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ORIGINAL CONTRIBUTION

Ready-to-eat cereals improve nutrient, milk and fruit intake at breakfast in European adolescents

Nathalie Michels[1] · Stefaan De Henauw[1,2] · Laurent Beghin[3] · Magdalena Cuenca-García[4] · Marcela Gonzalez-Gross[5,6] · Lena Hallstrom[7,8] · Anthony Kafatos[9] · Mathilde Kersting[10] · Yannis Manios[11] · Ascensión Marcos[12] · Denes Molnar[13] · Romana Roccaldo[14] · Alba M. Santaliestra-Pasías[15] · Michael Sjostrom[8] · Béatrice Reye[16] · Frank Thielecke[16,19] · Kurt Widhalm[17,18] · Mandy Claessens[1]

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Abstract

Purpose Breakfast consumption has been recommended as part of a healthy diet. Recently, ready-to-eat cereals (RTEC) became more popular as a breakfast item. Our aim was to analyse the dietary characteristics of an RTEC breakfast in European adolescents and to compare them with other breakfast options.

Methods From the European multi-centre HELENA study, two 24-h dietary recalls of 3137 adolescents were available. Food items (RTEC or bread, milk/yoghurt, fruit) and macro- and micronutrient intakes at breakfast were calculated. Cross-sectional regression analyses were adjusted for gender, age, socio-economic status and city.

Results Compared to bread breakfasts (39 %) and all other breakfasts (41.5 %), RTEC breakfast (19.5 %) was associated with improved nutrient intake (less fat and less sucrose; more fibre, protein and some micronutrients like vitamin B, calcium, magnesium and phosphorus) at the breakfast

In the same European adolescent population, RTEC consumption has been associated with dietary intake over the whole day and body composition. The corresponding article can be found here: http://link.springer.com/article/10.1007%2Fs00394-014-0805-x

✉ Nathalie Michels
nathalie.michels@ugent.be

1 Department of Public Health, Faculty of Medicine and Health Sciences, University Hospital, Ghent University, 4K3, De Pintelaan 185, 9000 Ghent, Belgium

2 Department of Health Sciences, Vesalius, Hogeschool Gent, Ghent, Belgium

3 CIC-9301-Inserm-CH&U and Inserm U995, IFR114, IMPRT, Centre Hospitalier & Universitaire de Lille, Université Nord de France, Lille, France

4 Department of Medical Physiology, School of Medicine, Granada University, Granada, Spain

5 Faculty of Physical Activity and Sport Sciences, University Polytechnic of Madrid, Madrid, Spain

6 Department of Nutrition and Food Science, University of Bonn, Bonn, Germany

7 School of Health, Care and Social Welfare, Märlardalens University, Västerås, Sweden

8 Department of Biosciences and Nutrition, Karolinska Institute, Huddinge, Stockholm, Sweden

9 Department of Social Medicine, Preventive Medicine and Nutrition Clinic, University of Crete School of Medicine, Heraklion, Crete, Greece

10 Research Institute of Child Nutrition, Dortmund, Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn, Germany

11 Department of Nutrition-Dietetics, Harokopio University Athens, Athens, Greece

12 Institute of Food Science and Technology and Nutrition, Spanish National Research Council, Madrid, Spain

13 Department of Paediatrics, Medical Faculty, University of Pecs, Pecs, Hungary

14 Agricultural Research Council, Food and Nutrition Research Centre (CRA-NUT), Rome, Italy

15 GENUD (Growth, Exercise, Nutrition and Development) Research Group, Faculty of Health Sciences, University of Zaragoza, Saragossa, Spain

16 Cereal Partners Worldwide S.A., Lausanne, Switzerland

17 Department of Pediatrics, Private Medical University Salzburg, Salzburg, Austria

18 Division for Clinical Nutrition, Obesity and Lipoprotein Disorders, Department of Pediatrics, Medical University, Vienna, Austria

19 Nestlé Research Center, Vers chez les Blanc, Lausanne, Switzerland

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occasion. Exceptions were more simple sugars in RTEC breakfast consumers: more lactose and galactose due to increased milk consumption, but also higher glucose and fructose than bread consumers. RTEC consumers had a significantly higher frequency (92.5 vs. 50.4 and 60.2 %) and quantity of milk/yoghurt intake and a slightly higher frequency of fruit intake (13.4 vs. 10.9 and 8.0 %) at breakfast. *Conclusions* Among European adolescents, RTEC consumers showed a more favourable nutrient intake than consumers of bread or other breakfasts, except for simple sugars. Therefore, RTEC may be regarded as a good breakfast option as part of a varied and balanced diet. Nevertheless, more research is warranted concerning the role of different RTEC types in nutrient intake, especially for simple sugars.

