The Optimized Fruit and Vegetable Combination for Children Aged 10–12 Years in Central Jakarta, Indonesia

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Abstract. Fruits and vegetables (FV) contain essential vitamins and minerals for children's growth and development. Introduction of FV in young children can improve their preference for healthy food. The purpose of this study was to develop FV combinations based on children's preferences and balanced diet recommendations. This study used a school-based cross-sectional design and was conducted in four phases, including market surveys, group interviews, the development of FV combinations, and a hedonic test. The market survey's goal was to compile a list of FV availability and pricing. Forty-two children aged 10–12 years from two schools in Central Jakarta, Indonesia, took part in six different group interviews to determine FV preferences and serving size. FV combinations were developed using Linear Programming for Nutrisurvey. The hedonic test of FV combinations was followed by 80 children aged 10–12 from the same schools. This study developed five optimized FV combinations from six fruits (papaya, banana, guava, mango, dragon fruit, and red apple) and five vegetables (broccoli, carrot, yardlong bean, beansprouts, and spinach) with serving sizes ranging from 300–400 g; a price of IDR 5,000 or less; meeting the minimum daily requirement of energy, fiber, vitamin A, and vitamin C; and having at least three different colors in each combination. The combination of papaya, banana, guava, broccoli, and carrot provided the most energy (157.1 Cal). Meanwhile, the combination of papaya, mango, yardlong bean, carrot, and beansprouts contained the most vitamin A (428 µg) and vitamin C (103.2 mg). The children preferred all FV combinations that contained approximately 21 g of fiber (children's preference score ranged from 4.25–4.65 out of 5). Color, taste, aroma, and texture preferences of children can be met by optimized FV combinations. These optimized FV combinations should be incorporated into health promotion messages to promote FV as nutrient-dense foods available in the local market and affordable for children aged 10–12 years. Furthermore, the effectiveness of these optimized FV combinations on nutrient intake and nutritional status of children aged 10 to 12 years should be assessed.

Keywords: fruit and vegetable consumption · optimized fruit and vegetable combinations · school-aged children

1   Introduction

Fruits and vegetables (FV) contain essential micronutrients for growth and development, and they have been linked to a lower risk of cardiovascular disease, cancer, and premature death [1, 2]. Because eating habits persist into adulthood, introducing healthy diets such as FV consumption during childhood is critical for improving food preferences and academic achievement [3–5]. Therefore, this period is an optimal window for promoting adequate consumption of FV.

However, poor FV consumption among school-aged children is evident across the globe, especially in low and middle-income countries [6, 7]. As a result, vitamin and mineral deficiencies are common in this age group [6–10]. Likewise, Indonesian school-aged children were reported to have had a suboptimal intake of energy, fiber, and essential vitamins and minerals [11]. In addition to this finding, an Indonesian national survey showed that 9 out of 10 school-aged children consumed inadequate FV with an average daily consumption of 26 g of fruit and 34 g of vegetables [12].

Recent evidence has suggested that low consumption of micronutrient-rich (vitamin and mineral) FV is becoming increasingly common among school-aged children [6]. This low-variety diet is associated with micronutrient deficiencies [13, 14]. Previous studies also revealed that children were more likely to eat FV when the colors were diverse, the smell was pleasant, or the flavor was likable [15, 16]. On the other hand, sensitivity to taste and smell stimuli among children was related to less FV consumption [17]. In terms of cost, children considered fruit to be pricey but did not have as high a satiety value as unhealthy food did [18]. Additionally, less FV consumption may be influenced by a lack of availability in the local neighborhood [19].

Furthermore, child dietary guidelines alone are insufficient [20, 21], thus the recommended serving of FV in the guideline needs to be translated into details so that children, parents/caregivers, or school staff can fully understand the messages. Involving children in organizing FV as a main or snack menu is necessary to obtain their preference regarding variety, serving size, and price of FV. The preferred FV combinations will encourage healthy eating habits among children and will also provide detailed recommendations for parents/caregivers and school-meal programs in setting up food menus favored by the children and locally acquired. All these factors should be considered when designing an intervention program to increase FV consumption among school-aged children. However, studies reporting FV combinations based on school-aged children's preferences and recommended diets are very few. Therefore, this study stresses the importance of tailored FV intervention tools for successfully improving FV consumption in school-aged children. Based on this insight, this study aimed to develop FV combinations based on children's preferences and balanced diet recommendations.

