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Nutritional Implications of an Increasing Consumption of Non-Dairy Plant-Based Beverages Instead of Cow's Milk in Switzerland

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Abstract

In Switzerland the consumption of non-dairy plant-based beverages increased (+19%) from 2011 to 2016 whereas the consumption of cow's milk decreased (-6%). This trend makes it necessary to investigate in detail which products are on the market, what they are composed of and the implications with regard to their nutritional value. The main supermarket chains in Switzerland sell 45 non-dairy plant-based beverages that were analysed as to their composition (information from the label and nutrient databases) and nutrient content per recommended serving size. This information was correlated to the recommended dietary allowances published by the Swiss Society for Nutrition (SSN), for adults (25-51), children (4-7 years) and toddlers (1-3 years). The main focus was placed on the protein content and amino acid composition of the beverages which is of great importance for different physiological functions. Furthermore, calcium, sugar, and salt content were discussed in detail. Altogether, replacing cow's milk with non-dairy plant-based beverages leads to a reduced intake of proteins, calcium, certain vitamins and minerals and to an increased intake of added salt. Therefore, such a substitution should be made with precaution and nutrient deficiencies balanced with other food sources.

Keywords: Dairy based beverages; Non-dairy plant-based beverages; Alternative proteins; Nutritional value

Introduction

In many countries, the consumption of milk has decreased in recent years. The same trend can be observed in Switzerland, where the quantity of milk per inhabitant has decreased by 6.2% between 2011 and 2016. In contrast, the consumption of non-dairy or plant-based beverages has increased by 19% during the same period [1].

The non-dairy beverages investigated in this study are beverages made from extracts of plant materials such as soy, rice, coconut, oats or quinoa. These beverages are commonly used as substitutes of cow's milk. The main medical reason for such a substitution, is cow milk protein allergy (CMPA), which is diagnosed when there are allergic reactions to casein or whey protein and is characterized by vomiting, loose stools, fussiness, and a reduced weight gain [2]. The incidence of CMPA is between 2-5% and it is normally present in children under the age of three [3]. For adults, the incidence is much lower. The symptoms of CMPA are normally confused with those of lactose intolerance. Lactose intolerance is due to deficiencies in intestinal lactase (hypolactasia) and leads to abdominal pain, bloating, and diarrhoea induced by lactose. Treatment of lactose intolerance can include lactose-reduced diet and enzyme replacement [4]. Lactose-free cow milk is a good alternative for people with lactose intolerance. However, some lactose-intolerant consumers might change to non-dairy plant-based beverages. Interestingly, the main reason for the increased consumption of milk alternatives is that consumers perceive non-dairy beverages as more natural and healthier choices than cow's milk [1].

Given this context, the aim of this study was to assess the nutrient contents of cow's milk and of non-dairy plant-based beverages available in Switzerland, and compare them to the requirements of different population subgroups. The focus was placed on protein content, composition and bioavailability. Sufficient intake of protein is essential for human growth and metabolism [5] and 20 different amino acids are needed. Eleven amino acids are classified as nonessential and are synthesised by the body using other ingested amino acids. The remaining nine are classified as essential amino acids (EAAs) and cannot be produced by the body, so they need to be consumed in the diet [6]. The presence of all these amino acids is essential for growth, repair, and maintenance of body tissue [5].

Proteins as such are linked to bioactive function. For example, lactoferrin in cow's milk has protective effects, ranging from anticancer, anti-inflammatory and immune-modulatory activities to antimicrobial activities against a large number of microorganisms [7]. During digestion, proteins are degraded in the jejunum, mainly to amino acids and peptides with an average length of 3-6 amino acids, before being resorbed into the blood [8]. Today, cow's milk is considered the most important source of bioactive peptides [9], but plant proteins also contain bioactive peptides and their potential is very interesting for future research [10].

