



# Healthy and sustainable school meals – proposal for a new quality index SMI-LE

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## Abstract

**Introduction and Objective.** Provision of healthy and high-quality school meals is an important solution to improve children's health and well-being. Moreover, the meals provided at schools should not only meet dietary guidelines but also questions of sustainability. The aim of the study was to develop a new index to assess the quality of school meal menus, specifically their accordance with actual regulations, dietary guidelines and some sustainability goals.

**Materials and method.** The School Meal Index-Lunch Evaluation (SMI-LE) is an originally created index to evaluate the quality of 5-day school menus. The general idea is to reflect the healthy and sustainability issues that should be present in school canteens according to WHO and EU recommendations. The index was tested in a real-life situation and fifty 5-day school menus available online from primary schools located in different regions of Poland, in rural and urban areas, were assessed with SMI-LE.

**Results.** The median value of SMI-LE equaled 52 /140 points. Most of the analyzed menus (72%) were classified as 'Medium' quality according to SMI-LE. The menus classified as 'Low' were characterized by the lowest energy value, the lowest content of calcium, magnesium, iron, potassium, and folates, while the highest of sodium. Menus from the 'Good' category had the highest nutritional value, as well as the lowest sodium content.

**Conclusions.** A novel tool to has been provided for measuring the quality of school meals that addresses health and sustainability issues. It responds to the need for new indices that would consider changes in dietary guidelines and increasing knowledge about the impact of food systems on the environment.

## Key words

sustainability, children and adolescents, health, school meals, meal quality index

## INTRODUCTION

Optimal growth and development in childhood and adolescence is crucial for lifelong health and well-being, in which food security plays a key role. School meals are one of the elements ensuring food safety for children and young people. Their importance is confirmed by the results of research conducted during the lockdown period during the COVID pandemic, which showed that the lack of a school meal, especially in children from families with a lower economic and social status, not only caused nutritional deficiencies, but also increased the consumption of 'junk foods' in this population group [1, 2]. Food insecurity linked to risk of weight gain and increased 'food insecurity' in children was observed during outbreak [3].

Currently, the global problem of overweight and obesity is being encountered in all population groups, including children and adolescents. The World Health Organization has stated that the prevalence of overweight and obesity among persons aged 5–19 was over 18% in 2016, and had risen dramatically from just 4% in 1975 [4]. In Poland, according to the report of the Supreme Audit Office, in 2018–2020, 21.7% of children had excessive body weight, out of which 1/3 had obesity. It has been noticed that this problem affects

increasingly younger children – even 3-year-old and children in early school age [5]. Excessive body weight in childhood has a significant negative effect on physical and mental health in the closer and further perspective. It might result in the development of non-communicable diseases, e.g., hypertension, prediabetes and type 2 diabetes, dyslipidaemias, metabolic-associated fatty liver disease (MAFLD), as well as cardiovascular diseases or some cancers in later life [6, 7]. Moreover, psychosocial, and emotional problems, anti-social behaviours and attention disorders are more common among children and adolescents with overweight and obesity than in their peers with normal body weight.

All those aspects contribute to lowering the quality of life, disturbing the proper functioning in society, and may pose risky practices leading to eating disorders [8]. Another growing problem among Polish teenagers is thinness, which is associated with a poor nutritional status, as well as the theory that under-nutrition in early life might promote obesity in adulthood. Generally, the prevalence of thinness in Polish children is higher than in other European countries, and was found in over 12% of rural Polish children and adolescents. Moreover, the worldwide rate of increase in the prevalence of obesity among in children and adolescents is greater than the rate of decline in undernutrition [9]. As indicated by Wolnicka et al., the prevalence of overweight among children from rural and urban areas in Poland is similar, but there are regional differences that may indicate the direction of local actions aimed at reducing inequalities resulting from nutritional well-being [10].

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According to the European Union's Action Plan on Childhood Obesity 2014–2020, the promotion of healthier environments, especially in schools (and pre-schools) is one of the key areas for action in tackling childhood obesity [11]. Globally, schools are recognized as an important place to promote healthy behaviours, as children typically spend a substantial number of hours at school [12]. It was shown that universal free school lunch may improve the overall diet quality, academic performance, student attendance specifically among higher-risk populations (e.g., lower-income and/or food insecure) [12]. Thus, provision of healthy and high-quality school meals, with limited access to less healthy food options, is an important solution to improve children's health and well-being.