Keywords Adolescents · Ready-to-eat cereals · Breakfast · Fruit · Milk · Nutrients

Introduction

Breakfast consumption (particularly if the meal includes cereals) has been associated with lower intakes of fat and higher intakes of carbohydrates, fibre and certain micronutrients [1, 2] and with lower obesity prevalence [3]. However, a comprehensive analysis on the role of ready-to-eat cereals (RTEC) in a pan-European population of adolescents is lacking.

Due to the desire for easy and convenient breakfast alternatives, RTEC have become increasingly popular at breakfast. A German longitudinal study in children and adolescents found that RTEC are increasingly consumed, while bread becomes less popular [4]. Around 35 % of a sample of French children was found to prefer RTEC, while 40 % preferred bread [5]. RTEC can be defined as a cereal food that is processed to the point where it can be eaten without further preparation (although milk is usually added). Because of the food being readily available without further preparation, the long shelf life and the attractive variety in choice, RTEC are regarded as a convenient breakfast that has a role to play, not only in preventing breakfast skipping but also in contributing to a consistent part of the recommended daily nutrients intake.

Although a considerable amount of literature exists on the relation between RTEC consumption and diet, overall daily intake has been the main focus up to now. Less research has been done on the relation of breakfast RTEC intake with adolescent's breakfast nutrient composition [6, 7] and food item intake [4, 8]. Nevertheless, the effects of RTEC consumption on dietary intake quality and quantity are more likely at breakfast. Moreover, the comparison between RTEC breakfast and the other classical breakfast type including bread would be of great interest. After all, in a large German longitudinal study, 62 % of the breakfasts were bread meals [4] and a cereal-containing breakfast has been recommended [1]. Up to date, the majority of research related to RTEC is reported at national levels specifically the USA. However, differences exist in RTEC composition and breakfast consumption between continents [9]; hence, a more comprehensive pan-European perspective is warranted.

The aims of this study were to analyse the dietary characteristics of RTEC for the breakfast occasion regarding (a) portion size, composition and socio-demographic differences; (b) the energy, macro- and micronutrient composition of the breakfast; and (c) the consumption of generally recommended food items (milk/yoghurt and fruit) [10–12] at breakfast. This was achieved by comparing RTEC to "bread breakfasts" and to "all other breakfasts". In contrast to most other studies in the literature [6–8] who compare RTEC versus non-RTEC breakfast, we focused on "bread breakfasts" as type of non-RTEC breakfast since bread at breakfast is consumed in a substantial proportion of the European adolescent population. As such, we close the gap in the literature concerning RTEC breakfast composition since the pure effects on nutrient intake of RTEC consumption can be best examined at breakfast. For this purpose, data were used from the "Healthy Lifestyle in Europe by Nutrition in Adolescence" (HELENA) study, the first large-scale pan-European survey on adolescents diet.

Methods

Population

The HELENA cross-sectional study is a population-based, multi-centre study of the nutritional and lifestyle status of adolescents, carried out in ten European cities from nine countries (Vienna in Austria, Ghent in Belgium, Lille in France, Dortmund in Germany, Athens and Heraklion in Greece, Pecs in Hungary, Rome in Italy, Zaragoza in Spain and Stockholm in Sweden). Data were collected from October 2006 to December 2007. A detailed description of the HELENA study design and sampling procedure has been published elsewhere [13, 14]. The study was performed following the ethical guidelines of the Declaration of Helsinki [15]. All study participants and their parents provided a signed informed consent form.

