Scandinavian Journal of Nutrition/Näringsforskning Vol 43:4-7, 1999

Added sugars and nutrient density in the diet of Danish children

By Niels Lyhne and Lars Ovesen

ABSTRACT

The relation between added sugars and density of dietary fibre and micronutrients was examined by analysing diets from 983 Danish girls and boys aged 4-14 years. The average intake of added sugars was 13.7 E% ranging from 3.4 to 38E%. One fourth of the diets were below the recommended maximum level of 10 E%. No differences between sex and age groups were found. The diets were ranked and divided into quintiles (fifths) according to percentage of energy from added sugars. A strongly significant decline in nutrient density for all nutrients, except vitamin C, was observed as sugar concentration rose across quintiles. Nutrient densities expressed relative to recommended values varied from 30% to 300% illustrating that the nutritional significance of the dilution effect of added sugars differs from one nutrient to another. The results support the concept of "empty calories" and restriction of added sugars should still be recommended. *Key words: Added sugars, children, empty calories, micronutrients, nutrient density*

Introduction

In the Nordic Nutrition Recommendations (NNR) it is recommended to limit the intake of refined sugars to achieve a sufficient intake of dietary fibre. For adults with a low energy intake as well as for children this limit is set to a maximum of 10% of the energy intake (1). This is a pragmatic level which will ensure an adequate supply of essential nutrients, reduce the risk of caries, and still allow space in the diet for the sweet taste. Refined sugars include sucrose, fructose, starch hydrolysates etc. as food components or added in food manufacturing (1). A popular phrase for these pure carbohydrates is "empty calories", because they contain no micronutrients and thus dilute the content of vitamins and minerals in the diet. The aim of this study was to examine the influence of refined or added sugars on the quality of children's diet with respect to the dilution hypothesis and the concept of "empty calories".

Niels Lyhne*, Senior Research Nutritionist, **Lars Ovesen**, M.D., Danish Veterinary and Food Administration, Institute of Food Research and Nutrition. **Correspondence:* Veterinær- og Fødevaredirektoratet, Mørkhøj Bygade 19, DK-2860 Søborg, Denmark. *E-mail:* nla@vfd.dk

Methods

Subjects

Data were drawn from the national dietary survey "Dietary Habits in Denmark 1995" (2). In this survey the participants (or their parents) kept a 7-day food record with preprinted response categories supplemented with open-ended alternatives. The quantity of foods eaten was estimated from household measures. The diets of 983 children (483 boys and 500 girls) aged 4-14 years were examined. In the survey response rate was 82% in this age group. The age group 4-14 years was chosen because the recommendations concerning refined sugars are primarily directed towards children, and the level of consumption of added sugars in Denmark is approximately 50% higher in children compared to adults (2).

Definitions

The term "added sugars" refers to refined or industrially produced sugars (usually sucrose) used as ingredient in processed foods or added at home in the kitchen or at the table. Added sugars do not include naturally occurring mono- and disaccharides in fruits, juices and milk. Most other studies on sugars and nutrient intake describe effects of total sugars or non-milk extrinsic sugars (NMES). Total sugars include all mono- and disaccharides in the diet irrespective of origin. NMES include all sugars that are neither components of milk, nor contained within plant cell walls (3). The major difference between NMES and added sugars is sugars from juices.

Calculations

Nutrient density expressed as amount of dietary fibre, vitamins and minerals per 10 MJ was calculated for each individual diet. The argument for expressing diet composition instead of absolute intakes is the wide variation in energy intake and expenditure between age and sex groups. Furthermore, the percentage of energy from added sugars was calculated. The analyses are based on ranking of diets in quintiles (fifths) according to energy percent from added sugars. In calculating nutrient contents corrections for losses in cooking are done (2). Nutrient data including added sugars are taken from the National Food Data Base (4). Results concerning differences related to age are grouped according to age groups in NNR (1).

Relative nutrient density is expressed in percent of recommended nutrient density, to be used for planning of diets to a heterogeneous group of boys and girls aged 4-14 years. The recommended densities for each nutrient are calculated according to NNR (1) and based on the age and sex category for which the highest nutrient density is required.