In Poland, the above-conditions were reflected in the first official regulation that was introduced in 2015 by the Ministry of Health, modified in 2016 [13, 14]. It regulates the food assortment that can be served in schools (and kindergarten) canteens, and sold in schools' shops, cafeteria, or vending machines. The regulation was based on the recommendations to increase in children's diets favourable foods like vegetables, fruit, dairy, fish, while decreasing discretionary foods with higher amounts of fat, added sugars and salt. The regulation states that school (and kindergarten) canteens should serve at least one portion of fish every week, and limit fried foods to maximally twice a week [14].

On the other hand, climate changes and increasing knowledge about the impact of food systems on the environment, raised the urgent demand to incorporate the notion of sustainability into the area of nutrition. Sustainable diets are defined as:

those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair, and affordable; nutritionally adequate, safe and healthy, while optimizing natural and human resources [15].

Some countries have already included environmental aspects in their food-based dietary guidelines, such as Germany, Finland, Denmark, the United Kingdom, the Netherlands, and Sweden, Australia, Brazil, Qatar, and Uruguay [16]. Many initiatives addressing not only healthy but also sustainable diets have been undertaken by various authorities and organizations worldwide, including Europe [15, 17, 18]. Sustainable school meals have been proposed as one of them [17]. Since 2018 in France, national regulation encourages school canteens to serve a vegetarian meal weekly, to increase the proportion of organic products up to 20%, to limit the use of plastic, and to prevent food waste in order to reduce the environmental impact of school canteens. Moreover, a daily vegetarian option at primary school canteens was proposed in 2021 [19]. In Sweden, many schools and municipalities attempt to reduce the environmental footprint, e.g., by serving more vegetarian meals or organic foods, or even calculating associated emissions of greenhouse gases. The results of a study carried out in Sweden showed that a properly balanced school meal can reduce carbon dioxide emissions by 28% [20]. Similarly, in Milan, Italy, CO<sub>2</sub> emissions from school meals have been reduced by 20% over the last few years [21].

An important initiative was also commenced in Poland, as the Committee on Human Nutrition of the Polish Academy of Sciences prepared a document 'Position on new standards for school meals' [22] which responded to the immediate need to also address sustainability issues in the school environment. Proposed new standards include, among others: gradual reduction of the portions of meat in school meals, availability of vegetarian dishes, and availability of at least two different portion sizes of school meal due to varying energy demands of children, depending on age. Currently, parents pay the same price for school meals, regardless of their child's age in most of primary schools attended by pupils aged 6–14 years.

Considering the above-mentioned arguments, the meals provided in schools should be nutritious and meet some quality criteria, derived from dietary guidelines and sustainability goals. This raises another question related to the assessment of the quality of such meals. Although some qualitative scoring methods, such as Starzyńska's menu scoring, or Bielińska's modified by Kulesza test exist, they were developed many years ago and are used to assess a daily menu, not a single meal, and do not reflect updated dietary guidelines, e.g., variety of vegetables and fruits or plant sources of protein (only animal protein is evaluated) [23]. Moreover, there is a lack of simple and easy to use tool for measuring the quality of school meals.

## OBJECTIVE

The study aimed to develop a new index to assess the quality value of school meal menus, specifically their accordance with actual regulations, dietary guidelines for children and teenagers, as well as some sustainability goals.

## MATERIALS AND METHOD

**The School Meal Index-Lunch Evaluation (SMI-LE) – components and scoring.** The SMI-LE is an originally-created index that helps to evaluate the quality of 5-day (week) school menus. Its general idea is to reflect the healthy and sustainability issues that should be present in school canteens according to WHO and EU recommendations [11, 17]. The main assumption was to increase the consumption of vegetable and fruits, wholegrain products, legumes, dairy, fish, and water, while decreasing the consumption of refined grain products, meat, fried foods, and sweetened drinks among school children. It is based on Polish dietary guidelines for children and teenagers [24] and for the general population [25], the Regulation of the Minister of Health on foods served in the units of the education system [14], and the Position of the Committee on Human Nutrition of the Polish Academy of Sciences on new standards for school meals [22]. Although this Index reflects Polish guidelines and regulations in detail, it is in accordance with general recommendation for school meals formulated by many countries. The form of SMI-LE scoring was inspired by the proposal of the Healthy Meal Index, a tool for assessing the healthfulness of foods served to children in a single meal [26].

