ECRONICON OPEN ACCESS

EC CLINICAL AND MEDICAL CASE REPORTS
Research Article

Fluoride Concentration in the Foods Most Frequently Consumed by Children from 0 to 12 Months in Chile

Yévenes I[1]*, Neira M[1], Diaz-Dosque M[1], Muñoz A[1], Cornejo M[1] and Pirela C[2]

[1]Research Institute in Dental Sciences, Faculty of Dentistry, University of Chile, Chile

[2]Department of Conservative Dentistry, Faculty of Dentistry, Universidad de Chile, Chile

***Corresponding Author:** Yévenes I, Research Institute in Dental Sciences, Faculty of Dentistry, University of Chile, Chile. Olivos 943, Independencia, Santiago, Chile.

Received: July 01, 2024; **Published:** September 11, 2024

Abstract

Fluoride was determined in 14 food groups of children from 0 to 12 months. Each group, except breast milk, was divided into 10 subgroups, each subgroup with three different batches, resulting in 390 foods analyzed in duplicate, totaling 780, plus 108 breast milk samples, accumulation 888 food samples for children up to 12 months

These groups consist of breast milk, first and second stage formula milk, green and colored vegetables, cereals, potatoes, meats, fish and seafood, legumes, eggs, oils, fruits and water.

The concentrations of fluoride (F^-) in the food were determined by microdiffusion technique and using an ion selective electrode. The concentrations of F^- are breast milk: 0.014 to 0.118 mg/L, formula milk: 0.015 to 0.081 mg/Kg, vegetables: 0.147 to 4.531 mg/Kg, potatoes: 0.140 to 0.880 mg/Kg, fish and shellfish: 0.098 to 5,898 mg/Kg. Legumes: 0.047 and 2.904 mg/Kg. Fruits: 0.090 to 0.406 mg/Kg, and drinking water: 0.574 to 0.643 mg/L. F^- in Subgroups: Luche (Chilean seaweed) 4.531 ± 0.304 mg/Kg and 2.383 ± 0.236 mg/Kg in Cochayuyo (brown seaweed). Coles: 1.091 ± 0.105 mg/Kg. Blanquillo (fish): 1.124 ± 0.137 mg/Kg. Canned sardines and clams: 5,898 ± 1,094 mg/Kg and 4,716 ± 4,379 mg/Kg.

Foods recommended by the Ministry of Health for children under 1 year of age, none of them have high levels of fluoride. All those analyzed (888) have fluoride, some with high concentrations being relevant in total daily intake.

The foods recommended for children from 0 to 12 months do not pose a risk to their oral health due to their fluoride content, with exceptions in foods that are above average.

Keywords: *Fluoride; Food; Analyzed; Children from 0 to 12 Months; Oral Health*

Abbreviations

F^-: Fluoride; INE: National Institute of Statistics of Chile; FAO: Food and Agriculture Organization of the United Nations; CONEAP: Committee on Nutrition of the European Academy of Pediatrics; ESPGHAN: Nutrition Committee of the European Academy of Pediatrics Society of Gastroenterology, Hepatology and Pediatric Nutrition; MINSAL-Chile: Ministry of Health of Chile; IFS: Iowa Fluoride Study; JUNJI: National Board of Kindergartens; APS: Primary Health Care; FSAI: Food Safety Authority of Ireland; EPA: Eicosapentaenoic Acid; DHA: Docosahexaenoic Acid; FSAI: Scientific Committee of the Food Safety Authority of Ireland; Seremi: Regional Ministry of Health; MR: Metropolitan Region; DARE: Database of Abstracts of Reviews of Effects

Introduction

1-year-old Child Population of the Metropolitan Region. The INE [1], according to its estimates and projections for 2024, the number of newborns is expected to be 100,736. This is the population to which our study is applied and where we determine the fluoride concentration of their foods during their first year to estimate their dietary fluoride intake. Waldbott in 1963 [2] already pointed out that fluoride was present in almost all foods and the highest concentrations in tea, shellfish, fish, bone meal and the lowest in citrus fruits, vegetables, eggs and milk. The amount of fluoride absorbed from foods is unpredictable and depends on their processing, preparation, dietary habits of the individual consumer, and other factors.

The nutritional guidelines for children from 0 to 12 months are based on the recommendations and technical reports of the FAO, the CONEAP [3], the ESPGHAN [4] and the MINSAL-Chile [5] and they define three stages: a) Period of exclusive breastfeeding. Milk is the only food, whether human or animal, from birth to 6 months. b) Transition period, weaning or BEIKOST. The minimum age to start it is from the fifth or sixth month. Appropriately prepared non-dairy foods are introduced. c) Digestive maturation period. The diet must be adapted to the digestive capacity and physiological development, gradually introducing new foods.

Excessive consumption of systemic F^- from birth to four years is key in the development of dental fluorosis in permanent upper central incisors [6]. Levy., *et al*. [7] suggest that six to nine months are determining factors in dental fluorosis in primary dentition. The risk of dental fluorosis in both dentitions depends on the time and period of excessive systemic exposure to F^- and it is important to control F^- intake during enamel formation to reduce the risk of dental fluorosis in both dentitions.

Dental fluorosis is observed more frequently in permanent teeth of children who have been fed milk-formula dispersed with fluoridated water than in those breastfed with breast milk [8]. The Iowa Fluoride Study (IFS) indicates that total fluoride intake is the true risk factor in dental fluorosis [9] and in babies it depends on: diet, F^- concentrations in breast milk and formula, foods/drinks during weaning, use of fluoridated toothpaste and tooth brushing.

This study will try to confirm that the concentration of fluorides in foods at the individual level first and at the community level later are very important in future recommendations on fluoride intake in the prevention of dental caries and the risk of dental fluorosis.

The proposed solution involves solving what is the contribution of fluorides during the first year of life from food? It is necessary to estimate the daily intake of fluoride in the country in children up to one year of age, to ensure safe and adequate intake of fluoride. In Europe and the United States, evaluations of this intake are carried out [10-13], where the acceptable amount of fluoride is suggested as part of daily nutrition.

Childhood dental fluorosis worldwide and in Chile is increasing according to the latest reports. The intake of fluorides from food in children 0 to 12 months is unknown. This is the earliest determination to explain the increase in fluorosis in the country because it represents almost all of the fluoride consumption in the first year and could be a response to its increase. The hypothesis proposed is that the dietary intake of fluoride during the first year exceeds 0.05 and 0.07 mg of fluoride per day per kg of body weight and the following objective is proposed: Determine the concentrations of fluorides in the foods of the diet. of children from 0 to 12 months of age residing in Chile. To the extent that this knowledge is achieved, some questions associated with the increase in fluorosis in children can be answered, which indicate that this pathology is increasing not only at the country level, but also in other Latin American countries.

Materials and Methods

Transactional non-experimental study, supported by a field study with a descriptive nature, which is the best strategy to meet the specific objectives.

Sample of food groups: The analysis based on consultations with three nutrition experts on the food groups recommended by the FAO, MINSAL and other institutions allowed us to obtain the "Food Groups and Age of Introduction in the Diet of Children from 0 to 12 Months in Chile" which is the sample to be analyzed. In table 1 in outline, the period of initiation and duration of consumption of the particular food is indicated.

Group	Food/Months	1	2	3	4	5	6	7	8	9	10	11	12	Remarks
1	Breast Milk	■	■	■	■	■	■	■	■	■	■	■	■	
2	Milk Formula Start	■	■	■	■	■	■							Can be used all year
3	Milk Formula Continuation							■	■	■	■	■	■	
4	Green Vegetables (spinach, chard, zucchini)						■	■	■	■	■	■	■	
5	Colored Vegetables (pumpkin, carrot, beets)						■	■	■	■	■	■	■	
6	Cereals (rice, noodles, oats, cornmeal)						■	■	■	■	■	■	■	
7	Tubers (potatoes)						■	■	■	■	■	■	■	Daily Frequency
8	Meats (beef: pink and black post, chicken, turkey)						■	■	■	■	■	■	■	
9	Fish and Seafood (Mackerel, sardine, hake, reinnet, tollo, congereel, Choritos, clams)										■	■	■	If no allergic history, otherwise after one year
10	Eggs (whole chicken egg)										■	■	■	If no allergic history, otherwise after one year
11	Legumes (beans, lentils, chickpeas)									■	■	■	■	
12	Oils (canola, soybean, others)								■	■	■	■	■	Daily frequency
13	Fruits (apple, pear, plum, strawberry, orange (juice)								■	■	■	■	■	Recommended to be cooked as compote
14	Potable Water								■	■	■	■	■	50 ml, 3 to 4 times a day, up to 150 - 200 mL away from milk or food

Table 1: *Food groups and age of introduction in the diet of children aged 0 to 12 months in Chile.*

These food groups are part of the diet of children who attend JUNJI institutionalized kindergartens and include MINSAL dietary recommendations implemented at the APS level.