The total HELENA population consisted of 3528 eligible adolescents (52.3 % females). For the current analyses, adolescents, aged 12.5–17.5 years, who provided breakfast data on one or both of the two requested 24-h dietary recalls, were included, resulting in 3137 subjects (51.5 % females). Data on 1 day is sufficient since analyses were done per day. Since for Heraklion and Pecs no full set of dietary data was available, these adolescents were excluded from the present

study. Age and gender did not differ between excluded and included cases, but more adolescents from high socio-economic status (SES) were included ($p < 0.001$). SES was examined by the Family Affluence Scale [16]; the scale is based on the concept of material conditions in the family. For some analyses, countries were organized into geographical regions: Greece, Italy and Spain represented the "Southern" region; (2) Sweden and Belgium represented the "Northern" regions and (3) France, Germany and Austria representing the "West/Central" region.

Diet

Dietary intake and RTEC consumption at breakfast were assessed by two 24-h recalls. Breakfast was defined as the first meal of the day (before 12 o'clock), the breakfast should include calories as a prerequisite for the analyses (without any threshold), and hence, breakfasts with only drinks like water, plain tea or coffee were not included. Consumed foods were translated into nutrients by the use of the German Food Code and Nutrient Data Base (Bundeslebensmittelschlüssel, BLS, version II.3.1) [17]. Portion sizes were defined by photographs in the software.

RTEC breakfast

An RTEC breakfast is defined as a breakfast that includes an RTEC item with or without additional food items. In reporting the RTEC type, no details on food fortification were available. The food composition linking used an aggregated mean of different RTEC brands (of the reported RTEC type) available in the BLS. In these intake data, RTEC were defined as a cereal food that is processed to the point where it can be eaten without further preparation. This includes mostly boxed cereals like extruded cereals or corn flakes but also muesli, oatmeal and cereal bars.

Bread breakfast

Among all the different breakfast options, bread was the main subgroup that was common and prevalent enough across all the different countries, like RTEC. Consequently, we decided not to test other subgroups of breakfast. A bread breakfast is defined as a breakfast that includes a bread item (including all types of bread and rolls, with or without additional food items, but no RTEC). In 3 % of the breakfasts, both RTEC and bread were consumed; these breakfasts were included in the RTEC group.

All other breakfasts

All other breakfasts were defined as breakfast containing no RTEC or bread.

Statistics

Analyses were performed with PASW Statistical Programme version 19.0 (SPSS Inc, IBM, IL, USA). Two-sided level of significance was set at $p < 0.05$. Non-normal data were transformed using the logarithmic or square root transformation to perform analyses, but data were back transformed into the original units for representation. The regression analyses were all corrected for age, gender, SES and city.

Differences in breakfast nutrient composition were examined between RTEC breakfast consumers versus "bread breakfast" consumers and "all other breakfast" consumers by a three-category containing predictor in linear regression. If energy intake differed, both raw nutrient intakes and energy-adjusted nutrient intakes were studied. Estimated marginal means from the regression were used in the representations.

The frequency of milk/yoghurt and fruit consumption during breakfast in RTEC breakfast versus bread or other breakfast was examined using Chi-square (χ^2). The same was done for quantity of milk/yoghurt and fruit intake during breakfast by linear regression, excluding those that did not consume milk/yoghurt or fruit. For fruit, also preserved/dried fruits were included but not those that were on the ingredients list of the RTEC type.

Results

Descriptive data

In total, 3415 adolescents had 24-h dietary recalls (547 adolescents provided one recall day and 2868 adolescents provided two recall days). Of these 6283 available recall days, only 5366 days (85.4 %) comprised a breakfast (with calories) and were considered for the analyses. Cases without calorie intake (e.g. just water or plain coffee/tea) were excluded for the analyses i.e. 2.7 %. In total, 3137 adolescents with breakfast information were included (2229 adolescents reported breakfast on both days). Of the 5366 breakfasts, 19.5 % ($N = 1050$) included an RTEC item, while 39 % ($N = 2092$) of these recall days included a bread item.

Concerning the broad type of RTEC, non-sweetened cornflakes (29.7 %), sweetened cornflakes (16.1 %), muesli (15.6 %), cornflakes with chocolate (15 %), puffed cereals (9.5 %), other wheat cereals (7.9 %), cereals made with whole grain (4.7 %), cereal bars (1.5 %) and oatmeal (0.1 %) were reported. The additional food items mainly consisted of drinks (24 % milk, 5.8 % juices, 4 % water, 2.8 % coffee/tea), fruit or yoghurt. When adolescents consumed RTEC, a median portion size (at one eating

occasion) of 35 g/portion (interquartile range 24–56) was found. This portion size of 35 g/portion as used by the 24-h recall is depicted in Fig. 1. The portion size was higher in boys than in girls (40 vs. 31 g, $p < 0.001$), higher in the adolescents older than 15 than those younger (40 vs. 33 g, $p < 0.001$), higher in North/Western countries than in Southern countries (44 vs. 24 g, $p < 0.001$), but no differences concerning SES categories were found (also not after stratifying by country).

