Risk assessment of titanium dioxide intake in the Northern Italy population

Marcella Malavolti[1], Carlotta Malagoli[1], Luciano Vescovi[1], Marco Vinceti[1,2] Tommaso Filippini[1,3]

Introduction

Titanium is primarily found in minerals in the form of titanium dioxide (TiO_2). This element is considered a contaminant of emerging interest especially since European Food Safety Authority (EFSA) experts raised concerns regarding the safety of TiO_2. Titanium is released into the aquatic environment, especially in the form of TiO_2 and it can be absorbed by biota and accumulated in aquatic organisms. It is used as food additive to accentuate the white color and improve the appearance of food. Food groups associated with greater amounts of TiO_2 include yeast breads, milk desserts, sauces, gravies, drinks, creams and cream substitutes. The widespread use of TiO_2 in the food supply chain requires systematic quantification of dietary TiO_2 exposure among population, especially taking into account the current concerns about the safety of TiO_2 as food additive.

Material and Methods

We measured titanium content in 908 food and beverage samples through inductively coupled plasma mass spectrometry. In order to compare our estimates with the safety assessment of TiO_2 (E171) by latest EFSA scientific opinion, we assumed that all titanium content in food samples was TiO_2, and according to previous studies and precautionary principle, we multiplied titanium content by 1.67. We then estimate TiO_2 intake using a validated semi-quantitative food frequency questionnaire (EPIC) in a representative sample of 719 individuals (319 males and 400 females) aged 18-87 years residing in Northern Italy.

Results

Higher TiO_2 concentrations were found in: dry fruits/seeds (2.042 mg/kg); milk and dairy products (1.839 mg/kg); sweets (1.573 mg/kg) and legumes (1.320 mg/kg). Especially, we detected the highest TiO_2 level in chocolate products and candy bar (5.573 mg/kg), nuts and seeds (2.672 mg/kg) and cheeses (2.414 mg/kg). Mean TiO_2 dietary intake in this population was 0.021 mg/kg body weight (bw) per day. Overall, estimates of their dietary intake were substantially far below the dose in animal models of 1000 mg/kg bw/day declared by EFSA Panel regarding safety assessment of TiO_2 as food additive (E171).

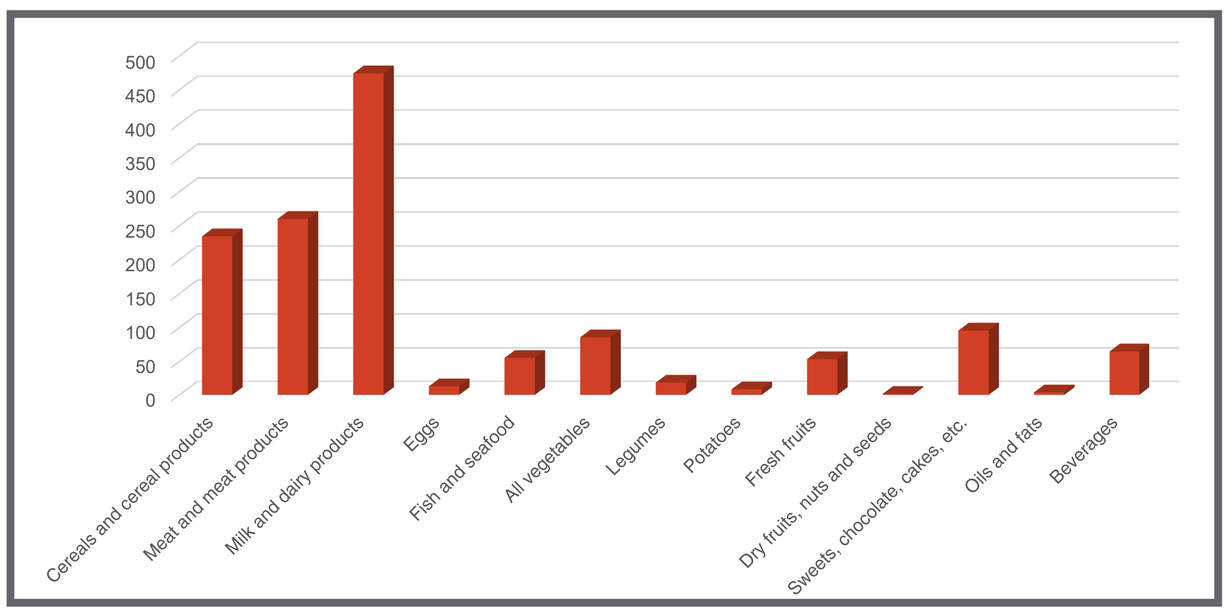

Figure 1. Titanium dioxide (TiO_2) intake in the study population (n=719) estimated through the EPIC food frequency questionnaire. Values in µg/day.