Food sample size: The sample was composed of units of analysis that are foods consumed by children from 0 to 12 months, where the random variable corresponded to the measurement of fluorides in each food. Since there are no studies in Chile that indicate average fluoride levels, convenience sampling was carried out. Fourteen food groups were included, incorporating drinking water, as recommended by the Ministry of Health. Fluoride concentrations were measured in these groups. From each group, except breast milk, the 10 most sold/consumed brands/varieties were selected, leaving each group with 10 sample units (can, bottle, bag or another packaging form). The sample units selected for each food group represent more than 80% of the group's consumption and three different lots were chosen. The total sample analyzed is 390 foods analyzed in duplicate, giving 780 samples plus 108 breast milk samples with a total of 888 food samples from children from 0 to 12 months of age.

Data management and statistical analysis: The fluoride concentration of each food group was reported by food type and the average of the sample and duplicate, in addition to the average and standard deviation for the entire group. Analysis of variance was used to determine any statistically significant differences between the fluoride concentrations of the groups. These analyzes were performed using Statistical Package for the Social Sciences 17.0 J (IBM, USA). The level of statistical significance was set at 5%.

Food groups: The characteristics of the food groups and their composition of your sample are detailed.

Group 01-Breast milk: To collect breast milk samples, authorizations were requested from the Ethics Committees of the Health Services of the participating CESFAMs. Monthly breast milk samples were obtained from lactating mothers, where their drinking water contained 0.7 mg/L fluoride. Participants did not use fluoride supplements during or after pregnancy. For their participation, they were verbally informed about the study and signed an Informed Consent reviewed by the corresponding Ethics Committees. They answered a brief survey to collect data of interest for the final objectives of the project.

To collect milk, the mother wiped with cotton and distilled water, gently compressed her breast, or used a breast pump to collect 15 - 20 ml of milk into previously labeled wide-mouth bottles. The transfer of the milk samples to the laboratory was carried out at ±4°C. The samples were frozen and stored until analysis and no preservatives were added to any sample.

Labeling of breast milk samples: Breast milk belongs to group 01 and each food group consists of subgroups of foods. The subgroup corresponds to the month of breastfeeding, from 0 to 12. The sample was labeled with food group 01, followed by the month of breastfeeding (0 to 12) and the mother's identity card.

Fluoride analysis and processing of breast milk samples. Fluoride concentrations of the samples were obtained using microdiffusion, specific electrode and ionometer that provides measurements in millivolts (mV). Sample volumes and reagent concentrations used in the fluoride microdiffusion analysis for breast milk are shown in table 2.

Sample	Volume or mass Sample Microdiffusion	Distilled Water	H_2SO_4 3M Sat. HDMS	[NaOH] 0,05N	[CH_3COOH] 0,1M	Final Volume Well
Food Menus	1 mL or 1,0g	2,0 mL	1 mL	50 µL	50 µL	100 µL

Table 2: *Concentration, volume of reagents and samples in the microdiffusion technique of fluorides.*

HDMS: Hexamethyldisiloxane; H_2SO_4: Sulfuric Acid; NaOH: Sodium Hydroxide; CH_3COOH: Acetic Acid.

The mV of the samples and the fluoride calibration curve are transformed into concentration using a log regression of mV and F^- concentration. Concentrations are expressed in mg F^-/L of milk or ppm F^- [14].

Group 02-Milk formula start: The formula milks were purchased in supermarkets and pharmacies in the city of Santiago. The brands were selected based on information from experts and the best sellers in the metropolitan region.

Labeling of milk samples-starting formula: Labeling includes group, 02; subgroup, corresponds to the brands chosen and numbered from 1 to 10. Lot assigned 1, 2 or 3 and a differentiating digit 1 for the sample and 2 for the duplicate. The label 020101/1 indicates that it belongs to group 2, subgroup 1, lot 1, and the measurement /1 corresponds to the sample.

Sample treatment: They were prepared according to the manufacturer's instructions with fluoride-free distilled water; The mass of the formulation used was recorded in duplicate with sensitivity to the milligram. All samples were completely dispersed using magnetic stirrers for 15 minutes. The remaining sample was sealed in its original container in a cool, dry place.

Fluoride measurements: The fluoride concentrations of the dispersed formula milk samples were analyzed in duplicate in a manner similar to that described for breast milk.

Group 03-Milk-continuation formula: Use from 6 to 12 months. The milk-continuation were purchased in supermarkets and pharmacies in the city of Santiago. The brands were selected based on information from experts and the best sellers in the metropolitan region.

Labeling of milk-continuation formula samples: The labeling includes group, 03; subgroup corresponds to the selected brands numbered from 1 to 10. Lot assigned 1, 2 or 3 differentiating digit 1 for sample and 2 for the duplicate. Label 030203/2 belongs to group 3, subgroup 1, lot 3, and /2 is the duplicate.

Sample treatment: The samples were prepared according to the manufacturer's instructions with fluoride-free distilled water; The masses of the formulation and water in duplicate were recorded with milligram sensitivity. The samples were dispersed using magnetic stirrers for 15 minutes. The rest of the sample was stored in its original container in a cool, dry place.

Fluoride measurements: Fluoride concentrations of milk-follow-on formula samples were analyzed in duplicate in a manner similar to that described for breast milk.

Group 04-Green vegetables: The sample of green vegetables was obtained from free fairs, central vega and supermarkets.

Sample treatment: Duplicates of 15 grams (clean) were crushed and chopped and 250 grams of fluoride-free distilled water, massed to the milligram, were added. They were cooked for 5 minutes in a pressure cooker and kneaded after cooling. The green vegetables were homogenized for 5 minutes using a blender until sampling was allowed.

Fluoride measurements: Fluoride concentrations of green vegetable samples were obtained similarly to breast milk. The values are expressed in mg of Fluoride/kg of green vegetables or ppm of fluoride.

Group 05-Colored vegetables: The colored vegetables were obtained from free fairs, central vega and supermarkets.

Sample treatment: Duplicates of 60 grams of green vegetables were crushed and 250 grams of fluoride-free distilled water, massed to the milligram, were added, except for Cochayuyo (*Durvillaea antarctica*) and Luche (*Porphyra columbina*) which were dispersed in 500 ml of water. They were cooked for 5 minutes in a pressure cooker and kneaded after cooling. The colored vegetables were completely homogenized for 5 minutes using a household blender until sampling was possible.

Fluoride measurements: Fluoride concentrations of colored vegetable samples were obtained similarly to breast milk samples. Fluoride values are expressed in mg of Fluoride/kg of colored vegetables or ppm of fluoride.

Group 06-Cereals: Cereal samples were obtained from markets, supermarkets and free fairs in the metropolitan region.

Sample treatment: Duplicates of 15 grams of cereals were massed and 500 grams of fluoride-free distilled water massed to the milligram were added. They were cooked for 5 minutes in a pressure cooker and massed after cooling. The cereals were completely homogenized for 5 minutes using a household blender until sampling was possible.

Fluoride measurements: Fluoride concentrations of cereal samples were obtained in a manner similar to that described for breast milk. Fluoride values are expressed in mg of Fluoride/kg of cereals or ppm of Fluoride.

Group 07-Potatoes (Tubers): In Chile there are 216 varieties of native potatoes; however, those commercially available are much less. Samples of potatoes were purchased in supermarkets, central vega and free fairs. They were selected according to consumption and availability of varieties.

Sample treatment: The potatoes were washed and all inedible parts were removed. Duplicates of 70g per milligram of potatoes were massed in 250g of fluoride-free distilled water. They were cooked for 15 minutes in a pressure cooker and massed after cooling. The tubers were completely homogenized for approximately 2 to 5 minutes using a household blender until allowing sampling.

Fluoride measurements: Fluoride concentrations were obtained from potato samples in a manner similar to those used in breast milk measurements. Fluoride values are expressed in mg of fluoride/kg of potatoes or ppm of fluoride.

Group 08-Meats: Meat samples were obtained from butcher shops, supermarkets, and meat warehouses.

Sample treatment: Meats should be washed and all inedible parts removed by children. Duplicate samples of 40g of meats were massed to the milligram in a volume of 250 ml of fluoride-free water. The meats were cooked for 20 minutes in a pressure cooker and kneaded again after cooling. The meats were completely homogenized for approximately 2 to 5 minutes (may vary depending on the type of meat) using a household blender until the homogenate could be sampled.

Fluoride measurements in meat: Fluoride concentrations of meat samples were obtained in a similar manner to breast milk samples. Fluoride values are expressed in mg of Fluoride/kg of meats or ppm of fluoride.

Group 09-Fish and Seafood: Samples of fish and shellfish were obtained from fishmongers, supermarkets, and fish and shellfish warehouses.

Sample treatment: The fish and shellfish were washed and all inedible parts (skin, viscera, shells) were removed. Duplicates of 40g were weighed to the nearest milligram and mixed with 250 ml of fluoride-free water. The samples were cooked for 20 minutes in a pressure cooker and reweighed after cooling. Samples were then completely homogenized for approximately 2 to 5 minutes (varies depending on sample type) using a household blender until sampling was permitted.