The bioavailability of the examined protein sources is not clear. In the literature, we only found Digestible Indispensable Amino Acid Scores (DIAAS) for the whole proteins that were used to qualify the proteins in the beverages. However, not many studies have so far investigated the effect of processing on protein bioavailability. For protein isolates, the isolation procedure can change the amino acid composition and thus influence their nutritional value.

Calcium, salt and sugar were also examined in detail. The nutrient content per serving size of non-dairy plant-based products was checked against cow's milk and the recommended dietary allowances

(RDAs) of the Swiss Society for Nutrition (SSN), for adults (25-51), children (4-7 years), and toddlers (1-3 years).

Methods

In order to define the nutrient content of cow's milk and non-dairy beverages, we gathered information from Coop and Migros, the largest retailers in Switzerland. These two supermarket chains were chosen because they account for the greatest share of sales of dairy and non-dairy beverages in Switzerland [1]. First, we conducted a search of the Coop and Migros websites to identify non-dairy products listed and the nutritional content given by the manufacturers on the label [11, 12]. We also visited several supermarkets of both chains to check the non-dairy beverages available on the shelves and their nutritional content, in order to complement the list of products located in internet. We contacted both supermarket chains to request additional information about their non-dairy plant-based beverages, concerning their nutritional content. For some products, we obtained nutritional data missing on the label from other sources, such as the Swiss Food Composition Database [13], the Playground Website of FoodCASE [14] and the literature.

We compared the nutrient content of non-dairy plant-based products with that of cow's milk and the recommended dietary allowances (RDAs) published by the Swiss Society for Nutrition (SSN), for adults (25-51), children (4-7 years), and toddlers (1-3 years). A literature review was conducted to identify the amino acid composition and the protein digestible indispensable amino acid score (DIAAS) of the different proteins. The DIAAS is the recommended approach to evaluate dietary protein quality in humans and is based on both amino acid composition and true ileal amino acid digestibility [15].

Results

In the supermarket chains 45 non-dairy plant-based beverages were identified. These were grouped in seven different categories, according to their main ingredient: soya products (17), oats (4), spelt (1), coconut (7), rice (11), quinoa (1) and almond (4) and compared to cow (1).

Table 1 shows the median value and the standard deviation of the nutrient profile for each of the groups of beverages, per 1 serving (200mL based on the Swiss food pyramid for adults [16]). The nutrient profile contains the information that was reported by the manufacturers on the label of the products. We found that the following information listed in the nutritional profile of all products: energy, lipids, saturated fatty acids, carbohydrates, sugar, fibre, protein and salt. Very few products gave information on calcium and vitamins D, B2 and B12. Most non-dairy beverages contain less saturated fatty acids and energy than cow's milk, except for the quinoa based beverage, which has the same number of calories as cow's milk 124kcal/ 200mL).

Nutritional content		Cow	Soya		Oats		Spelt	Coco		Rice		Almond		Quinoa
	unit		Median	SD	Median	SD		Median	SD	Median	SD	Median	SD	
Energy	kcal	124	90	10.49	85	4.85	84	46	18.47	112	10.23	102	22.19	124
Lipids	g	6.8	4	0.2	2.9	0.06	3	0.4	1.32	2.2	0.75	8	1.6	2
Sat fatty acids	g	4	1	0.11	0.4	0.12	0.4	0	1.18	0.2	0.24	0.8	0.19	0
Carbo-hydrates	g	9.2	5	2.54	13	0.96	12.4	10.2	1.77	22	0.85	3.5	1.57	24
Sugar	g	9.2	5	2.54	10.4	1.24	11.4	8	1.74	14.8	2.21	3	1.28	12
Fibre	g	0	1	0.41	1.6	0.26	1.6	0	0	1	0.18	1	0.06	1
Protein	g	6.6	7	0.36	1	0.22	0.26	0.2	0.19	1	0.3	2.9	0.54	2
Salt	g	0.2	0.21	0.21	0.22	0.03	N/A	0.06	0.04	0.14	0.06	0.12	0.05	0.2
Vitamin D	µg	0.2	0.00[a]	0.3	N/A	N/A	N/A	N/A	0.53	N/A	N/A	N/A	N/A	NA
Vitamin B2	mg	0.3	0.02[a]	0.07	0.03[a]	0	N/A	N/A	N/A	0.01	0	N/A	N/A	0.03[a]
Vitamin B12	µg	0.22	0.00[a]	0.13	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NA
Calcium	mg	240	26.00[a]	54.09	11.88[a]	57.03	N/A	N/A	N/A	1.12[a]	57.7	36.00[a]	3.39	23.78[a]
n		1	17		4		1	7		11		4		1