The SMI-LE includes 20 components: 5 components connected with vegetable and fruits consumption, 3 with starchy foods (grains and potatoes), 7 with protein sources, 2 with drinks, and the remainder with sweet dishes, fried

foods, and different portion sizes. SMI-LE is calculated as the sum of the points assigned to components depending on 'Yes' and 'No' answers. The answer 'No' always gives 0 points, while a 'Yes' answer may give 10 points for main food groups, or 5 points for subcategories or additional questions. Some exceptions are made for 3 components when 2 points ( $\geq 2$  different vegetables every day and fruit every day) or 1 point (raw vegetable every day) can be assigned for each day.

SMI-LE may range from 0 – 140 points, where a higher sum of points indicates healthier and more sustainable school meals. Components with '0' points show the areas that can be improved in planning school menus to increase their quality. The set of components of the SMI-LE and scoring are presented in Table 1.

Based on the final scoring, 3 categories of school menus were created for further analysis: low, medium, and good quality, assigned  $\leq 35$  points ( $\leq 25\%$  of total points), 36–70 points (26–50% of total points), and  $> 70$  points ( $> 50\%$  of total points), respectively.

### Verification of the School Meal Index-Lunch Evaluation.

The SMI-LE was tested in a real-life situation and fifty 5-day school menus available online from primary schools located in different regions of Poland, in rural and urban areas, were

assessed with SMI-LE independently by both authors of this study. Krippendorff's alpha coefficient was calculated for the inter-rater agreement. The coefficient equaled 0.83 indicating the very good agreement between both authors.

Further, the energy, micronutrients, some vitamins, and minerals contents were analyzed in selected 5-day menus from 3 quality categories with low, medium, and good scoring. In each quality category, the menus were ranked according to the increasing number of final points, and the menus with the lowest, middle and highest number of points were selected. The number of menus selected for the dietary evaluation depended on the number of menus assigned to each quality category, and accounted for 17% (in the most numerous category when 6 out of 36 menus were calculated) to 50% (in the lowest when 3 out of 6 menus were evaluated). The nutrients were selected according to the common insufficient or excess intakes observed in children and teenagers, namely: vitamin C, folates, calcium, magnesium, iron, potassium, and sodium, as well as dietary fibre. Although vitamin D deficiency occurs commonly in this population, its content in school menus was not analyzed as very few food sources of this vitamin exist. The dietary programme Kcalmar.pro was used to calculate the energy and nutritional value. The values obtained for energy, macronutrients, dietary fibre,

**Table 1.** School Meal Index-Lunch Evaluation (SMI-LE) for a one-week menu – components and scoring

Components	Score (Points)			Comments	Inclusions/exclusions/examples
	0	5	10		
$\geq 2$ different vegetables every day	No	Yes	2 points for each day		raw, cooked, baked, soured, vegetable soups can be counted, including mushroom, tomato or green pea soup, but excluding starchy soups like 'krupnik', 'zacierkowa', or based on legumes like 'split pea soup'
Raw vegetable every day	No	Yes	1 point for each day		all kinds of raw vegetables served separately or as salads, including beetroot salad and soured vegetables like sauerkraut, sour cucumber, etc., but excluding tinned or pickled vegetables
Dark green vegetable: $\geq$ twice/week	No	Yes			raw, cooked or baked, e.g., broccoli, rocket, spinach, green beans, sorrel, Brussels sprouts, etc.
Fruit every day	No	Yes	2 points for each day		fresh, frozen, also in a form of fruit salad or mousse
$\geq 3$ different fruits/week	No	Yes			
Wholegrain product: $\geq$ twice/week	No	Yes			e.g., buckwheat, wholegrain pasta, brown rice, also in soup like 'krupnik'
Refined grain product: $\leq$ twice/week	No	Yes			e.g., regular pasta, rice, white bread
Potatoes as a starchy product in a second dish: $\leq$ twice/week	No	Yes			cooked or baked, also in the form of dumplings
Dairy product/dish: $\geq$ twice/week	No	Yes	without added sugars		natural yoghurt, kefir or cheese added to dishes, e.g., spaghetti
Fish: $\geq$ once/week	No	Yes			baked, boiled, stewed, or fried
Vegetarian dish based on legume for all students: once/week	No	Yes			all kinds of legumes: beans, lentils, chickpeas, split pea, tofu, also in the form of soups like split pea soup (but without meat addition)
<i>Additional</i> vegetarian dish (non-sweet, without fish) for all students: once/week	No	Yes			e.g., pancakes with spinach, egg cutlets, etc.
Vegetarian alternative for vegetarians: every day	No	Yes			
Meat: $\leq$ twice/week	No	Yes			
Red meat: $\leq$ once/week	No	Yes			
Sweet dish: $\leq$ once/week	No	Yes			e.g., pancakes with cheese, dumplings with cheese, rice with apples
Fried food: $\leq$ twice/week	No	Yes			e.g., pork chops, fried fish
Drinks: water or tea without added sugar: every day	No	Yes			
Drinks: juice, compote $\leq$ twice/week	No	Yes			
Portion size: at least 2 different every day	No	Yes			