For the "bread breakfast", spreads were in decreasing order of frequency: oil/butter/margarine (47 %), meat (33.8 %), cheese (30.4 %), chocolate (20.4 %), jam (19.6 %). Regional differences ($p < 0.001$) were seen with highest consumption of oil/butter/margarine in Southern regions, highest intake of honey/jam and meat in Western countries and highest intake of chocolate spread and cheese in Western and Northern countries. Types of bread were most often white bread (35.2 %), brown or wholemeal (25 %), rolls/baguettes/sandwiches (16.9 %) and crackers (8.6 %). The additional food products mainly consisted of cake/biscuit, drinks and fruit.

The category "all other breakfasts" was very divers. Hot drinks only with calorie intake were reported in 24 % of the cases. Other types of breakfast include e.g. cake/biscuit only (20.8 %), confectionary only (6.4 %), a hot dish (3.5 %) or only fruit and drinks (1.8 %). The prevalence of all these types of breakfasts was significantly different between countries. Drinks only and cake/biscuit/confectionary were seldom reported in the Northern countries, while bread intake was highest in the Northern countries. Hot dishes were almost exclusively reported in Southern countries. For RTEC, a trend to geographical differences was found: 16 % in Southern, 19 % in West/Central and 24.3 % in Northern countries.

Fig. 1 Portion size of 35 g as defined by the 24-h recall

For descriptive purposes, whole-day macronutrient and micronutrient intake for all analysed adolescents (irrespective of breakfast type) was compared to the recommended intakes by the FAO/WHO [18, 19]. Overall, only 8 % of the adolescents had a higher carbohydrate intake than recommended (>60 E %), but 63 % of the adolescents had high fat intake (>35 E %). For fibre, 34.3 % had a low intake (<20 g/day). For most vitamins and minerals, the recommended intake was achieved. This was absolutely not the case for vitamin D since none of the adolescents reached the recommended 5000 ng/day. For calcium, only 10.8 % reached the recommended intake (1300 mg/day). For iron, 51.2 % (67.9 % of the boys and 38 % of the girls) reached the gender- and age-specific recommended intake.

Breakfast nutrient composition

The breakfast intake for total energy and macro- and micronutrients of an RTEC breakfast was compared with "bread breakfast" and "all other breakfast" (see Table 1). Since an RTEC breakfast differed in energy content, the analyses were done on both the raw (= absolute) and energy-corrected (= relative) intakes.

Compared to "bread breakfast", an RTEC breakfast had a lower energy content. Concerning macronutrients, those with an RTEC breakfast had a lower fat intake (and all its subtypes) but a higher protein, carbohydrate and fibre intake. Concerning simple sugars, an RTEC breakfast resulted in a lower intake of sucrose and a higher intake of glucose, fructose, galactose and lactose. Concerning micronutrients, RTEC breakfast consumers had a higher intake of calcium, magnesium, phosphorus, potassium, vitamin B (except B9) and energy-adjusted vitamin C, but lower intake of sodium and vitamins A, E and K.

Compared to "all other breakfasts", an RTEC breakfast had higher energy content. Concerning macronutrients, differences were almost the same as when comparing RTEC breakfast with "bread breakfast" except for a lower saturated fat, unsaturated fat and maltose intake, a higher glucose and fructose intake in "all other breakfasts". Concerning micronutrients, calcium, magnesium, phosphorus and all vitamins B were again lower, but iron, sodium, zinc, vitamin K and vitamin A were now also lower in "all other breakfasts" versus RTEC breakfast.