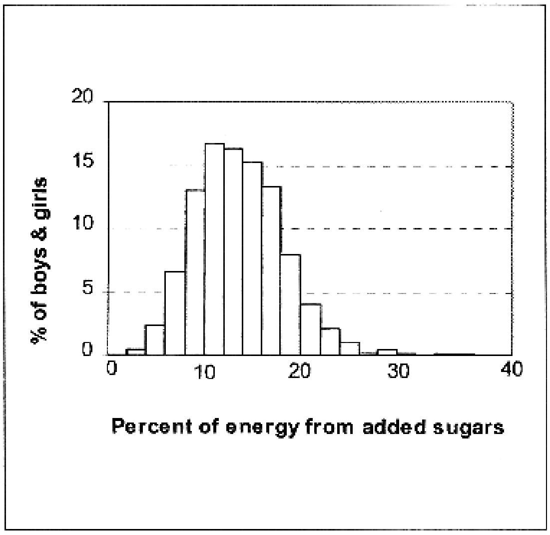
Table 1. Contribution of added sugars in the average diet from different food groups.

Food group	% of total
Sweets, cakes, table sugar	47.5
Ice cream	4.6
Soft drinks, sugar added	17.9
Fruit juice, sweetened	17.7
Other fruit products	5.6
Milk products	3.7
Cereals	2.5
Other	0.5
Total	*100*

Table 2. Intake of energy and energy percent from added sugars in 983 boys and girls aged 4-14 years; mean (standard error). Differences in added sugars are not significant. Differences in energy intake are significant in all age and sex groups (p<0.001).

Age	Sex	n	Added sugars (E%)	Energy (MJ/day)
4-6 years	Boys	136	13.3 (0.37)	8.0 (0.14)
	Girls	137	13.5 (0.41)	7.3 (0.12)
	All	273	13.4 (0.28)	7.6 (0.09)
7-10 years	Boys	185	13.5 (0.36)	9.8 (0.13)
	Girls	191	13.9 (0.30)	9.0 (0.13)
	All	376	13.7 (0.23)	9.4 (0.09)
11-14 years	Boys	162	13.9 (0.38)	10.8 (0.19)
	Girls	172	13.9 (0.39)	9.2 (0.16)
	All	334	13.9 (0.27)	10.0 (0.13)
4-14 years	Boys	483	13.6 (0.21)	9.6 (0.10)
	Girls	500	13.8 (0.21)	8.6 (0.09)
	All	983	13.7 (0.15)	9.1 (0.07)

Figure 1. Intake distribution of added sugars (E%); diets from 983 boys and girls aged 4-14 years.



Statistical analyses

Differences between the quintiles are assessed by one-way analysis of variance and differences between age and sex groups by unpaired t-test.

Results

More than half of the added sugars in the average diet derives from sweets, cakes, ice cream and table sugar, and more than one third from sweetened beverages equally divided between sweetened fruit juices and carbonated soft drinks (Table 1). The remaining minor part of the sugars comes from cereals, fruit and milk products.

Energy intake rises with increasing age, and boys have a significantly higher energy intake than girls in all age groups (Table 2). No differences are found in percentage of energy from added sugars between sex and age groups.

The level of added sugars is close to 14 E%. The intake distribution is shown in Figure 1. Approximately one fourth of the children's diets are below the recommended maximum of 10 E%. Since no differences in E% are found between sex and age groups, the diets of all children are analysed together in order to improve statistical power.

Table 3 shows the major statistics of percent energy derived from sugar (E%) after ranking and dividing into quintiles. The E% distribution of the lower and upper quintiles are skewed to the left and to the right, respectively, while E% in each of the three quintiles in the middle are uniformly distributed.

The energy intake of each age group divided into quintiles of energy percent from added sugars is shown in Table 4. Mean energy intakes when all children are grouped together tend to rise slightly as intake of added sugars increases, even though differences between quintiles are not significant. Within each age group no systematic changes across quintiles are found, and only the older age group shows significant differences.

The nutrient density across quintiles of energy percent from added sugars is shown in Table 5 for dietary fibre and 10 vitamins and 9 minerals. Figures 2-4 are typical representatives of the general picture. Except for vitamin C the nutrient density decreases with increasing content of added sugars in the diet. Relative nutrient densities expressed in percent of recommended values for planning of diets (1) are presented in Figure 5. The percentage of coverage is above or well above hundred for vitamin A, thiamin, riboflavin, niacin, vitamin B_6, vitamin B_{12}, vitamin C and phosphorous in all quintiles. For folate, calcium, magnesium and zink full coverage is only reached in lower quintiles. Dietary fibre and the remaining nutrients – vitamin D, vitamin E, iron, iodine, selenium and potassium – do not fulfil the recommended levels – not even in the low sugar quintile.