Fluoride measurements in fish and shellfish: The fluoride concentrations of the fish and shellfish samples were obtained in a similar way to those described for breast milk. Fluoride concentrations are expressed in mg F^-/Kg of fish and shellfish or ppm F^-.

Group 10-Eggs (Whole chicken egg): The egg samples were purchased in markets, free fairs, central vega and supermarkets.

Sample treatment: The eggs were divided into white and colored, four sizes being selected for each variety: small (S), medium (M), large (L) and extra-large (XL). The fluoride analyzed comes from boiled eggs. Duplicates of the mixed yolk and white were taken and from the mixture 30g of sample and 250 ml of fluoride-free water were measured, both massed to the milligram. They were cooked for 10 minutes in a pressure cooker and weighed again after cooling. Eggs and water were completely homogenized for approximately 5 minutes using a household blender until sampling was possible.

Fluoride measurements in eggs: Fluoride concentrations of egg samples were measured in a manner similar to that described for measurement in breast milk. Fluoride concentrations are expressed in mg F/Kg of eggs or ppm F^-.

Group 11-Legumes: The legumes samples were acquired in markets, free fairs, central plains and supermarkets.

Sample treatment: Legumes should be washed and all inedible parts removed by children. Duplicates of 100 g per milligram of legumes were massed in a volume of 500 grams of fluoride-free water. The pulses were cooked for 30 minutes in a pressure cooker and kneaded again after cooling. Legumes were completely homogenized for approximately 5 minutes using a household blender until sampling was possible.

Fluoride measurements in legumes: The fluoride concentrations of the legume samples were obtained in an identical manner to that mentioned in the measurement of fluoride in breast milk. Fluoride concentrations are expressed in mg F^-/Kg of legumes or ppm F^-.

Group 12-Oils: The oil samples were acquired in markets, free fairs, central plains and supermarkets. The feeding guide for children under 2 years of age in its section "Food between 6-11 months of age" [5] establishes: The porridge must contain cereals, various vegetables, beef, poultry or fish, and when serving it is recommended add "Crude vegetable oil, preferably canola or soybean and, if possible, olive oil".

Sample treatment: The oil samples did not require treatment and duplicates of 1 ml of the crude oil samples massed to the milligram were used.

Fluoride measurements in oils: Fluoride concentrations of oil samples were obtained in a manner similar to that described for fluoride medication in breast milk. Fluoride concentrations are expressed in mg F^-/L of oils or ppm F^-.

Group 13-Fruits: Fruit samples were requested in supermarkets, central plains, free fairs and markets.

Sample treatment: The following fruits were processed cooked: red apple, yellow pear, red plum, green apple and green pear. The fruits were washed and the inedible parts were removed by the children. The quantities were 125 g massed to the milligram in 250 grams of water also massed to the milligram. The fruits were cooked for 10 minutes in a pressure cooker and massed again after cooling. The fruits were completely homogenized for approximately 5 minutes using a household blender to allow sampling. For raw fruits such as banana, kiwi and orange, the same amounts of fruits and water were used and homogenized similarly to cooked fruits.

Fluoride measurements in fruits: Fluoride concentrations of fruit samples were measured in a manner similar to that used in the measurement of breast milk. Fluoride values are expressed in mg of fluoride/kg or L of fruits or ppm of fluoride.

Group 14-Drinking water: Samples were taken from 5 kindergartens at 3 different points of the water network and were also obtained from various places until the total number of sampling points was reached.

Once the child begins to receive foods other than milk, water (boiled, warm or cold if not drinkable) can be offered without adding sugar, honey or other flavorings or sweeteners. It can be offered in quantities of 50 ml 3 to 4 times a day, achieving a total of 150 to 200 ml, separated from milk or meals.

Sample treatment: Drinking water samples do not require treatment. Only samples with clear signs of impurities were filtered. Duplicates of 1 ml of the water samples massed to the milligram were used.

Fluoride measurements in drinking water. Fluoride analysis was performed on drinking water samples in a manner similar to that described for measuring fluoride in breast milk. Fluoride concentrations are expressed in mg F^-/L of water or ppm F-.

Results and Discussion

Fluoride concentration in breast milk (group 1): The average and standard deviation of the 108 samples is 0.042 ± 0.021 mg of fluoride per liter of breast milk. The distribution of samples by month can be seen in table 3.

Age (months)	Number of Samples	Fluoride Concentration Average (mg F^-/L)	Standard Deviation (mg F^-/L)
0	2	0,025	0,006
1	15	0,033	0,030
2	8	0,035	0,009
3	10	0,034	0,025
4	10	0,059	0,060
5	22	0,051	0,053
6	9	0,049	0,029
7	7	0,056	0,049
8	7	0,052	0,043
9	6	0,053	0,073
10	3	0,014	0,008
11	3	0,016	0,005
12	6	0,025	0,011
Total	108	0,042	0,021

Table 3: *Fluoride content in breast milk per month of breastfeeding between 1 to 12 months.*

In the reviewed literature, no studies were found with monthly measurements of fluoride in breast milk. These measurements are unique and exclusive data for the country. These results can be seen in figure 1. On the curve, the blue circles indicate the measured values and the dotted line represents the fourth-order exponential trend. The equation relates mg of fluoride in breast milk to the age of the child, indicating the trend of the concentration of fluoride in milk as a function of the age of the child.

The first group of foods analyzed corresponded to breast milk, with samples collected from birth to month 12. In children under 6 months, a milk-based diet is usually the main or even the only source of fluoride from the diet [15]. In this period, the most consumed food is breast milk or, failing that, infant formulas [16,17].

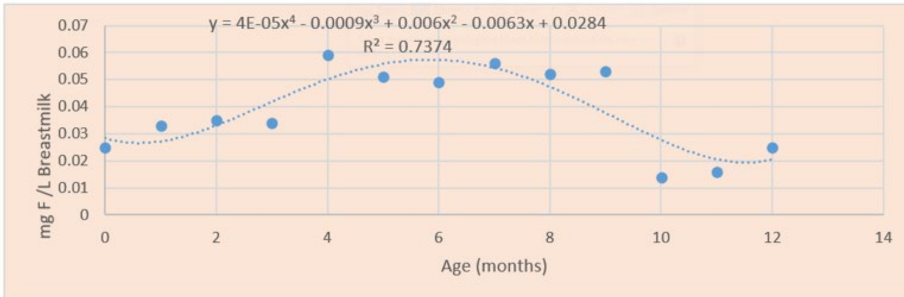

Figure 1: *Average fluoride concentration values in breast milk according to the infant's age.*

When showing the concentration of fluoride in the first 6 months of breastfeeding, which is the critical period according to the WHO for infant nutrition, we find a growing increase in its concentration. Our results indicate that in the last months of breastfeeding, the fluoride concentration decreases. However, we do not know if this is due to lower consumption or another associated variable.

The values reported in the literature by Koparal., *et al.* in 2000 [18] in breast milk from 57 mothers without specifying the age of the child were 0,019 ± 0,004 ppm of fluoride. In another study by Sener., *et al.* in 2007 [19], which included 125 mothers who had given birth within 5 to 7 days, hence the baby was 0 months old, fluoride values were 0,006 ± 0,002 ppm. The monthly average values of fluoride concentration obtained in this research are higher than the measurements by Koparal and Sener but these are general averages without known collection conditions.

Fluoride concentration in Milk formula start (group 2): "Starter formulas" are an adapted dairy product that provides 67 Kcal/100 ml [20]. They cover the nutritional requirements of healthy, full-term infants during the first 6 months of life.

Ten brands of starter formula milk were sampled and from each brand three lots with different manufacturing dates were selected to ensure the randomness of the sample. This distribution does not give 30 milks, which with its duplicate does not give 60 samples. The average results, standard deviation and median can be seen in table 4.

Total samples of infant formulas from 0 to 6 months	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median [F^-] (mg F^-/Kg)
Total	60	0,053	0,047	0,034

Table 4: *Average and median fluoride concentration in total samples of infant formulas from 0 to 6 months.*

The range of fluoride concentration in the 60 samples of Infant Starter Formula varied between 0.022 and 0.169 mg of fluoride per kilo of milk. Values reported by Bussell., *et al.* in 2016 [16] in England, in 17 brands of starter infant formulas with averages of 0.017 ± 0.007 ppm fluoride. Van Winkle., *et al.* in the USA in 1995 [21], without differentiating by age, indicates a concentration range for 17 brands of 0.05 to 0.28 ppm fluoride with an average of 0.138 ± 0.082 ppm fluoride. Mohd Desa., *et al.* in Malaysia [22] in 2020 in 8 brands of infant formulas indicates a concentration of 0.049 ± 0.034 ppm of fluoride. Publications indicate fluoride values in infant formula that vary according to the country studied and the year reported. The values obtained in the USA are the highest and the lowest is reported in England. The values found in our country are more similar to those of Malaysia.

The fluoride concentrations in the selected samples of starter Milk-Formula from the Chilean market are low, of the order of 0.05 ppm of fluoride, which means 0.05 mg of fluoride per kilo of formula milk, where the highest value likely to find in any brand is the median, which is 0.034 mgF^-/kg of milk-formula.