Note: The information on the nutritional composition of each product comes from the manufacturer`s label. Data marked with (a) comes from the Swiss Food Composition Database OSAV (2017); ETH: Playground Website of FoodCASE (2017); and FAO: Quinoa - 2013 International year (2013).

Table 1: Descriptive statistics of the nutritional composition per serving of dairy and non-dairy beverages (200 mL=1 serving based on the Swiss food pyramid for adults). Sample=52 products.

To visualise the importance of the protein content, we calculated what percentage of the RDA was covered by a recommended serving. Figure 1 shows the protein content of one child or adult serving (100mL and 200mL respectively, based on the Swiss food pyramid) of all products compared with the RDAs for toddlers, children, and adults.

	Energy	Lipids	Sat. fatty acids	Carbohydrates	Sugar	Protein	Salt	Vitamin D	Vitamin B2	Vitamin B12	Calcium	n
Adult (25-51yrs)												
Swiss RDA	2000 kcal	70 g	18 g	275 g	50 g	57 g	3.75g	20µg	1.4 mg	3µg	1000 mg	
Cow (%)	6.2	9.7	22.2	3.3	18.4	11.6	5.3	1.0	21.4	7.3	24.0	1
Soy (%)	4.5	5.7	5.6	1.8	10.0	12.3	5.60	0.00	1.43	0.00	2.60	17
Oats (%)	4.3	4.1	2.2	4.7	20.8	1.8	5.87	0.00	N/A	0.00	1.19	4
Spelt (%)	4.2	4.3	2.2	4.5	22.8	0.5	N/A	N/A	N/A	N/A	N/A	1
Coco (%)	2.3	0.6	0.0	3.7	16.0	0.4	1.6	N/A	N/A	N/A	N/A	7
Rice (%)	5.6	3.1	1.1	8.0	29.6	1.8	3.7	N/A	0.7	N/A	0.1	11
Almond (%)	5.1	11.4	4.4	1.3	6.0	5.1	3.2	N/A	N/A	N/A	3.6	4
Quinoa (%)	6.2	2.9	0.0	8.7	24.0	3.5	5.3	N/A	2.3	N/A	2.4	1
Children (4-7yrs)												
Suisse RDA	1400-1700 kcal	52g	14g	168.5g	38g	18g	1.3g	20µg	0.8mg	1.5µg	750mg	
Cow (%)	4.1	6.5	14.3	2.7	12.1	18.3	8.0	0.5	18.8	7.3	16.0	1
Soy (%)	3.0	3.8	3.6	1.5	6.6	19.4	8.40	0.00	1.25	0.00	1.73	17
Oats (%)	2.8	2.8	1.4	3.9	13.7	2.8	8.80	0.00	N/A	0.00	0.79	4
Spelt (%)	2.8	2.9	1.4	3.7	15.0	0.7	N/A	N/A	N/A	N/A	N/A	1
Coco (%)	1.5	0.4	0.0	3.0	10.5	0.6	2.4	N/A	N/A	N/A	N/A	7
Rice (%)	3.7	2.1	0.7	6.5	19.5	2.8	5.6	N/A	0.6	N/A	0.1	11
Almond (%)	3.4	7.7	2.9	1.0	3.9	8.1	4.8	N/A	N/A	N/A	2.4	4
Quinoa (%)	4.1	1.9	0.0	7.1	15.8	5.6	8.0	N/A	2.0	N/A	1.6	1
Toddlers (1-3yrs)												
Suisse RDA	1100-1300 kcal	42g	11g	130g	30g	14g	1g	20µg	0.7mg	1µg	600mg	
Cow (%)	5.2	8.1	18.2	3.5	15.3	23.6	10.0	0.5	21.4	11.0	20.0	1
Soy (%)	3.8	4.8	4.5	1.9	8.3	25.0	10.50	0.00	1.43	0.00	2.17	17
Oats (%)	3.5	3.5	1.8	5.0	17.3	3.6	11.00	0.00	N/A	0.00	0.99	4
Spelt (%)	3.5	3.6	1.8	4.8	19.0	0.9	N/A	N/A	N/A	N/A	N/A	1
Coco (%)	1.9	0.5	0.0	3.9	13.3	0.7	3.0	N/A	N/A	N/A	N/A	7
Rice (%)	4.7	2.6	0.9	8.5	24.7	3.6	7.0	N/A	0.7	N/A	0.1	11
Almond (%)	4.3	9.5	3.6	1.3	5.0	10.4	6.0	N/A	N/A	N/A	3.0	4
Quinoa (%)	5.2	2.4	0.0	9.2	20.0	7.1	10.0	N/A	2.3	N/A	2.0	1
Note: WHO RDA of less than 5g of salt per day for an adult differs from the Swiss RDA of 3.75 gr which is the minimum value of salt intake.												