**Range of points: 0-140**

calcium, magnesium, iron, potassium, and sodium were reduced by 10%, and for vitamin C and folates by 50%. The energy and nutritional values were compared with the Polish Dietary Recommended Intakes (DRIs), assuming the target value of 30–35% of the DRIs for a child aged 10–12 years with moderate physical activity (Tab. 2).

**Table 2.** Polish Dietary Recommended Intakes (DRIs) for energy and selected nutrients

Energy and nutrients	DRIs	Values per day	Values per lunch 30–35% of DRIs
Energy [kcal]	EER	2225*	668–779
Protein [% of total energy]		10–20%	10–20%
Fat [% of total energy]	RI	20–35%	20–35%
Carbohydrates [% of total energy]		45–65%	45–65%
Dietary fibre [g]	AI	19	5.7–6.7
Calcium [mg]	RDA	1300	390–455
Magnesium [mg]	RDA	240	72–84
Iron [mg]	RDA	10	3.0–3.5
Sodium [mg]	AI	1300	390–455
	DRV <sup>1</sup>	2000	–
Potassium [mg]	AI	2400	720–840
Vitamin C [mg]	RDA	50	15.0–17.5
Folates [µg]	RDA	300	90–105

\*average value for girls and boys; <sup>1</sup>European Food Safety Authority (EFSA)

Data are presented as means and standard deviations (firstly calculated for 5 days in each selected school, and secondly for each quality category). The differences in energy, nutrients, and SMI-LE scoring among 3 quality categories were examined by the Kruskal-Wallis test. Statistical analysis was conducted using STATISTICA software version 12.0 (StatSoft INC., Tulsa, OK, USA; StatSoft, Kraków, Poland). A  $p$ -value < 0.05 was considered statistically significant.

## RESULTS

**The SMI-LE – scoring and quality categories.** Among the analyzed menus, the mean and median values equaled 55 and 52 out of 140 points, respectively (Tab. 3). Most of the menus were rated as ‘Medium’ quality according to SMI-LE index. In the ‘Good’ quality category, 126 points was the highest value achieved.

**Table 3.** School Meal Index-Lunch Evaluation scoring according to quality category

Variable	Total sample N = 50	Quality category		
		Low N = 6	Medium N = 36	Good N = 8
Mean ± SD	55.0 ± 19.7	28.3 ± 5.3	51.9 ± 10.4	92.4 ± 11.9
Median (25th; 75th)	52.0 (40.0; 65.0)	28.0 <sup>a</sup> (26.0; 33.0)	50.0 <sup>b</sup> (42.0; 59.0)	89.0 <sup>c</sup> (81.0; 96.0)
Minimum – maximum	20.0–126.0	20.0–35.0	36.0–69.0	72.0–126.0

SD – standard deviation

<sup>a,b</sup> non-identical superscripts indicate significant difference among menu categories,  $p < 0.05$

**Nutritional quality of school meals.** Considering the energy and nutritional value (Tab. 4), the menus classified into the

SMI-LE category as ‘Low’ were also characterized by the lowest energy value, as well as the lowest content of calcium, magnesium, iron, potassium, and folates, while the highest for sodium. In turn, menus from the ‘Good’ category had the highest nutritional value, including the lowest sodium content. The mean values of calcium content were much below the references, regardless the quality category.