Breakfast items

Table 2 shows the percentage of consumers of milk/yoghurt and fruit consumption in RTEC breakfast versus all other and bread breakfasts. More frequent consumption of milk/yoghurt and fruit at breakfast was seen in participants consuming an RTEC breakfast ($p < 0.001$). The quantity of fruit intake at breakfast was not significantly different

Table 1 Intake of energy, macro- and micronutrients during breakfast, comparing RTEC breakfast (1050 days) with bread breakfast (2092 days) and all other breakfasts (2224 days)

	Estimated raw nutrient intake			Estimated energy-adjusted nutrient intake (/1000 kcal)		
	RTEC	Bread	Other	RTEC	Bread	Other
Energy (kcal)	495	540*	299**			
Fat (g)	10	16**	8	23	34**	25
Monounsaturated (g)	3.9	6.1**	1.9**	8.8	12.6**	7.5**
Polyunsaturated (g)	1.1	1.8**	0.5**	2.3	3.6**	2.1
Saturated (g)	5.8	8.6**	4.1**	13.5	17.8**	11.9*
Protein (g)	15	14	7**	36	32**	26**
Carbohydrate (g)	64	62	36**	151	130**	139**
Monosaccharide (g)	5.1	3.8**	2.7**	11.3	7.1**	12.6
Glucose	2.3	1.6**	1.1**	4.4	2.6**	5.9*
Fructose	3.1	2.1**	1.4**	6.0	3.9**	7.7*
Galactose	0.18	0.01*	0.04**	0.39	0.02**	0.19
Disaccharide (g)	23	22	20*	54	46**	80**
Sucrose	8	14**	10*	14	23**	42**
Lactose	12	4**	6**	27	8**	14**
Maltose	0.2	0.1	0.01**	0.3	0.2	0.01**
Polysaccharide (g)	32	27**	6**	76	59**	14**
Fibre (g)	3.7	3.6	1.2**	8.6	7.6**	3.7**
Soluble fibre (mg)	1029	1135*	293**	2352	2465	886**
Insoluble fibre (mg)	2689	2458*	929**	6201	5187**	2815**
Calcium (mg)	348	240**	169**	852	524**	686**
Iron (µg)	1981	2160*	1023**	4564	4416	4243*
Magnesium (mg)	78	66**	41**	185	139**	163**
Phosphorus (mg)	408	331**	152**	957	737**	688**
Potassium (mg)	690	501**	311**	1575	1058**	1702
Sodium (mg)	434	542**	120**	1023	1192**	505**
Zinc (µg)	2199	2322	960**	4911	4956	4406**
Vitamin A (µg)	113	154**	57**	244	326**	238
Vitamin B1 (µg)	268	211**	97**	646	457**	418**
Vitamin B2 (µg)	523	357**	236**	1318	777**	981**
Vitamin B3 (µg)	1780	1477**	568**	4342	3234**	2489**
Vitamin B5 (µg)	1289	945**	592**	3146	2043**	2388**
Vitamin B6 (µg)	264	233**	114**	633	508**	438**
Vitamin B7 (µg)	13	9**	7**	31	19**	26**
Vitamin B9 (µg)	34	36*	18**	81	79	80
Vitamin B12 (ng)	1077	762**	416**	2653	1679**	1535**
Vitamin C (mg)	11	10	8**	25	20*	34**
Vitamin D (ng)	219	267*	183*	515	559	579
Vitamin E (µg)	1119	1494**	581**	2281	3036**	2311
Vitamin K (µg)	21	29**	9**	47	62**	39**

Estimated marginal means after correction for age, gender, city and socio-economic status are given
Significance compared to RTEC: ** $p < 0.001$, * $p < 0.05$

between RTEC, bread and all other breakfasts consumers ($p = 0.181$). The quantity of milk/yoghurt intake at breakfast was significantly higher for an RTEC breakfast versus bread and all other breakfasts ($p < 0.001$; mean 279 vs. 217 and 225 ml).