Fluoride concentration in milk formula continuation (group 3): Continuation formulas [23] are available and are indicated from 6 months of age. The following formulas are used at a dilution of 14 - 15%, without additives, using the measurements provided on each container. This food covers the nutritional needs from 6 months as part of a diversified diet, this means that the follow-on milk must be combined with other foods to ensure that the child is adequately nourished.

The follow-on formula milk samples include 10 brands (including MINSAL), with three different batches per brand, with different manufacturing dates to ensure the randomness of the sample. This includes sample and duplicate by brand providing a total of 60 follow-on milk formulas.

The average results of fluoride concentration, standard deviation and median for continuation formula milks can be seen in table 5.

Our results in follow-up formula milk ranged from 0.012 to 0.103 mgF/kg of milk with averages of 0.055 ± 0.026 mgF/kg of milk. A bibliographic review by Vélez-León., *et al*. in 2023 [24], reveals that among the 17 studies that evaluate fluoride levels in infant formulas, formulas based on cow's milk exhibit a range of 0.01 to 0.92 ppm, with only two studies exceeding 1.30 ppm. This indicates a great variability in the concentration of fluoride in the milk analyzed, with several factors associated with these measurements such as origin of the milk, types of food and soil used by the animal, industrial treatment of the milk, fluoride measurement techniques. carried out by researchers and analysts. The study by Chandio., *et al*. in 2022 [25] shows a slight upward trend in the fluoride content in infant formulas with increasing age. Starter formula averages 0,24 ppm of fluoride, while follow-on formula shows fluoride concentrations of 0,28 ppm. A similar trend was observed in the UK study, where there is a slight increase in fluoride content in milks from birth to 10 months of age [16]. The concentrations of continuation formula milk (0.055 ± 0.026 mgF/kg) are slightly higher than the starting formula milk (0.053 ± 0.047 mgF/kg), without statistically significant differences and are lower than those found in several studies. Our values are in the range of fluoride concentrations reported by countries such as the United Kingdom (0.017 ± 0.005 mgF/kg) [16], New Zealand (0.069 ± 0.043 mgF/kg) [26], Malaysia (0.038 ± 0.028 mgF/kg) [22] and Japan (0.090 ± 0.030 mgF/kg) [27].

Fluoride concentration in green vegetables (group 4): Fluoride is more soluble in acidic soils and in these soils its absorption by plants is increased and it accumulates mainly in the leaves. Excessive accumulation of fluoride in plants causes visible damage to leaves, fruits and changes in yield. Fluoride levels in green vegetables depend on the nature of the soil and the quality of the irrigation water [28]. Table 6 shows the name of the green vegetable, concentration and median of fluoride for the types of vegetables.

Name of the Green Vegetable	Number of Samples	Mean [Fluoride] ($mg F^-$/Kg)	Standard Deviation ($mg F^-$/Kg)	Median of [Fluoride] ($mg F^-$/Kg)
Spinach	6	0,435	0,147	0,434
Chard	6	0,460	0,089	0,506
Zucchini	6	0,366	0,084	0,353
Green Beans	6	0,393	0,147	0,345
Celery	6	0,213	0,033	0,210
Broccoli	6	0,248	0,061	0,256
Cabbage	6	0,208	0,037	0,197

Green Pepper	6	0,419	0,088	0,394
Lettuce	6	0,288	0,050	0,288
Kale	6	1,091	0,105	1,085
Total	60	0,411	0,206	0,324

Table 6: *Name of the green vegetable, concentration, standard deviation and median of fluoride in the total sample of green vegetables.*

The samples of green vegetables indicate fluoride values of 0.148 to 1.222 mg F/kg weight with an average of 0.411 ± 0.206 mg F/kg weight. Kales have the highest concentration of fluoride, which is statistically higher than all concentrations in the green vegetable group ($p<<0.05$). Chard, Spinach and Green bell pepper present statistically higher concentrations of fluoride than other vegetables ($p<0.05$). Cabbage and celery with approximate averages of 0.21 ppm of fluoride, which are lower than those reported by Bhat., *et al*. of 0.4 to 0.7 ppm of fluoride for the same varieties [29]. Jain., *et al*. in 2017 [30] reported fluoride concentrations of 4.4 mg/kg in spinach leaves (*Spinach oleracea*) and for the other variety (*Amaranthus spinach*) 1.5 mg F^-/kg. The two varieties of spinach tend to accumulate fluoride when the irrigation water contains fluoride, indicating that the higher the concentration in the water, the higher the content in the food [30]. The analyzed spinach shows much lower values with an average of 0.435 ± 0.147 mg F/kg of weight.

Kale-Brussels sprouts show average values of 1.091 ± 0.105 mg F/kg weight, this value being high for group 4 but lower than values reported in the literature. The fluoride concentration of cabbages (*Brassica oleracea*) from Kenya in 2020 is 13.33 ± 0.29 mg F/kg of weight, very high values explained by soil types, rainy periods and other climatic factors [31]. In Kenya in 2022, Gevera., *et al*. determined the amounts of fluoride contained in kale and soils and reported that the average fluoride concentration in food crops ranged from 700 mg/kg in kale. The fluoride concentration in agricultural soils ranged from 0 to 3.47 mg/kg (mean 0.87 mg/kg) and showed a strong and significant positive correlation ($p = 0.03$) with fluoride values in crops [32].

Fluoride concentration in colored vegetables (group 5): The Scientific Committee of the Food Safety Authority of Ireland (2018) [33] reports for 410 samples of green and colored vegetables, raw and cooked, a fluoride content of 0.229 ± 0.259 mg/kg weight. If raw foods are eliminated, because in this study all meals are cooked, the average content rises to 0.510 ± 0.188 mg/kg of weight. The samples of colored vegetables were 10 types according to MINSAL instructions [34] with three lots per type of vegetable. This gives a total sample of 60 samples, see table 7. It indicates: name of the vegetable, average concentration and median fluoride by type of vegetable in addition to the average of group 5.

Name of the Colored Vegetable	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of concentrations (mg F^-/Kg)
Yellow Squash	6	0,468	0,068	0,488
Carrot	6	0,193	0,068	0,180
Beet	6	0,376	0,118	0,403
Eggplants	6	0,175	0,024	0,175
Tomato	6	0,147	0,015	0,146
Red Pepper	6	0,248	0,061	0,256
Cochayuyo	6	2,383	0,236	2,356
Luche	6	4,531	0,302	4,607
Mushrooms	6	1,727	0,532	1,913
White and Red Radish	6	0,594	0,062	0,600
Total	60	1,085	1,369	0,456

Table 7: *Name of the colored vegetable, concentration, standard deviation and median of fluoride in the total sample of colored vegetables.*

The results for the complete sample of colored vegetables have fluoride concentrations from 0.100 to 4.915 mg/kg and an average of 1.085 ± 1.369 mg F^-/kg of weight. Our fluoride values are higher than those of the Irish study [33], this influenced by the high fluoride values of Cochayuyo and Luche (Chilean seaweed) in the total sample. If we see the median value of the colored vegetable samples, it is 0.456 mg/kg of weight, which is similar to the Irish sample of 0.518 mg/kg of weight. The role of fluoride in marine algae is unknown and Camargo in 2003 [35] points out that for brown algae, F^- increases growth and metabolism. Al-Adilah., *et al*. in 2020 [36] reports fluoride levels in two seaweeds (*Sargassum aquifolium* and *Podium papillotomy*) ranging from 0.20 to 72.32 mg/kg weight. Cochayuyo and Luche were analyzed, without previous studies and with values of 2.383 ± 0.236 mg/kg of weight and 4.531 ± 0.302 mg/kg of weight. These values are the highest found in the study, but within the range reported for algae by Al-Adilah., *et al*. in 2020. In Iwate, Japan in 2011 [37] in mushrooms it is reported that their fluoride concentration ranges from 7 to 68 ppm. In canned mushrooms, USDA in 2005 [38] reports that they have 0.10 mg/kg fluoride. The fluoride concentrations in mushrooms are 1.727 ± 0.302 mg/kg of weight, values higher than the group, but within the range of the literature that goes from 0.10 to 68 mg/kg of weight.

Fluoride concentration in Cereals (group 6): Jaudenes., *et al.* in 2020 [39] in samples of cereals and cereal products reports fluoride concentrations between 0.70 and 3.20 mg/kg and averages of 1.84 ± 0.84 mgF^-/Kg. In India [40] cereals were grown on fluoridated and non-fluorinated soils. The results for cereals grown in fluoridated soils (1.22 ± 0.84 mg F^-/kg) have fluoride values of 4.63 ± 0.45 mg/kg. In non-fluorinated soils (0.40 ± 0.02 mg F^-/kg) the values in cereals were 0.44 ± 0.04 mg F^-/kg. The MINSAL [34] recommends 10 types of cereals with three lots per cereal, sample and duplicate originating the total sample. Table 8 indicates the name of the cereal, average concentration and median fluoride for each cereal and for the total sampled.