Discussion

The results clearly show a general trend of declining nutrient density with increasing percentage of energy from added sugars. The negative association is much stronger than demonstrated in earlier studies (3,5-8). However, comparison is complicated by the fact that some of these studies deal only with total sugars (5, 6) or NMES (3), which might explain why they show a weaker dilution effect. Another complicating factor is the common practice to estimate the effect of sugars on absolute intakes of nutrients rather than nutrient densities. *Rugg-Gunn* et al. (7) found a

Table 3. Percent of energy from added sugars divided into quintiles (Q). Data from diets of 983 boys and girls aged 4-14 years.

Q	Mean	Median	SE	Range
1	7.7	8.1	0.107	3.4-9.7
2	11.0	11.0	0.049	9.7-12.1
3	13.4	13.4	0.051	12.1-14.7
4	15.9	15.9	0.060	14.7-17.4
5	20.5	19.4	0.24	17.4-37.7

Table 4. Energy intake (MJ/day) of 983 children aged 4-14 years across quintiles of energy percent from added sugars; mean (standard error). Boys and girls are grouped together.

Age	4-6 years		7-10 years		11-14 years		4-14 years	
1. quintile	7.5	(0.24)	9.6	(0.26)	9.1[a]	(0.27)	8.9	(0.16)
2. quintile	7.8	(0.18)	9.1	(0.18)	9.7[a,b]	(0.30)	8.9	(0.15)
3. quintile	7.6	(0.19)	9.5	(0.21)	10.6[c]	(0.30)	9.3	(0.16)
4. quintile	7.4	(0.21)	9.7	(0.20)	10.2[b,c]	(0.27)	9.3	(0.15)
5. quintile	7.9	(0.23)	9.0	(0.18)	10.1[b,c]	(0.28)	9.1	(0.15)
p[1]	NS		NS		**		NS	

[1] One way ANOVA; NS = not significant;

** p<0.01; quintiles that share a common letter (a,b,c) are not significantly different.

Table 5. Nutrient densities (per 10 MJ) of diets from 983 boys and girls aged 4-14 years divided into quintiles of energy percent from added sugars. Recommended nutrient densities for planning of diets from Nordic Nutrition Recommendations (NNR)(1).

			1. quintile n=197	2. quintile n=197	3. quintile n=196	4. quintile n=196	5. quintile n=197	p	NNR
Dietary fibre	g/10 MJ	Mean	22.4	21.7	20.5	19.2	17.9	***	30
		SE	0.28	0.27	0.26	0.22	0.24		
Vitamin A	RE/10 MJ	Mean	1,623	1,535	1,421	1,324	1,186	***	950
		SE	57	70	50	45	45		
Vitamin D	µg/10 MJ	Mean	3.0	2.6	2.6	2.3	2.2	***	7
		SE	0.17	0.09	0.09	0.08	0.08		
Vitamin E	α-TE/10 MJ	Mean	8.4	8.3	7.8	7.7	7.1	***	10
		SE	0.17	0.17	0.14	0.13	0.12		
Thiamin	mg/10 MJ	Mean	1.45	1.40	1.33	1.27	1.20	***	1.2
		SE	0.015	0.015	0.015	0.016	0.016		
Riboflavin	mg/10 MJ	Mean	2.30	2.15	2.07	1.92	1.74	***	1.4
		SE	0.032	0.035	0.030	0.030	0.028		
Niacin	mg/10 MJ	Mean	26.9	24.3	23.3	22.2	20.9	***	16
		SE	0.31	0.28	0.27	0.25	0.29		
Vitamin B_6	mg/10 MJ	Mean	1.65	1.52	1.46	1.35	1.30	***	1.3
		SE	0.019	0.018	0.017	0.015	0.017		
Folate	µg/10 MJ	Mean	293	280	268	251	233	***	280
		SE	4.0	5.2	3.8	3.5	3.4		
Vitamin B_{12}	µg/10 MJ	Mean	7.2	6.4	6.0	5.4	4.8	***	2.4
		SE	0.20	0.22	0.15	0.14	0.13		
Vitamin C	mg/10 MJ	Mean	80	75	79	73	71	NS	60
		SE	2.4	2.4	2.7	2.4	2.7		
Calcium	mg/10 MJ	Mean	1,379	1,270	1,246	1,162	1,049	***	1,100
		SE	21	22	22	21	18		
Phosphorous	mg/10 MJ	Mean	1,818	1,684	1,617	1,514	1,376	***	800
		SE	17	17	15	16	15		
Magnesium	mg/10 MJ	Mean	329	310	300	284	264	***	330
		SE	3.1	2.9	2.7	3.0	2.8		
Iron	mg/10 MJ	Mean	10.4	10.3	9.9	9.6	9.3	***	14
		SE	0.11	0.11	0.10	0.09	0.09		
Zinc	mg/10 MJ	Mean	12.8	11.8	11.3	10.7	9.8	***	11
		SE	0.12	0.12	0.11	0.10	0.10		
Iodine	µg/10 MJ	Mean	90	82	81	77	70	***	180
		SE	2.1	1.7	1.5	1.7	1.3		
Selenium	µg/10 MJ	Mean	40	37	35	33	31	***	48
		SE	0.62	0.56	0.47	0.51	0.49		
Sodium	g/10 MJ	Mean	3.5	3.3	3.2	3.1	2.9	***	max. 2
		SE	0.042	0.036	0.035	0.034	0.035		
Potassium	g/10 MJ	Mean	3.3	3.0	3.0	2.8	2.6	***	3.7
		SE	0.031	0.032	0.028	0.029	0.028		