Table 2: Nutritional content in one serving of dairy and non-dairy beverages compared to the Swiss RDA in different population subgroups (200 mL for adults and 100 mL for children 1-6 years= 1 serving based on the Swiss food pyramid).

In general, we noted large differences between dairy and plant-based beverages. Com`s milk was found to contain higher quantities of protein per serving than plant-based beverages, except for soy beverages. One serving of cow's or soy milk provides an amount of

protein equivalent to around 24% of the RDA for toddlers, 18% of the RDA for children and 12% of the RDA for adults. The rest of the plant-based beverages provide less than half that amount. Coconut and spelt milk contained by far the least protein, about 32 times less than cow's milk.

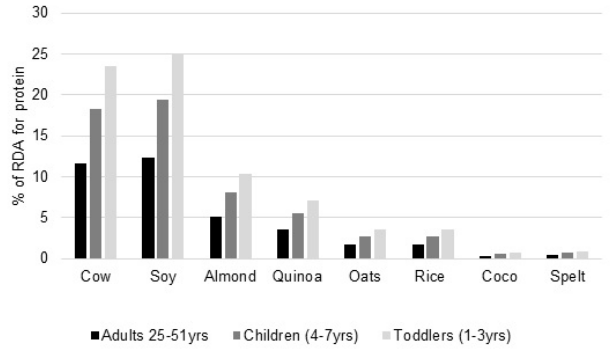

Figure 1: Proportion of RDA for protein covered by one serving of the product for different population sub-groups (200 mL for adults and 100 mL for children 1-6 years=1 serving based on the Swiss food pyramid).

Figure 2 shows the essential amino acid (EAA) composition of the different proteins [17–22]. As expected the EAAs concentration is always greater in the animal proteins than in the plant proteins. Cow's milk protein contains 11% more EAAs than soy protein (which come from the plant-based beverage with similar amounts of protein to cow's milk). When we compared the EAA profiles, we found that bovine milk protein has much higher amounts of certain amino acids than soy protein: 49% more methionine, 20% more valine, 17% more leucine and 13% more lysine. The other plant-based proteins investigated (coconut, rice, quinoa, almond and oat) also have lower levels of EAAs than bovine milk protein: between 40% and 98% lower. Almond, coconut and rice based beverages have the lowest amounts of EAAs, particularly methionine, lysine and tryptophan (see OSM1 for the compiled data on EEAs).