	n	Median	IQR
Cereals and cereal products	112	395.84	(258.44-1109.75)
Pasta, other grain	41	376.47	(251.81-1192.30)
Rice	8	390.52	(203.38-1109.75)
Bread	42	502.9	(286.11-1304.94)
Crackers, crispbread, salty snacks	21	336.73	(225.93-467.93)
Meat and meat products	86	550.6	(333.29-2225.50)
Red meat	28	381.24	(280.37-1511.18)
White meat	12	2023.37	(550.16-3192.26)
Processed meat	36	611.98	(402.09-2333.79)
Offal	10	1379.44	(445.50-2747.49)
Milk and dairy products	72	1100.75	(667.31-4800.02)
Milk and yogurt	13	925.63	(226.41-1288.21)
Cheese	59	1445.5	(750.03-6832.63)
Fresh cheese	17	1655.12	(502.15-4799.90)
Aged cheese	42	1085.76	(901.62-6832.63)
Eggs	9	450	(26.31-973.21)
Fish and seafood	62	453.96	(286.80-1342.46)
Fish	41	395	(278.63-1342.46)
Preserved and tinned fish	9	488.53	(344.03-797.81)
Non-piscivorous fish	15	357.88	(223.01-1342.46)
Piscivorous fish	17	410.48	(316.97-1875.04)
Crustaceans and molluscs	21	521.44	(310.87-1309.63)
All vegetables	201	163.73	(65.93-471.55)
Leafy vegetables	40	557.03	(196.25-1165.27)
Tomatoes	19	69.47	(33.07-229.54)
Other vegetables	63	118.06	(52.21-483.10)
Root vegetables	46	121.8	(56.14-252.39)
Cabbage	28	207.87	(103.63-536.30)
Mushrooms	5	313.27	(201.69-329.24)
Legumes	43	790.47	(490.35-1031.42)
Potatoes	14	207.16	(85.09-447.81)
Fresh fruits	60	56.87	(30.32-152.52)
Citrus fruits	12	163.81	(92.12-238.13)
All other fruits	48	51.07	(28.80-101.48)
Dry fruits, nuts and seeds	45	1222.86	(711.37-6671.81)
Dry fruits	8	707.59	(292.04-1418.91)
Nuts and seeds	37	1600.09	(791.08-7317.6)
Sweets, chocolate, cakes, etc.	79	941.98	(414.39-1922.09)
Sugar, confectionery not chocolate	8	373.4	(128.20-898.03)
Chocolate, candy bars, etc.	21	3336.91	(1604.50-3600.71)
Ice-cream	5	297.17	(143.59-517.86)
Cakes, pies and pastries	30	1041.35	(658.86-1662.83)
Biscuits, dry cakes	15	577.61	(362.38-981.77)
Oils and fats	23	35.26	(10.87-111.97)
Vegetable fats and oils (not olive)	12	27.73	(6.80-35.79)
Olive oil	4	39.11	(17.81-82.71)
Butter and other animal fats	7	146.01	(50.60-198.70)
Beverages	102	76.67	(41.95-132.50)
Coffee and tea	8	36.18	(9.40-86.22)
Wines	50	79.17	(62.01-99.00)
Red wine	27	80.74	(67.31-100.24)
White wine	23	73.02	(54.09-99.00)
Aperitif wines and beers	8	73.47	(41.23-201.39)
Spirits and liqueurs	21	31.28	(6.92-93.92)
Fruit juices	8	185.67	(76.71-237.18)
Soft drinks	7	132.5	(2.74-177.01)

Table 1. Titanium content in the 908 food and beverages samples analysed in the study. Results are expressed in µg/kg.

Conclusions

Our findings provide updated estimates of food levels and dietary intake of TiO_2 in a Northern Italy community. Intake of certain foods such as milk and dietary products, meat, and cereals were associated with higher TiO_2 content. There is a need for valid estimation of TiO_2 intakes via the improvement of a dietary assessment method and a TiO_2 food composition database. Future research based also on biomonitoring data, should be performed to evaluate the relation between TiO_2 intake to adverse health outcomes in humans.

Dr. Marcella Malavolti, *marcella.malavolti@unimore.it*

Affiliations: [1]CREAGEN – Environmental, Genetic and Nutritional Epidemiology Research Center, Department of Biomedical, Metabolic and Neural Sciences, University of Modena and Reggio Emilia, Modena, Italy; [2]Department of Epidemiology, Boston University School of Public Health, Boston, MA, USA; [3]School of Public Health, University of California Berkeley, Berkeley, CA, USA.