A presença de nitrito e nitrato na dieta diária de escolares do município de São Paulo, SP

The presence of nitrite and nitrate in the daily diet of students - São Paulo, SP

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ABSTRACT

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Nitrites and nitrates are substances naturally found in foods either from animal or vegetal source, and also in drinking water. Concern has repeatedly been expressed in the scientific and popular literature about the extent and effects of nitrate and nitrite in our diet. The aim of this study was to estimate the presence of nitrate and nitrite, in the daily diet food of students, applying a questionnaire form asking which of the 25 food items were eaten the day before (diet recall). The students attend from 1st to 8th grade in private or public schools in São Paulo city, State of São Paulo, Brazil (in all turns, with people from 6 to 25 years-old). 6,185 students filled the form and 5,991 informed complete dietary data. 80% of them consumed rice, and 65% of them consumed rice and bean, a staple Brazilian food. 72% of them ate bread, mostly with cheese or meat products. Raw lettuce was consumed by 43% of the students. Other cooked vegetables containing similar level of nitrate were consumed by 35%. The students intake were higher for nitrate from vegetables than for nitrite from cured meats, which actually does not represent a serious concern.

Keywords: nitrate/nitrite; dietary estimate intake; elementary students; highschool students

RESUMEN

Nitritos y nitratos son substancias que ocurren naturalmente in alimentos tanto de origen vegetal como animal como agua de beber. A preocupación con la presencia de estas substancias en la dieta son reportadas tanto en la literatura popular como científica. Se estimó la ingesta dietética de nitritos y nitratos en la alimentación habitual de 5991 escolares, de cursos diurnos y nocturnos, de 6 a 25 años de edad, de escuelas públicas y particulares, del municipio de San Pablo, Brasil. El arroz fue el alimento mas frecuente en la dieta (80%) sendo que en 65% das veces era ingerida acompañado de frijole, combinación más común en la alimentación brasileña. Cerca de 72% de los escolares ingería pan acompañado de queso o derivados de carne. La mayor parte de ellas son fornecidas por vegetales. Lechuga es frecuente en la dieta de 43% de escolares y otros vegetales cosidos, ricos en nitratos y nitritos son consumidos por 35% de ellos. La ingestión de nitrato de los vegetales es mayor do que de nitrito de los productos lácteos o derivados de carnes, industrializados, sendo que el total ingerido es inferior al nivel de riesgo.

Palabras clave: nitrato/nitrito; ingesta dietética; escolares

RESUMO

Nitritos e nitratos são substâncias que ocorrem naturalmente em alimentos tanto de origem vegetal como animal, e água de beber. A preocupação com a presença destas substâncias na dieta são relatadas tanto na literatura popular como científica. O objetivo deste estudo foi estimar o teor de nitritos e nitratos na alimentação habitual de escolares de 1º gráu (1ª a 8ª séries), frequentando períodos diurno e noturno de escolas públicas e particulares, com idades entre 6 e 25 anos. Verificou-se que entre os 5991 questionários analisados, 80% registravam o consumo de arroz sendo que 65% deles, acompanhado de feijão. Pão foi citado em 72% dos questionários, a maior parte das vezes acompanhado de queijo ou frios. Dos vegetais fontes de NO3, destaca-se a alface frequente na dieta de 43% dos escolares e outros vegetais que são ingeridos cozidos por 35% da população. O consumo de nitratos de vegetais e nitritos de carnes curadas, pela frequência e quantidade, não representa um risco importante para a população estudada.

Palavras-chave: nitrato/nitrito, ingestão dietética, escolares

INTRODUCTION

Nitrites and nitrates are substances naturally found in foods (either animal or vegetal source) and in drinking water. Spinach, beets, potatoes, radish, eggplant, celery, cabbage, lettuce, turnip, carrots, and cauliflower are important sources of these compounds. The presence of nitrates in the ground, which is indispensable to the vegetable metabolism, is a natural by-product of the decomposition of vegetables, animals and microorganisms. As nitrate is very soluble in water, all vegetables absorb it.