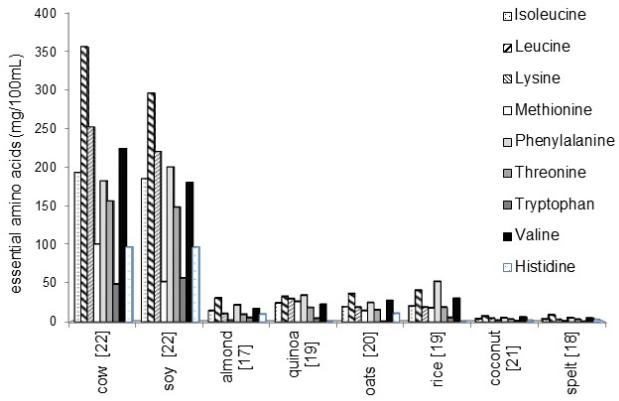

Figure 2: Essential amino acid content of the different products mg/100mL.

Although DIAAS is the preferred approach to evaluate dietary protein quality in humans, information was not available for all proteins, so the Protein Digestibility Corrected Amino Acid Score (PDCAAS) was substituted for the missing information, see table 3 [23, 24, 26]. The DIAAS of cow's milk protein is 20% higher than that of soy protein, and 50 to 54% above those of rice and oat protein [23]. The differences are similar when looking at the PDCAAS values: almond protein in particular has the lowest PDCAAS [24].

The exact amount of nutrients and the RDAs of the products are shown in table 2. Figure 3 shows the calcium content in one serving (100mL for children and 200mL for adults, based on the Swiss food pyramid) of all products compared to the RDAs for toddlers, children, and adults. We found large differences in the quantity of calcium available in dairy and plant-based beverages. One serving of cow's milk provides calcium amounting to 20% of the toddler's RDA, 16% of the children's RDA, or 24% of the adults' RDA. In contrast, almond, soy and quinoa based beverages show the highest amount of calcium of the plant-based beverages, have between 7 and 9 times less calcium than cow's milk, contributing to around 2% of the RDA of calcium for toddlers, children, and adults. Oat and rice based beverages have the lowest calcium content: less than 20 times that of cow's milk.

	Cow	Soy	Rice	Quinoa	Almond	Oats
DIAAS	1.18 [23]	0.90 [23]	0.59 [23]			0.54 [23]
PDCAAS (%)	1 [24]	0.91[24]	0.53 [26]	0.78 [26]	0.22-0.24 [26]	0.66 [26]
% of EAA to TAA	49% [24]	38% [24]	37% [24]	39% [24]		36% [24]

Table 3: DIAAS and PDCAAS of different proteins (%).

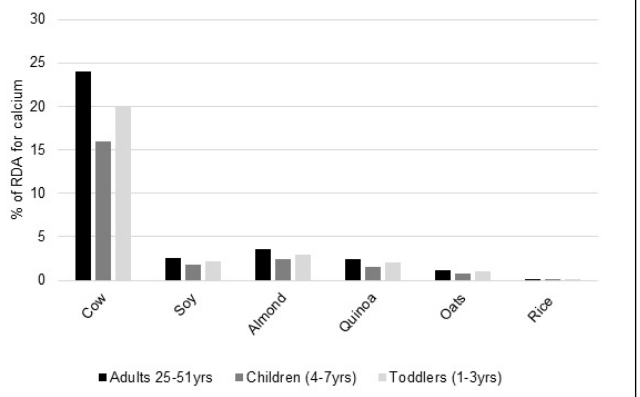

Figure 3: Proportion of RDA for calcium covered by one serving of the product for different population sub-groups (200 mL for adults and 100 mL for children 1-6 years = 1 serving based on the Swiss food pyramid)

In this study, we found that plant beverages have naturally very low levels of calcium and a few are fortified with calcium and vitamins. Of the 45 non-dairy beverages 33% were fortified with calcium and 14% with one or more vitamins, e.g. D, B2 or B12. When the beverages were fortified, the amounts were equivalent to the amounts of vitamins and calcium present in cow's milk. We found that the main source of added calcium are: 1) calcium phosphate, 2) lithothamnium calcareum, 3) calcium carbonate, 4) tricalcium orthophosphate, and 5) tricalcium phosphate.

