

Color Station	Workshop 1	Workshop 2
Red	Peppers Grape Tomatoes Watermelon	Apple Peppers Strawberries
Orange	Baby Carrots Orange Slices Cantaloupe	Baby Carrots Peppers Apricots
Yellow	Peppers Corn Asian Pears	Bananas Pineapple Corn
Green	Celery Cucumber Chayote	Sugar Snap Peas Green Grapes Spinach
Blue/Purple	Blueberries Purple Cabbage Plums	Blueberries Purple Cabbage Blackberries

Data Collection

Baseline intention to consume and actual consumption of fruit and vegetables was measured 11 days prior to the beginning of the intervention through observation with a digital photography record (Martin, Nicklas, Gunturk, Correa, Allen, & Champagne, 2014) and actual weights (as described by Sirikulchayanonta et al., 2010, and Witt & Dunn, 2012). Cherry tomatoes, watermelon, carrots, oranges, yellow peppers, Asian pear, celery, cucumbers, purple cabbage, and blueberries were offered during a school-scheduled pizza lunch (“pizza day”). All the children had the same lunch period and ate at the same time.

The post-intervention observation was conducted two days after the school assembly and used the same procedure with the same fruit and vegetables as baseline. Given the nature of the study as a pilot, a short follow-up period made the most sense logistically. Data was collected soon after to allow immediate assessment of whether the teaching methods were suitable for kindergarten children including the manner of explanation of the RP concept (Frazier, Gelman, & Wellman, 2016).

Children were each given a plate with an ID number and selected fruit and vegetables on their own. Before receiving their pizza or eating a home-made lunch, the plates were photographed and weighed at the photograph station: a digital camera mounted on a tripod in front of a tared scale that captured food selection and weight (grams). If children wanted more, a new plate with the same ID number was provided and marked to signify second or third helping. After lunch, research assistants (RAs) collected the plates, threw out remaining pizza or home-made lunch, and photographed and weighed the plates again.

The outcome variables were: children's intention to eat fruit and vegetables (weight placed on plate), number of colors on the child's plate scored from one to five colors (red, orange, yellow, green, and blue/purple), and the weight of fruit and vegetables consumed. The children's understanding and short-term retention of the RP concept was evaluated by identifying the number of colors on the theoretical RPs in the second workshop. The data was input into SPSS by one research assistant and verified by a second.

Data Analysis

Wilcoxon signed-rank test was used to investigate the pre- and post-intervention differences in children's intention to eat fruit and vegetables (weight placed on plate), number of colors on the child's plate, and weight of fruit and vegetables consumed before and after the intervention. Linear regressions were applied to investigate whether the difference between pre- and post-intervention were associated with gender, classroom or grade. Statistical tests were two-sided and significance level was set at $p < 0.05$. All statistical analyses were conducted using SAS software V9.4 (SAS Institute Inc. Cary, NC, USA).

RESULTS

Intention to Eat Fruit and Vegetables

The mean intentions to eat fruit and vegetables pre- and post- intervention as assessed based on student self-selection of offered produce items were 185.96 and 261.13 grams, respectively. The intervention significantly increased participants' intention to eat fruit and vegetables with a mean difference of 75.17 grams ($p < 0.001$) as shown in Table 3. This was a 40% increase. These differences were not associated with gender, grades, and classrooms, after adjustments for the pre-intervention values.

Number of Colors on Children's Plates

The mean number of colors on children's plate in pre- and post-intervention were 3.18 and 3.51 respectively (based on a 1-5 scale). The total number of colors represented on children's plates significantly increased from pre- to post-intervention. See Table 3. The least change was seen among children who already added a variety of colors to their plates at baseline. Similarly, no significant differences by gender, classroom or grades, after adjusting for the pre-intervention values, were seen.

Fruit and Vegetable Consumption

The mean fruit and vegetable consumption pre- and post-intervention was 106.74 grams and 159.35 grams, respectively. There was a significant pre- and post-intervention difference seen in fruit and vegetable consumption mean of 52.61 or 50%, as shown in Table 3. These differences were not associated with gender, grades and classrooms, after adjustments for the pre-intervention values.

Theoretical Rainbow Plates

Approximately 75% of the 72 participants included four or five colors on their theoretical RP, and about 20% included two or three colors. The average number of colors on a plate was

four, indicating a good understanding of the RP concept. There was no significant difference between gender (P=0.07) and grade (P=0.28).