**Table 4.** Energy and selected nutrients content in school menus across three categories of school meals quality (Mean ± SD)

Energy, nutrients, and points	Quality category			30–35% of DRIs
	Low N = 3	Medium N = 6	Good N = 3	
Energy [kcal]	567 ± 212	666 ± 96	679 ± 204	668–779
Protein [% of total energy]	21.2 ± 0.4 <sup>a</sup>	19.0 ± 1.0 <sup>b</sup>	16.7 ± 1.5 <sup>c</sup>	10–20%
Fat [% of total energy]	25.9 ± 1.5	30.8 ± 5.1	29.7 ± 4.2	20–35%
Carbohydrates [% of total energy]	52.9 ± 1.3	50.2 ± 4.7	53.6 ± 4.0	45–65%
Dietary fibre [g]	11.1 ± 5.0	12.5 ± 1.6	17.7 ± 4.6	5.7–6.7
Calcium [mg]	200 ± 28.8	252 ± 115	262 ± 27.3	390–455
Magnesium [mg]	110 ± 28.0	147 ± 15.7	143 ± 19.2	72–84
Iron [mg]	4.9 ± 0.8	5.6 ± 1.1	7.6 ± 0.7	3.0–3.5
Sodium [mg]	1308 ± 10.2	1077 ± 294	854 ± 95	390–455
Potassium [mg]	1277 ± 363	1592 ± 135	1750 ± 504	720–840
Vitamin C [mg]	43.0 ± 14.1	42.2 ± 8.0	51.2 ± 9.9	15.0–17.5
Folates [µg]	32.7 ± 8.8	107 ± 26.2	114 ± 24.9	90–105
Points	23.5 ± 4.9 <sup>a</sup>	56.0 ± 12.5 <sup>b</sup>	98.3 ± 10.7 <sup>c</sup>	–

SD – standard deviation

<sup>a,b</sup> non-identical superscripts indicate significant difference among menu categories,  $p < 0.05$

Examples of 5-day menus are presented in Table 5, one for each quality category, while Table 6 presents the points assigned to individual SMI-LE categories. Additionally, in Table 7, the energy and nutritional value of the ‘Good’ quality menu is shown. All menus met the criteria for serving for following: refined grain products maximally 2 times per week, potatoes in a second dish maximally twice a week, sweet dish maximally once a week, and fried foods maximally twice a week. In the ‘Low’ quality menu, a small variety of foods was observed, as well as a low frequency of vegetables and fruits, but a high frequency of meats, including red meat. On the contrary, the ‘Good’ quality menu accomplished all but 2 goals, namely, at least 2 different portion sizes every day, and drinks like juice and compote served maximally twice a week. This menu can be characterized as adequate in vegetables and fruits, and varied in many aspects. Moreover, it met all the DRIs except calcium, for both vegetarian and non-vegetarian options of menus.

## DISCUSSION

The proposed School Meals Index-Lunch Evaluation is a tool that aims to assess the qualitative value of school meals with particular emphasis on health and sustainability issues that are not determined in the quantitative assessment. It includes a set of foods in relation to dietary guidelines which inform about total diet [24, 25], as well as to official regulations [14], and statements by experts [22] that refer particularly to school meals. This index produces individual component scores

**Table 5.** Examples of 5-days school menus across three quality categories

Day	Quality category		
	Low 25 points	Medium 59 points	Good* 126 points
1 (Monday)	Stuffed cabbage with pork meat in tomato sauce; potatoes; orange; compote	Cucumber soup with potatoes; stuffed cabbage with pork meat and rice in tomato sauce; mint tea with lemon and sugar; apple	Split pea soup; dumplings with white cheese and natural yoghurt; pieces of vegetable and fruit: chicory, kohlrabi, orange; water or compote
2 (Tuesday)	Breaded chicken cutlet; potatoes; beets with horse radish; compote	Rice soup; pork chop; potato puree; roasted beetroot salad; apple juice	Chicken broth/vegetable broth; roast chicken leg/chickpea and millet baked balls; potatoes; Greek salad; steamed vegetables (cauliflower, carrot, zucchini); water or compote
3 (Wednesday)	Beans with pork sausage in tomato sauce; wheat roll; muffin; compote	Soup with pearl barley; pancakes with apples and yogurt sauce; carrot salad; tea with lemon and sugar; banana	Broccoli soup; pasta with tomatoes and cheese; Chinese cabbage with vegetables, sunflower seeds, and vinaigrette; water or compote
4 (Thursday)	Pork goulash; pearl barley; pickled cucumber; compote	Red beetroot borscht with sour cream; buckwheat groats; turkey stew; sour cucumber; cherry tea with sugar	Vegetable soup; turkey tagine with apricots/ vegetable and lentil tagine with apricots; bulgur groats; cucumber and pomegranate salad; apple pieces; water or compote
5 (Friday)	Creamy mushroom soup with peas puff; crepes with cottage cheese; compote	Tomato soup with noodles and sour cream; breaded hake fillet; potatoes; sauerkraut salad; fruit-vegetable juice	Red beetroot borscht; wholegrain pasta with pieces of salmon and broccoli in a creamy sauce; carrot and leek salad; banana; water or compote