Sodium and potassium nitrite or nitrate salts have been used for centuries to preserve foods. The use of sodium nitrite/nitrate in meats started after observing that rock salt was able to preserve food color and flavor at a time when there were no refrigeration systems. It was also noticed that microorganisms could not grow in the presence of nitrite or after nitrate bacterial reduction (CASSENS, 1997).

Scientific and popular literature has always expressed their concern about the effects of nitrate and nitrite in human diet. For a general perspective on the amounts, the relative influence to the USA diet of several sources of nitrate and nitrite was calculated (WHITE Jr., 1975). The real interest in these two inorganic compounds is related to the nitrosamine formation (SLORACH, 1987), which is known for its teratogeny in humans (ESTADOS UNIDOS, 1981). The possible harm of these compounds starts with the fast reduction of nitrate into nitrite in the body (TOLEDO and REYES, 1990), which in turn reacts with amines and amides present in the diet, producing the so called nitrosamines, or nitrosamides (ARAUJO and MIDIO, 1989). Despite being natural products, present in food and water, they are not generally recognized as safe (GRAS). This concern is aggravated by the use of these substances as a preservative in meat products, and by the increasing number of other applications in food. It is important to highlight that the risk of gastric diseases is proportional to the nitrite level. On the other hand, nitrite is an anti-microbial agent, specially used to prevent the development of *Chlostridium botulinum*, which produces the thermostable and highly lethal botulism toxin. This explains why NO_3^-/NO_2^- compounds are considered indispensable to preserve cured and canned meat.

Generally, nitrites and nitrates are fastly absorbed by the intestine and excreted by the kidneys through the urine. But evidences show that the speed of this process is related to the stomach acidity, the intestinal flora and the maturity of the gastric system.

It is not possible to determine the relation between nitrate intake and nitrite sources, and/or whether they are pre-formed in the human body through the nitrosamine production, and therefore related to gastric cancer. However, there are evidences that the higher intake of these compounds, the higher the predisposition or vulnerability to carcinogenesis (KNIGHT et al, 1987).

From a biological point of view, there is more evidence that nitrite and/or the substances derived from its reaction play an important role in human physiology (CASSENS, 1997).

The levels of nitrate, grouped by either endogenous or exogenous sources, are analyzed according to the frequency of intake and potential level of nitrites. It is important to mention that it is difficult to perform an analysis about the risk of exposure to food nitrosamine in humans, because experimental results can not be directly transposed. However, epidemiological studies based on individual detailed diet records represent a possible method of study. The concentration of these substances in different food products is vital to establish a link between the exposure level and the risk (CORNÉE et al, 1992).

Considering the arguments above mentioned, the objectives of this work is to learn students food habits, which would represent diet practices related to the presence of nitrite/nitrate sources, and to predict whether excessive intake represents a risk to this population.

METHODOLOGY

Schools (half private, half public) were chosen according to their localization in the neighborhoods. The next step was to contact school-heads to authorize the research, twenty-four of the thirty schools contacted, accepted it. 6,185 students filled the form and 5,991 students from 13 private and public schools in the State of São Paulo, from high school or from 11th grade up, informed complete diary data. The schools belonged to the 4 main district area of the city (North, South, East and West). The students were asked to filled in a form, recording their meals from the last 24 hours (the day before) (DWYER, 1988). The form was applied from Tuesday to Friday, in order to exclude the unusual weekend diet. The 25 food items were distributed in natural sources of nitrates/nitrites (vegetables), processed meat or milk products, and usual Brazilian dishes. Through this classification, it was possible to estimate the food intake, and the frequency of each food in current meals (breakfast, lunch, dinner, and snacks).