2   Materials and Methods

This study uses a cross-sectional design and was conducted in 2017 in two primary schools in Central Jakarta, randomly selected from a list of primary schools obtained from the Central Jakarta Education Office. The study was conducted through 4 phases: (1) market survey (preliminary study); (2) group interviews; (3) development of FV

combinations; and (4) hedonic test. Data collection activities were conducted by trained enumerators with a community nutrition background.

2.1 Market Survey

This activity aimed to obtain information on the availability and price of fruits and vegetables (FV) near children's homes. The market survey was conducted in five markets, consisting of four traditional markets and one modern market. Available FV in the market were listed and then provided for the group interviews. The FV prices were converted to prices per 100 g of edible portion and were included in the analysis of developing FV combinations [22].

2.2 Group Interviews

This activity was carried out to obtain information about the preferred type and serving size of FV and the desired price to buy these FV. The qualitative approach of group interviews was selected as the data collection method because it allowed us to answer questions about the experience, meaning, and perspective of the participant [23]. The researchers recruited 42 children aged 10–12 years, purposively from 2 selected primary schools. These children were divided into 6 group interviews based on their ages: 2 each for the ages of 10, 11, and 12 years. Group interviews lasted for 60–90 min. This group interview was combined with a simulation of an FV shopping game for children led by a moderator. Researchers provided a variety of FV available on the market, a food scale, and stationery to record the FV weight. The moderator asked the children to playact shopping for FV in the market and chose 5 types of combined FV with the serving size they wanted to consume in a day. Under the supervision of the research team, the children were asked to weigh each of the selected FV. The note taker helped the children to write the type and weight of the selected FV into the form. Furthermore, each group discussed the amount of pocket money that children were willing to spend on FV. This activity was audio-recorded and transcribed by the research team.

One day before group interviews, structured interviews using questionnaires and anthropometric measurements were conducted among 42 children to obtain data on children's characteristics, including gender, parental working status, daily pocket money, nutritional status, and children's daily FV consumption. Anthropometric measurements were carried out by following standard procedures to obtain data on the nutritional status of children aged 10–12 years [24]. Height was measured using a height-measuring instrument and weight was measured using a digital AND scale [25]. The measurement results were used to calculate the nutritional status of children based on the body mass index-for-age z-score (BAZ) using the WHO AnthroPlus software [26]. The nutritional status of children was classified as thinness ($-3SD \leq BAZ < -2SD$), normal ($-2SD \leq BAZ \leq +1SD$), overweight ($+1SD < BAZ \leq +2SD$), and obese ($BAZ > +2SD$) [27]. Daily FV consumption was assessed using a semi-quantitative food frequency (SQ-FFQ) questionnaire.

Table 1. Data for analysis using LP for Nutrisurvey

	Minimum requirements
Energy (kcal)	$6\% \times 2.100 = 126$
Vitamin A (mcg)	$30\% \times 600 = 180$
Vitamin C (mg)	$30\% \times 50 = 15$
Fiber (g)	$\{(10 + 5) + (11 + 5) + (12 + 5)\}/3 = 16$
The total weight (g)	300–400

2.3 Development of Fruit and Vegetable Combination

The FV combination was developed using Linear Programming (LP) for Nutrisurvey software, which consisted of formulation and refinement stages [28]. Data from a market survey (price per 100 g of edible portion FV) and group interviews (type and serving size of preferred FV, desired price spent on FV) were prepared for analysis using LP for Nutrisurvey. The minimum and maximum serving sizes of FV combinations were set up according to the recommendation of 300–400 g of daily FV consumption for school-aged children [20]. Minimum consumption of energy and nutrient was calculated based on the Indonesian recommended dietary allowance (RDA) for boys aged 10–12 years [29] as follows: (a) energy meets a minimum of 6% of the Indonesian RDA [30] and (b) vitamin A and vitamin C meet a minimum of 30% of Indonesian RDA [31]. The minimum consumption of fiber was calculated based on the formula of children's age added with 5 (age + 5) (Table 1) [32]. The FV combination obtained from the formulation stage was then re-analyzed in the refinement stage with the consideration of seasonality and color variation.