\* This menu includes vegetarian options for each day, presented after slash when the meat option was also served

**Table 6.** SMI-LE scoring for selected school menus presented in Table 5

Components	Scoring (Points)			Quality category		
	0	5	10	Low	Medium	Good
≥ 2 different vegetables every day	No	Yes	2	6	10	
Raw vegetable every day	No	Yes	1	4	5	
Dark green vegetable: ≥ twice/week	No	Yes	0	0	5	
Fruit every day	No	Yes	2	4	6	
≥ 3 different fruits/week	No	Yes	0	0	5	
Wholegrain product: ≥ twice/week	No	Yes	0	10	10	
Refined grain product: ≤ twice/week	No	Yes	5	5	5	
Potatoes as a starchy product in a second dish: ≤ 2 times/week	No	Yes	5	5	5	
Dairy product/dish: ≥ twice/week	No	Yes	0	0	10	
Fish: ≥ 1 time/week	No	Yes	0	10	10	
Vegetarian dish based on legume for all students: once/week	No	Yes	0	0	10	
<i>Additional</i> vegetarian dish (non-sweet, without fish) for all students: once/week	No	Yes	0	0	5	
Vegetarian alternative for vegetarians: every day	No	Yes	0	0	10	
Meat: ≤ twice/week	No	Yes	0	0	5	
Red meat: ≤ once/week	No	Yes	0	0	5	
Sweet dish: ≤ once/week	No	Yes	5	5	5	
Fried food: ≤ twice/week	No	Yes	5	5	5	
Drinks: water or tea without added sugar every day	No	Yes	0	0	10	
Drinks: juice, compote ≤ twice/week	No	Yes	0	5	0	
Portion size: at least 2 different every day	No	Yes	0	0	0	
<b>Total points:</b>			<b>25</b>	<b>59</b>	<b>126</b>	

which can be examined collectively and give the overview of the 5-days school menu. It can indicate the qualitative value of a one week school menu, and achieving higher scores indicates the menus of higher overall quality. Moreover, it shows which components/areas need to be improved.

School is a natural and favourable environment for nutrition-related education, both formal (e.g., during biology

**Table 7.** Energy and nutritional value of the menu in the 'Good' category (mean ± standard deviation)

	Non-vegetarian meals	Vegetarian meals	30–35% of DRIs
Energy [kcal]	684 ± 98	702 ± 90	668–779
Protein [% of total energy]	20 ± 4.5	19 ± 4.1	10–20%
Fat [% of total energy]	28 ± 7.3	28 ± 7.2	20–35%
Carbohydrates [% of total energy]	52 ± 6.4	53 ± 4.1	45–65%
Dietary fibre [g]	17 ± 1.9	19 ± 3.4	5.7–6.7
Calcium [mg]	262 ± 82	255 ± 70	390–455
Magnesium [mg]	165 ± 28	171 ± 26	72–84
Iron [mg]	7.5 ± 2.0	8.2 ± 1.8	3.0–3.5
Sodium [mg]	986 ± 127	929 ± 57	390–455
Potassium [mg]	1645 ± 374	1574 ± 361	720–840
Vitamin C [mg]	53 ± 20	51 ± 23	15.0–17.5
Folates [µg]	124 ± 84	149 ± 45	90–105

lessons) and informal (e.g., in canteens), and school meals play a relevant nutritional and social role. School meals can significantly contribute to healthy dietary behaviour during the critical period of growth, as well as to formulation of desirable food preferences and eating habits which can be maintained until adulthood [20].

Initially, school meals were supposed to provide sufficient food energy to lower socio-economic groups; later, the shift from food security to food quality dominated, specifically in developed countries when the problem of obesity escalated. Nowadays, a third phase of changes is taking place – the idea of integrating health and sustainability concerns into school meal programmes [27].

In contrast to most of the indices, the SMI-LE is based on the availability of foods (i.e. served in school canteens) and does not account for quantity of foods. The main concept of the current study was to create a quick and relatively simple tool which could be applied by non-professionals and without special equipment/devices, e.g., professional dietary programmes.