*** $p<0.001$; one-way ANOVA

Figure 2. Nutrient density of dietary fibre (g/10 MJ) across quintiles of energy percent from added sugars. Mean and 95% CI. NNR-line represents the recommended level in diets for this group of children (1).

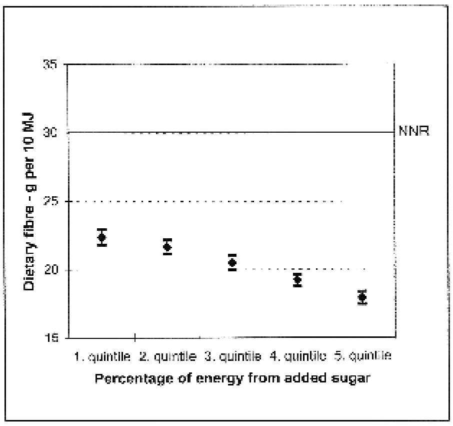


Figure 3. Nutrient density of vitamin A (RE/10 MJ) across quintiles of energy percent from added sugars. Mean and 95% CI. NNR-line represents the recommended level in diets for this group of children (1).

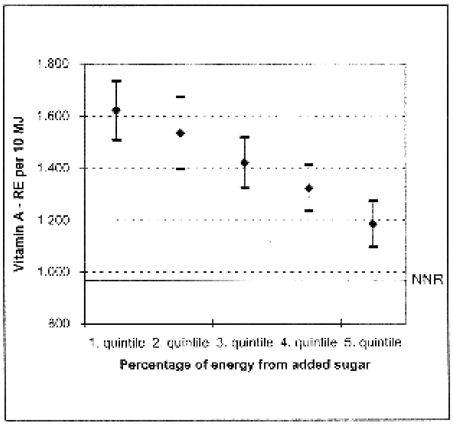


Figure 4. Nutrient density of zinc (mg/10 MJ) across quintiles of energy percent from added sugars. Mean and 95% CI. NNR-line represents the recommended level in diets for this group of children (1).

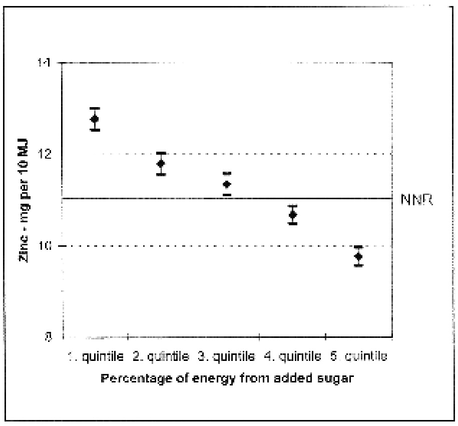
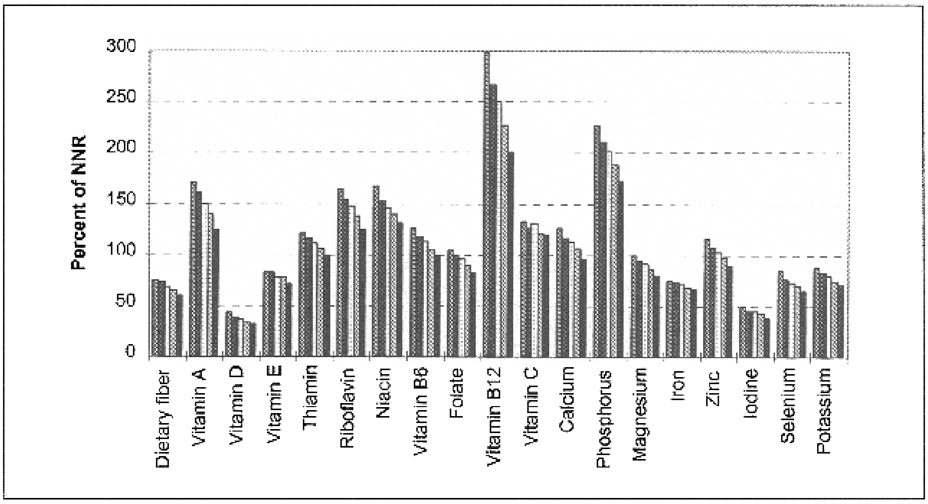