2.4 Hedonic Test

This activity aimed to obtain an acceptance score of an optimized FV combination among school-aged children using a hedonic test [33]. A total of 80 children aged 10–12 years from 2 primary schools were randomly selected to participate in the hedonic test [34]. The hedonic scale used a 5-scale hedonic questionnaire that contained a series of facial expression images arranged sequentially, starting from a frowning face to a grinning face, representing the ratings "very much dislike (score 1)", "dislike a little (score 2)", "not sure (score 3)", "like a little (score 4)", and "very much like (score 5)". This hedonic scale was more suitable for children or younger age groups due to its simplicity [33]. The assessment included the color, taste, aroma, and texture of the optimized FV combination (Fig. 1).

2.5 Data Analysis

The characteristics of children, type of FV, serving size of FV, and price per 100-g edible portion of FV was analyzed descriptively. An optimized FV combination was
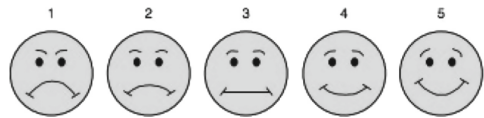
Fig. 1. The facial hedonic test scale used in the study

developed using LP for Nutrisurvey and the result of each stage was presented descriptively. Energy, fiber, and nutrient content were determined using the Indonesian food composition database and calculated by NutriSurvey for Windows, version 2007 [35, 36]. Acceptance of the optimized FV combination was presented as a mean score hedonic test in the chart.

2.6 Ethical Considerations

This study received research ethical approval from the Health Research Ethics Commission of the National Institute of Health Research and Development of the Indonesian Ministry of Health. All school-aged children and their parents were fully informed about this study and signed informed consent before data collection.

3 Results

Of the 42 children aged 10–12 years, more than half (64.3%) were boys, and half of them were overweight (33.3%) and obese (16.7%). More than 40% of children lived with working parents and had an average amount of pocket money of IDR 10,000 per day. The average fruits and vegetables (FV) consumption of children was 77 g and 25 g per day, respectively (Table 2).

Table 3 summarizes the types, serving sizes, and prices per 100 g of the edible portion of children's preferred FV. Group interviews produced 33 types of preferred FV, including 19 fruits and 14 vegetables with desirable one-day serving sizes. Children preferred red apples the most (45.2%), followed by mango (42.9%), banana (38.1%), dragon fruit (23.8%), and oranges (23.8%). Carrots had the highest proportion of vegetable consumption (40.5%), followed by spinach (23.8%), water spinach (19%), cucumber (19%), and broccoli (14.3%). Bananas (IDR 1,026) and mustard greens (IDR 863) had the lowest average prices in the FV group (the inflation rate at the time of the study was 3.72% [37]). Group interviews revealed that children would spend up to IDR 5,000 of their pocket money on FV.

As shown in Table 4, analysis during the formulation stage yielded 30 FV combinations, with the final 5 FV combinations successfully developed for school-aged children. These 5 optimized FV combinations met the recommended daily serving size of FV consumption; met the minimum daily requirement of energy, fiber, and nutrient; were inexpensive for children; had 3–4 different colors; and were available in the local market.

Table 5 shows the five optimized FV combinations. Six fruits (papaya, banana, guava, mango, dragon fruit, and red apple) and five vegetables (carrot, yardlong bean, beansprouts, spinach, and broccoli) were used to create the combinations. A combination

Table 2. Characteristics of children aged 10–12 years (n = 42)

	n	**%**	**Median (min-max)**
Sex			
Boys	27	64.3	
Girls	15	35.7	
Nutritional Status[1]			
Thinness	4	9.5	
Normal	17	40.5	
Overweight	14	33.3	
Obese	7	16.7	
Father's working status[2]: working	41	100	
Mother's working status[2]			
Working	18	43.8	
Not working	23	56.1	
Pocket money per day (IDR)			10,000 (5,000–25,000)
Consumption of FV per day[3]			
Fruit consumption (gram)			77 (0–529)
Vegetable consumption (gram)			25 (0–232.9)

[1]Nutritional status based on body mass index-for age z-score (BAZ); [2] n = 41; [3] SQ-FFQ methods, FV consumption in the last month; Min = minimum; max = maximum

Table 3. Type, serving size, and price of preferred FV among children aged 10–12 years (n = 42)