In the proposed index, particular emphasis is placed on increasing not only the availability of vegetables and fruits,

but also on their variety: at least 2 different vegetables per day, raw vegetable every day, at least 3 different fruits per week. The intention was to stress the need for including dark-green vegetables into school menus. A higher consumption of vegetable and fruits is important for the prevention of non-communicable diseases, including obesity, due to their vitamin, mineral, dietary fibre, and bioactive content [28]. Data from the systematic reviews and observational studies reveal that intake of certain types of vegetables and fruits, among others dark-green vegetables (specifically leafy), have superior effects on health, including biomarkers and outcomes of chronic disease [28]. The special importance of green leafy vegetables was expressed in the MIND diet (Mediterranean-DASH diet Intervention for Neurodegeneration Delay), as this food group is one out of 10 dietary components considered brain healthy included into the diet score [29]. It is recommended that food-based dietary guidelines comprise the consumption of raw fruits and vegetables because they maximize mental health benefits (e.g. reduced depressive symptoms and higher positive mood, and life satisfaction) [30].

Unfortunately, the vast majority of the analyzed school menus did not meet the proposed criteria regarding vegetables and fruits, as well as the current nutritional guidelines informing that vegetables and/or fruits should account for half of the 'healthy eating plate' [25]. It is worth promoting various solutions that would increase the consumption of vegetables (and fruits) by children and adolescents and reduce food waste in school canteens; the possibility to choose the type and portion size of vegetables and fruits from buffets could be one of them [22]. If such ideal option cannot be introduced in school canteen, a few bowls with ready-to-eat pieces of fresh vegetables and fruits might be a substitute for a real buffet. Single portions, composed of different sets of vegetables and fruits, can also be prepared to limit self-service (e.g. in epidemic conditions) [31].

The proposed index also promotes more whole grains and less refined grain products in school menus. Whole grains are healthy dietary components in all stages of life, also in childhood. Their intake was associated with an overall protective cardiometabolic profile in a cross-sectional study in 713 Danish children aged 8–11 years [32]. According to an umbrella review of meta-analyses, dietary whole grain intake might be beneficial in the prevention of type 2 diabetes, cardiovascular disease, and colorectal, pancreatic, and gastric cancers [33]. Whole grain products are more nutrient-dense than the refined variety, and contain certain amounts of dietary fibre, minerals, vitamins, and phytochemicals, and are recommended as part of healthy and sustainable diets [34]. A higher share of whole grain products in school menus can be achieved by introducing groats (e.g., buckwheat, millet, pearl barley), hence the proposal to limit potatoes in the second course of a main meal to a maximum of twice a week. Potatoes, as an important food group in traditional Polish cuisine, can be served in soups (preferable vegetable), or in the second course, but interchangeable with groats or whole grain pasta. This also guarantees a greater variety in the meals. The analyzed school menus revealed that whole grain products were offered rarely, and when offered, refined grains predominated.

In accordance with current Polish dietary guidelines [25] and the concern for environment, animal-based foods should be limited, specifically meat, while plant-based

sources of protein, e.g. legumes, should be increased. Large prospective studies and meta-analyses generally show that total mortality rates are modestly higher in participants who have high intakes of red and processed meat. Furthermore, meat production contributes significantly to greenhouse gas emissions and freshwater usage [35]. The school menus assessed in the current study were rich in meat; it is therefore worth considering a greater share of legumes in dishes for all pupils. Moreover, it is recommended to have an offer of vegetarian dishes in schools [22], specifically that the number of vegetarians in Poland is constantly growing, also in the younger age groups [36]. Some schools have already met that recommendation.

Analysis of school meals in France showed that both vegetarian and non-vegetarian meals had a similar good nutritional quality, but greenhouse gas emissions were more than twofold reduced in vegetarian compared to non-vegetarian meals. The authors concluded that increasing the frequency of vegetarian meals, by serving egg-based, dairy-based or vegan recipes more frequently, would reduce greenhouse gas emissions while maintaining adequate nutritional quality of primary school meals [19]. Besides, a study of 5,000 lunches served in the USA during the 2014–15 school year, indicated that redesigning school lunches could provide high-quality nutrition while benefiting the environment, and additionally reducing food costs, as the estimated food costs were lower for school lunches meeting sustainability (EAT-Lancet) targets than for traditional school lunches [37].