Figure 4 shows the salt (a) and sugar (b) content in one serving 100mL for children and 200mL for adults, based on the Swiss food pyramid) of all products compared with the RDA for toddlers, children, and adults. We found that most plant-based beverages have added salt, while cow`s milk only had the naturally occurring salt. One serving of oat beverage provides an amount of salt equivalent to 11% of the toddler's RDA, 9% of the children's RDA and 6% of the adults' RDA. It is important to highlight that we used the RDA for salt from the Swiss Society of Nutrition, which corresponds to the minimum quantity of salt required. For example, in adults, this is 3.75g which differs from the WHO's recommendation of 5g [25].

With regard to sugar, we found that rice, quinoa, spelt and oat based beverages contain more sugar than the other non-dairy beverages, but is it natural. We observed that many non-dairy plant-based beverages can be found either unflavoured or with various added flavours such as vanilla, chocolate, mango etc. The beverages with added flavours contain between 2 to 8 times more sugar than the unflavoured beverages.

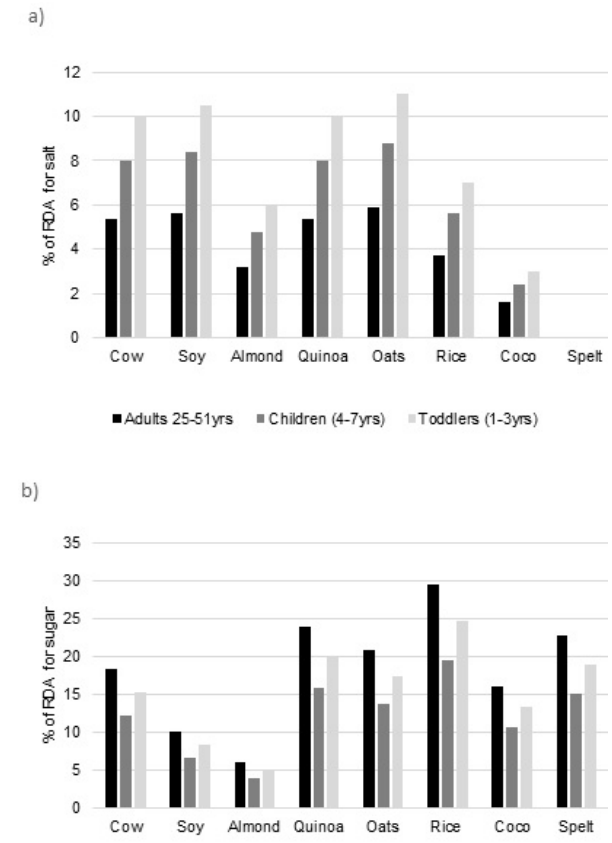

Figure 4: Proportion of RDA for salt (a) and sugar (b) covered by the content in one serving of the product for different population sub-groups (200 mL for adults and 100 mL for children 1-6 years = 1 serving based on the Swiss food pyramid). Data on salt for spelt was not available.

Discussion and Conclusion

Proteins are the primary components of all cells throughout the body and are essential for the growth, repair and maintenance of the body. Like Singahl et al. (2017), who conducted a similar study in the US, we found that cow's milk has more protein than most non-dairy plant-based beverages, except for soy milk [27]. However, cow's milk protein is of higher quality than soy milk, with 11% more essential amino acids and a higher DCAAS. Moreover, for children under three suffering from CMPA, soy protein is not recommended as a substitute of cow's milk, since it may be just as allergenic [2]. Our results show that the quality of plant-based proteins is lower than bovine milk protein and that almond protein in particular is of poor nutritional quality, in line with Ahrens et al., (2005) [17]. As for the other of plant-based proteins (coconut, rice, quinoa, almond and oat), they have far lower levels of all EAAs than cow's milk protein. This is particularly significant, as a lack of essential amino acids hampers the synthesis and recycling of body proteins [6]. The amount of sulphur-containing amino acids, especially, was very low. Methionine is the initiating amino acid in the synthesis of virtually all eukaryotic proteins and cysteine plays a crucial role in protein structure and protein-folding

pathways [28]. Another example is leucine, that plays an important role in muscle protein synthesis [29].