Discussion

Our primary aim was to examine the nutrient composition and food items of an RTEC breakfast compared to "bread breakfasts" and "all other breakfasts" in a European

Table 2 Milk/yoghurt and fruit consumption in RTEC breakfast versus bread breakfast and all other breakfasts

	RTEC breakfast (1050 days)	Bread breakfast (2092 days)	All other breakfasts (2224 days)
Percentage consumers[a]			
Milk or yoghurt	92.5 %	50.4 %**	60.2 %**
Fruit	13.4 %	10.9 %*	8.0 %**
Quantity of intake[b]			
Milk or yoghurt (ml)	279	217**	225**
Fruit (gram)	135	147	147

Significance compared to RTEC: ** $p < 0.001$, * $p < 0.05$

[a] χ^2 statistic; [b] estimated marginal means for regression after correction for age, gender, city and socio-economic status

population. Although RTEC were popular in our adolescent sample over all European partners (in 19 % of the breakfast entries; median portion size 35 g), bread was still the most popular (in 39 % of the breakfast entries, especially in Northern countries).

RTEC have been commercialized as a healthy breakfast item mainly due to its fibre content, and some varieties made with whole grain. Moreover, most RTEC are fortified with a range of micronutrients including vitamin B and iron [20, 21]. Despite the efforts of some cereal companies to improve nutritional quality, some RTEC products commercialized for children/adolescents can be low in fibre and high in added sugar [22]. Previous literature suggests that RTEC consumption is associated with less fat, a better micronutrient composition and a higher fruit and milk intake as well as higher sugars content [4, 6–8]. Up to now, no information on a multi-centre European sample was available.

Nutrient intake at breakfast

In our study, an RTEC breakfast resulted in a higher *energy* intake at breakfast compared to "all other breakfasts". Of course, it should be considered that some adolescents only consumed a beverage or a small snack at breakfast. Comparing RTEC breakfast with the common "bread breakfast" suggests that adolescents consuming RTEC breakfast had a lower energy content and consequently a lower macronutrient content. However, with energy-adjusted intakes at breakfast, the results for *macronutrients* were similar for both types of breakfasts: an RTEC breakfast resulted in higher carbohydrate, higher protein, lower fat and higher fibre intake. This advantage is of public health importance in this population with overall high fat and low fibre intake.

Regarding *simple sugars*, an RTEC breakfast provided higher relative intake of galactose and lactose, but lower intake of sucrose than "all other breakfasts" and "bread breakfast". Compared to "bread breakfast", RTEC breakfast also provided more glucose and fructose. This is the first study giving detailed information on all subtypes of sugars. In the literature, we found one study examining only sucrose in US adolescents, and in contrast to our result, they showed higher sucrose intakes in RTEC consumers. Relevant interpretation for the differences in simple sugars intake is difficult since two reviews found no conclusive evidence to set up an upper limit for mono- and disaccharide intake when considering later disease risk [18, 23]. This analysis reveals that the elevated monosaccharide and some disaccharide (lactose) intake in RTEC breakfast consumers might partially be due to the increased consumption of milk/yoghurt (lactose) and fruit (fructose). For example, fructose was higher in RTEC consumers, but only half of the fructose in the breakfast came from the RTEC itself (RTEC types differed in fructose content between 0 and 6400 mg/100 g). Although recent research highlights the health impact of added fructose (in the form of high-fructose corn syrup) [24], the database did not allow us to make a distinction between naturally present fructose (e.g. fruit pieces) and added fructose.

An RTEC breakfast had the advantage of a more beneficial *micronutrient intake*, especially for vitamins B (except B9), calcium, magnesium, phosphorus and potassium. Apart from the cereals' natural micronutrient content, the association of RTEC with a more beneficial mineral and vitamin intake is in agreement with the literature finding that food fortification contributes to increased vitamin and mineral intakes in childhood and adolescence [21, 25, 26]. After all, children and adolescents are the population group running the highest risk of nutritional deficiencies particularly for iron and vitamins C, E and B6 and also calcium in more Southern countries [21]. Also, the higher intake of milk products in RTEC breakfast can explain some higher mineral intakes e.g. calcium. RTEC, and especially RTEC marketed to children and teens, are often considered as high in sodium [22]. Yet, in our analyses, the sodium content of an RTEC breakfast was lower than a bread breakfast but higher than in the other breakfast groups. In contrast to the beneficial B vitamin status in RTEC breakfast consumers, the fat-soluble vitamins were mostly higher in the "bread breakfast" consumers (in the percentage of daily

recommended intake: 19 vs. 26 and 0.1 % for vitamin A; 0.04 vs. 0.05 and 0.03 % for vitamin D; 14 vs. 19 and 7 % for vitamin E; 52 vs. 72 and 22 % for vitamin K; for RTEC versus bread and other breakfasts).