The SMI-LE proposal should also promote a decrease in the amounts of sugar in school meals. Therefore, water (and unsweetened teas) is proposed as the main beverage, and sweet meals limited to a maximum of once a week. This is a crucial element in prevention of non-communicable diseases, including obesity. Since Polish children and adolescents consume sugar in excessive amounts (above the European average), primarily in the form of sweets and sweetened beverages [38], schools should limit the availability of foods with added sugars in canteens and shops/vending machines [14, 22]. A study by Korzycka showed that sweet snacks (biscuits, candy bars, chocolate) and sweet carbonate drinks were available in 35% and 6% of schools, respectively [39]. Moreover, a significantly greater availability of sweet snacks was found in large, urban schools, whereas flavoured milk with added sugar was more often available in small and rural schools [39]. Research conducted in almost 8,000 adolescents aged 12–17 years indicated that 1/5 of them snacked on sweets between meals [40].

An important policy in reducing sugar consumption in children on the national level has been undertaken, and since the 2018–2019 school year within the Programme for Schools, flavoured milks or yoghurts with added sugar can no longer be offered to pupils [39].

Water is an elementary beverage in a diet and schools need to provide children and adolescents with access to free drinking water as an alternative to sugar-sweetened beverages, also in school canteens [11, 22]. The simplest and cheapest solution is to serve water instead of sweet beverages like compotes. An addition of fruit or fresh herbs can make drinking water more attractive to children.

As mentioned previously, some components of the proposed Index are derived directly from the Ministry of Health regulation [14], namely, fish served at least once a

week and the limitation of fried foods to a maximum of twice a week. While the aspect of limiting fried dishes was fulfilled in the majority of schools, the lack of fish in school meals was commonly observed. Fish, particularly oily fish, is an important source of n-3 long chain polyunsaturated fatty acids (n-3 LC-PUFAs), which are important for brain development, as well as of vitamin D which has pleiotropic effects on the organism [41, 42].

In the 2020–2021 school year, there were approx. 13,200 primary schools in Poland – 5,100 in cities and 8,100 in rural areas [43]. According to data from the COSI study conducted in 9 randomly-selected provinces in Poland, in a total of 37 counties, 90.4% of elementary schools had canteens, 96.7% in urban and 77.3% in rural areas, respectively [39]. Nutritional inadequacies occur among Polish school children from both urban and rural areas, but according to a study by Sygit et al., a higher percentage of rural children skipped meals, especially breakfast. Besides, school children relatively often chose and consumed unhealthy products, such as sweets, junk food and crisps [40]. Access to a nutritional-rich school meal seems to be a priority task to change habits among the young population.

In Poland, there are established two school meal programmes: School Meals Programme / Meals at School and at Home and School Scheme. In addition to financial support for municipalities by providing assistance for meal or food purchase, the programmes includes financial support for the organization of canteens and catering outlets in schools. This is notably important in the case of small schools, which tend to have poorer infrastructure and conditions that are less conducive to healthy eating. According to a report by the Supreme Audit Office, students' parents were more likely to buy lunches at school when the meals were prepared in school kitchens, which also translates into their price [44].

Considering the number of schools and students in Poland, as well as the problems and solutions discussed above, it seems necessary to introduce changes in the approach to the 'school meal' task. Adopting sustainable practices in school canteens should combine the usage of local, regional, and seasonal products, as well as the reduction of food waste [22], but those issues are beyond the concept of the SMI-LE.

It is time to raise awareness of the importance of healthy foods for the advantage of both the children and the environment. New tools are needed to plan sustainable school meals and enforce proper school menus which can also be reinforced by the implementation of one-course sustainable school meals. The government and schools should invest more in qualified staff and infrastructure, and be more vigilant in eliminating unhealthy school meals. Implementing healthier school programmes will require stricter policies and ongoing monitoring [45].

## CONCLUSIONS

The study proposes a novel tool, an index for measuring the quality of school meals that addresses questions of health and sustainability. It responds to the need for new indices that would consider changes in dietary guidelines and increasing knowledge about the impact of food systems on the environment. The proposed index is based on current Polish dietary guidelines, official regulations, and the opinions of experts.

The use of this tool is both simple and quick and does not require the professional programmes. It can be used for both evaluating the existing school menus and planning new ones which, to a greater extent, will take into account the sustainable targets. It might also raise the environmental awareness of all school participants. Properly balanced school meals are a missed opportunity to address health, a balanced diet, education, and prevention of non-communicable diseases.

The SMI-LE can be a lever for nutritionist and dieticians who plan menus, not only for schools but also for individuals. It indicates the commitment to introduce changes in the dietary habits of societies for their health and the 'health of the planet', starting from the earliest years, e.g., in schools, and provides the opportunity to disseminate such ideas in the large community of children and adolescents, teachers and their families.

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