Name of the cereal sample	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of concentrations (mg F^-/Kg)
Rice Brand	6	0,512	0,123	0,480
Noodles Brand1	6	0,402	0,117	0,346
Polenta Brand1	6	0,370	0,087	0,423
Oats Brand1	6	0,181	0,027	0,181
Quinoa Brand1	6	0,500	0,043	0,483
Noodles Brand2	6	0,378	0,082	0,385
Polenta Brand2	6	0,356	0,069	0,333
Rice Brand2	6	0,458	0,109	0,454
Noodles Brand3	6	0,459	0,080	0,453
Rice Brand3	6	0,434	0,060	0,430
Total	60	0,406	0,122	0,423

Table 8: *Name of the cereals, average fluoride concentration, standard deviation, and median fluoride concentration in the total sample of 60 samples.*

In Chile we do not find studies related to the concentration of fluoride in soils nor its final concentration in plants. Fluoride is fixed and does not leach easily into the soil because most of it is not soluble or exchangeable. However, high fluoride concentrations associated primarily with the soil colloid or clay fraction can increase fluoride levels in the soil solution and increase uptake through the plant root. In soils, more than 90% of natural fluoride, ranging from 20 to 1000 mg F^- per 1000g, is insoluble or bound to soil particles [41].

Fluoride values fluctuate between 0.131 to 0.679 mg F^-kg and with averages in the total cereal sample of 0.406 ± 0.122 mg/kg. These concentrations are lower than those reported by Jaudenes., *et al*. 2020 [39] with values of 1.84 ± 0.84 mg F^- kg, but higher than those reported in Ireland [33] with 0.225 ± 0.24 mg F^- kg and similar to those of India [40] for non-fluorinated soils with 0.44 ± 0.04 mg/kg of cereal.

The diversity of results in fluoride measurements in cereal samples depends on the country where they are grown and analyzed, the type of soil (fluoridated or not), year of the article and other factors such as the methodology used for fluoride analysis. This leads us to point out that each Latin American country should be able to generate its own fluoride values for plain or processed food products because there are many factors that could modify that result.

Fluoride concentration in potatoes (group 7): The MINSAL recommends potatoes daily in children from 6 to 12 months in an amount of 50g for a 200 g soup-puree [34]. The potato samples are 10 varieties according to MINSA, with three lots per variety with sample and duplicate per lot obtained, a total sample of 60 potato variety. Table 9 indicates the name of the potato variety, the average concentration and the median of fluoride for each variety and the total sampled.

Potato Variety Name	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of Concentrations (mg F^-/Kg)
“Early Potato”	6	0,469	0,077	0,452
“New Potato”	6	0,140	0,029	0,146
Mona Lisa, “yellow potato”	6	0,156	0,018	0,156
Desiree, “Large Potato”	6	0,181	0,023	0,186
Chilotas or colored	6	0,880	0,123	0,927
Coraila	6	0,213	0,068	0,210
Asterix	6	0,222	0,090	0,208
Symfonia	6	0,180	0,038	0,162
Agata	6	0,459	0,080	0,453
Rodeo	6	0,206	0,068	0,197
Total	60	0,292	0,226	0,187

Table 9: *Name of the potato variety, average fluoride concentration, standard deviation and median of fluoride in each variety and in the total sample.*

For a total of potato samples, fluoride concentrations fluctuate between 0.097 to 0.996 mg/kg and with an average of 0.292 ± 0.226 mg/kg.

Chilotas potatoes showed a value significantly higher than the average with 0.880 ± 0.123 mg/kg, these potatoes, originally from the Chiloé Archipelago (Chile), have various shapes, colors and textures [42]. In Poland in 1998, the fluoride content was determined in 65 samples of the most consumed vegetables, including potatoes, and the fluoride levels in these potato samples were 1.02 mg/kg [43]. In India, fluoride concentrations of potatoes were measured at four locations where the soil had 1.02 mg/kg soil and the tubers had a similar average to the soil [44].

In various culinary forms and cooked potatoes, the USDA Database, version 2 of 2005 [38] indicates an average fluoride for culinary forms with potatoes of 0.303 ± 0.149 mg/kg and for cooked potatoes of 0.49 ± 0.158 mg/kg. Fluoride values in the total tuber sample are lower than those reported by Poland and India, similar to those published by USDA [38]. The value reported in that study for "cooked potatoes" used in children's diets (0.49 ± 0.158 ppm) are higher than our general average.

The fluoride concentrations of the Chilean potato samples present values significantly lower than those described from India and Poland, with values equal to each other, but much higher than our measurements. Regarding the USD database report and their fluoride values for "cooked potatoes" they are double our fluoride concentrations.

Fluoride concentration in meats (group 8): The MINSAL in "Feeding Guide for Girls and Boys Under 2 Years of Age" of 2023 in Annex 1: Quantity and Frequency of Each Food to Incorporate for Girls and Boys from 6 to 12 Months; indicates that meats should be given 3 times a week, in an amount of 30 grams for a 200 g soup-puree [34]. The puree recommended in the guide should contain cereals, as well as various vegetables depending on availability, and preferably low-fat meats such as beef, poultry or fish; When serving, it is recommended to add raw vegetable oil, preferably canola or soy, and if possible, olive oil.

The meat samples were 10 types according to MINSAL [34], with three different batches per type and sample and duplicates totaling 60 samples. Table 10 indicates the name of the meat, the average and median concentration of fluoride for each type of sample.

Name of Meat Type	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of Concentrations (mg F^-/Kg)
Whole Black Beef	6	0,124	0,077	0,120
Whole Pink Beef	6	0,156	0,027	0,163
Chicken Drumstick	6	0,542	0,079	0,546
Turkey Drumstick	6	0,148	0,065	0,111
Pork	6	0,499	0,085	0,503
Lamb	6	0,127	0,010	0,129
Ground Black Beef	6	0,123	0,016	0,124
Ground Pink Beef	6	0,148	0,041	0,144
Chicken Breast	6	0,435	0,080	0,425
Turkey Breast	6	0,147	0,028	0,134
Total	60	0,245	0,171	0,154

Table 10: *Name of the type of meat, average fluoride concentration, standard deviation and median of fluoride concentration in the total meat sample.*

For a total of meat samples, fluoride concentrations fluctuate between 0.093 to 0.675 mg/kg and with an average of 0.245 ± 0.0171 mg/kg. The FSAI Scientific Committee in 2018 [33] in its report on meat and meat products, included pork, beef, minced meat, beef burger, chicken, turkey, lamb and internal meats such as kidney and liver and indicated an average fluoride value of 0.073 ± 0.032 mg/kg for a sample of 150 meat foods (15 products), with values ranging between 0.005 and 0.202 mg/kg of meat. In Thailand in 2022 [45] fluoride concentrations were determined in beef, chicken and fish. The concentration in beef is 0.81 mg/kg and the measurement in chicken is 0.10 mg/kg and it was also measured in river fish (*Oreochromis Niloticus*) with a value similar to chicken. The total sample has an average fluoride of 0.34 ± 0.22 mg/kg. Cantoral., *et al*. in 2019 [46] analyzed fluoride in foods and beverages in Mexico City. The sample included chicken, pork, beef and other foods, with an average fluoride concentration of 1.915 ± 3.757 mg/Kg. Considering only the chicken (thigh or breast) and lean beef samples, the average fluoride concentrations are 0.278 ± 0.163 mg/Kg of meat. Chandio., *et al.* in 2022 [25] in Australia reports an average fluoride concentration of 0.520 ± 0.515 mg/Kg in 57 samples of meat with vegetables and chicken with vegetables.

Our average fluoride values of 0.245 ± 0.171 mg/Kg in the total meat sample are higher than those reported by Ireland [38], but lower than those reported by Thailand, Australia and Mexico City.

Fluoride concentration in fish and seafood (group 9): The MINSAL indicates that fish and shellfish (all varieties) are given 2 times/week, with 30 grams for 200 g soup-puree [32], at 8 months of age, without a history of allergies, or at one year. The MINSAL recommends consuming fatty fish (mackerel, salmon, sardines), due to their content of DHA and EPA fatty acids. These acids play a critical role in visual and cognitive development during the last trimester of pregnancy and the first years of life, prioritizing DHA over EPA [47].

The fish and shellfish samples consist of 10 species according to the MINSAL [34] with three batches per species and includes sample and duplicate per species with a total of 60 samples.

Table 11 indicates fish or shellfish species, average fluoride concentration, standard deviation and median of fluoride.

Fish or Seafood Type	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of Concentrations (mg F^-/Kg)
Hake	6	0,841	0,250	0,757
Reineta	6	0,605	0,172	0,524
Tollo	6	0,439	0,078	0,416
Black Conger Eel	6	0,098	0,050	0,081
Canned Sardines	6	5,898	1,094	5,924
Blanquillo	6	1,214	0,137	1,253
Southern Hake	6	0,931	0,164	0,869
Canned Mackerel	6	1,588	0,834	1,680
Salmon	6	0,463	0,209	0,335
Canned and Fresh Mussels and Clams	6	4,716	4,379	2,062
Total	60	1,679	2,376	0,774

Table 11: *Average fluoride concentration, standard deviation and median fluoride for 60 Fish and Seafood samples and for the total sample.*

In the total samples of fish and shellfish, fluoride concentrations ranged between 0.056 and 11.063 mg/kg and with an average of 1.679 ± 2.376 mg of fluoride/kg and a median of 0.744 mg F/kg.