We found that non-dairy plant-based beverages have much less calcium than cow's milk. In the US, non-dairy beverages are fortified with calcium and vitamins [27]. In contrast, in this study, we found that in Switzerland, very few non-dairy beverages are fortified with calcium and vitamins. Of the 45 non-dairy beverages, only 33% were enriched with calcium. Calcium is an essential mineral for bone and teeth development, blood clotting, muscle contraction and nerve transmission. However, not all calcium that is present in food is absorbed by the body. The bioavailability of calcium (fraction that is absorbed into the body) depends on the type of food. For example, 30% to 32% of the calcium naturally present in dairy products is absorbed, compared to 20 to 30% of the calcium from plant sources, such as almonds and beans [6]. Differences in bioavailability also occur in fortified beverages. Even when their content of fortified micronutrients equals that of cow's milk, they cannot be considered equivalent, because the bioavailability of the added calcium also depends on the type of food [27]. A study comparing the bioavailability of calcium citrate malate and of a combination of tricalcium phosphate and calcium lactate (tricalcium phosphate/calcium lactate) found that equivalent calcium contents on a nutritional label do not guarantee equivalent nutritional value [30].

We found that most non-dairy plant-based beverages contain added salt. The increased consumption of sugar and salt has been associated with the development of non-communicable diseases (NCDs), such as obesity, hypertension, diabetes, and cardiovascular diseases (WHO 2016). Reducing sugar and salt intake is particularly important for Switzerland, as the health care costs due to NCDs are growing [31]. The Swiss nutrition strategy 2017-2024 highlights the challenge to reduce added sugar and salt in products [32]. Sugar and salt are normally added in food and beverages by the food industry to preserve, enhance flavour or improve texture. However further actions need to be taken to decrease their quantity, since, as shown in this paper, most non-dairy plant-based beverages have added salt and those with flavours also have added sugar.

The limitations of this study should be considered when interpreting the findings. We used information on the nutritional content listed on the product label by the manufacturers. It would be beneficial to have the full nutrient profile. For some products, information on the calcium content and on the amount of vitamins D, B2 and B12 was not available. We tried to mitigate this problem by using other sources of information to complement the data missing on the labels. Thus, further research should be undertaken to conduct laboratory tests and analyse the full nutritional composition of non-dairy beverages, in order to verify their content of all minerals and vitamins. For example, previous research found that quinoa is a good source of iron, magnesium and zinc when compared to the daily mineral recommendations [33]. The non-dairy plant-based products contain beneficial nutrients and, possibly, bioactive substances that might exhibit positive health effects. In our study, we focussed on protein, calcium, salt and sugar content, but all the other nutrients should be considered as well. In addition, we only focussed on the recommended serving size and did not consider the calories intake with the beverages. For example, the consumption of a less caloric plant-based beverage might induce a higher uptake of other protein sources at other meals.

Despite the limitations due to the data, this study has highlighted some critical issues relating to the nutritional content of dairy and plant-based beverages. Based on the findings in this study, non-dairy plant-based beverages cannot be generally considered healthier choices than cow's milk, because they contain less proteins, vitamins minerals, and calcium, but more added salt. The findings in this study suggest that the consumption of non-dairy beverages to replace cow's milk could result in nutritional deficiencies, particularly in children and elderly people. Thus, caution should be exercised when substituting cow's milk with non-dairy beverages and nutrient deficiencies should be compensated with other food sources.

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