Table 3. ***Change in Mean Representation of Intention, Color, and Consumption of Fruits and Vegetables between Pre- and Post-Intervention***

Outcome[1]	Pre	Post	Difference	P value[2]
Intention to consume (grams)[3]	185.96 (166.86)	261.13 (187.93)	75.17 (151.87)	<0.001
Colors, number added[4]	3.18 (1.35)	3.51 (1.33)	0.33 (1.31)	<0.02
Consumption (grams)	106.74 (99.65)	159.35 (142.03)	52.61 (102.29)	<0.001

1. Outcomes are presented as a mean (standard deviation)
2. P values are calculated using Wilcoxon signed-rank test
3. Intention to consume was measured by weight (grams) of self-selected fruit and vegetables (cherry tomatoes, watermelon, carrots, oranges, yellow peppers, Asian pear, celery, cucumbers, purple cabbage, and blueberries)
4. There were a total of 5 color categories: red, orange, yellow, green and blue/purple

DISCUSSION

Comprehension and Retention

The results show that most children who attended the workshops demonstrated a greater selection and variety of colored fruit and vegetables on their plates post intervention based on children self-selection of produce items offered. Children also exhibited a greater consumption of fruits and vegetables with an increase of approximately 53g post intervention. Children also understood and retained the RP concept in the short-term, as demonstrated by most of the participants adding a variety of colors of fruit and vegetables to their theoretical and actual lunch plates.

In addition to the simple and memorable message, the workshop's visual and auditory components likely contributed to the children's understanding and retention of the information. They were able to handle, taste, smell and explore the fruit and vegetables showcased, and the RP rhyme engaged children. Semantically congruent auditory and visual components can significantly improve children's recognition and retention of concepts (Heikkilä & Tiippana, 2016). Similarly, when children integrate information from two or more senses, recognition and recall increase (Bjorklund, 2005). Thus, the workshops' engagement of multiple senses, as demonstrated in past research, likely made the RP concept more memorable.

The timing of the workshops was also designed for optimal child learning. The workshops were spaced two to three days apart, which has been shown to improve memory retention in children under six years old (Schneider et al., 2009). Additionally, following the workshops, children could bring home all their completed RPs, affixed with magnets. They could display the plates at home as cues to action, as outlined by the Health Belief Model (Glanz, Rimer, & Viswanath, 2015), for themselves and their families.

Intervention Impact

The results from this study are similar to evaluations of other food education programs with sensory-based components. Witt and Dunn reported an increase in fruits and vegetables (31% and 24%, respectively) one week after their intervention and at three month post-intervention (20.8% and 33.1%, respectively), suggesting sustained benefits (2012). Sirikulchayanonta et al. (2010) reported an increase in vegetable (100% or 24g) and fruit (45%

or 12g) intake following an intervention compared to our findings which showed increases of both fruit and vegetables combined (50% or 53g). Similar to our study, these two studies also observed and measured actual food intake during school lunches, rather than relying on parental reports of intake or proxy measures including "liking" as measured by Coulthard et al. (2018) and Coulthard & Sealy (2017).

Witt and Dunn (2012) and Sirikulchayanonta et al. (2010) conducted larger interventions with multiple components delivered over six and eight weeks, respectively, with comparable results to Rainbow Food Heroes. Rainbow Food Heroes primarily focused on sensory-based exploration of food, and was only offered as two workshops within a one-week period; thus, promising similar results with less intensity and effort than previous multi-week interventions. Experiential learning, such as taste testing, gardening and food preparation, has been recommended as a strategy to promote fruit and vegetable consumption in children enrolled in kindergarten to grade 12 (Ciliska et al., 2000; Langellotto & Gupta, 2012). In younger children, studies on various ages from 2 to 6 years, taste and other sense exposure have shown greater effect on food preferences, selection and consumption than other aspects of experiential learning (Nekitsing et al., 2018).

Schools provide an excellent intervention opportunity as they can expose children to food, and contribute to creating social norms about tasting healthy and/or unfamiliar foods (Battjes-Fries et al., 2015). Comprehensive school policies can give students consistent, health-reinforcing messages from multiple sources (e.g., classrooms, food services, health services), by example or role modeling and through teaching (Brug, Tak, te Velde, Bere, & de Bourdeaudhuij, 2008). This may be crucial, because children tend to have less autonomy in making food choices, so environmental rather than personal factors may be more important determinants of their nutrition/eating behaviors (Brug et al., 2008).

Limitations & Strengths

Since the study was a pilot, the intervention was only evaluated in the short-term, within two weeks after the workshops and two days after the school assembly. This is a relatively short follow-up period compared to other studies that cited a 3-month follow-up period (Sirikulchayanonta et al., 2010; Witt & Dunn, 2012). The study population was relatively small, and using a non-randomized design limits any direct identification of cause and effect. Confounding variables, such as which snacks the children ate before lunch on the pre- and post-evaluation days, may have affected the results. Although lunch monitors were supervising the children for adherence to the instructions, measurement errors from children exchanging fruit and vegetables, eating off each other's plates, or accidently throwing out food or dropping it could have occurred. One classroom had many more students than others, which slowed food selection. This may have affected participants' decisions or ability to take seconds. Additionally, fruit and vegetable intake was not measured separately.