Prabhakar and Hegde in 2021 [48] determined fluoride concentrations in freshwater fish (croaker, mullet, rohu and green chromium) and sea fish (mackerel, bigeye tuna, sardine and sole) in India. The fluoride concentration in freshwater fish was 2.888 ± 0.887 mg F/kg and for seawater it was 2.865 ± 0.608 mg F/kg. For the total sample, the fluoride concentration was 2.858 ± 0.705 mg F/kg. In a sample of fish and seafood carried out by Cantoral M., *et al*. in 2019 [46], which included cooked fish, cooked and canned seafood, the fluoride concentration determined was 3,713 ± 5,517 mg/Kg sample. Zohoori and Duckworth in 2017 [49] in canned seafood samples obtained from the USA and the United Kingdom, found an average fluoride of 2,837 ± 3,145 mg/Kg of sample.

The seafood and fish sample has a fluoride concentration of 1.679 ± 2.376 mg F/kg. These fluoride values are lower than studies from the US-UK, Mexico and India, which reported values of 3 ppm fluoride. The high standard deviation value obtained is explained by the concentration of two subsamples with values close to 5 ppm. These values in samples of fish and shellfish in Chile confirm the study carried out by Waldbott in 1963 [2], who indicated that fluoride is present in almost all foods, with the highest concentrations found in shellfish and fish.

Fluoride concentration in eggs (group 10): The MINSAL in 2023 [34] recommends eggs 2 times a week, as a substitute for meat. Its introduction is delayed in preschoolers from 10 months of age without an allergic history, or at the end of the year if there is one. Lutter., *et al.* in 2021 [50] state that the introduction of potentially allergenic foods (eggs, legumes and fish) into the diet should not be delayed when starting complementary feeding. According to Greer., *et al*. in 2019 [51], these foods do not have an increased risk of causing food allergies if introduced after 6 months.

The egg samples as mentioned above were 90 in total. Table 12 indicates the type of egg, average fluoride concentration, standard deviation and median of fluoride for each sample type and for the total sample.

Egg Type	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of Concentration (mg F^-/Kg)
Small White Egg (P)	6	0,119	0,015	0,117
Medium White Egg (M)	6	0,179	0,066	0,169
Large White Egg (G)	6	0,190	0,028	0,190
Extra Large White Egg (XG)	6	0,175	0,027	0,174
Small Brown Egg (P)	6	0,125	0,019	0,123
Medium Brown Egg (M)	6	0,120	0,035	0,111
Large Brown Egg (G)	6	0,118	0,020	0,114
Extra Large Brown Egg (XG)	6	0,227	0,043	0,227
White Egg 1 Medium (M1)	6	0,104	0,063	0,072
Brown Egg 2 Medium (M2)	6	0,242	0,061	0,238
Total	60	0,160	0,063	0,147

Table 12: *Average fluoride concentration, standard deviation and median fluoride for 60 Egg samples and for the total sample.*

The concentration of fluoride in the egg sample ranges from 0.055 to 0.364 mg F^-/kg and with an average of 0.160 ± 0.063 mg F^-/kg of egg.

In 10 samples of fried eggs reported by the FSAI in 2018 [33] the average fluoride concentration is 0.007 mg/kg egg, a fairly low value compared to our values. The USDA database version 2 in 2005 [38] reports an average fluoride concentration in 66 samples of boiled eggs of 0.05 ± 0.60 mg/kg egg. In 9 types of white and brown eggs, Cantoral., *et al*. in 2019 [46] found an average of 0.023 ± 0.007 mg F^-/kg eggs. In 8 types of egg dishes cooked and processed in different ways, Zohoori and Duckworth in 2017 [49] found an average fluoride of 0.008 ± 0.112 mg/kg eggs.

Our results for a sample of 60 types of eggs were much higher than those reported in the three aforementioned studies. The explanation is not clear, but we can look for it in the fluoridated water (known factor) given to the chickens and/or in their food, mainly based on fish meal, but no information was found regarding the concentration of fluoride in chicken feed.

Fluoride concentration in Legumes (group 11): It is recommended to incorporate legumes at least twice a week to replace meat, in accordance with the "Guidelines for feeding children under 2 years of age from the MINSAL" from 2023 [34].

The samples were 60 types of legumes, similar to the other food groups. Table 13 indicates the name of the type of legume, average fluoride concentration and the median fluoride for each type and for the total sample of legumes.

Name of Legume Type	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of Concentrations (mg F^-/Kg)
Bean brand 1	6	0,105	0,061	0,085
Lentil Brand 1	6	0,047	0,005	0,047
Chickpea brand 1	6	0,159	0,071	0,132
Bean Brand 2	6	2,904	0,363	2,970
Lentil Brand 2	6	0,266	0,145	0,248
Chickpea brand 2	6	0,314	0,106	0,284
Bean brand 3	6	0,455	0,270	0,483
Lentil brand 3	6	0,452	0,157	0,425
Chickpea brand 3	6	0,257	0,045	0,246
Bean brand 4	6	1,351	0,128	1,326
Total	60	0,615	0,791	0,282

Table 13*: Average fluoride concentration, standard deviation and median fluoride for 60 Legumes samples and for the total sample.*

Fluoride concentration values for the 60 legume samples ranged between 0.041 and 2.969 mg F/kg with concentration averages of 0.615 ± 0.791 mg F/kg legumes. This high standard deviation, greater than the average, leads to significant variations in fluoride concentration, which is reflected in the low value of the median fluoride. For 27 types of legumes prepared in different ways Cantoral., *et al*. in 2019 in Mexico [46] they report an average fluoride level of 0.8491 ± 1.0123 mg Fluoride/kg legumes. The USDA database, version 2 in 2005 [38] for 66 legumes and legume menus finds an average fluoride of 0.156 ± 0.199 mg F^-/kg legumes. Jaudenes., *et al*. in 2020 [39] reported an average fluoride concentration in legumes of Spanish origin of 0.683 ± 0.298 mg F^-/kg of legumes. Comparing our results in legumes with information from international publications is difficult because several do not indicate whether the fluoride measurement was in fresh or cooked samples and where our studied population of 0 and 12 months old all their foods must be given cooked. The average fluoride values for all samples in this investigation indicate that they are lower than those reported in the Mexico study, similar to what was reported in Spain, and higher than those reported by the USDA.

Fluoride concentration in Oils (group 12): The feeding guide for children under 2 years of age in its section "Food between 6 to 11 months of age" [34] establishes: The porridge must contain cereals, various vegetables, beef, poultry or fish, and when serving it is recommended add "Crude vegetable oil, preferably canola or soybean and, if feasible, olive oil". Annex 1 of the MINSAL Guide establishes that oils (Canola, soybean, olive) are provided daily in a quantity of 3 to 5 g raw [34]. The sampling included a sample for each type of oil, analyzing a total of 60 samples that are seen in table 14. It indicates the name of the type of oil, the average and median concentration of fluoride for each type of oil and for the entire sample.

Name of Oil Type	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of Concentration (mg F^-/Kg)
Canola Brand 1	6	0,064	0,018	0,057
Soy brand 1	6	0,022	0,003	0,022
Canola brand 2	6	0,017	0,002	0,018
Soya brand 2	6	0,021	0,04	0,020
Sunflower brand 1	6	0,019	0,002	0,018
Oliva brand 1	6	0,023	0,003	0,022
Canola brand 3	6	0,390	0,118	0,431
Soy brand 3	6	0,025	0,003	0,026
Sunflower brand 2	6	0,042	0,005	0,044
Olive brand 2	6	0,578	0,112	0,556
Total	60	0,120	0,026	0,194

Table 14: *Average fluoride concentration, standard deviation and median fluoride for 60 Oils samples and for the total sample.*

The values found in our study for 60 samples of vegetable oils ranged from 0.014 to 0.792 mg F^-/kg oil with averages of 0.120 ± 0.026 mg F^-/kg oil.

The Irish study in 2018 [33] on 3 types of oils and fats with a total of 30 samples found an average fluoride concentration of 0.005 mg/kg oil.

Buldini., *et al*. in 1997 [52] reported concentrations of fluoride produced from whole olives (traditional method) of 1.41 ± 0.45 mg/kg oil. The same authors, in samples of olive oil from pitted olives from olive groves in Sicily-Italy, evaluated the influence of water on oil extraction and its effect on the fluoride concentration of olive oil from the olives in two lots, A with less water and B with more water. The fluoride concentrations in batches A and B were 0.41 ± 0.10 and 1.93 ± 0.98 mg/kg oil, where the extracted oils with a higher water content had a higher fluoride concentration. La Pera., *et al*. in 2010 [53] studied refined oils from commercial seeds produced in Italy, analyzing five samples of peanut, sunflower, soybean and corn oils. The average concentrations of fluoride in these oils were: Corn 0.92 ± 0.35, Sunflower 1.21 ± 0.75, Soybean 1.4 ± 0.63 and Peanut 1.02 ± 0.55 mg/kg of oil.