Commodity[1]	**n**	**%**	**Median serving size (g)[1] (min-max)**	**The median price per 100-g edible portion (IDR)[2] (min-max)**
Fruits				
Apple	19	45.2	127 (79–338)	3,409 (2,841–4,420)
Mango	18	42.9	238 (40–300)	2,769 (2,308–3,677)
Banana	16	38.1	125 (100–148)	1,026 (1,000–2,093)
Dragon fruit	10	23.3	170 (111–201)	3,008 (2,707–4,511)
Orange	10	23.8	84 (74–164)	2,613 (1,750–2,778)
Watermelon	8	19	143 (73–240)	1,717 (1,304–2,174)
Grapes	8	19	60 (20–87)	5,625 (4,500–7,000)
Longan	8	19	25 (9–120)	7,500 (7,475–7,500)

(*continued*)

Table 3. (*continued*)

Commodity[1]	n	%	Median serving size (g)[1] (min-max)	The median price per 100-g edible portion (IDR)[2] (min-max)
Strawberry	7	16.7	46 (15–104)	6,198 (4,115–9,449)
Mangosteen[3]	6	14.3	27 (21–60)	8,779
Snake fruit	5	11.9	84 (64–127)	1,398 (1,075–1,774)
Melon	4	9.5	205 (160–275)	1,721 (790–2,238)
Papaya	3	7.1	132 (125–145)	1,333 (533–1,933)
Avocado	3	7.1	121 (79–155)	3,270 (2,459–5,984)
Guava	3	7.1	133 (95–190)	1,220 (976–1,463)
Soursop	3	7.1	197 (146–244)	2,346 (2,206–2,485)
Roseapple	3	7.1	53 (50–56)	2,998 (889–3,889)
Pear	2	4.8	100 (94–106)	2,347 (2,000–2,941)
Pineapple	2	4.8	92 (85–98)	1,509 (833–1,694)
Vegetables				
Carrot	17	40.5	47 (22–87)	1,250 (706–2,176)
Spinach	10	23.8	26 (6–137)	1,380 (1,127–1,761)
Water spinach	8	19	20 (9–30)	1,389 (1,333–2,83)
Cucumber	8	19	52 (26–136)	1,455 (667–4,891)
Broccoli	6	14.3	63 (7–138)	3,125 (1,875–7,363)
Beansprouts	5	11.9	15 (9–21)	900 (700–1,200)
Mustard greens	4	9.5	25 (10–39)	863 (697- 1,149)
Yardlong bean	2	4.8	43 (40–45)	1,175 (800–1,630)
Cauliflower	2	4.8	47 (39–54)	3,071 (2,632–3,509)
Oyster mushroom[3]	2	4.8	40 (37–43)	2,000
Chayote	1	2.4	166	1,928 (964–2,410)
Tomato	1	2.4	114	1,200 (1,000–1,500)
Green bean	1	2.4	37	1,333 (1,111–2,500)
Napa cabbage	1	2.4	29	1,266 (588–2,059)

[1]Group interviews; [2] Market survey near children's homes; [3] Only available in 1 market; Min = minimum; max = maximum

of papaya, banana, guava, broccoli, and carrots provided the most energy (157.1 Cal). Meanwhile, the combination of papaya, mango, yardlong bean, carrot, and beansprouts provided the most vitamin A (428 g) and vitamin C (428 g) (103.2 mg). All FV combinations contained about 21 g of fiber.

Figure 2 displays the results of a hedonic test of five optimized FV combinations in children aged 10–12 years. With an average score of 4.25–4.65 out of 5, children preferred

Table 4. Development of optimized FV combinations for children aged 10–12 years

Stages[1]	Number of combinations
Fruits and Vegetable Identification	
Formulation	
Ensuring the serving size of FV ≥ 0	138
Ensuring the serving size of FV $\geq$ minimum (gram) and $\leq$ maximum (gram)	94
Ensuring the nutrient content $\geq$ minimum nutrition requirement	89
Ensuring the fiber content $\geq$ minimum fiber requirement	82
Ensuring the price of FV combination $\leq$ the desired price[2]	30
Refinement	
Combining FV based on local and seasonal commodities	25
Ensuring color variation ≥ 3 colors	10
Ensuring the total serving size of FV combination 300–400 g	5

[1] Analysis using LP for Nutrisurvey software; [2] Price were obtained from group interviews (IDR 5,000)

Table 5. The optimized FV combination for daily consumption of children aged 10–12 years