Increased food intake during school lunchtime may not translate to changes in eating habits at home. For instance, children may not have an array of fruits and vegetables available or the opportunity to choose foods at home. However, school environments may increase an intervention's impact due to peer effect, as research suggests that peer modelling strongly influences young children's (age 3 to 5 years) preferences and willingness to try new foods (Birch, 1980; Dovey, Staples, Gibson, & Halford, 2008; Hendy & Raudenbush, 2000). Furthermore, observing children's eating behaviors at school controls the environment for food consumption assessment, as children have equal access to the same food, unlike the methodologies of home-based food education evaluations. Also, this study did not rely on children's or parents' self-reports, but measured actual consumed food weights.

Future Research

There is a growing body of evidence that indicates that sensory-based food education increases children's fruit and vegetable consumption, which may lead to healthier lifelong eating

habits. The results of this pilot study are promising, and further research on the sustainability of its short-term impact is warranted. Rainbow Food Heroes is a non-intensive and potentially cost-effective intervention that can be relatively easily integrated into children's education curriculum.

CONCLUSIONS AND APPLICATION

The Rainbow Food Heroes sensory-based food education program delivers a simple message using food exploration with colorful fruits and vegetables, multi-sensory interaction with food, along with visual and auditory learning. The results demonstrate effectiveness in children's understanding and retention of the Rainbow Plate concept. In the short term, this program appears to have increased children's intention to eat, as measured by self-served selection, and actual consumption of fruit and vegetables, thus helping kindergarten children make better food choices. Encouraging children to have fun exploring food can expand their food preferences and facilitate positive associations with a variety of healthy foods. Food education beginning in childhood may crucially contribute to sustainable healthy food habits that lead to better overall nutrition throughout the lifespan.

Although research on sensory-based food education is still on-going, the positive results from the body of research to date warrant consideration by curriculum decision-makers for inclusion in kindergarten and pre-school curricula. Sensory-based food education may be adopted as a module or curriculum element into existing nutrition education programs, such as Canadian health curricula, the USDA Child Nutrition Program including the Fresh Fruit and Vegetable Program, or the youth Expanded Food and Nutrition Education Program (EFNEP). The RP concept is easy to implement and can also be adapted to any existing food pattern, cultural preference, or regionally available fruits and vegetables. Translation and additional culturally appropriate symbolism, stories, and songs may be developed, but the current materials are already inclusive: a rainbow is a nearly-universally known and appealing symbol for children.

The assembly may be implemented as described, or modified to meet the needs and preferences of various schools or communities. A community gathering or project that involves leadership and recognition of the children for their understanding of healthy food choices could be similarly effective and could be substituted for the school assembly. Some important outcomes of community involvement include community awareness and support, and greater peer and adult role-modelling that help sustain healthy choices over the years (Bandura, 2004; Brug et al., 2008; Holley, Farrow, & Haycraft, 2017).

The cost of the implementation of the RP concept as a food education module is a consideration. Because it is a low-intensity intervention, the cost would be less than other multi-week intensive interventions, such as the intervention assessed by Sirikulchayanonta et al. (2010). Pairing the RP concept with existing school gardens, farm-to-school produce programs, or school breakfast and lunch programs could be an efficient, and possibly lower cost way to integrate current school food programs with sensory food education. There are challenges, of course, in partnering sensory food education with gardens or farm-to-school programs, including the seasonality of many fruits and vegetables, timing of delivery and meals, the need for procuring extra fruit and vegetables, and addressing food safety considerations. Nonetheless, the intervention is easily implemented because the concept has already been fully developed.

The best results for food and nutrition education are most likely to occur if the information is reinforced throughout the school year, among multiple grade levels, during school breakfast and lunch program meal periods, and at home, as suggested by the ecological approach to health promotion campaigns (Story, Kaphingst, Robinson-O'Brien, & Glanz, 2008; Townsend & Foster, 2013). The RP message could easily be printed on posters, on material disseminated within schools, and sent home. Workshop activities, such as the creation of the Rainbow Plate

that result in take-home material can be a part of the media that is sent home as reminders to nudge children and their families toward eating a variety of fruit and vegetables.

Consideration of school food policies should be included in any effort to increase children's consumption of fruits and vegetables as the environment and role-modeling have a significant influence on young children's food choices (Brug et al., 2008). Changing the school food environment in support of healthy options is necessary to give children the opportunity for making healthy choices. Despite regulation aimed to improve school food environments in Canada, availability of healthy options has not been supported in a significant number of schools (Fitzpatrick et al., 2017). In the United States, at many schools, the school food environment is significantly influenced by the National School Lunch Program (NSLP). Recent efforts have been made to improve the nutritional quality of NSLP food through the Healthy, Hunger-Free Kids Act in 2009 (Rouse, 2018), with success in many, but not all, schools (Mansfield & Savaiano, 2017). Time spent on meals is another important school food policy factor: children tend to eat more fruit and vegetables when they have more time to explore and eat their food (Cohen et al., 2015). Sensory-based food education programs, such as the Rainbow Food Heroes program, when used in context of a supportive school environment and complementing larger school campaigns to promote and support healthy eating, would likely have a much greater impact on children's consumption of fruit and vegetables than when used without changes to the food and social environment.

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