USDA in 2005 in 50 samples of edible oils and fats, which included 6 types of fats and oils, found an average fluoride value of 0.118 ± 0.103 mg/kg oil or fat [38]. Cantoral., *et al*. in 2019 [46] in Mexico reports on 5 types of oils and fats with an average fluoride concentration of 0.017 ± 0.024 mg/kg oil or fat, with corn and canola oils presenting even lower fluoride values.

Our average fluoride values are lower than those reported in Italy [53] and very similar to the average reported by USDA in 2005 [38]. And they are higher than those reported in Ireland [38] and those indicated by Cantoral., *et al*. in Mexico in 2019 [46]. The high fluoride values of olive oil are explained because the amount of fluoride depends on the extraction method, the use of water and whether the whole olive is used or not [52].

Fluoride concentration in fruits (group 13): The MINSAL in the section "Food between 6 to 11 months of age" [34] indicates; as a dessert, any fruit is recommended, raw or cooked, without the addition of saccharose or honey due to their excessive amount of free sugars and the risk of botulism in children under 2 years of age. It is preferable to opt for natural fruit over any type of fruit juice, even juices prepared from whole fruit. The study samples were 10 types of fruit recommended by the MINSAL, seasonality and consumption in kindergartens, analyzing 60 samples in total; see table 15. It indicates the name of the fruit, average and median fluoride concentration for each type of fruit.

Name of Fruit Type	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of Concentration (mg F^-/Kg)
Red Fresh Apple	6	0,311	0,088	0,344
Yellow Fresh Pear	6	0,151	0,048	0,146
Red Fresh Plum	6	0,173	0,051	0,174
	6	0,198	0,018	0,203
Fresh Banana	6	0,406	0,041	0,401
Fresh Orange	6	0,172	0,121	0,089
Fresh Kiwi	6	0,319	0,036	0,320
Green Fresh Apple	6	0,100	0,028	0,097
Green Fresh Pear	6	0,090	0,028	0,087
Fresh Melon	6	0,117	0,005	0,117
Total	60	0,204	0,116	0,165

Table 15: *Average fluoride concentration, standard deviation and median fluoride for 60 Fruits samples and for the total sample.*

Our results for fluoride in 10 types of fruits, mostly fresh, range from 0.046 to 0.461 mg/kg fruit, averaging a fluoride concentration of 0.204 ± 0.116 mg/kg fruit.

The study in Ireland in 2018 [33] on 200 samples found an average fluoride concentration of 0.079 ± 0.132 mg/kg fruit. Jaudenes., *et al*. in 2020 [39] on 24 samples of oranges, bananas and apples found fluoride only in bananas with a fluoride concentration of 1.72 ± 0.73 mg/kg fruit. Cantoral., *et al.* in 2019 [46] in Mexico City on 12 types of fruit found a fluoride concentration of 0.038 ± 0.034 mg/kg fruit. USDA in 2005 [38] on 38 samples of fruits and fruit juices reports an average of 0.35 ± 0.52 mg fluoride/kg fruit or juice and only in fruits the average is 0.04 ± 0.03 mg fluoride/kg fruit. The amount of fluoride found in fruits, mostly of Chilean origin, is higher than those mentioned in the reviewed literature, only surpassed by Jaudenes., *et al*. 2020 [39] with a much higher fluoride concentration in bananas. We do not have an explanation for this, but it could be related to the irrigation water used for fruit cultivation, the fluoride content of the soils (unknown) or the use of phosphate fertilizers that generally contain high concentrations of fluoride, although these concentrations are also unknown.

Fluoride concentration in Water (group 14): The Seremi controls the fluoridation of drinking water and the concentration for the Metropolitan Region is 0.6 mg/L. Water fluoridation in the region is carried out by six Drinking Water Companies with 74 services. The National Fluoride Report of the 2021 indicates that the annual concentration of fluoride in water reported by the water companies was 0.581 ± 0.123 mg/L and by the Seremi it was 0.517 ± 0.119 mg/L of drinking water. A total of 60 drinking water samples were analyzed, see table 16. The table indicates the average fluoride concentration, standard deviation and median of fluoride in the total samples.

Total water samples	Number of Samples	Mean [Fluoride] (mg F^-/Kg)	Standard Deviation (mg F^-/Kg)	Median of Concentration (mg F^-/Kg)
Total	60	0,613	0,046	0,621

Table 16: *Average fluoride concentration, standard deviation and median fluoride for 60 Waters samples and for the total sample.*

Our results indicate an average concentration ranging from 0.481 to 0.687 mg/L of fluoride for 60 drinking water samples with a mean of 0.613 ± 0.046 mg F^-/L and a median of 0.621 mg F^-/L. In 160 water samples from natural streams in Nepal in 2022 [54], the fluoride concentration was 0.369 ± 0.275 mg/L. In Brazil in 2012 [5] 591 samples were analyzed for fluoride in fluoridated drinking water (0.6 - 0.8 mgF^-/L). The results indicate that 397 samples had normal values, 122 samples are below 0.6 mgF/L, 68 samples are between 0.8 and 1.2 mg F^-/L and 4 samples have above 1.2 mg F^-/L. These fluoride values are slightly higher than those reported by the annual reports of 2021 of the water companies (0.581 ± 0.123 mg F^-/L) and Seremi (0.517 ± 0.119 mg F^-/L) but within the range of the sanitary resolution of 0.6 mg/L [56]. This could be explained by the methodology used where water companies such as SEREMI use the potentiometric method, but not microdiffusion.

Final results: For eight hundred and eighty-five food samples analyzed for fluoride from the diet of a child aged 0 to 12 months, the overall average was 0.408 ± 0.873 mg F^-/kg of food and the median was 0.178 mg F^-/kg of food. We can point out that the food group with the highest concentration of fluoride is Fish and Seafood, followed by Colored Vegetables, Legumes and Drinking Water. Among the groups with the lowest concentration of fluoride are breast milk and starter and follow-on formulas. When ingesting any food or mixture of foods, the most likely value to be found would be 0.178 mg F^-/kg of food.

Conclusions

The objective of this research was to determine the concentration of fluoride in foods consumed by children from 0 to 12 months. In this regard, we can state that:

1. The thirteen food groups plus the drinking water analyzed present some degree of fluoride concentration in their composition. However, these foods, including water, when ingested as part of the daily diet of children up to one year of age, do not represent a risk due to the low contribution of fluoride to the total daily intake, except for some foods in particular that present high concentrations.
2. The information provided is relevant because it is the first in the country to systematically disclose the fluoride concentrations of most of the main foods consumed by children from birth to 12 months of age. This contributes to the public health of the country by allowing the fluoride contribution of these foods in the daily diet to be inferred.

Acknowledgements

Thanks to the FONIS SA21I0117 Project that allowed this research to be carried out and the funding of this publication.

Thanks to the International Advisors: Dr. Farith Gonzalez, Cartagena University, Colombia. Dr. Raquel Gallara, National University of Córdoba, Argentina. Dr. Rubén Ponce, National University of Córdoba, Argentina. Dr. Heriberto Núñez, National University of Asunción, Paraguay, who were part of the research and reviewed this publication.

Thanks to the Technical Support Staff: Carla Benavente P., David Beltrán M., Valentina Aurora Pérez, Paulina Rojas G., Francisco Sepúlveda V., who performed the chemical analyses of the project samples.

Thanks to the Administrative Staff: Rebeca Galarce B., Sabrita Chandía E., who allowed the start and end of the research project**.**

Conflict of Interest

The authors of the publication declare that they have no conflict of interest of any kind**.**

Bibliography

1. INE. "Population projections. Base projection. Estimates and projections 2002-2035, commune and urban and rural area. Metropolitan Region" (2017).
2. GL Waldbott. "Acute fluoride intoxication". *Acta Medica Scandinavica* 174.400 (1963): 5-44.
3. PAHO and WHO. "Guiding principles for complementary feeding of the breastfed child". In: Spanish Pediatrics Association (2018).
4. M Fewtrell., *et al*. "Complementary Feeding". *Journal of Pediatric Gastroenterology and Nutrition* 64.1 (2017): 119-132.
5. MINSAL. "Growth patterns for nutritional evaluation of children and adolescents, from birth to 19 years of age". Department of Nutrition and Food (2018).
6. A Bardsen. "Risk periods associated with the development of dental fluorosis in maxillary permanent central incisors: a meta-analysis". *Acta Odontologica Scandinavica* 57.5 (1999): 247-256.
7. SM Levy., *et al*. "Primary tooth fluorosis and fluoride intake during the first year of life". *Community Dentistry and Oral Epidemiology* 30.4 (2002): 286-295.
8. PP Hujoel., *et al*. "Infant formula and enamel fluorosis: a systematic review". DARE: Quality-assessed Reviews (2009).
9. RW Evans and BW Darvell. "Refining the estimate of the critical period for susceptibility to enamel fluorosis in human maxillary central incisors". *Journal of Public Health Dentistry* 55.4 (1995): 238-249.
10. R Yanagida., *et al*. "Estimation of daily fluoride intake of infants using the microdiffusion method". *Journal of Dental Science* 14.1 (2019): 1-6.
11. PE Petersen and H Ogawa. "Prevention of dental caries through the use of fluoride--the WHO approach". *Community Dental Health Journal* 33.2 (2016): 66-68.
12. L Singer and R Ophaug. "Total fluoride intake of infants". *Pediatrics* 63.3 (1979): 460-466.