Estimates of nitrate and nitrite contents: For vegetables, the average level was established 1,500 mg nitrate/kg (WALKER, 1975). For meat products and cheese, which contain added nitrite, we estimated the maximum level allowed by Brazilian Legislation - 200mg/kg, expressed in sodium nitrite. Food portions were estimated by the software Virtual-Nutri (PHILIPPI et al, 1996). The food intake frequency was analyzed according to:

age: the groups were divided in: 6 to10; 11 to 14; 15 to 19 and above 19 years-old;

school turns: three periods of classes were considered (morning, afternoon and evening);

school: private or public;

sex: male or female.

The average daily intake of nitrite and nitrate was estimated in grams, by the average in one portion. For analysis purposes, the food items were divided in the following groups:

- Fresh meats and egg.
- Cured meats and milk products: In this group, nitrite/nitrate is usually added in the production process.
- Salads: lettuce and tomato;
- Vegetables: cabbage, cauliflower, lettuce, spinach, potatoes, chicory, radish, beet, carrot, and other important sources of nitrite/nitrate.

We did not consider milk and water, as their consumption is well distributed among the target population. Therefore, we assumed that the whole group is under similar conditions in this matter.

The following hypothesis were established:

- Among children (6 to 10 years old), nitrite and nitrate consumption is restricted to vegetables. In this group, the consumption of snacks is less frequent.
- Among teens and adults (≥ 11 years old), both sources of nitrites and nitrates are frequently included. The consumption of meat products is higher in this group, which means that they may ingest more nitrite than the previous group.
- Comparing with the others, students attending to evening classes consume more cured meats.
- Public schools students eat more vegetables than private schools students do.
- Boys eat more cured meats than girls do, and girls eat more vegetables than boys do.

Statistical Analysis

Data were processed using SPSS 9.0 for Windows in order to separate the averages.

RESULTS AND DISCUSSION

Table 1 presents, in decreasing order, the intake frequency of the studied foods by the 5,991 students that filled the forms, in quantity considered an average portion.

The results of this research confirm the assumption that students follow the Brazilian eating habits. Rice is the most consumed food. In some cases, it is increased to 77% when eaten with beans, the standard daily Brazilian dish. As expected, replacing rice and beans by pasta does not happen very often (once a week). In the 1,508 forms that reported the consumption of pasta, rice was consumed too. Rice and beans served together is a such popular regional dish, that it is served in coffee-shops and food service systems, even when pasta is the main dish. The population eats fresh meats every day. Potatoes were consumed daily by 41.5% of the students.

Bread is largely consumed in the breakfast, and it was mentioned in 72.2% of the cases, when rice, pasta and potatoes were not present. Bread might be eaten in the breakfast as the main food, and in lunch or dinner as sandwiches.

TABLE 1 Frequency of positive answers in number and percentage of selected food items

FOOD (estimated NO_3/NO_2 in mg, per portion in g)	Nº	%	FOOD (portion average in g)	Nº	%
rice (150)	4,913	82.0	sausage[1] (80) - 16.0mg	874	14.6
bread (75)	4,323	72.2	fish (150)	750	12.5
beans (100)	3,799	63.4	lingüiça[1] (50) fresh pork sausage - 10.0mg	633	10.6
beef (100)	3,796	63.4	cabagge[2] (44) 66mg	557	9.3
cheese[1] (52) - 10.4mg	2,633	44.0	salami[1] (32) 6.4mg	537	9.0
lettuce[2] (30) - 45mg	2,587	43.2	mortadella[1] (31) 6.2mg	500	8.3
potato[2] (50) - 72mg	2,487	41.5	cauliflower[2] (60) 90mg	467	7.8
tomato[2] (100) - 30.0mg	2,462	41.1	beet[2] (44) 13.2mg	372	6.2
chicken (130) - 39.0mg	2,086	34.8	bacon[1] (15) 3.0mg	331	5.5
egg (50) - 15.0mg	1,563	26.1	spinach[2] (60) 90mg	317	6.3
pasta (150)	1,508	25.2	radish[2] (30) 45mg	115	1.9
ham[1] (40) - 8.0mg	1,315	21.9	chicory[2] (15) 23mg	62	1.0
carrot[2] (43) - 20mg	1,266	21.1			

1 - added nitrite and 2 - natural nitrate source

The frequency of animal source foods calls attention. Beef, fish, chicken and/or eggs are consumed every day practically by 90% of the students. Considering also cured meats, the percentage increases up to 96%.