Description	Weight (g)	Household serving size		
Combination 1:				
Papaya	100	1 medium slice	Price (min–max)	= Rp 4,947 (4,345–11,169)
Banana	120	1 big size	Energy	= 157.1 Cal
Guava	80	1 small size	Fiber	= 21.2 g
Broccoli	25	2 tbsp	Vitamin A	= 215.2 µg
Carrot	50	5 tbsp	Vitamin C	= 88.8 g
Total weight	375			
Combination 2:				
Papaya	145	1 big slice	Price (min–max)	= Rp 4,963 (3,600–12,045)
Mango	60	¼ medium size	Energy	= 127.9 Cal
Yardlong bean	45	3 tbsp	Fiber	= 21.5 g
Carrot	60	6 tbsp	Vitamin A	= 428 µg

(continued)

Table 5. (*continued*)

Description	Weight (g)	Household serving size		
Beansprouts	10	1 tbsp	Vitamin C	= 103.2 g
Total weight	320			
Combination 3:				
Papaya	90	1 medium slice	Price (min–max)	= Rp 4,955 (4,291–15,536)
Mango	40	¼ medium size	Energy	= 155.3 Cal
Guava	140	1 big size	Fiber	= 21.3 g
Spinach	50	½ cup	Vitamin A	= 260 µg
Carrot	20	2 tbsp	Vitamin C	= 69.8 g
Total weight	340			
Combination 4:				
Papaya	130	1 big slice	Price (min–max)	= Rp 4,905 (6,130–16,590)
Red apple	40	¼ big size	Energy	= 142.9 Cal
Banana	100	1 medium size	Fiber	= 21 g
Carrot	25	2 ½ tbsp	Vitamin A	= 243.7 µg
Yardlong bean	40	3 tbsp	Vitamin C	= 95 g
Total weight	335			
Combination 5:				
Papaya	145	1 big slice	Price (min–max)	= Rp 5,000 (5,831–9,784)
Dragon fruit	70	½ small size	Energy	= 131 Cal
Carrot	25	2 ½ tbsp	Fiber	= 21.6 g
Yardlong bean	40	3 tbsp	Vitamin A	= 242.7 µg
Beansprouts	20	2 tbsp	Vitamin C	= 92.8 g
Total weight	300			

Household serving size = a measure commonly used in everyday households to estimate the amount of food consumed, eaten, or cooked; tbsp = tablespoon; Min = minimum; Max = maximum.

all optimized FV combinations. Combination 3 (papaya, mango, guava, spinach, and carrots) received the highest overall score (4.65) (color = 4.43; taste = 4.48; aroma = 4.30; texture = 4.53).
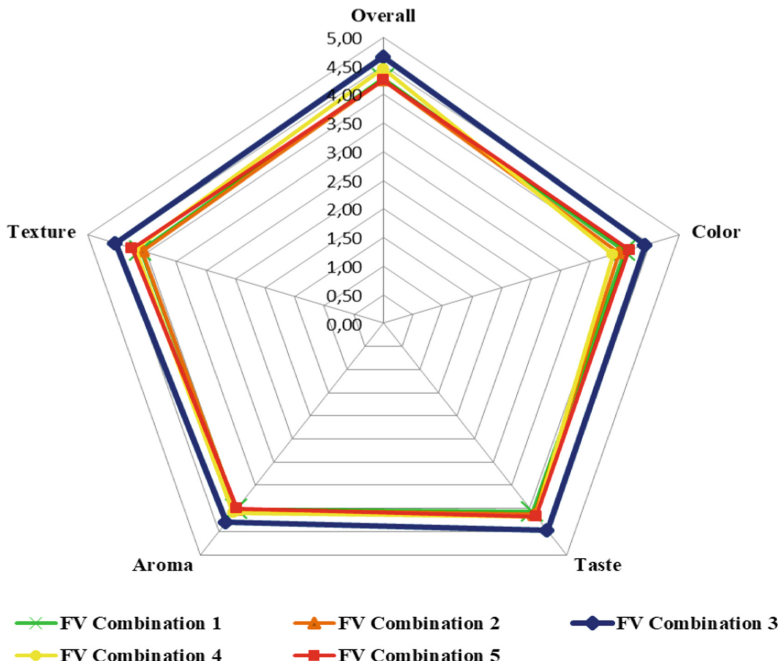
Fig. 2. A score of hedonic tests of optimized FV among children aged 10–12 years