Food item intake at breakfast

Apart from nutrient composition, RTEC consumption may also influence the accompanying food items during breakfast. In total, 92.5 % of European adolescents consumed RTEC with milk, hence resulting in a higher frequency and quantity of *milk* intake compared to subjects having no RTEC breakfast. This is in agreement with previous findings showing that 95 % of RTEC consumers consumed their cereal with milk in a US study [8] or even 99 % (vs. 74 % in the RTEC non-consumers) in a German study [4]. In our study, RTEC consumers also reported a higher *fruit* intake frequency during breakfast, but when they consumed it, they consumed the same absolute amount of fruit as RTEC non-consumers. Consequently, RTEC breakfast consumers have a more routine habit of fruit consumption at breakfast (although 13.4 % only), independent of the portion size. Only a German study in children and adolescents also reported a more frequent fruit intake at RTEC breakfast compared to bread breakfast, although with a much smaller between-group difference (37 vs. 32 % fruit intake) than our study [4]. This observed higher fruit and milk intake also links with the most beneficial vitamin and calcium intake in an RTEC breakfast and may also contribute to the observed higher monosaccharide and lactose intake in an RTEC breakfast.

Daily intake

In the same European adolescent population, RTEC consumption has been associated with intake over the whole day [27]. Also over the whole day, RTEC consumers scored better in fruit and milk intake and they had an overall higher dietary quality (based on a diet quality index), as well as a better body composition, illustrated by better BMI, body fat and waist circumference. This confirms that the dietary routines in RTEC consumers are more in agreement with the guidelines. Interestingly, RTEC consumers had no differences in carbohydrate intake over the whole day compared to non-RTEC consumers. Consequently, the higher simple sugars intake during breakfast does not result in a higher intake of simple sugars over the whole day.

Strengths and limitations

Our data were derived from a large European study including adolescents from eight different countries with extensive, standardized dietary information. This allowed the description of portion size, composition and geographical differences. In studying breakfast differences, nutrient composition (including carbohydrate subtype analysis for the first time in the literature) and breakfast food item differences (both frequency and quantity of intake) were analysed. In contrast to the existing literature, the RTEC breakfast was separately compared to bread breakfast. By doing this, we could detect whether RTEC are indeed a healthy alternative for the more classical slice of bread.

Apart from these strengths, a major limitation is that no clear distinction could be made between different RTEC types due to the lack of detail in the dietary recall. Consequently, no separation was possible in whole grain versus refined RTEC or on nutrient density (healthy versus those high in fat, sugars or sodium), although a wide variety exists [20]. This might make the interpretation of results more difficult since the different types could result in a different nutrient intake [28]. Furthermore, the food composition linking used an aggregated mean of different RTEC brands (of the reported RTEC type) available in the German Food Code and Nutrient Data Base, which might have introduced some bias in the micronutrient intakes due to important differences in the level of fortification between RTEC types available in Europe e.g. the RTEC from the database were not fortified with vitamin D.

Conclusion

This is the first analysis in a multi-centre European adolescent population that examines the role of RTEC breakfast on nutrient intake and elucidates new information concerning portion size and breakfast composition. Consumers of RTEC breakfast had less fat and sucrose intake, and a higher fibre, protein, vitamin B and mineral intake. They also had a more frequent consumption of fruit and milk. Interestingly, fat, fibre, calcium and vitamin D were the nutrients for which the adolescents most often failed to reach the recommended daily intake. In our analyses, an RTEC breakfast was beneficial for all these nutrients except for vitamin D. On the other hand, RTEC breakfast had a higher simple sugars content: more lactose and galactose due to increased milk consumption, but also higher glucose and fructose than bread consumers.

Taken together, RTEC may be regarded as a good breakfast option as part of a balanced and varied diet. However, more research is needed to better understand the effects of different RTEC types with regard to their nutritional composition including fat, fibre and simple sugars content.

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Conflict of interest F.T. and B.R. were affiliated at Cereal Partners Worldwide S.A. at the time this analysis was conducted. This did not affect our scientific integrity.

Ethical standards The study was performed following the ethical guidelines of the Declaration of Helsinki 1964 and its later amendments. All study participants and their parents provided a signed informed consent form.

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