The number of students that eat vegetables is surprising: 3,429 (57.2%) of them reported eating salads (tomatoes and/or lettuce). 35.4% of them ate at least more than one of these items: lettuce, tomato, carrot, potatoes, cabbage, cauliflower, beet, spinach, radish, and chicory, which are all natural nitrate sources. The intake by children under 5 years old is lower.

We would like to emphasize that in our Food Expenditure Study (ENDEF, 1977) reported that infants usually presented a low ingestion of vegetables. So, it is surprising to verify that the menus are no longer so unvaried, especially because it shows that kids are paying more attention to their diets. LARA et al. (1980) carried out a report about baby food (juices, soups, creams, milks, puddings, etc.), and recommended to reduce the spinach content in soups.

It is also important to observe the various ways of cooking. Nitrate highest sources are lettuce and tomato, which are far from the others in intake importance. Lettuce and

tomato are consumed fresh, so nitrate keeps its original structure. Potatoes or spinach are normally served cooked, and they can reach different levels or forms of nitroso compounds, especially when considering water cooking. Were they steamed? Was the cooking water also ingested? What if they were cooked in a little amount of water, not forming residues? What about refried, fried, baked, or any other cooking way that does not require water?

In Brazil, pediatricians recommend to use the remaining water from cooking vegetables for cooking rice or other dishes. As nitrate is very soluble in water, it migrates to the cooking water. Preparing other dishes with this water results in a food with high nitrate content. It is important to emphasize that the most frequently baby salt food generally come from vegetable soup prepared with meat or another protein source. Therefore, the most vulnerable population is the most exposed to the risks.

Tables 2 and 3 present the estimates of potencial levels of nitrate and nitrite in average daily portions. When compared to the literature data, the results (table) show that there is no risk of overconsuming nitrate and nitrite (WHO, 1978). The data are very homogenous for all items studied (Table 3): sex of students, period of the school and if they are private or public.

TABLE 2 Estimates of potential levels of nitrate and nitrite in average daily portions

ITEM Average Body weight in kg (NCHS)	Number of students	% of students that ingested NO_2/NO_3	Average level of NO_3 in vegetables (mg/kg)	Average level of NO_3 in meats (mg/kg)	ADI - 0 to 0.4mg/Kg b. w. NO_2	ADI - 0 to 5mg/kg b/w. NO_3	Acceptable average (mg/kg)	Total intake average (mg/kg)
6 to 10 years-old - 26	1,552	77	114	2.3	10	128	138	116
11 to 14 years-old - 43	2,145	81	122	2.3	17	213	230	124
15 to 18 years-old - 64	1,975	82	124	2.3	26	321	347	126
≥ 19 years-old - 69	180	90	136	1.9	28	344	372	138

ADI → acceptable daily intake (WHO, 1978) b/w → body weight

TABLE 3 Nitrite/Nitrate Intake by the students

ITEM	Number of students NO_2/NO_3	% of students that ingested vegetables (mg/kg)	Average level of NO_3 (mg/kg)	Average level in meats (mg/kg)	Total intake average
Sex: Male	2,511	82	123	25	273
Female	3,194	80	120	21	259
Period: Morning	3,333	81	122	24	268
Afternoon	1,881	80	120	23	261
Evening	737	78	118	18	254
School: Public	2,438	80	120	22	263
Private	3,553	81	121	23	266
TOTAL	5,991	81	121	24	267

ADI → acceptable daily intake (WHO, 1978) b/w → body weight

The hypothesis presented in this paper could not be confirmed. Nitrate and nitrite intake was very similar in all categories: age, sex, school localization, kind of school (private or public, which reflects the economic situation) or school period (students that attend schools in the evenings are older than the others). The Table 4 presents the summary of the students' characteristics.