4   Discussion

The study has developed five optimized fruit and vegetable (FV) combinations for children aged 10–12 years. This result is in line with the Indonesian Balanced Nutrition Guidelines (BNG) encouraging the concept of eating plenty of FV [20]. The five FV combinations not only met the minimum daily requirements of essential nutrients, but they were also affordable, available in local markets, and well-accepted by children in terms of color, taste, aroma, and texture. However, in contrast to the Indonesian BNG, the developed FV combinations had larger serving sizes of fruit than vegetables. The FV serving size obtained from group interviews may explain this result, as it expressed the preferred amount of FV consumed per day by children who had more fruit than vegetables on their plates. Moreover, fruits typically have sweeter flavors than vegetables, making them more appealing to children. This finding was supported by a qualitative study of school-aged children aged 10–11 in Belgium and the Netherlands [38, 39]. Furthermore, the LP approach allows us to consider other food-related factors such as availability, desired nutrient content, and price, allowing us to vary the type and serving size of FV in the combination [28].

Parents and caregivers are encouraged to include these optimized FV combinations into their current family dietary practices and to spend their food budget on them. Planning family meals with children is essential to have healthy foods they enjoy at home.

Moreover, nutrition education and behavior-change communication are necessary to promote these optimized FV combinations. Thus parents, caregivers, and schoolteachers can educate children about the types and portions of FV they should consume daily.

This study also highlighted the finding of insufficient FV consumption among school-aged children. This result was even lower than the national average daily FV consumption among Indonesian children aged 5–12 years, which was 109.2 g for fruit and 52.7 g for vegetables [40]. This finding was confirmed by a systematic review of Indonesian studies involving adolescents aged 10–19 years [41]. This pattern was also observed in European studies, which reported a significant disparity between fruit and vegetable consumption among children aged 10–12 years and its recommendation in food-based dietary guidelines [42, 43]. Poor FV consumption among school-aged children is associated with factors across multiple levels. A scoping review study in US elementary students found that serving sliced fruits and vegetables first, allowing more time for eating, using incentives, using social marketing and/or nutrition education curricula, and using the updated nutrition standards all had a consistent positive association with FV consumption at school lunch [44]. Environmental factors influence FV intake by influencing FV availability. In Brazil, neighborhoods with a higher density of healthy food stores had higher FV consumption [45]. Furthermore, increased exposure to unhealthy foods and fewer affordable healthy food options near schools provide a barrier for children to consume FV [46].

Adequate FV consumption is a simple indicator of a balanced diet because it contains fiber as well as essential vitamins and minerals that may help prevent chronic diseases. According to a systematic analysis for the Global Burden of Disease Study 2017, low fruit intake was one of the leading dietary risk factors for 2 million deaths and 65 million disability-adjusted life-years (DALYs) globally and in many countries [47]. A meta-analysis of 26 cohort studies found that consuming 5 servings of FV per day was associated with lower total mortality, CVD mortality, cancer mortality, and respiratory disease mortality [48]. Inadequate FV consumption also impacted the country's economic burden, with estimates ranging from $CAN 3.3 billion per year in the Canadian adult population, 30.5% on direct healthcare costs and 69.5% on indirect costs related to lost productivity [49]. Therefore, effective intervention to increase FV consumption during childhood is critical to establishing healthy eating habits and better health outcomes later in life.

The use of purposeful sampling in group interviews, which allowed the results to be extrapolated only for children in the population with similar characteristics to this sample study, was a limitation of this study. Despite these constraints, to the best of our knowledge, this is the first study to develop optimized FV combinations for children aged 10–12.

5   Conclusion

The current dietary practice of FV in children aged 10–12 years in this study did not meet the Indonesian BNG. The five optimized FV combinations developed in this study met the minimum daily requirements of essential nutrients, were affordable, available in local markets, and well-accepted by children in terms of color, taste, aroma, and texture. These

optimized FV combinations should be incorporated into health promotion messages to promote FV as nutrient-dense foods for children aged 10–12 years. Furthermore, the effectiveness of these FV combinations on the nutrient intake of children aged 10–12 years should be evaluated. This study recommends interventions to increase FV consumption in children aged 10–12 years. To achieve children's liking and acceptance of FV, a multicomponent intervention involving parents/caregivers and teachers is required. Parents can provide FV access and serve as role models for their children by eating FV at home, while teachers can educate children to consume more healthy foods and encourage decision-makers to provide FV in the school canteen.

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