Figure 5. Relative nutrient density across quintiles of energy percent from added sugars; percent of recommended nutrient density according to Nordic Nutrition Recommendations 1996 (1); diets from 983 boys and girls aged 4-14 years.



positive association between intake of added sugars and micronutrients reflecting that energy intake is the major predictor of nutrient intake. This is not the case in a study by *Gibson* (8) of the diet of British adults, which showed that as the percentage of energy from added sugars increased, then energy intake increased and intake of micronutrients decreased slightly. However, many nutrients showed a non-linear relationship with sugar energy with the highest nutrient intake among average sugar consumers. This finding could be explained by a general underreporting of food intake among consumers in the lowest quintile of sugar intake.

In our study energy intake only increases slightly and insignificantly across quintiles of energy percentage from added sugars. So, differences in absolute intake of nutrients will follow the same pattern as nutrient density do, i.e. intakes of dietary fibre and micronutrients are negatively associated with intake of added sugars.

The only exception from the marked negative association is vitamin C showing a non-significant ($p=0.09$) lower nutrient density in the upper quintiles. This finding reflects that some of the foods, rich in added sugars, are also sources of vitamin C. Sweetened fruit juice is most important in this respect.

Even if the results do support the concept of "empty calories", the nutritional significance of increasing added sugars in the diet differs strongly from one nutrient to another. The effect ranges from no significance at all to a higher probability of insufficient intake as sugar concentration increases. But since a surplus of one nutrient can not compensate a possible insufficient intake of other nutrients, recommendations for dietary changes must focus on those nutrients of borderline adequacy. It seems prudent to continue recommending moderation in intake of added sugars. In fact, one may conclude that further restriction of added sugars and foods supplying the majority of refined sugars could be an important means to increase concentrations of dietary fibre and marginal vitamins and minerals in the diet. This is certainly a must when energy intake is restricted, i.e. if energy expenditure is low or in slimming diets.

REFERENCES

1. Nordic Nutrition Recommendations 1996: Scand J Nutr/Näringsforskning 1996;40:161-5.
2. Andersen NL, Fagt S, Groth MV, Hartkopp HB, Møller A, Ovesen L, Warming DL: Dietary Habits in Denmark. Main results. Publication no. 235, National Food Agency, Søborg 1996. *(In Danish. English summary).*
3. Gibson SA: Non-milk extrinsic sugars in the diets of pre-school children: association with intakes of micronutrients, energy, fat and NSP. Br J Nutr 1997;78:367-78.
4. Møller A, Saxholt E: Food Tables, 4th edition. National Food Agency, Søborg 1996.
5. Naismith DJ, Nelson M, Burley V, Gatenby S: Does high-sugar diets promote overweight in children and lead to nutrient deficiences? J Hum Nutr Dietet 1995;8:249-54.
6. Gibson SA: Consumption and sources of sugars in the diets of British school children: are high-sugar diets nutritional inferior? J Hum Nutr Dietet 1993;6:355-71.
7. Rugg-Gunn AJ, Hackett AF, Jenkins GN, Appleton DR: Empty calories? Nutrient intake in relation to sugar intake in English adolescents. J Hum Nutr Dietet 1991;4:101-11.
8. Gibson SA: Do diets high in sugars compromise micronutrient intakes? J Hum Nutr Dietet 1997;10:125-33.