TABLE 4 Summary of the students' characteristics

Population Characteristics that ate	Nitrite/Nitrate %	Nitrite %	Nitrate %
Boys	27,51		
Girls	13,49		
Girls private schools 1-4th grade and adults	6,94		
Boys and girls, public school south/west pre, 2nd and 3rd grade		27,51	0
Boys and girls, south/west, 1st, 4th and 8th grades		27,51	0
Boys and girls, north/east morning		27,51	0
Girls private, 1st, 3rd or 4th north and west	6,83		
Boys and girls private, south/west, pre, 2nd or 3rd grades		28,71	0
Boys and girls private school, north/east, afternoon or all day		10,45	
Girls private, south/east, 1st, 3rd or 4th			5,81

Oliveira et al. (1995), in a paper related to nitrate, nitrite and volatile nitrosamines, in whey-containing food products from samples purchased in retail outlet of Belo Horizonte, Minas Gerais, Brazil, related that every analyzed sample contained nitrate levels ranging from 4.9 to 1,250 mg/kg. 60% of the samples presented detectable levels of nitrite that varied from 1.1 to 4.6mg/kg. The levels of nitrate detected in one portion of some of the products exceeded the acceptable daily intake (0 to 0.4mg/kg of body weight, recommended by WHO (1978) for children weighting less than 10 kg).

It was clearly revealed that, against our expectations, vegetables play a major role related to excessive intake of nitrite and nitrate than cured meats do. Höyem (1974), studying Norwegian diet, observed that 90 to 98% of nitrate intake came from vegetables. He suggested to reduce the nitrate content in vegetables, or to combine it with proper storage, to prevent nitrate turning into nitrite. Knight et al. (1987), in a survey conducted in Great Britain to estimate the dietary intake of nitrate and nitrite, found that Oxford and South-East students had a higher intake of dietary nitrate, due to the high consumption of vegetables, whereas those from North Wales and the North-East had a higher nitrite intake due mainly to a

greater consumption of bacon. White Jr. (1975) estimated that 4/5 of the nitrate intake came from vegetables, and less than 1/6 was originated from cured meats. Other foodstuffs (fruits, dairy products, water, and bread) were not significant. The saliva originates 2/3 of the nitrite found in the stomach, and slightly less than 1/3 is originated from cured meats. Other sources of nitrite were not significant. Laitinen et al. (1993) studied dietary intakes of nitrate and nitrite of 1,212 Finns and calculated food consumption by the 48-hour recall method. They verified that nitrate intake was 54 mg, and nitrate intake was 1.4 mg. Vegetables, including potatoes, contributed with 86% of nitrate intake, and meat products contributed with 69% of nitrite intake, which differ from Brazilian nitrate sources. Besides, potatoes were present in the diet of the major part of the population.

Ellen et al. (1990) conducted a survey of essential and non-essential trace elements, nitrate, nitrite and N-nitrosamines intake by Dutch adults, estimated by a 24-hour duplicate portion study. The average nitrate intake was 52 mg NO_3^-/day, representing nearly 25% of the ADI. Only 16 cases presented a measurable amount of nitrite. The highest daily intake (0.7mg NO_2^-) was less than 10% of the ADI.

CONCLUSIONS

It was observed that the student population eats according to Brazilian food standards: rice and bean are consumed twice in three daily main meals. Bread is often present in breakfast, or in snacks during the day. In these cases, bread is frequently accompanied by cured meat and cheese. Vegetables are consumed daily, representing students' main source of nitrate and nitrite. The estimated levels of nitrate and nitrite presented here do not represent a Brazilian public health problem.

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