13. JR Heilman., *et al.* "Fluoride concentrations of infant foods". *Journal of the American Dental Association* 128.7 (1997): 857-863.
14. EA Martínez-Mier., *et al*. "Development of gold standard ion-selective electrode-based methods for fluoride analysis". *Caries Research* 45.1 (2011): 3-12.
15. FV Zohoori and A Maguire. "Are there good reasons for fluoride labelling of food and drink?" *British Dental Journal* 224 (2018): 215-217.
16. RM Bussell., *et al*. "Fluoride levels in UK infant milks". *European Archives of Paediatric Dentistry* 17.3 (2016): 177-185.
17. CX Harriehausen., *et al*. "Fluoride intake of infants from formula". *Journal of Clinical Pediatric Dentistry* 43.1 (2019): 34-41.
18. E Koparal., *et al*. "Fluoride levels in breast milk and infant foods". *Journal of Clinical Pediatric Dentistry* 24.4 (2000): 299-302.
19. Y Sener., *et al*. "Fluoride levels of human plasma and breast milk". *European Journal of Dentistry* 1.1 (2007): 21-24.
20. MINSAL. "Sanitary Regulation of Food". Subsecretary of Public Health Document No. 977/96 D.OF. 13.05.97. (1997).
21. S Van Winkle., *et al*. "Water and formula fluoride concentrations: significance for infants fed formula". *Pediatric Dentistry Journal* 17.4 (1995): 305-310.
22. SNF Mohd Desa S., *et al*. "A laboratory study of fluoride concentration in infant formulas marketed in Malaysia and estimation of daily intake". *International Food Research Journal* 27.5 (2020): 893-902.
23. MINSAL. "Sanitary Regulation of Food". Document No. 977/96 (D.OF. 13.05.97). TITLE XXVIII. Special Dietary Foods. Paragraph II.- Infant formulas. Articles 493 to 497 (1997).
24. E Vélez-León., *et al*. "Worldwide variations in fluoride content in beverages for infants". *Children* 10.12 (2023): 1896.
25. N Chandio., *et al*. "Fluoride content of ready-to-eat infant foods and drinks in Australia". *International Journal of Environmental Research and Public Health* 19.21 (2022): 14087.
26. P Cressey. "Dietary fluoride intake for fully formula-fed infants in New Zealand: Impact of formula and water fluoride". *Journal of Public Health Dentistry* 70.4 (2010): 285-291.
27. K Nohno., *et al*. "Fluoride intake of Japanese infants from infant milk formula". *Caries Research* 45.5 (2011): 486-493.
28. LA Dagnaw., *et al*. "Fluoride content of leafy vegetables, irrigation water, and farmland soil in the rift valley and in non-rift valley areas of Ethiopia". *Fluoride* 50.4 (2017): 409-429.
29. N Bhat., *et al*. "Assessment of Fluoride Concentration of Soil and Vegetables in Vicinity of Zinc Smelter, Debari, Udaipur, Rajasthan". *Journal of Clinical and Diagnostic Research* 9.10 (2015): ZC63-ZC66.
30. A Jain., *et al*. "Estimating concentration of fluoride in edible leaves locally grown around Raipur, Chhattisgarh". *Journal of Indian Association of Public Health Dentistry* 15.2 (2017): 177-180.
31. M Maina., *et al*. "Analysis of Fluoride in Kales (*Brassica oleracea*) and Tomatoes (*Lycopersicum esculentum*) from Nakuru County, Kenya". *Africa Environmental Review Journal* 4.1 (2020): 35-42.

32. PK Gevera., *et al*. "Potential fluoride exposure from selected food crops grown in high fluoride soils in the Makueni County, south-eastern Kenya". *Environmental Geochemistry and Health* 44.12 (2022): 4703-4717.

33. FSAI Report. "Total Diet Study 2014-2016: Assessment of dietary exposure to fluoride in adults and children in Ireland in 2018". The Exchange George's Dock, IFSC. Dublin D01 P2V6.

34. MINSAL. "Feeding guide for children under 2 years old and feeding guide up to adolescence". Department of Nutrition and Food of the Ministry of Health (2023): 1-145.

35. JA Camargo. "Fluoride toxicity to aquatic organisms: A review". *Chemosphere* 50.3 (2003): 251-264.

36. H Al-Adilah., *et al*. "Iodine and fluorine concentrations in seaweeds of the Arabian gulf identified by morphology and DNA barcodes". *Botanica Marina* 63.6 (2020): 509-519.

37. J Itoh., *et al*. "Elemental analysis of edible plants in natural environment: Trace elements in wild plants". *International Journal of PIXE* 17.3 (2007): 119-127.

38. USDA. "National Fluoride Database of Selected Beverages and Foods, Release 2". Nutrient Data Laboratory. Beltsville Human Nutrition Research Center. Agricultural Research Service (2005).

39. JR Jaudenes., *et al*. "Fluoride risk assessment from consumption of different foods commercialized in a European region". *Applied Sciences* 10.18 (2020): 6582.

40. R Havale., *et al*. "Estimation of fluoride uptake in soil and staple food crops produced in highly fluoridated and non fluoridated regions of Raichur district, Karnataka, India". *Journal of Family Medicine and Primary Care* 11.7 (2022): 3546-3552.

41. BD Hong., *et al*. "Fluoride in soil and plant". *Korean Journal of Agricultural Science* 43.4 (2016): 522-536.

42. A Contreras. "Importance of Native Potatoes in Chile". INIATierra Adentro. Special Genetic Resources (2009): 39-41.

43. D Sawilska-Rautenstrauch., *et al*. "Fluorine in vegetables and potatoes from the market in Warsaw, Poland". *Roczniki Państwowego Zakładu Higieny* 49.3 (1998): 341-346.

44. G Arora and S Bhateja. "Estimating the fluoride concentration in soil and crops grown over it in and around Mathura, Uttar Pradesh, India". *American Journal of Ethnomedicine* 1.1 (2014): 036-041.

45. W Tewarangsri., *et al*. "Knowledge level and consumption behavior of native plants, meats, and drinking waters with high fluoride concentrations about the relation to the potential health risk of fluoride in Lamphun Province, Thailand: A Case Study". *Sustainability* 14.4 (2022): 8701.

46. A Cantoral., *et al*. "Fluoride content in foods and beverages from Mexico city markets and supermarkets". *Food and Nutrition Bulletin* 40.4 (2019): 514-531.

47. PC Calder. "Omega-3 fatty acids and inflammatory processes". *Nutrients* 2.3 (2010): 355-374.

48. P Prabhakar and V Hegde. "Estimation of fluoride in freshwater fish and marine water fish". *Journal of Multidisciplinary Dental Research* 7.1 (2021): 37-40.

49. F Zohoori and RM Duckworth. "Fluoride: Intake and metabolism, therapeutic and toxicological consequences". In Molecular, Genetic, and Nutritional Aspects of Major and Trace Minerals. Elsevier (2017): 539-550.

50. CK Lutter., *et al*. "Complementary feeding of infants and young children 6 to 23 months of age". *Nutrition Reviews* 79.8 (2021): 825-846.

51. FR Greer., *et al*. "The effects of early nutritional interventions on the development of atopic disease in infants and children: the role of maternal dietary restriction, breastfeeding, hydrolyzed formulas, and timing of introduction of allergenic complementary foods". *Pediatrics* 143.4 (2019): e20190281.

52. PL Buldini., *et al*. "State of the art ion chromatographic determination of inorganic ions in food". *Journal of Chromatography A* 21.783.1-2 (1997a): 529-548.

53. L La Pera., *et al*. "Chapter 35 - Inorganic anions in olive oils: application of suppressed ion exchange chromatography (IEC) for the analysis of olive oils produced from de-stoned olives and traditional extraction methods". Editors: VR. Preedy, RR Watson. Olives and Olive Oil in Health and Disease Prevention. Academic Press (2010): 317-324.

54. R Chaulagain., *et al*. "Mean fluoride concentration in drinking water sources of a municipality: a descriptive cross-sectional study". *Journal of Nepal Medical Association* 60.255 (2022): 947-951.

55. SA Moimaz., *et al*. "Fluoride concentration in public water supply: 72 months of analysis". *Brazilian Dental Journal* 23.4 (2012): 451-456.

56. MINSAL. "National report on fluoride in drinking water by region year 2021 in Chile". Department of Oral Health (2022): 1-49.

Volume 7 Issue 10 October 2024